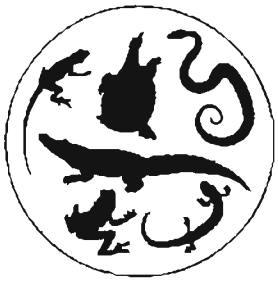
Proceedings of the

24th INTERNATIONAL HERPETOLOGICAL SYMPOSIUM

July of 2000



Hosted by
Audubon Park and Zoological Gardens

July 19 - July 22, 2000
New Orleans, Louisiana, USA

Prepared for Publication
by
Jeff Ettling, Vice President, IHS
Curator of Herps and Aquatics, Saint Louis Zoo

April 2001

24th Annual Meeting

International Herpetological Symposium

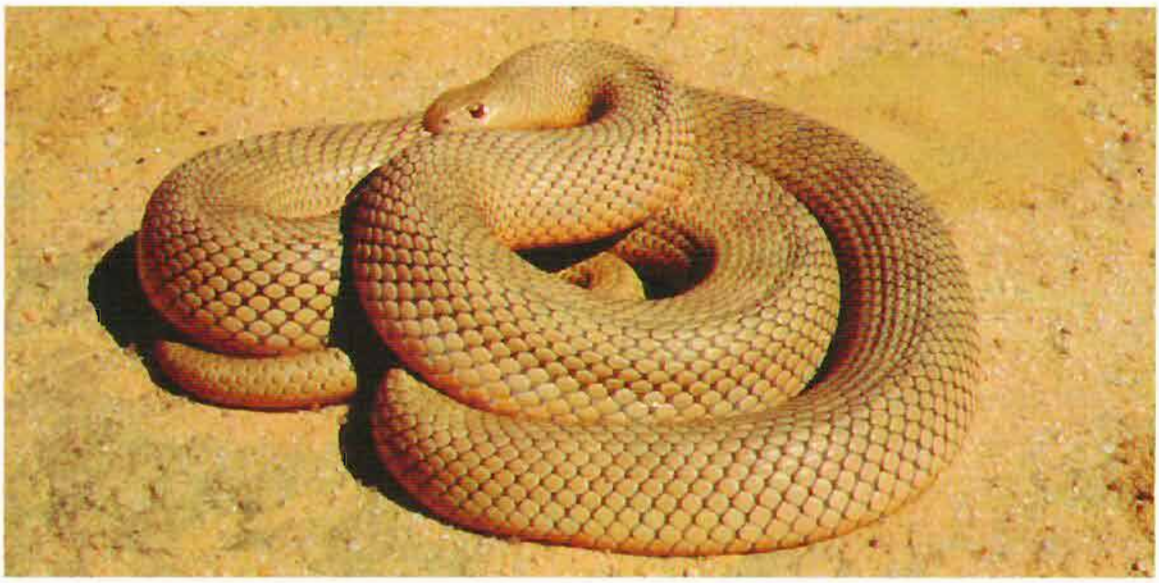
Hosted by

Audubon Park and Zoological Gardens

July 19 – July 22, 2000

New Orleans, Louisiana, USA

PROGRAM AND ABSTRACTS



Welcome to the
24th Annual Meeting of the
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International Herpetological Symposium, Inc.
24th Annual Meeting

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24th INTERNATIONAL HERPETOLOGICAL SYMPOSIUM

July 19 – July 22, 2000
New Orleans, Louisiana USA

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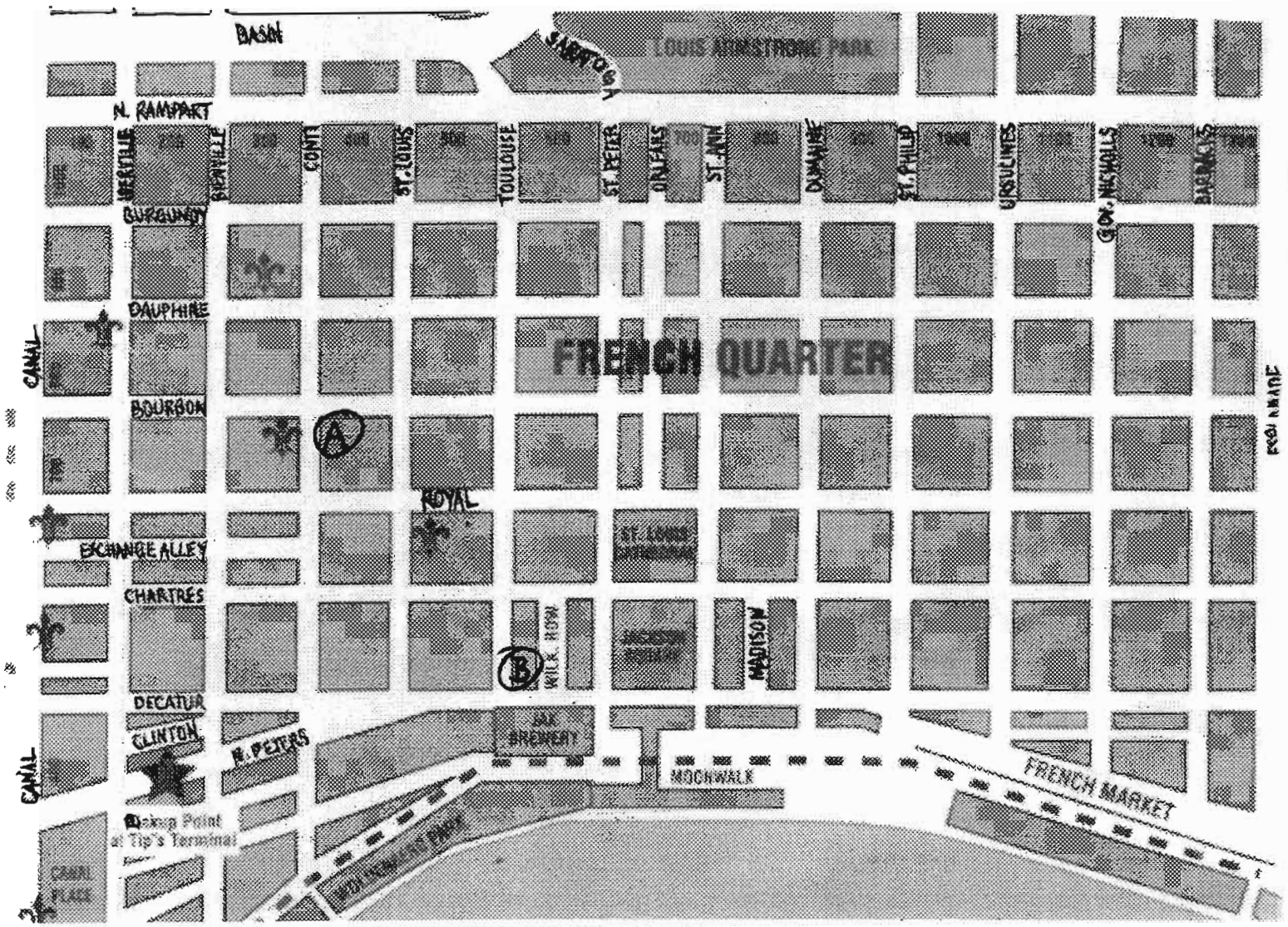

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INTERNATIONAL HERPETOLOGICAL SYMPOSIUM
24TH ANNUAL MEETING

PROGRAM

Wednesday, July 19th

7:00 - 10:00 p.m.	Registration - Radisson Hotel

Thursday, July 20th

8:00 - 5:00 p.m.	Open Registration - Radisson Hotel
8:00 - 8:15 a.m.	Opening Remarks & Introduction
8:15 - 9:00 a.m.	**Dr. Perran Ross** Crocodile Conservation in the Old World, Win Some, Lose Some
9:00 - 9:45 a.m.	**Dr. Dwight Lawson** Natural History of Exploited Rainforest Reptiles in Cameroon, Africa: Implications of Domestic Consumption for International Conservation
9:45 - 10:00 a.m.	*Break*
10:00 - 10:45 a.m.	**Paul Freed** - Herping in Usambara Mountains, Tanzania
10:45 - 11:30 a.m.	**Kelly Bradley** - Crocodile Monitor Reproduction at the Fort Worth Zoo
11:30 a.m. - 12:15 p.m.	**Vicky Poole** Big and Red: Natural Breeding of the Tomato Frog at the Baltimore Zoo
12:15 - 1:45 p.m.	*Lunch Break*
1:45 - 2:30 p.m.	**Sam Lee** - Monitor Reproduction at the Bronx Zoo
2:30 - 3:15 p.m.	**Craig Hoover** The Roles of the U.S. and China in the Global Turtle Trade
3:15 - 4:00 p.m.	**Charles Innis, VMD** - The Use of Endoscopy in Herpetological Medicine
4:00 - 4:15 p.m.	*Break*
4:15 - 5:15 p.m.	WORKSHOPS: Photographic Workshop: **David T. Roberts** Ask the Vets Workshop: **Drs Boyer, Mitchell and Innis**
7:30 - 9:30 p.m.	Icebreaker - Aquarium of the Americas

Friday, July 21

8:30 - 12:00 noon	Open Registration
8:30 - 8:45 a.m.	Announcements/Comments
8:45 - 9:45 a.m.	**Captain Al Cruz** The Florida Antivenin Bank, Creation and Operation
9:45 - 10:30 a.m.	**Karl Switak** Herpetofauna of the Kalihara Desert
10:30 - 10:45 p.m.	*Break*
10:45 - 11:30 a.m.	**Philip Bergmann** The Effects of Human-Facilitated Hybridization of Conservation and Biodiversity in Herpetoculture
11:30 a.m. - 12:15 p.m.	**Kamuran Tepedelen** Chinese Ratsnakes and the Impact of the Consumption Trade
12:15 - 1:45 p.m.	*Lunch Break*
1:45 - 2:30 p.m.	**Matthew Moyle** Long-term Breeding Program for Uromastyx
2:30 - 3:15 p.m.	**Mark Mitchell, DVM** *Salmonella* Research
3:15 - 4:00 p.m.	**John Cann** New Freshwater Tortoises of Australia
5:00 p.m.	Shuttle Buses to Audubon Zoo for Open House and Hosted Dinner
8:30 p.m.	Shuttle Buses Return

Saturday, July 22nd

8:00 - 8:15 a.m.	Announcements/Comments
8:15 - 9:00 a.m.	**Dr. Peter Pritchard** The Giant Softshells of Asia
9:00 - 9:45 p.m.	**Greg Lepera** Shifts, Squeezes, Tubes, and Conditioning: Techniques for Managing Mambas and Crocodiles
9:45 - 10:00 a.m.	*Break*

10:00 - 10:45 a.m.	**Thomas Boyer, DVM** The Importance of Reptile Quarantine
10:45 - 11:30.a.m.	**David Barker** The Mechanics of Python Reproduction
11:30 a.m. - 12:15 p.m.	**Alan Kardon** Life and Times of the Pad A Dedicated Amphibian Facility at the San Antonio Zoo
12:15 - 1:45 p.m.	*Lunch Break*
1:45 - 2:30 p.m.	**Andrew Snider** The National Amphibian Conservation Center: A New Window on a Wet World
2:30 p.m. - 3:15 p.m.	**Gregory George** Concrete Solutions to Exhibit Problems
3:15 - 4:00 p.m.	**Jack Cover** Exhibit Design at the National Aquarium
4:00 - 4:30 p.m.	*Break*
4:30 - 5:30 p.m.	**John Tashjian** Mystery Herp Quiz (Prize to winner!)
7:00 - (?)	Banquet Dinner - Radisson Hotel **John Cann**, Banquet Speaker Travels on the Top End of OZ (Frazer Island, Cape York Peninsula, Gulf of Carpentaria, The Kimberleys and Arnhem Land) Announcements Presentation of the Laszlo Memorial Award Auction (Get ready for this and remember proceeds benefit next year's IHS!)

ABSTRACTS

DAVID G. BARKER
Vida Preciosa International, Inc., Pythons, P.O. Box 300, Boerne, TX 78006, USA. (830) 537-5000 (tel and fax), vpi@gvtc.com (e-mail), www.vpi.com

The Mechanics of Python Reproduction Illustrated by Dissection and Sonography

The development of the oocyte into a fertile egg is illustrated by the dissection of pythons in the various stages of reproduction. These stages of development are also illustrated by sonograms of the ovaries and oviducts of living pythons. The reproductive organs of both make and female pythons are illustrated. The mechanics of copulation and fertilization are illustrated and discussed.

PHILIP J. BERGMANN, *Department of Biological Sciences*
Vertebrate Morphology Research Group, University of Calgary, 2500 University Dr. N.W., Calgary, Alberta, Canada, T2N 1N4, (403) 220-7638 or (403) 220-7258 (tel), (403) 289-9311 (fax)

The Effect of Human-Facilitated Hybridization on Conservation and Biodiversity in Herpetoculture.

Hybridization, the production of offspring by interbreeding individuals from genetically distinct populations (regardless of taxonomic status), can either be natural or human-facilitated. Natural hybridization contributes to rapid speciation and radiation of taxa, and can be an important impetus for evolutionary change. Human-facilitated hybridization is often highly detrimental, and can lead to the genetic extinction of taxa. This is a growing concern with respect to captive propagation as well as conservation of species, and is here explored in a herpetocultural/herpetological context. Examples from whiptail lizards, *Cnemidophorus*, python genus *Morelia*, Burmese python, *Python molurus*, the sea turtles, Cheloniidae, and other taxa are utilized to support arguments. In the past, human propagators of various organisms have faced the question of whether or not to hybridize. The herpetocultural community, which is relatively young, is now faced with the same questions. The production of hybrids by humans provides the opportunity to damage natural populations from a genetic standpoint. Hybridization of this sort can act to destroy coadapted gene complexes, resulting in animals poorly adapted to their specific, local environment. Release or reintroduction of such animals threatens both the fitness of wild individuals, and the genetic integrity of their species. This damage is often difficult to identify and therefore quantify, hindering conservation efforts. Hybridization, if used in a highly controlled and well-planned manner, can be helpful in "last resort" conservation efforts. With the exception of these efforts, it is imperative that the products of human-facilitated hybridization be removed from natural situations. Measures should also be taken to ensure that intentional hybridization is done in a responsible and controlled manner, or not at all.

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Quarantine of Reptiles

Reptiles entering established collections should be sequestered from the main collection for three months for lizards, chelonians and crocodilians and six months for snakes. Quarantine facilities ideally should be physically separated from the collection and serviced after the main collection. There should be no exchange of items between quarantine and the main collection. A separate ventilation system, sink, foot baths, disposable gloves and multiple quarantine rooms are highly recommended. Strict pest control is a must. During quarantine the reptile should gain weight, be tested and/or treated for endoparasites (particularly nematodes and protozoa) and ectoparasites (particularly mites and ticks) and establish a normal feeding routine. Ancillary diagnostics such as a complete blood count, chemistry panel and paramyxovirus HI titer (for viperids) are recommended depending on the species and temperament. Animals that fail to thrive, loose weight or are questionable should not be moved to the main collection. Animals that die should undergo a thorough necropsy, including histology, if an obvious cause of death is not apparent.

For chelonians important contagious diseases to detect during quarantine are upper respiratory tract disease and herpesvirus. For snakes contagious infectious diseases include cryptosporidiosis, paramyxovirus, inclusion body disease virus and other viruses. For lizards contagious infectious diseases include adenovirus and potentially paramyxovirus. For crocodilians poxvirus and mycoplasma are concerns. Amoebiasis is a problem for all groups.

KELLY BRADLEY, ***Keeper***
Reptile Department, Fort Worth Zoo, 1989 Colonial Pkwy., Fort Worth, TX 76110 USA, (817) 871-7000 (tel), (817) 871-7012 (fax)

Captive Reproduction of the Crocodile Monitor, *Varanus salvadorii*, the Fort Worth Zoo

The crocodile monitor, *Varanus salvadorii*, is an impressive species from the island of New Guinea. This species is considered by many to be the longest lizard in the world. Except for several locality reports, very little information is available concerning the ecology or natural history of this species. Recently, more information dealing with captive husbandry has become available through the zoological community and the private sector. Crocodile monitors are held in relatively few American zoos due to its large space demands, and potential to inflict severe injuries to keepers.

The Fort Worth Zoo has bred crocodile monitors on two occasions, once in 1997 and again in 1999. A total of ten offspring were successfully hatched from eleven fertile eggs. The Fort Worth Zoo utilized several husbandry techniques to induce successful reproduction. These methods, along with egg incubation techniques and neonate husbandry, will be discussed in detail.

JOHN CANN
26 Yarr Rd., Phillip Bay, New South Wales, 2036 Australia

New Freshwater Tortoises of Australia

Research into Australian freshwater turtles has greatly advanced during the last decade. Numerous new forms have been formerly described, and many papers describing turtles have been submitted or are in their final stages of preparation.

This new work has been driven by extensive surveys for new forms, to which I am pleased to have contributed substantially, renewed interest in turtle taxonomy by some bright students, and the introduction of some modern molecular techniques to the problem of defining species boundaries objectively.

This work has confirmed many ideas on new species, as outlined in the literature, but it has also yielded some surprises. The cryptic species pair of saw-shell turtles, *Elseya georgesi*, from the Bellinger and *Elseya purvesi* from the Manning, is one example. Three instances of hybridization among the snake-necked turtles, *Chelodina* provide other examples. *Chelodina novaeguineae* is hybridizing with *Chelodina longicollis* where their ranges meet in central Queensland, and *C. novaeguineae* is hybridizing with *C. rugosa* in the Gulf country, despite their distant relationship. Back-crossed individuals have been found, providing a real challenge to our ideas of what a *Chelodina* species is.

Whatever the final figure is for the number of Australian freshwater turtle species, this critical information is coming to light at a time when many populations of turtle are in decline as human and aquatic wildlife populations compete for a very limited resource in Australia - water. This fundamental taxonomic work is critical if we are to balance conservation concerns with development.

JOHN F. COVER, ***Curator of Rain Forest Exhibits***
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Exhibit Design at the National Aquarium in Baltimore

Zoo and aquarium exhibits have changed drastically from the Victorian style of the past, when "stamp-book" collections of animals were displayed in stark, barren enclosures. In the 1960's a revolution in zoo/aquarium displays began as efforts shifted towards naturalistic habitat recreations, and the first visitor immersion exhibits were created. This effort continues to evolve and improve as new materials, techniques, and technologies are utilized.

Another exhibit concept, long used by art museums and gaining popularity in the zoo/aquarium industry, is the creation of a changing exhibit space. These exhibits are temporary and typically change on a one- to two-year cycle. Changing exhibits present the opportunity to explore various topics in detail and to create displays presenting new information. New exhibits are a tremendous aid in stimulating repeat visitation.

The National Aquarium in Baltimore (NAIB) is committed to displaying animals in naturalistic environments and to cutting-edge exhibitry. The lecture will discuss the exhibit design and creation process at NAIB, focusing on our Rain Forest exhibits, the newly opened Amazon River Forest exhibit and our last changing exhibit Venom: Striking Beauties.

The true beauty and display value of reptiles and amphibians is sometimes lost due to poor lighting and poorly designed exhibits. Naturalistic habitats can not only enhance specimen beauty but can also stimulate natural behaviors such as foraging and breeding behaviors. Such activity makes the exhibit more interesting to visitors. The same techniques can be utilized by home hobbyists to stimulate natural behaviors of their captives.

CAPTAIN AL CRUZ
Miami-Dade Fire Rescue, Florida Antivenin Bank, Special Operations Division, (786) 331-5000 Non emergency, fdvenom@aol.com (e-mail)

The Florida Antivenin Bank, Creation and Operation

Miami-Dade County is the largest importer of exotic venomous snakes in the United States, and possibly the world, importing more than 1,500 snakes annually. From 1946 through 1988, the Miami Serpentarium handled the needs for antivenin throughout the state of Florida. Due to the closure of the facility in 1988, South Florida had no access to antivenin with a 250 mile radius and there has been an alarming increase of envenomations (venomous snakebites) and subsequent need for antivenin. Shortly after the closing of Miami Serpentarium, an adult male was bitten by a cobra, and it took 17 public and private agencies to bring this individual back to life.

To date, the State of Florida has issued approximately 100 venomous reptile licenses to residents in Miami-Dade county, and an additional 400 permits have been issued throughout the entire state. According to the Florida Fresh Water & Game Commission, 3 to 5 times more people are keeping venomous snakes without acquiring permits.

Venomous snakebite incidents continue to occur at an average rate of 300 per year in the state of Florida and at the rate of 8,000 nationally. According to the Florida Poison Control Center, Miami-Dade, Broward and Palm Beach counties average 150 snakebites a year, 40 percent of which are poisonous. However, there is a drastic reduction in the stocking of antivenin serum, and most hospitals are at a disadvantage when confronted with an envenomation incident.

Until the creation of the Antivenin Bank, many local hospitals were not stocking proper quantities of antivenin to treat envenomations. In the past, foreign antivenin had been maintained exclusively in zoos, where the sera was not readily available in cases of snakebites.

Recognizing the gap in emergency medical service for snakebite victims, the Miami-Dade Fire Rescue Department created the Florida Antivenin Bank to treat incidents involving venomous snakes. The department's Emergency Medical Services (EMS) Division created its own antivenin bank (the Florida Antivenin Bank) in June of 1998. By October, a local fire station was stocked with antivenin serum, and the bank was fully operational to supply antivenom for the majority of venomous snakes maintained in captivity. Its resources are available statewide, nationwide and worldwide, if requested.

An extension of the Florida Antivenin Bank was initially established at Winter Park Fire and Rescue in central Florida to expedite availability of serum to all residents of the state of Florida. This site guarantees deployment of antivenin within the timeframe of one hour to urban communities and two hours to rural communities.

The Florida Antivenin Bank works closely with hospitals in the state and with the Florida Poison Control Center. In an agreement with Miami-Dade Fire Rescue's EMS Division, ten local area hospitals maintain an in-house stock of antivenin to treat native venomous snakebites. The Florida Antivenin Bank

trains hospital personnel in the latest snakebite treatment modalities and the identification of native and commonly kept exotic venomous snakes. The maintenance of this antivenin bank greatly improves the quality of care provided to our citizens.

The Antivenin Bank is available on a 24-hour basis to render assistance with venom-related emergency calls involving requests for antivenin serum in and outside Miami-Dade County. Some of the antivenin available through the bank is the only one of its kind in the southeastern United States. The bank can be reached through the Miami-Dade Communications Center by dialing 911.

Since the implementaion of the Florida Antivenin Bank, no fatalities have occurred within the State of Florida. The program itself has proven successful, providing antivenin or expertise in 37 incidents, even when activated to assist on a national and international level.

PAUL FREED, *Senior Keeper,*
Reptile Department, Houston Zoo, 1513 N. MacGregor, Houston, TX 77030 USA, (713) 284-1300 (tel), (713) 284-1329 (fax)

Herping in Usambara Mountains, Tanzania

Located along southeastern Africa, Tanzania boasts an impressive diversity of approximately 375 species of reptiles and amphibians. Due to the numerous isolated mountains founds throughout the country, many of the herp species are endemic. This includes over 50 species of reptiles and nearly an equal number of amphibians that are found only in these remote and often inaccessible mountain ranges.

With the assistance of an in-country guide, several weeks were spent collecting herpetological specimens in northern Tanzania as well as the Usambara Mountains. The Usambaras are home to many endemic species, including caecilians, frogs, toads and half a dozen varieties of chameleons. Tanzania has over 30 taxa of chameleons, many of which were found in the Usambaras.

Unfortunately, even in protected areas such as the Usambaras, much of the habitat is being cut down and degraded for agricultural use and for the timber industry. During the brief time we spent in these mountains, we could clearly see the destructive impact the local people have inflicted on this once pristine region. At this accelerated rate of deforestation, it won't take long before most of Tanzania's treasures are lost forever.

GREGORY GEORGE
Petraworks-Concrete Sculpture and Casting, 4407 North Fairmount Road, Signal Mountain, TN 37377 USA 423-886-7870

Concrete Solutions to Exhibit Problems

Many reptile and amphibian collections across the country are housed in older facilities built during an era which emphasized a diversity of specimens. These buildings, designed by "collectors," characteristically present cubicle exhibits in a formal, linear arrangement. In today's zoos and aquariums the emphasis has changed to more complex, mixed species exhibits portraying a section of a particular environment. Interpretive graphics and educational messages relating to adaptation, behavior and reproductive strategies of the exhibited species as well as physical characteristics of their environment are becoming more popular.

The primary goals in exhibit design are to elicit natural behavior from the species while accommodating the needs of the keeper, maximizing space, minimizing animal stress, and incorporating feeding stations, life support systems and natural planting. "Concrete Solutions to Exhibit Problems" addresses these challenges inherent to exhibit design and construction while demonstrating practical and affordable materials and methods necessary to implement positive changes in reptile and amphibian exhibits

CRAIG HOOVER, *TRAFFIC North America*
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The Roles of the United States and China in the Global Turtle Trade

The two most significant players in the global turtle trade may very well be the United States and China. Though the United States serves largely as a supplier, it is also a significant consumer of native and exotic species, both as pets and for food. China, though a producer of significant numbers of turtles, is currently consuming turtles at a rate that threatens not only the more than 80 species in Asia, but turtle species throughout the world.

By far the largest group of reptile species exported from the United States is our native turtles, and this trade has expanded rapidly over the last decade. Approximately 10 million hatchling red-eared slider turtles, *Chrysemys scripta elegans,* and quantities exceeding 200,000 of more than a dozen other species are exported from the United States each year to supply pet and food trades around the world.

Rising demand for freshwater turtles and tortoises in China has provoked serious concern that many Asian species are in serious decline and facing extinction in the wild. This enormous demand for turtles, which are primarily consumed as food and medicine, is fueled mainly by China's South and Southeast Asian neighbors, which continue to send tons of live turtles to China. In this presentation, we will compare and contrast the turtle trades in the United States and China, and assess the impacts that these two nations are having on wild turtle populations.

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Use of Endoscopy in Herpetological Medicine

Endoscopy has been used for many years in both human and veterinary medicine. Only recently, however, has endoscopy been used to any extent in reptiles or amphibians. Endoscopy involves the use of a fiberoptic lens system or camera system to visualize the internal structures of the patient. Common uses in humans include arthroscopy (visualization of the interior of a joint), bronchoscopy (visualization of the airways), and colonoscopy (visualization of the lining of the colon). These techniques are favored because they are minimally invasive, do not involve large incisions, and can be used to obtain tissue biopsies.

In herpetological medicine, the veterinarian is often faced with a very stoic patient. Reptiles have the ability to appear quite normal externally, while actually being extremely ill internally. As a result, it is often necessary to perform some type of diagnostic testing to try to determine why the animal is ill. Blood testing, including cell counts, blood chemistry values, and antibody levels to specific diseases, is often helpful but is equally often unhelpful. It is possible to have a completely normal blood result in a very ill reptile. Similarly, radiographs ("x-rays"), and ultrasound images are sometimes useful, but only provide an indirect, limited view of organs. Because of these limitations, veterinarians may now favor endoscopy to allow direct visualization and evaluation of reptile and amphibian patients.

There are numerous areas where endoscopy may be useful. In general a small incision (about one cm) must be made in the body wall under general anesthesia. Coelioscopy, or internal examination of the coelomic cavity, provides direct view of the liver, lungs, kidneys, heart, spleen, bladder, gastrointestinal tract, pancreas, and gonads. This technique can be used to evaluate these organs for abnormalities including organ enlargement, abscesses (infection), tumors, bleeding, etc. Visualization of the gonads can be used to determine the gender of individuals of sexually monomorphic species or juveniles of dimorphic species. Fieldwork on juvenile desert, *Gopherus agassizi,* and Galapagos tortoises, *Geochelone nigra,* and hellbenders, *Cryptobranchus alleganiensis,*has demonstrated the utility of endoscopy for gender identification. Endoscopy can also be used in reptiles to look into the trachea and bronchi to evaluate cases of respiratory disease. It can be used to retrieve foreign bodies from the gastrointestinal tract (eg. coins swallowed by crocodilians). Finally, and perhaps most importantly, endoscopic instruments allow the veterinarian to obtain tissue biopsies of diseased organs. By obtaining biopsies, it may be possible to

provide a more precise diagnosis and prognosis than previously available through other diagnostic testing. For example, based on bloodwork an animal may be said to have a liver problem; but with endoscopy, a more definite diagnosis such as a fungal liver infection may be made, thus allowing precise treatment for the precise problem.

Advanced herpetoculturists should be aware of the availability of endoscopy and consider seeking a veterinarian that can provide this service if other diagnostic options have been unrewarding.

ALAN KARDON, ***Curator of Reptiles and Amphibians***
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Life and Times of the Pad: A Dedicated Amphibian Facility at the San Antonio Zoo

In the spring of 1997, the San Antonio Zoo converted an all desert, mixed animal species' facility to an all amphibian species' facility. The idea for a totally separate building (out of and away from the reptile house) was based on a paper by Karl H. Peterson: The Global Decline in Amphibian Species: A Perceptual Deficit in the Zoo and Conservation Community. Bull. Chicago Herp. Soc. 31(2):22-26, 1996. This paper dealt with the distinct differences between reptiles and amphibians, and how zoos and the conservation communities have historically viewed the two as one and the same. A separate facility is better able to highlight and educate zoo visitors about the uniqueness of amphibians. The 100 square foot building was renovated to display seventeen species including Japanese giant salamanders, *Andrias japonicus*. The public is treated to a cacophony of frog calls when visiting, courtesy of a continually playing CD. A 440 square foot reserve area affords room for additional species that are not on display. Some of the zoo's successful breeding efforts to date have included the Asian leaf frog, *Megophrys montana*, monkey tree frogs, *Phyllomedusa sauvagei*, golden mantellas, *Mantella aurantiaca*, and poison dart frogs, *Dendrobates azureus, D. leucomelas* and *D. tinctorius*.

DWIGHT P. LAWSON, ***General Curator***
Zoo Atlanta, 800 Cherokee Avenue, S, Atlanta, GA 30315 USA, (404) 624-5619 (tel), (404) 627-7519 (fax)

Natural History of Exploited Rainforest Reptiles in Cameroon, Africa: Implications of Domestic Consumption for International Conservation.

The conservation implications of domestic reptile consumption are currently eclipsed by a focus on highly visible and regulatory-friendly issues such as the international pets and skin trades, and recently, for turtles in the Chinese food markets. While these issues are clearly significant and worthy of attention, the magnitude of domestic consumption remains unstudied for most taxa, and current regulatory efforts aimed at international trade practices do not address this underlying problem in source countries. Social and economic forces drive local consumption and make international exploitation of some reptile species possible. Compounding the problem, the profound absence of basic natural history information for even the most prominent and easily recognized species precludes a realistic assessment of offtake impact, hampering the development of effective measures aimed at protecting populations and species. To preserve un-charismatic species in the wild, there is no substitute for local, field-based conservation initiatives.

To illustrate these points, I present the results of four individual research projects on the natural history and domestic consumption of five prominent but poorly studied Central African rainforest reptiles that are heavily exploited locally. Based on radio telemetry studies and social surveys conducted in southwestern Cameroon, I discuss home range, habitat use, seasonal activity patterns, and offtake of the gaboon and rhinoceros viper, *Bitis gabonica* and *B. nasicornis*, African rock python, *Python sebae*, and forest-dwelling hingeback tortoise, *Kinixys erosa* and *K. homeana*.

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Monitor Reproduction at the Bronx Zoo

The Reptile House at the Wildlife Conservation Park, a.k.a. the Bronx Zoo, celebrated its 100th birthday last November. The zoo has been a forerunner in establishing and breeding many reptiles, notably large boids, elapids, viperids and chelonians. However, among the 15 species of varanids maintained throughout the zoo's history, only recently has the herpetology department been successful in breeding monitor lizards.

This paper will focus on the husbandry and captive propagation of two species of monitor lizards that the department has enjoyed good success in breeding, the ornate forest monitor, *Varanus ornatus*, and Mertens' water monitor, *Varanus mertensi*. Other species currently being worked with will be discussed as well.

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Shifts, Squeezes, Tubes, and Conditioning:
Techniques for Managing Mambas and Crocodiles

Zoological institutions often include potentially dangerous reptiles in their collections, and in many cases, these animals are crocodilians or venomous snakes. A significant number of serious injuries to zoo staff members have occurred while working directly with such species, and despite improved husbandry methods, bites continue to occur on a regular basis. In 1994, the Jacksonville Zoo began major renovations under a new Master Plan, with multiple new exhibits being considered for reptiles. During the exhibit design process, we refined some techniques already in use for effectively managing these animals. Staff safety is always of special concern, and limiting direct staff contact with two of our most dangerous species by creating shift enclosures solved a number of management issues. Our Nile crocodile, *Crocodylus niloticus*, exhibit was constructed in 1996 with three off-display holding areas with concrete pools. The three areas connect to the exhibit through large guillotine doors, and each shift connects to the adjoining shift through a sliding door. The crocodiles were behaviorally conditioned to come to an audible cue for food. They can be maneuvered throughout the exhibit, as well as into and between shifts by making a loud popping sound that is somewhat reminiscent of a juvenile crocodile. Most crocodilians can be conditioned in this manner, allowing the animals to be locked off-display, and creating an extra margin of safety for staff during routine servicing of exhibits. Shifts are especially useful with large, agile elapids, and are regularly incorporated as a management tool for these animals. The shift boxes that we use for our west African green mamba, *Dendroaspis viridis*, integrate several components into a single unit. The boxes have removable covers permitting visual access to the interior, and allowing staff to lighten or darken the inside of the box. Each box can be locked and removed from the exhibit. The boxes contain a lateral squeeze feature, facilitating access for injections, if necessary. A large PVC fitting with a sliding, lockable door accepts clear acrylic restraint tubes, making it much safer to "tube" a snake for closer examination. Getting the mambas to use the shifts proved problematic, and we began to explore the use of operant conditioning methods to encourage the snakes to utilize the boxes more consistently. Our ultimate goal is to have the snakes enter the boxes on cue to allow unrestricted access to the exhibit for routine maintenance, and we have made considerable progress toward that end. Conditioning methods have been used extensively in the captive management of mammals, but rather infrequently with reptiles. Operant conditioning in particular has promise as a means to increase safety while working closely with dangerous reptiles.

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Reptile-associated salmonellosis

The incidence of reptile-associated salmonellosis cases in humans has increased dramatically during the past decade. In 1996, the Centers for Disease Control estimated that reptiles accounted for 3-5% of the 2-6 million cases of human salmonellosis in the U.S.. In most documented reptile-associated cases of salmonellosis, the strain of *Salmonella* spp. isolated from the patient was common to the pet reptile suggesting the source of infection. The majority of the reptile-associated salmonellosis cases reported in the United States are diagnosed in immunocompromised individuals and infants. The increased incidence of reptile-associated salmonellosis has been associated with the increased popularity of these animals as pets during the past decade. From 1989 to 1993 imports increased 82%, from 1.1 million to 2.1 million animals. Unfortunately, little is know about the epidemiology of *Salmonella* spp. and reptiles. The increased popularity of reptiles with attendant risks of salmonellosis in owners and contacts of both clinically affected and normal animals merits study.

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Long-Term Breeding Program for Uromastyx

Uromastyx comprise a group of unusual, medium-sized agamids, ranging from north Africa to the Indian subcontinent. These desert-hardened lizards are characterized by a stout head, a heavy-set body and a unique spiny tail. Most species are attractively colored while a few, such as *U. acanthinurus* and *U. ocellatus ornatus*, are endowed with spectacular and highly variable hues including red, yellow, orange, green and blue. Consequently, Uromastyx have been well represented in the pet trade for decades, with several species being subjected to massive exports from their countries of origin in the last ten years. The entire genus is listed under CITES Appendix II, however the status of wild populations in the face of recent intense collecting for the pet trade is not clear. Despite their exposure to herpetoculture, Uromastyx are seldom bred in captivity. This could be due to a poor understanding of basic maintenance and propagation requirements for this genus. We describe here the ingredients of a successful breeding program for *U. acanthinurus* that has spanned ten years through multiple generations.

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Big & Red: Natural breeding of the tomato frog, *Dyscophus antongili*, at The Baltimore Zoo

The northern tomato frog, *Dyscophus antongili*, is a large and attractive species of microhylid from the northeastern coast of Madagascar. Unlike the more common species of tomato frogs from Madagascar, *D. guineti* and *D. insularis*, the *D. antongili* is protected under C.I.T.E.S. Appendix I and endangered in its native country as a result of over-collecting for the pet industry and habitat loss.

Jeopardized by a shortage of animals and a lack of genetic diversity, the ability to breed *D. antongili* has been vital to preserving the species in captivity. Researchers have successfully reproduced tomato frogs utilizing the hormone LHRH since 1988, and with the exception of one spontaneous natural breeding from a group of animals maintained in a year-round greenhouse environment, The Baltimore Zoo reproduced the frogs naturally through environmental manipulation in 1996. Over 4,500 eggs were produced by one female, of which 204 black and gold froglets were allowed to metamorphose. The frogs from this spawning and successive years have been placed in the collections of other institutions with the goals of pairing the frogs when new bloodlines become available and educating staff and visitors on the plight of this beautiful animal.

In addition to captive reproduction efforts, The Baltimore Zoo has been actively involved in other *D. antongili* conservation projects. These include funding the construction of a tomato frog exhibit in Madagascar, as well as providing photographs for their educational graphics, and supporting the DNA testing of captive animals in order to determine exact lineages to minimize future inbreeding.

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Giant Softshell Turtles of Asia

Softshell turtles, family Trionychidae, are named after a relatively inconspicuous feature, namely the presence of only three claws on each limb. Nevertheless, they are in many ways the most divergent and specialized of all turtles, especially in their drastic shell modifications which include the elimination of all of the scutes and major changes in the bony carapace and plastron also.

The softshell turtle occurs in North America, extreme southeastern Europe, Africa and southern and southeast Asia and Indonesia, and only reach south of the Equator in southern Africa and southern New Guinea. They show a remarkable variation in size, ranging from species that may reach maturity at 15 cm or less to some true giants; the largest occurring in Asia, and includes species which may exceed 110 cm in carapace length.

We have made efforts to gather data on the gigantic and almost extinct species Shanghai softshell, *Rafetus swimhoei*, in Vietnam and China and also on the narrow-headed softshell genus, *Chitra*, long considered to include only a single species, *C. indica*, in the Indian subcontinent, with a second species. *C. chitra* from Thailand, recognized in recent years. But recent fieldwork has shown that the genus is far more wide ranging and diverse, with a chain of taxa extending from the Indus River of Pakistan to the eastern end of the island of Java. This huge distribution undoubtedly has gaps where watersheds are separated by high country, but nonetheless these gaps are considerably more narrow than had generally been supposed.

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Photographic Workshop

David, a professional photographer and writer, will discuss various techniques to capture sharp detailed images of various subjects including reptiles, amphibians, insects and arachnids on film. The workshop will cover basic techniques for color macro and wide angle natural history photography. Composition, lighting, and equipment basics for 35mm SLR cameras will be discussed. Specialty tools used in the field and other related equipment will be on display. A short introductory slide show will be used to illustrate exposure, depth of field, lighting (natural and flash) and choice of subject. The workshop is open to photographers of all levels. Bring your camera!

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Conservation of Crocodiles in the Old World, Win Some, Lose Some

The majority of the family crocdylidae occur in the old world and their conservation status there provides some stark contrasts and illustrations both of the difficulties and of some successes in conserving them. In Africa the widespread Nile crocodile, *Crocodylus niloticus*, is still widespread and locally abundant in many countries of southern and eastern Africa but it is depleted and fragmented throughout west Africa. In Southern Africa, conservation and management models developed in South Africa and Zimbabwe have been widely applied. Crocodile ranching, protection in National parks and reasonably effective regulation of trade in crocodile products have resulted in stable, and in some places growing populations. The current issues affecting crocodile conservation in that region are the effects of world

economic markets on sustainable use programs and the increasing conflicts of expanding crocodile populations with the dense human population. Conservation issues lie mainly in the socio-economic sphere and biology and protection have relatively little application.

Australia, and to a more limited extent, Papua New Guinea, provide similar examples of the application of regulated harvest systems to conservation goals and demonstrated recovery and present stability of crocodile populations.

At the other extreme, in China, the Chinese alligator, *Alligator sinensis*, is on the verge of extinction in the wild despite a program over two decades of complete protection, reserves, captive breeding and an intense effort in US zoos. Recent analysis of the problem reveals that very intense land use and a culturally unique perspective on conservation combine to make the plight of wild Chinese alligators extreme. A major global initiative is presently underway to prevent this extinction but success is far from assured. Almost equally depressing are the situations of the Philippine crocodile, *Crocodylus mindorensis*, and Siamese crocodile, *Crocodylus siamensis*. Both are increasingly fragmented and depleted by human land use activity.

In India, a three decade program of protection and restocking of muggers, *Crocodylus palustris*, and gharials, *Gavialis gangeticus*, is foundering due to lack of adequate provision of habitat protection and lack of funding for these activities. The gharial is also currently threatened by plans for hydroelectric schemes in its few remaining habitats in Nepal.

I will attempt to summarize these examples and draw some conclusions of general application. Ironically, in those countries where crocodiles are subject to regulated exploitation, they prosper and in those countries where they are completely protected, they face extinction. Understanding and explaining this anomaly is the challenge for crocodile conservation. Land use practices, expanding human populations and booming economies are clearly the major threat to crocodiles in the Old World. Exploitation for commercial use has changed from being a threat to being, in a few important cases, a major incentive for conservation. The solutions to crocodile conservation, and probably to conservation in general, lie in adapting social, economic and cultural perspectives into an integrated whole for habitat and ecosystem management. Such an approach may have broad applicability to other reptilian conservation issues, particularly the current crisis in the massive trade of freshwater turtles in the food trade.

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The National Amphibian Conservation Center: A New Window On A Wet World

The National Amphibian Conservation Center (NACC) is a $6 million, 12,000-square foot, state of the art facility designed for and dedicated to amphibians. The focus of the NACC is conservation, research and education of the public; it is scheduled to open to the public in late spring of 2000. Approximately 1000 specimens of 60-100 species of amphibians will be housed here, including members of all three major groups: caecilians, salamanders, and frogs.

In this paper, I will discuss the thought processes that went into the initial design and creation of the facility and its surrounding two acre wetlands. Design and implementation of graphics and interpretive will be discussed, as will exhibit design and construction. Acquisition, quarantine, and housing/acclimation of the amphibian specimens pre-opening will be discussed, as will the reasoning behind "master planning" of certain species. Conservation programs, including SSP will be addressed, as will projects currently in the works such as importation of Kihansi spray toads, *Nectophrynoides asperginis*, at the request of the Tanzanian government, and "Project Golden Frog", *Atelopus zeteki*, in Panama. Ties to other "amphibian-friendly" organizations such as the Declining Amphibian Populations Task Force (DAPTF), The Nature Conservancy (TNC), and the Michigan Department of Natural Resources will be emphasized.

Due to the world-wide decline in amphibian species, it is hoped that this facility will provide a template for other zoos and aquariums to follow. Amphibians, as never before, need to have more emphasis and money dedicated to them in the zoo/aquarium community and it is hoped that this facility will help to bolster support for this cause.

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Herpetofauna of the Kalahari Desert

The Kalahari Desert of southern Africa harbors a great diversity of herpetological presence. It is also a region of great contrast, exemplified by summer temperatures the likes of hell, followed by winter months when the mercury often drops below freezing. Mix into this a combination of dust and sand storms, torrential downpours (summer months) plus the occasional hail storm and I give you the Kalahari.

Unfortunately this sandy domain is much too great a piece of real estate to be covered in a time-span of short duration. For this reason I shall restrict my presentation to the west and slightly southwestern area, specifically known as the Kalahari Gemsbok National Park (South Africa) and Botswana's counterpart the Gemsbok National Park. Recently the two merged to form the massive Kgalagadi Transfrontier Park.

Amphibians, in part are represented here by rain frogs, *Breviceps*, Cacos, *Cacosternum*, bull frogs, *Pyxicephalus*, and sand frogs, *Tomopterna*. Turtles that frequent the region are helmeted terrapin, *Pelomedusa subrufa*, leopard tortoise, *Geochelone pardalis*, and Kalahari tent tortoise, *Psammobates oculifer*.

Lizards in the Kalahari are not only conspicuous by their great numbers, but also by the diversity of species. Among these are barking geckos, *Ptenopus*, giant sand geckos, *Chondrodactylus*, black tree skinks, *Mabuya*, colorful and acrobatic ground agama, *Agama aculeata*, plus an assortment of speed demons better known as *Lacertids*, just to mention a few.

Of all the serpents that frequent the Kalahari, I believe the most spectacular to be the extremely venomous Cape cobra, *Naja nivea*; they are diurnal, they are nocturnal . They climb acacia trees and they slither across a sandy substrate with great agility. Their color is blinding.

Prime snake activity takes place in late winter (depending on weather), then early to mid spring. During these periods one can find mole snakes, *Pseudaspis cama*, dwarf beaked snakes, *Dipsina multimaculata*, sand snakes, *Psammophis*, the occasional puff adder, *Bitis arietans*, and, with some luck, a reddish-colored horned adder, *Bitis caudalis*.

To fully appreciate the Kalahari's herpetofauna one must look at the beast itself, the habitat it lives in, plus the prey and predators that surround it. This presentation, in part, will cover all these aspects.

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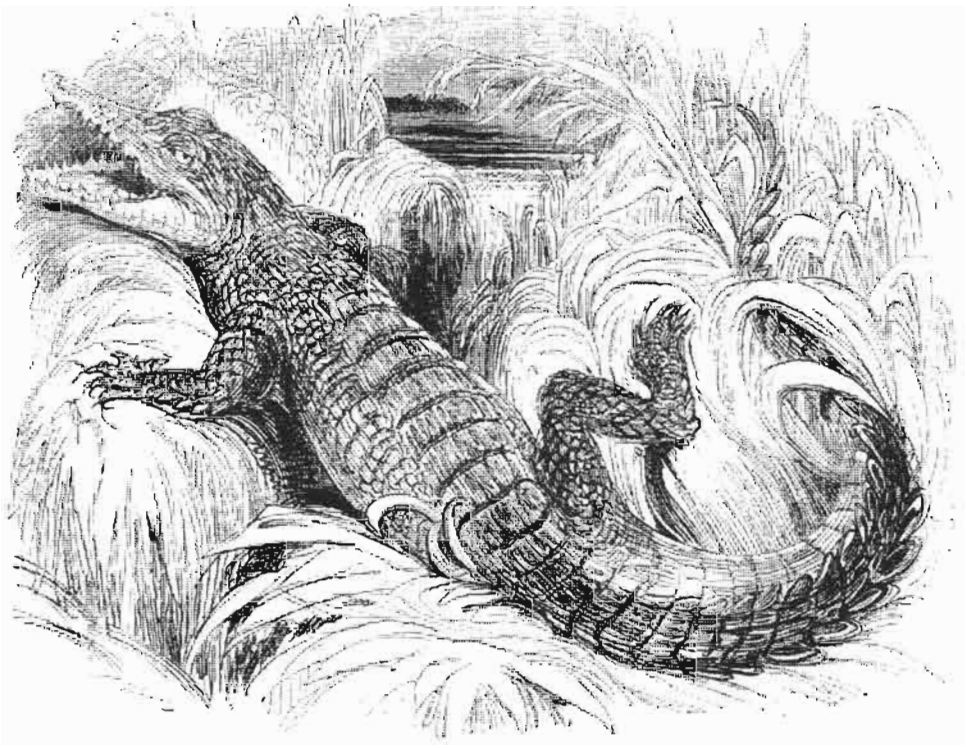
Chinese Elaphe and the Impact of the Consumption Trade

Kamuran Tepedelen is the owner and operator of Bushmaster Reptiles Inc. of Boulder, Colorado. His personal interest include Chinese ratsnakes, *Elaphe*; he has traveled to China on five separate occasions to perform field studies and document the habitat of this genus. He has collaborated with Klaus-Dieter Schulz of Wurselen Germany, the author of "A Monograph of the Colubrid Snakes of the Genus *Elaphe*". Together they have obtained and bred some of the more rare and difficult to keep Chinese *Elaphe*.

This talk will identify both rare and common Chinese *Elaphe* with a focus on the species that are actively collected for consumption. The current impact of the food market will be discussed, as well as the short and long term consequences of this trade. A focus on the importance of captive breeding in order to preserve species, which may become threatened for future generations, will include a list of species that deserve this attention. This talk will also feature photographic slides which exhibit various species, their habitat and the food market which threatens them.

NOTES



ABSTRACTS, EXCERPTS, and DESCRIPTIONS

["*" Indicates that complete paper is included in IHS/24 Proceedings]

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The Mechanics of Python Reproduction Illustrated by Dissection and Sonography

The development of the oocyte into a fertile egg is illustrated by the dissection of pythons in the various stages of reproduction. These stages of development are also illustrated by sonograms of the ovaries and oviducts of living pythons. The reproductive organs of both male and female pythons are illustrated. The mechanics of copulation and fertilization are illustrated and discussed.

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*The Effect of Human-Facilitated Hybridization on Conservation and Biodiversity in Herpetoculture

Hybridization, the production of offspring by interbreeding individuals from genetically distinct populations (regardless of taxonomic status), can either be natural or human-facilitated. Natural hybridization contributes to rapid speciation and radiation of taxa, and can be an important impetus for evolutionary change. Human-facilitated hybridization is often highly detrimental, and can lead to the genetic extinction of taxa. This is a growing concern with respect to captive propagation as well as conservation of species, and is here explored in a herpetocultural/herpetological context. Examples from whiptail lizards, *Cnemidophorus;* python genus *Morelia*; Burmese python, *Python molurus*; the sea turtles, Chelonidae; and other taxa are utilized to support arguments. In the past, human propagators of various organisms have faced the questions of whether or not to hybridize. The herpetocultural community, which is relatively young, is now faced with the same question. The production of hybrids by humans provides the opportunity to damage natural populations from a genetic standpoint. Hybridization of this sort can act to destroy co-adapted gene complexes, resulting in animals poorly adapted to their specific, local environment. Release or reintroduction of such animals threatens both the fitness of wild individuals and the genetic integrity of their species. This damage is often difficult to identify and therefore quantify, hindering conservation efforts. Hybridization, if used in a highly controlled and well-planned manner, can be helpful in "last resort" conservation efforts. With the exception of these efforts, it is imperative that the products of human-facilitated hybridization be removed from natural situations. Measures should also be taken to ensure that intentional hybridization is done in a responsible and controlled manner, or not at all.

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Quarantine of Reptiles

Reptiles entering established collections should be sequestered from the main collection for three months, for lizards, chelonians and crocodilians; and six months for snakes. Quarantine facilities ideally should be physically separated from the collection and serviced after the main collection. There should be no exchange of items between quarantine and the main collection. A separate ventilation system, sink, foot baths, disposable gloves and multiple quarantine rooms are highly recommended. Strict pest control is a must. During quarantine the reptile should gain weight, be tested and/or treated for endoparasites (particularly nematodes and protozoa) and ectoparasites (particularly mites and ticks) and establish a normal feeding routine. Ancillary diagnostics such as a complete blood count, chemistry panel and paramyxovirus HI titer (for viperids) are recommended depending on the species and temperament. Animals that fail to thrive, lose weight or are questionable should not be moved to the main collection. Animals that die should undergo a thorough necropsy, including histology, if an obvious cause of death is not apparent.

For chelonians, important contagious diseases to detect during quarantine are upper respiratory tract disease and herpes virus. For snakes, contagious infectious diseases include cryptosporidiosis, paramyxovirus, inclusion body disease virus and other viruses. For lizards, contagious infectious diseases include adenovirus and potentially paramyxovirus. For crocodilians, poxvirus and mycoplasma are concerns. Amoebiasis is a problem for all groups.

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Captive Reproduction of the Crocodile Monitor, *Varanus salvadorii*, at the Fort Worth Zoo

The crocodile monitor, *Varanus salvadorii*, is an impressive species from the island of New Guinea. This species is considered by many to be the longest lizard in the world. Except for several locality reports, very little information is available concerning the ecology or natural history of this species. Recently, more information dealing with captive husbandry has become available through the zoological community and the private sector. Crocodile monitors are held in relatively few American zoos due to its large space demands and potential to inflict severe injuries to keeper.

The Fort Worth Zoo has bred crocodile monitors on two occasions, once in 1997 and again in 1999. A total of ten offspring were successfully hatched from eleven fertile eggs. The Fort Worth Zoo utilized several husbandry techniques to induce successful reproduction. These methods, along with egg incubation techniques and neonate husbandry, will be discussed in detail.

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***A New Look at the Freshwater Tortoises of Australia**

Research into Australian freshwater turtles has greatly advanced during the last decade. Numerous new forms have been formally described, and many papers describing turtles have been submitted or are in their final stages of preparation.

This new work has been driven by extensive surveys for new forms, to which I am pleased to have contributed substantially, renewed interest in turtle taxonomy by some bright students, and the introduction of some modern molecular techniques to the problem of defining species boundaries objectively.

This work has confirmed many ideas on new species, as outlined in the literature, but it has also yielded some surprises. The cryptic species pair of saw-shell turtles, *Elseya georgesi*, from the Bellinger and *Elseya purvesi* from the Manning, is one example. Three instances of hybridization among the snake-necked turtles, *Chelodina*, provide other examples. *Chelodina novaeguineae* is hybridizing with *Chelodina longicollis* where their ranges meet in central Queensland, and *C. novaeguineae* is hybridizing with *C. rugosa* in the Gulf country, despite their distant relationship. Back-crossed individuals have been found, providing a real challenge to our ideas of what a *Chelodina* species is.

Whatever the final figure is for the number of Australian freshwater turtle species, this critical information is coming to light at a time when many populations of turtle are in decline as human and aquatic wildlife populations compete for a very limited resource in Australia - water. This fundamental taxonomic work is critical if we are to balance conservation concerns with development.

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Exhibit Design at the National Aquarium in Baltimore

Zoo and aquarium exhibits have changed drastically from the Victorian style of the past, when "stamp book" collections of animals were displayed in stark, barren enclosures. In the 1960s a revolution in zoo/aquarium displays began as efforts shifted towards naturalistic habitat recreations, and the first visitor immersion exhibits were created. This effort continues to evolve and improve as new materials, techniques, and technologies are utilized.

Another exhibit concept, long used by art museums and gaining popularity in the zoo/aquarium industry, is the creation of a changing exhibit space. These exhibits are temporary and typically change on a one-to-two-year cycle. Changing exhibits present the opportunity to explore various topics in detail and to create displays presenting new information. New exhibits are a tremendous aid in stimulating repeat visitation.

The National Aquarium in Baltimore (NAIB) is committed to displaying animals in naturalistic environments and to cutting-edge exhibitry. The lecture will discuss the exhibit design and creation process at NAIB, focusing on our Rain Forest exhibits, the newly opened Amazon River Forest exhibit, and our last changing exhibit, Venom: Striking Beauties.

The true beauty and display value of reptiles and amphibians is sometimes lost due to poor lighting and poorly designed exhibits. Naturalistic habitats can not only enhance specimen beauty but can also stimulate natural foraging and breeding behaviors. Such activity makes the exhibit more interesting to visitors. The same techniques can be utilized by home hobbyists to stimulate natural behavior of their captives.

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The Florida Antivenin Bank, Creation and Operation

Miami-Dade county is the largest importer of exotic venomous snakes in the United States, and possibly the world, importing more than 1,500 snakes annually. From 1946 through 1988, the Miami Serpentarium handled the needs for antivenin throughout the state of Florida. Due to the closure of the facility in 1988, South Florida had no access to antivenin within a 250 mile radius, and there has been an alarming increase of envenomations (venomous snake bites) and subsequent need for antivenin. Shortly after the closing of Miami Serpentarium, an adult male was bitten by a cobra, and it took 17 public and private agencies to bring this individual back to life.

To date, the State of Florida has issued approximately 100 venomous reptile licenses to residents in Miami-Dade county, and an additional 400 permits have been issued throughout the entire state. According to the Florida Fresh Water & Game Commission, three to five times more people are keeping venomous snakes without acquiring permits. Venomous snakebite incidents continue to occur at an average rate of 300 per year in the state of Florida and at the rate of 8,000 nationally. According to the Florida Poison Control Center, Miami-Dade, Broward and Palm Beach counties average 150 snake bites a year, 40 percent of which are VENOMOUS. However, there is a drastic reduction in the stocking of antivenin serum, and most hospitals are at a disadvantage when confronted with an envenomation incident.

Until the creation of the Antivenin Bank, many local hospitals were not stocking proper quantities of antivenin to treat envenomations. In the past, foreign antivenin had been maintained exclusively in zoos, where sera were not readily available in cases of snakebite. Recognizing the gap in emergency medical service to snakebite victims, the Miami-Dade Fire Rescue Department created the Florida Antivenin Bank to treat incidents involving venomous snakes. The department's Emergency Medical Services (EMS) Division created its own antivenin bank (the Florida Antivenin Bank) in June of 1998. By October, a local fire station was stocked with antivenin serum, and the bank was fully operational to supply antivenin for the majority of venomous snakes maintained in captivity. Its resources are available statewide, nationwide and worldwide, if requested.

An extension of the Florida Antivenin Bank was initially established at Winter Park Fire and Rescue in central Florida to expedite availability of serum to all residents of the state of Florida. This site guarantees deployment of antivenin within the time frame of one hour to urban communities and two hours to rural communities.

The Florida Antivenin Bank works closely with hospitals in the state and with the Florida Poison Control Center. In an agreement with Miami-Dade Fire Fescue's EMS Division, ten local area hospitals maintain an in-house stock of antivenin to treat native venomous snake bites.

The Florida Antivenin Bank trains hospital personnel in the latest snakebite treatment modalities and the identification of native and commonly kept exotic venomous snakes. The maintenance of this antivenin bank greatly improves the quality of care provided to our citizens.

The Antivenin Bank is available on a 24-hour basis to render assistance with venom-related emergency calls involving requests for antivenin serum in and outside Miami-Dade County. Some of the antivenin available through the bank is the only antivenin of its kind in the southeastern United States. The bank can be reached through the Miami-Dade Communications Center by dialing 911.

Since the implementation of the Florida Antivenin Bank, no fatalities have occurred within the state of Florida. The program itself has proven successful, providing antivenin or expertise in 37 incidents, even when activated to assist on a national and international level.

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***Herping in Usambara Mountains, Tanzania**

Located along southeastern Africa, Tanzania boasts an impressive diversity of approximately 375 species of reptiles and amphibians. Due to the numerous isolated mountains found throughout the country, many of the herp species are endemic. This includes over 50 species of reptiles and nearly an equal number of amphibians that are found only in these remote and often inaccessible mountain ranges.

With the assistance of an in-country guide, several weeks were spent collecting herpetological specimens in northern Tanzania as well as the Usambara Mountains. The Usambaras are home to many endemic species, including caecilians, frogs, toads, and half a dozen varieties of chameleons. Tanzania has over 30 taxa of chameleons, many of which were found in the Usambaras.

Unfortunately, even in protected areas such as the Usambaras, much of the habitat is being cut down and degraded for agricultural use and for the timber industry. During the brief time we spent in these mountains, we could clearly see the destructive impact the local people have inflicted on this once pristine region. At this accelerated rate of deforestation, it won't be long before most Tanzania's treasures are lost forever.

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Concrete Solutions to Exhibit Problems

Many reptile and amphibians collections across the country are housed in older facilities built during an era which emphasized a diversity of specimens. These buildings, designed by "collectors," characteristically present cubicle exhibits in a formal, linear arrangement. In today's zoos and aquariums the emphasis has changed to more complex, mixed species exhibits portraying a section of a particular environment. Interpretive graphics and educational messages relating to adaptation, behavior and reproductive strategies of the exhibited species as well as physical characteristics of their environment are becoming more popular.

The primary goals in exhibit design are to elicit natural behavior from the species while accommodating the needs of the keeper, maximizing space, minimizing animal stress, and incorporating feeding stations, life support systems and natural planting. "Concrete Solutions to Exhibit Problems" addresses these challenges inherent to exhibit design and construction while demonstrating practical and affordable materials and methods necessary to implement positive changes in reptile and amphibians exhibits.

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The Roles of the United States and China in the Global Turtle Trade
The two most significant players in the global turtle trade may very well be the United States and China. Though the United States serves largely as a supplier, it is also a significant consumer of native and exotic species, both as pets and for food. China, though a producer of significant numbers of turtles, is currently consuming turtles at a rate that threatens not only the more than 80 species in Asia, but turtle species throughout the world.

By far the largest group of reptile species exported from the United States is our native turtles, and this trade has expanded rapidly over the last decade. Approximately 10 million hatchling red-eared slider turtles, *Chrysemys scripta elegans*, and quantities exceeding 200,000 of more than a dozen other species are exported from the United States each year to supply pet and food trades around the world.

Rising demand for freshwater turtles and tortoises in China has provoked serious concern that many Asian species are in serious decline and facing extinction in the wild. This enormous demand for turtles, which are primarily consumed as food and medicine, is fueled mainly by China's South and Southeastern Asian neighbors, which continue to send tons of live turtles to China. In this presentation, we will compare and contrast the turtle trades in the United States and China, and assess the impacts that these two nations are having on wild turtle populations.

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***Use of Endoscopy in Herpetological Medicine**
Endoscopy has been used for many years in both human and veterinary medicine. Only recently, however, has endoscopy been used to any extent in reptiles or amphibians. Endoscopy involves the use of a fiberoptic lens system or camera system to visualize the internal structures of the patient.

This paper points out the numerous areas where endoscopy may be useful in herpetological medicine.

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Life and Times of the Pad: A Dedicated Amphibian Facility at the San Antonio Zoo

In the spring of 1997, the San Antonio Zoo converted an all desert, mixed animal species' facility to an all amphibian species' facility. The idea for a totally separate building (out of and away from the reptile house) was based on a paper by Karl H. Peterson: The Global Decline in Amphibian Species: A Perceptual Deficit in the Zoo and Conservation Community, Bull. Chicago Herp. Soc. 31(2):22-26. This paper dealt with the distinct differences between reptiles and amphibians, and how zoos and the conservation communities have historically viewed the two as one and the same. A separate facility is better able to highlight and educate zoo visitors about the uniqueness of amphibians. The 100 square foot building was renovated to display seventeen species including Japanese giant salamanders, *Andrias japonicus.* The public is treated to a cacophony of frog calls when visiting, courtesy of a continually playing CD. A 440 square foot reserve area affords room for additional species that are not on display. Some of the zoo's successful breeding efforts to date have included the Asian leaf frog, *Megophrys montana*, monkey tree frog, *Phyllomedusa sauvagei*; golden mantellas, *Mantella aurantiaca*; and poison frogs, *Dendrobates azureus*, *D. leucomelas* and *D. tinctorius.*

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Natural History of Exploited Rainforest Reptiles in Cameroon, Africa: Implications of Domestic Consumption for International Conservation

The conservation implications of domestic reptile consumption are currently eclipsed by a focus on highly visible and regulatory-friendly issues such as the international pets and skin trades, and recently, for turtles in the Chinese food markets. While these issues are clearly significant and worthy of attention, the magnitude of domestic consumption remains unstudied for most taxa, and current regulatory efforts aimed at international trade practices do not address this underlying problem in source countries. Social and economic forces drive local consumption and make international exploitation of some reptile species possible. Compounding the problem, the profound absence of basic natural history information for even the most prominent and easily recognized species precludes a realistic assessment of offtake impact, hampering the development of effective measures aimed at protecting populations and species. To preserve uncharismatic species in the wild, there is no substitute for local, field-based conservation initiatives.

To illustrate these points, I present the results of four individual research projects on the natural history and domestic consumption of five prominent but poorly studied Central African rainforest reptiles that are heavily exploited locally. Based on radio telemetry studies and social surveys conducted in southwestern Cameroon, I discuss home range, habitat use, seasonal activity patterns, and off take of the gaboon and rhinoceros vipers, *Bitis gabonica* and *B. nasicornis;* African rock python, *Python sebae;* and forest-dwelling hingeback tortoises, *Kinixys erosa* and *K. homeana*.

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***The Captive Maintenance and Propagation of the Ornate Monitor, *Varanus ornatus* (Daudin, 1803) and Mertens' Water Monitor, *Varanus mertensi* (Glauert, 1951) at the Wildlife Conservation Park (Bronx Zoo)**

The ubiquitous Nile monitor, *Varanus niloticus*, has been featured in nature documentaries as well as many natural history books. After the savannah monitor, it is probably the next most frequently purchased monitor lizard in the pet trade. Unfortunately, it is often purchased on impulse, and not much thought is given to the large size it attains or to its husbandry needs (Faust and Bayless, 1996). Less frequently imported is the ornate Nile or rainforest monitor, *Varanus ornatus*, a form recently elevated to a full-species on the basis of significant morphological and ecological differences (Böhme and Ziegler, 1997).

One of the many specialized varanids in terms of morphology and habitat use is the Mertens' water monitor, *Varanus mertensi* (Shine, 1986). Glauert named the species after the late herpetologist Robert F. Mertens (1894-1975), well known for his contributions to varanid taxonomy and morphology. This article focuses on the husbandry and reproduction of these species maintained at the Wildlife Conservation Society Park (Bronx Zoo) [The first *Varanus ornatus* breeding occurred at the author's residence in 1998.]

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Shifts, Squeezes, Tubes, and Conditioning: Techniques for Managing Mambas and Crocodiles

Zoological institutions often include potentially dangerous reptiles in their collections, and in many cases, these animals are crocodilians or venomous snakes. A significant number of serious injuries to zoo staff members have occurred while working directly with such species, and despite improved husbandry methods, bites continue to occur on a regular basis. In 1994, the Jacksonville Zoo began major renovations under a new Master Plan, with multiple new exhibits being considered for reptiles. During the exhibit design process, we refined some techniques already in use for effectively managing these animals. Staff safety is always of special concern, and limiting direct staff contact with two of our most dangerous species by creating shift enclosures solved a number of management issues. Our Nile crocodile, *Crocodylus niloticus*, exhibit was constructed in 1996 with three off-display holding areas with concrete pools. The three areas connect to the exhibit through large guillotine doors, and each shift connects to the adjoining shift through a sliding door. The crocodiles were behaviorally conditioned to come to an audible cue for food. They can be maneuvered throughout the exhibit, as well as into and between shifts by making a loud popping sound that is somewhat reminiscent of a juvenile crocodile. Most crocodilian can be conditioned in this manner, allowing the animals to be locked off-display, and creating an extra margin of safety for staff during routine servicing of exhibits. Shifts are especially useful with large, agile elapids, and are regularly incorporated as a management tool for these animals.

The shift boxes that we use for our west African green mamba, *Dendroaspis viridis*, integrate several components into a single unit. The boxes have removable covers permitting visual access to the interior, and allowing staff to lighten or darken the inside of the box. Each box can be locked and removed from the exhibit. The boxes contain a lateral squeeze feature, facilitating access for injections, if necessary. A large PVC fitting with a sliding, lockable door accepts clear acrylic restraint tubes, making it much safer to "tube" a snake for close examination. Getting the mambas to use the shifts proved problematic, and we began to explore the use of operant conditioning methods to encourage the snakes to utilize the boxes more consistently. Our ultimate goal is to have the snakes enter the boxes on cue to allow unrestricted access to the exhibit for routine maintenance, and we have made considerable progress toward that end. Conditioning methods have been used extensively in the captive management of mammals, but rather infrequently with reptiles. Operant conditioning in particular has promise as a means to increase safety while working closely with dangerous reptiles.

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Reptile-Associated Salmonellosis

The incidence of reptile-associated salmonellosis cases in humans has increased dramatically during the past decade. In 1996, the Centers for Disease Control estimated that reptiles accounted for 3-5% of the 2-6 million cases of human salmonellosis in the United States. In most documented reptile-associated cases of salmonellosis, the strain of *Salmonella* spp. isolated from the patient was common to the pet reptile, suggesting the source of infection. The majority of the reptile-associated salmonellosis cases reported in the U.S. are diagnosed in immunocompromised individuals and infants. The increased incidence of reptile-associated salmonellosis has been associated with the increased popularity of these animals as pets during the past decade. From 1989 to 1993, imports increased 82%, from 1.1 million to 2.1 million animals. Unfortunately, little is known about the epidemiology of Salmonella spp. and reptiles. The increased popularity of reptiles with attendant risks of salmonellosis in owners and contacts of both clinically affected and normal animals merits study.

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Long-Term Breeding Program for *Uromastyx*

Uromastyx comprises a group of unusual, medium-sized agamids, ranging from north Africa to the Indian subcontinent. These desert-hardened lizards are characterized by a stout head, a heavy-set body and a unique spiny tail. Most species are attractively colored while a few, such as *U. acanthinurus* and *U. ocellatus ornatus*, are endowed with spectacular and highly variable hues including red, yellow, orange, green and blue.

Consequently, *Uromastyx* have been well represented in the pet trade for decades, with several species being subjected to massive exports from their countries of origin in the last ten years. The entire genus is listed under CITES Appendix II; however, the status of wild populations in the face of recent intense collecting for the pet trade is not clear. Despite their exposure to herpetoculture, *Uromastyx* are seldom bred in captivity. This could be due to a poor understanding of basic maintenance and propagation requirements for this genus. We describe here the ingredients of a successful breeding program for *U. acanthinurus* that has spanned ten years through multiple generations.

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Big & Red: Natural Breeding of the Tomato Frog, *Dyscophus antongili*, at the Baltimore Zoo

The northern tomato frog, *Dyscophus antongili*, is a large and attractive species of microhylid from the northeastern coast of Madagascar. Unlike the more common species of tomato frogs from Madagascar, *D. guineti* and *D. insularis*, the *D. antongili* is protected under CITES Appendix I and endangered in its native country as a result of over-collecting for the pet industry and because of habitat loss.

Jeopardized by a shortage of animals and a lack of genetic diversity, the ability to breed D. antongili has been vital to preserving the species in captivity. Researchers have successfully reproduced tomato frogs utilizing the hormone LHRH since 1988, and with the exception of one spontaneous natural breeding from a group of animals maintained in a year-round greenhouse environment, The Baltimore Zoo reproduced the frogs naturally through environmental manipulation in 1996. Over 4,500 eggs were produced by one female, of which 204 black and gold froglets were allowed to metamorphose. The frogs from this spawning and successive years have been placed in the collections of other institutions with the goals of pairing the frogs when new bloodlines become available and educating staff and visitors on the plight of this beautiful animal.

In addition to captive reproduction efforts, The Baltimore Zoo has been actively involved in other *D. antongili* conservation projects. These include funding the construction of a tomato frog exhibit in Madagascar, as well as providing photographs for their educational graphics, and supporting the DNA testing of captive animals in order to determine exact lineages to minimize future inbreeding.

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Giant Softshell Turtles of Asia

Softshell turtles, family Trionychidae, are named after a relatively inconspicuous feature, namely the presence of only three claws on each limb. Nevertheless, they are in many ways the most divergent and specialized of all turtles, especially in their drastic shell modifications which include the elimination of all of the scutes and major changes in the bony carapace and plastron also.

The softshell turtle occurs in North America, extreme southeastern Europe, Africa and southern and southeast Asia and Indonesia, and only reach south of the Equator in southern Africa and southern New Guinea. They show remarkable variation in size, ranging from species that may reach maturity and 15 cm less to some true giants; the largest occurring in Asia, and includes species which may exceed 110 cm in carapace length.

We have made efforts to gather data on the gigantic and almost extinct species Shanghai softshell, *Rafetus swimhoei*, in Vietnam and China and also on the narrow-headed softshell genus, *Chitra*, long considered to include only a single species, *C. indica*, in the Indian subcontinent, with a second species, *C. chitra* from Thailand, recognized in recent years. But recent fieldwork has shown that the genus is far more wide-ranging and diverse, with a chain of taxa extending from the Indus River of Pakistan to the eastern end of the island of Java. This huge distribution undoubtedly has gaps where watersheds are separated by high country, but nonetheless these gaps are considerably more narrow than had generally been supposed.

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Photographic Workshop

David, a professional photographer and writer, will discuss various techniques to capture sharp detailed images of various subjects including reptiles, amphibians, insects and arachnids on film. The workshop will cover basic techniques for color macro and wide angle natural history photography. Composition, lighting, and equipment basics for 35mm SLR cameras will be discussed. Specialty tools used in the field and other related equipment will be on display. A short introductory slide show will be used to illustrate exposure, depth of field, lighting (natural and flash) and choice of subject. The workshop is open to photographers of all levels. Bring your camera!

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Conservation of Crocodiles in the Old World: Win Some, Lose Some

The majority of the family Crocodylidae occur in the old world and their conservation status there provides some stark contrasts and illustrations both of the difficulties and of some successes in conserving them. In Africa the "widespread" Nile crocodile, *Crocodylus niloticus*, is still widespread and locally abundant in many countries of southern and eastern Africa, but it is depleted and fragmented throughout west Africa. In southern Africa, conservation and management models developed in South Africa and Zimbabwe have been widely applied. Crocodile ranching, protection in national parks, and reasonably effective regulation of trade in crocodile products have resulted in stable and, in some places, growing populations. The current issues affecting crocodile conservation in that region are the effects of world economic markets on sustainable use programs and the increasing conflicts of expanding crocodile populations with the dense human population. Conservation issues lie mainly in the socioeconomic sphere, and biology and protection have relatively little application.

Australia, and to a more limited extent, Papua New Guinea, provide similar examples of the application of regulated harvest systems to conservation goals and demonstrated recovery and present stability of crocodile populations.

At the other extreme, in China, the Chinese alligator, *Alligator sinensis*, is on the verge of extinction in the wild despite a program over two decades of complete protection, reserves, captive breeding and an intense effort in U.S. zoos. Recent analysis of the problem reveals that very intense land use and a culturally unique perspective on conservation combine to make the plight of wild Chinese alligators extreme. A major global initiative is presently underway to prevent this extinction but success is far from assured. Almost equally depressing are the situations of the Philippine crocodile, *Crocodylus mindorensis*, and Siamese crocodile, *C. siamensis*. Both are increasingly fragmented and depleted by human land use activity.

In India, a three decade program of protection and restocking of muggers, *Crocodylus palustris*, and gharials, *Gavialis gangeticus*, is foundering due to lack of adequate provision of habitat protection and lack of funding for these activities. The gharial is also currently threatened by plans for hydroelectric schemes in its few remaining habitats in Nepal.

I will attempt to summarize these examples and draw some conclusions of general application. Ironically, in those countries where crocodiles are subject to regulated exploitation, they prosper; and in those countries where they are completely protected, they face extinction. Understanding and explaining this anomaly is the challenge for crocodile conservation. Land use practices, expanding human populations and booming economics are clearly the major threat to crocodiles in the Old World. Exploitation for commercial use has changed from being a threat to being, in a few important cases, a major incentive for conservation. The solutions to crocodile conservation, and probably to conservation in general, lie in adapting social, economic and cultural perspectives into an integrated whole for habitat and ecosystem management. Such an approach may have broad applicability to other reptilian conservation issue, particularly the current crisis in the massive trade of freshwater turtles in the food trade.

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***The National Amphibian Conservation Center: A New Window on a Wet World**

The National Amphibian Conservation Center (NACC) is a $6 million, 12,000-square foot, state of the art facility designed for and dedicated to amphibians. The focus of the NACC is conservation, research, and education of the public; it is scheduled to open to the public in late spring of 2000. Approximately 1000 specimens of 60-100 species of amphibians will be house here, including members of all three major groups: caecilians, salamanders, and frogs.

In this paper, I will discuss the thought processes that went into the initial design and creation of the facility and its surrounding two acre wetlands. Design and implementation of graphics and interpretives will be discussed, as will exhibit design and construction. Acquisition, quarantine, and housing/acclimation of the amphibian specimens pre-opening will be discussed, as will the reasoning behind "master planning" of certain species. Conservation programs, including SSP will be addressed, as will projects currently in the works such as importation of Kihansi spray toads, *Nectophrynoides asperginis*, at the request of the Tanzanian government, and "Project Golden Frog (*Atelopus zeteki*)" in Panama.

Ties to other "amphibian-friendly" organizations such as the Declining Amphibian Populations Task Force (DAPTF), The Nature Conservancy (TNC), and the Michigan Department of Natural Resources will be emphasized.

Due to the world-wide decline in amphibian species, it is hoped that this facility will provide a template for other zoos and aquariums to follow. Amphibians, as never before, need to have more emphasis and money dedicated to them in the zoo/aquarium community and it is hoped that this facility will help to bolster support for this cause.

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***Herpetofauna of the Kalahari Desert**

The Kalahari Desert of southern Africa harbors a great diversity of herpetological presence. It is also a region of climatological contrast, exemplified by summer temperatures the likes of hell, followed by winter months when the mercury often drops below freezing. Mix into this a combination of dust and sand storms, precipitation via torrential downpours (summer months) plus the occasional hail storm, and I give you the Kalahari.

To fully appreciate the Kalahari's herpetofauna one must look at the beast itself, the habitat it lives in, plus the prey and predators that surround it. This presentation, in part, will cover all these aspects.

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Chinese *Elaphe* and the Impact of the Consumption Trade

Kamuran Tepedelen is the owner and operator of Bushmaster Reptiles Inc. in Boulder, Colorado. His personal interests include Chinese ratsnakes, *Elaphe*; and he has traveled to China on five separate occasions to perform field studies and document the habitat of this genus. He has collaborated with Klaus-Dieter Schulz (of Wurselen, Germany), the author of "A Monograph of the Colubrid Snakes of the Genus *Elaphe*." Together they have obtained and bred some of the more rare and difficult to keep Chinese *Elaphe*.

This talk will identify both rare and common Chinese *Elaphe* with a focus on the species that are actively collected for consumption. The current impact on the food market will be discussed, as well as the short and long term consequences of this trade. A focus on the importance of captive breeding in order to preserve species, which may become threatened for future generations, will include a list of species that deserve this attention. This talk will also feature photographic slides which exhibit various species, their habitat, and the food market which threatens them.

The following paper was presented at the 23rd IHS.

We thank Joseph P. Marek, Jr., IHS Treasurer, for his translation of Mr. Getz's paper.

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***Herpetariums and Herpetological Collections in Mexico**

Mr. Gtez provided information on the historical and mythological aspects of reptiles in Mexico and provided lists of zoos that maintain reptiles but do not have herpetariums, herpetariums in Mexico, herpetological collections in Mexican institutions, and Mexican institutions with developed herpetological activities. He also describes significant collections in Mexico, including their design and content.

THE EFFECT OF HUMAN-FACILITATED HYBRIDIZATION ON CONSERVATION AND BIODIVERSITY IN HERPETOCULTURE

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Hybridization, the production of offspring by interbreeding individuals from genetically distinct populations (regardless of taxonomic status), can either be natural or human-facilitated. Natural hybridization contributes to rapid speciation and radiation of taxa, and can be an important impetus for evolutionary change. Human-facilitated hybridization is often highly detrimental, and can lead to the genetic extinction of taxa. This is a growing concern with respect to captive propagation as well as conservation of species, and is here explored in a herpetocultural/herpetological context. Examples from *Cnemidophorus*, *Morelia*, *Python molurus*, *Hyla*, Cheloniidae and *Vipera berus* are utilized to support arguments. In the past, human propagators of various organisms have faced the question of whether or not to hybridize. The herpetocultural community, which is relatively young, is now faced with the same questions. The production of hybrids by humans provides the opportunity to damage natural populations from a genetic standpoint. Hybridization of this sort can act to destroy coadapted gene complexes, resulting in animals poorly adapted to their specific, local environment. Release or reintroduction of such animals threatens both the fitness of wild individuals, and the genetic integrity of their species. This damage is often difficult to identify and therefore quantify, hindering conservation efforts. Hybridization, if used in a highly controlled and well planned manner, can be helpful in "last resort" conservation efforts. With the exception of these efforts, it is imperative that the products of human-facilitated hybridization be isolated from natural situations. Measures should also be taken to ensure that intentional hybridization is done in a responsible and controlled manner, or not done at all.

Introduction

In recent decades, many advances have been made in the husbandry and propagation of both amphibians and reptiles. What were once thought to be species almost impossible to maintain in captivity are now being bred in great numbers (e.g. *Morelia spilota spilota*, Chamaeleonidae). These advances have contributed to a reduction in demand for animals from wild populations to satisfy the pet trade. However, our refinement of propagation techniques of these animals has also resulted in significant efforts being put into the production of hybrids, especially in last few years.

Jungle Corn Snakes (*Elaphe guttata* X *Lampropeltis getulus*) are available in pet stores (pers. obs.). This is indicative of hybrid reptiles being accessible to virtually anyone. Appendix 1 of this paper lists all documented reptile and amphibian hybrids that I know of (54 types of hybrids, from 25 sources – this is by no means a complete listing). Clearly, hybridization is becoming quite common in herpetoculture and, therefore, is an important issue to discuss and address. This is particularly important because many people often do not fully realize the complexity of what they are working with and misunderstand the

possible outcomes of their actions, which can be significant. In this paper I define hybridization, attempt to integrate hybridization into the concept of species, discuss both natural and human-facilitated hybridization, and provide a framework for herpetoculturists, conservationists, and governments for dealing with hybrids and hybridization in an objective and responsible manner.

Hybridization

Hybridization has traditionally been defined as the production of offspring from the crossing of two species (Sykes, 1982). This definition is over-simplified and requires expansion and clarification. Hybridization can also be defined as the interbreeding of individuals from what are believed to be genetically distinct populations, regardless of the taxonomic status of such populations (Rhymer and Simberloff, 1996). Alternatively, others (Arnold *et al.*, 1991) have maintained the distinction by suggesting that the term *hybrid* be used for offspring resulting from the mating between two species, *intergrade* be used for a mating between subspecies, and *cross* or *interbreed* for a mating between two distinct populations. This can potentially confuse the situation, so the two definitions can be synthesized into one by considering the terms intergrade and interbreed as subsets of hybrid. Rhymer and Simberloff's (1996) definition of hybrid is objective and defines hybridization from a modern biological standpoint. I here adopt Rhymer and Simberloff's (1996) explanation as my working definition (with intergrade and cross as subsets).

In a practical sense, the discussion of hybridization is made more complex in light of a dichotomy between natural processes and those mediated by human activities such as habitat modification and captive breeding projects. I thus further recognize two forms of hybridization, natural and human-facilitated. Each is discussed in turn, but before this can be done, it is important to address what a species is and how hybridization can be included in a species concept.

Species concepts

Species concepts are used to define species conceptually and practically (Ridley, 1996). There are three main categories of species concepts: morphology based concepts, reproduction based concepts, and history based concepts. These three groups were developed historically in the above order and are additive, each new group building conceptually on the previous one.

Species concepts based on morphology include the morphological and typological species concepts (Ridley, 1996), and more recently, the genotypic cluster definition (or species concept; Mallet, 1995). Essentially, these species concepts define a species as a set of organisms that resemble one another and are distinct from other such sets (Ridley, 1996). The main problem with the older concepts in this group is that they are very arbitrary and have no philosophical basis (Ridley, 1996). These problems have been addressed with the genotypic cluster definition, which defines species as genotypic clusters (Mallet, 1995), and asserts that species are not real and that life is just a genetic continuum (Brookes, 1999).

The second group of species concepts are based on reproduction. The biological species concept and the recognition species concept are included here (Ridley, 1996). These concepts stipulate that species are real entities that can be considered as individuals (Mallet, 1995). The biological species concept has been heavily criticized for both theoretical and practical problems (Echelle, 1990, Frost and Hillis, 1990, Mallet, 1995, Brooks, 1999, etc.), although it still has supporters that argue that reproduction is the basis of defining a species (Smith, 1990). The biological species concept defines a species as a group of interbreeding natural populations that are reproductively isolated from other such groups (Ridley, 1996). This concept cannot be applied to uniparentals (asexually reproducing organisms; Frost and Hillis, 1990), or hybrids (Brooks, 1999). However, Species Mate Recognition Systems (SMRSs) and Reproductive Isolating Mechanisms (RIMs) arising from these concepts are still a useful consideration as barriers to gene flow and the evaluation of the naturalness of hybrids.

Natural barriers to gene flow can simply include allopatry (discussed below), but can also be more subtle, as demonstrated in the example of human-facilitated hybridization of *Hyla cinerea* and *Hyla gratiosa*, below. Even organisms in sympatry may not hybridize naturally. Organisms may be ecologically isolated, filling different niches in sympatry, or seasonally isolated, breeding during different times of the year (Ridley, 1996). Alternately, these animals can be behaviourally, mechanically (incompatible genitalia), or gametically (incompatible gametes) isolated from one another (Ridley, 1996). These latter three forms of isolation are not relevant because they would prevent hybridization even in captivity, as would post-mating reproductive isolating mechanisms.

The third group of species concepts includes the evolutionary species concept and the phylogenetic species concept, both of which incorporate historical aspects into the species definition. The evolutionary species concept considers species to be entities that have objective reality (Frost and Hillis, 1990). A species is monophyletic and the largest

lineage on a single evolutionary path (Wiley, 1978; Frost and Hillis, 1990). This concept can be applied to uniparentals and hybrids if a species can have phenotypic cohesion (due to developmental, genetic, and ecological constraints) without gene flow (Echelle, 1990).

The phylogenetic species concept defines a species in a similar way to the evolutionary species concept (Echelle, 1990). However, it is novel because it characterizes a species as the smallest possible (irreducible) cluster of organisms that is unique (Echelle, 1990, Frost and Hillis, 1990), instead of the largest lineage on a single evolutionary path. Like the genotypic cluster concept, it treats species as quantitatively, not qualitatively, different (Mallet, 1995). It can be applied to uniparentals and hybrids if one accepts individual mutants as species which last for one generation and give rise to groups of new species through reproduction (Echelle, 1990). In other words, each hybrid or uniparental is its own species.

From this overview of species concepts, it becomes apparent that all have something to offer. Instead of completely dismissing any, it is prudent to retain the parts of each that are reasonable and build on these (Smith, 1990). Species are dynamically evolving (Frost and Hillis, 1990), and their reality is debatable (Mallet, 1995). This means that any rules and operations for defining species will fail at some level (Frost and Hillis, 1990). Yet, since hybrids are natural (Cole, 1990, Mallet, 1995, Ridley, 1996), they should be incorporated into taxonomic schemes. Currently, in biology there is a tendency towards treating species as clusters in a quantitative continuum (Echelle, 1990, Mallet, 1995, Brookes, 1999). In light of the existence of hybrids, this view of species is most elegant and consistent. A combination of the genotypic cluster concept and historical species concepts may be most relevant. This combines a morpho/molecular basis to an historical concept. From a conservation perspective, concepts of "evolutionary unit" (convergent with the phylogenetic species concept) are becoming more prevalent as well (Rhymer and Simberloff, 1996).

A species may well be considered a group of organisms, clustering in morpho/molecular space, that have been and continue to be under similar selective pressures. Treating species in this way (as part of a continuum with no requirement for gene flow) allows for the incorporation of hybrids (and uniparentals) without the unreasonable need for treating every individual as a separate species.

Natural hybridization

The biological species concept has been the most influential concept for years, but it cannot be applied to hybrids or uniparentals because this species concept defines species

based on organisms' ability to interbreed. In the past, species concepts as well as our tendency to classify and catalogue have led to the obfuscation of our understanding of hybridization (Brookes, 1999). Under the biological species concept, hybrids have been viewed as violating natural boundaries (Brookes, 1999). It is true that on an individual basis, few organisms (animals especially) hybridize, species integrity being maintained by strong selective pressures against hybrids. For example, many hybrids of Darwin's finches (*Geospiza* spp.) on the Galapagos cannot feed as efficiently as either parent species due to an intermediate beak morphology (Brookes, 1999), decreasing their fitness and chance of survival. Like mutation, hybridization can be highly detrimental to the individual (Brookes, 1999).

However, hybridization, like mutation, can also be beneficial and in these cases novel genes resulting from it can be passed between species (*e.g.* genes for pesticide resistance; Brookes, 1999). Hybridization can result in rapid evolutionary change by producing novel gene combinations in populations (Rhymer and Simberloff, 1996). It has been suggested that hybrid speciation has played a key role in the radiation of taxa such as birds, fishes, mammals, and insects (Rhymer and Simberloff, 1996, and references therein). At the specific level, it is estimated that about 10% of all animal species and 20% of all plant species hybridize (Brookes, 1999). It is evident that hybridization plays potentially important roles in nature.

Reptiles are no exception to this. The genus *Cnemidophorus* is well known to include parthenogens that have originated through hybridization of bisexual species (Behler and King, 1979, Dessauer and Cole, 1991, Paulissen *et al.*, 1992). The hybrids then reproduce asexually to produce genetically identical individuals (Paulissen *et al.*, 1992). At least nine species of *Cnemidophorus* in the United States alone are of hybrid origin (*C. dixoni, C. exsanguinis, C. flagellicaudus, C. laredoensis, C. neomexincanus, C. sonorae, C. tesselatus, C. uniparens,* and *C. velox*; Behler and King, 1979).

An example of such a parthenogenetic hybrid system is that of *Cnemidophorus laredoensis*, which is a *C. gularis* X *C. sexlineatus* hybrid, *C. gularis* being maternal (Walker, 1987, Paulissen *et al.*, 1992). *C. sexlineatus* ranges extensively in the United States, but its range ends north of the Rio Grande, while *C. gularis* ranges in Texas, south into Tamaulipas, Mexico (Stebbins, 1966, Behler and King, 1979, Walker, 1987). Although *C. sexlineatus* does not co-occur with *C. laredoensis*, the hybrid's range, extending 350 km in a northwest to southeast direction, within 10 km of Rio Grande, lies entirely within that of *C. gularis* (Walker, 1987, Paulissen *et al.*, 1992). Where they co-occur, *C. laredoensis* and *C. gularis* do not differ significantly in abundance, have an almost identical diet and foraging behavior, and ecologically seem to differ only in burrowing behavior (Paulissen, *et al.*, 1992).

This demonstrates that a hybrid can be sympatric with its parent species. Furthermore, *C. laredoensis* is able to thrive in habitat degraded by humans, while *C. gularis* cannot (Paulissen *et al.*, 1992).

Human-facilitated hybridization

If hybridization is a natural process, then why and how can it be detrimental? Problems arise when human-facilitated hybridization occurs. This is any hybridization that would not occur in nature without human intervention. "Non-indigenous species can bring about a form of extinction of native flora and fauna by hybridization and introgression either through purposeful introduction by humans or through habitat modification, bringing previously isolated species in contact." (Rhymer and Simbrloff, 1996: 83). Essentially, hybridization can lead to the genetic extinction of a rare species, especially when the rare species comes in contact with a more abundant one (Rhymer and Simberloff, 1996). Furthermore, small populations can be threatened by hybridization even if there is no mixing of gene pools (*i.e.* hybrids are infertile) simply through wasted reproductive effort (Rhymer and Simberloff, 1996).

The fact that hybrids are often very difficult to differentiate morphologically from the parent species has resulted in the great majority of hybridization and introgression going undetected (Rhymer and Simberloff, 1996). Only in recent years has this problem been able to be addressed because of the advent of genetic and other molecular techniques (Karl *et al.*, 1995, Rhymer and Simberloff, 1996). Mitochondrial DNA (mtDNA) analysis even allows for the determination of each parent species gender (Karl *et al.*, 1995, Rhymer and Simberloff, 1996).

Human-facilitated hybridization through habitat modification.

Habitat modification can lead to the genetic mixing of two indigenous populations or an indigenous one with an introduced one (Rhymer and Simberloff, 1996). Regional habitat modification can lead to range expansion of one species into that of another (Rhymer and Simberloff, 1996).

Local habitat modification can work in less foreseeable and more subtle ways. This can be illustrated with the case of *Hyla gratiosa* and *Hyla cinerea* hybridization in artificial ponds in Auburn, Alabama (Schlefer *et al.*, 1986, Rhymer and Simberloff, 1996). *H. gratiosa* males call while floating near the banks of ponds (Schlefer *et al.*, 1986, Rhymer and Simberloff, 1996). In undisturbed areas, *H. cinerea* males call from the emergent

vegetation and shrubs near the bank, while in artificial conditions (where emergent vegetation is lacking) they call from trees overhanging the ponds (Schlefer *et al.*, 1986, Rhymer and Simberloff, 1996). Most hybridization occurs with male *H. cinerea* intercepting and mating with female *H. gratiosa* (Schlefer *et al.*, 1986). *H. gratiosa* is most affected by this due to its patchy distribution and a continuing influx of *H. cinerea* into the ponds (Schlefer *et al.*, 1986). Field, acoustical, morphological, and electrophoretic analyses confirmed that hybridization has persisted between *H. cinerea* and *H. gratiosa* since the construction of the ponds in 1966 (Schlefer *et al.*, 1986). Hybrids are intermediate to the parent species in morphology and acoustics, but backcrosses also occur (Schlefer *et al.*, 1986). These backcrosses are more difficult to distinguish from parent species, resulting in a morphological and acoustical continuum (Schlefer *et al.*, 1986). Hybrids also appear to have reduced viability (Schlefer *et al.*, 1986).

Human-facilitated hybridization by introduction: roles of herpetoculture.

Much of the previous discussion focused on hybridization in nature without the influence of captive propagation. The question of how herpetoculture can contribute to detrimental hybridization will now be addressed. Since hybridization in herpetoculture is in its infancy, it is also of interest to examine how other hobbies have approached hybridization in the organisms they work with.

Orchids have been grown and propagated for hundreds of years and are easily hybridized. With over 100,000 hybrid orchids registered and about 200 new hybrids registered every month with the Royal Horticultural Society (Nash, Pers. Comm.), hybridization has become a major part of orchid growing. Hybridization in orchids is so prevalent that it has acted to increase the price of pure species (Girard, Pers. Comm.). However, I can find little evidence that orchid hybridization has threatened natural systems. This is mainly due to the containability of plants (they are not mobile), low seed survivorship, and very high pollinator specificity (human-made orchid hybrids must be pollinated by people)(Nash, Pers. Comm.).

However, it seems that animal hybrids may be potentially more detrimental and less containable than plant hybrids due to their mobility and lack of pollinator co-evolution. This is reflected in the stance that aviculture has taken towards hybridization. The International Aviculturists Society does not condone interspecific hybridization (Porter, Pers. Comm.). The Parrot Society of Australia will not allow advertisement of hybrids in its publications, or allow the sale of such birds at shows (Williamson, Pers. Comm.). In fact, it is illegal to produce hybrid parrots in Queensland (Williamson, Pers. Comm.).

Hybrids are viewed as "contaminating" the gene pools of species, decreasing breeding population size of pure species, wasting reproductive effort (especially in the case of rare species), and contributing to raising of prices of pure species (Unterschultz, Pers. Comm.). The practice gives those opposed to the captive husbandry of exotic animals yet another argument to bolster their point of view (Unterschultz, Pers. Comm.). These arguments are substantiated by the fact that the Red Siskin (*Carduelis cucullata*) has become highly endangered (listed on CITES Appendix I) due to captive hybridization (WCMC, 2000). In short, it is argued that human-facilitated hybridization of captive birds benefits neither them nor mankind (Unterschultz, Pers. Comm.).

With increased knowledge of the reproductive biology of reptiles and amphibians, herpetoculture is currently faced with responsibility of addressing hybridization. It has been argued in this paper that there is a very important distinction between hybridization that can and does occur in a natural setting and that which can only originate in captivity because the latter generates genetic combinations that would normally be impossible. This can be illustrated simply with two examples: intergradation in *Python molurus* and in *Morelia spilota*.

Python molurus contains three subspecies: *P.m. pimbura* occurs on Sri Lanka only (Gay, Pers. Comm.). *P.m. molurus* occurs on peninsular India, west to Pakistan, and east to Bengal and Bangladesh (Smith, 1943, Kluge, 1993). *P.m. bivittatus* occurs in Myanmar, southern China, northern Thailand to Vietnam, Java, Borneo, and Sulawesi (Kluge, 1993), but is absent from the Malay Peninsula and Sumatra (Smith, 1943). It is apparent that these three subspecies are in fact allopatric (Gay, Pers. Comm., Fig. 1). Due to this, none of these subspecies intergrade in the wild. In captivity, however, intergrades have been produced in past decades with increasing incidence, resulting in the near disappearance of the endangered *P.m. molurus* (CITES Appendix I) and *P.m. pimbura* (Ross and Marzec, 1990, Gay, Pers. Comm.). Due to genetic mixing, it is only with great difficulty that one can identify pure *P.m. molurus* and *P.m. pimbura* (Ross and Marzec, 1990, Gay, Pers. Comm.). This makes it extremely difficult to establish parentage in captivity, jeopardizing the maintenance of pure subspecies.

Intergradation is of some concern with the python *Morelia spilota* as well (Ross and Marzec, 1990). Currently this species contains numerous subspecies, contributing to a complex biogeography (Fig. 2). It is clear that *M.s. imbricata* is geographically isolated from all other subspecies (Fig. 2, Barker, Pers. Comm.). This is correlated with genetic isolation (Rawlings, Pers. Comm.), so intergradation is not an issue with this taxon.

M.s. metcalfei is also genetically distinct (Rawlings, Pers. Comm.), although it does intergrade naturally with *M.s. mcdowelli* at their range interface (Barker, Pers. Comm.). It is also apparent that *M.s. spilota* is allopatric from *M.s. variegata* and *M.s. cheynei* (Fig. 2). Although intergradation is becoming less common due to habitat fragmentation (Rawlings, Pers. Comm.), *M.s. variegata, M.s. cheynei,* and *M.s. mcdowelli* intergrade naturally and may not represent valid subspecies (Barker, Pers. Comm.). In contrast, in captivity, the most commonly produced intergrade is *M.s. spilota X M.s. cheynei*, which cannot occur naturally due to allopatry.

Hybridization concerns have also been expressed for *Boa constrictor* (Ross and Marzec, 1990). Phylogeographically, this species is quite poorly studied, and recently captive intergradation seems more prevalent in these forms. The problem is that often hybridization is practiced with rare taxa, whose genetic integrity is less robust simply due to their numbers. In the three examples presented above, *Python molurus molurus* and *Boa constrictor occidentalis* are listed on CITES Appendix I, signifying endangerment (CITES, 1997).

Morelia spilota spilota, the Diamond Python, although not endangered, is a rather sensitive and difficult snake in captivity (Barker and Barker, 1994), resulting in its high price on the herpetocultural market. As a result, hybridization of these animals is undesirable from both conservation and propagation points of view.

The effects of hybridization on species integrity and persistence of a species in captivity and in the wild can vary depending on which species are hybridized. In captivity, hybridization, if not practiced in a responsible manner (discussed below), automatically threatens the integrity of the captive gene pool. As indicated with both aviculture and horticulture, hybridization has acted to raise costs of specimens of pure species (above), and there is no reason that this would not happen in herpetoculture as well.

There is a distinction in the risk involved with hybridization of exotic versus local animals, with respect to integrity of natural populations. The hybridization of exotic animals (those that do not occur in the geographic area of the hybridizer) mainly has the potential to threaten a natural population when an animal of uncertain parentage is used in a conservation effort, such as reintroduction or population enrichment. At first glance, this suggests that there is little risk associated with the hybridization of exotic animals, especially when most of these animals will never be used in any conservation effort. However, with a tendency towards global trade even in herpetoculture, what may be an exotic where it is produced, may well not be one where it is sold.

The risk involved with the hybridization of local animals (those that naturally occur in the same geographic area as the hybridizer) is much greater. In addition to the risks associated with exotic hybridization (above), there is also the probability of escape. Anyone who has kept snakes knows all too well that they are among the most accomplished of escape artists. As a result, there is a high probability of hybrid animals escaping from captivity. Hybrids of local species may then backcross to animals in the natural population, introducing foreign genes. Unlike many mutant animals (*e.g.* albinos), hybrids are often difficult to distinguish from the parent species, and therefore, may not be subject to high risk of predation due to colour and pattern. Unfortunately, the majority of hybrids are being produced in the United States from crossing animals that occur in the United States.

As will be discussed below in further detail, hybridization can result in the dissociation of evolved characters. For example, the ecology of the jungle corn snake (*Elaphe guttata X Lampropeltis getulus*) is unknown. *Elaphe guttata* is a widely distributed species that feeds mainly on small mammals and birds (Stebbins, 1966). In contrast, *Lampropeltis getulus* feeds on other snakes (including crotalids, being immune to their venom), lizards, and frogs in addition to what *E. guttata* consumes; it is also widely distributed (Stebbins, 1966). The question arises of what the hybrid of these two species would eat in the wild. Also, one has to wonder whether venom-immunity genes could become represented in *Elaphe guttata* populations, or lack of these genes in *Lampropeltis getulus* populations. These alternatives could cause irreparable damage to either of these species, possibly even changing the ecology of entire regions of their range.

Human-facilitated hybridization by introduction: roles of conservation.

Hybridization is an important concept to consider in conservation as well. Conservation of infraspecific entities is important for the preservation of genetic variation (Rhymer and Simberloff, 1996). Numerous conservation efforts have resulted in hybridization and further endangerment of the species being conserved (reviewed in Rhymer and Simberloff, 1996). With genetic mixing, conservation efforts may solve some problems, while causing others. For example, some fish hatchery stocks are inbred (have low genetic diversity) and domesticated, and introduction of these stocks facilitates the spread of phenotypes maladaptive to the target environment (Rhymer and Simberloff, 1996). Hybridization resulting in sterile offspring is detrimental when either of the parent species is rare because reproductive effort is wasted (Rhymer and Simberloff, 1996). On the other hand, the culling of hybrids must also be carefully evaluated, as this decreases genetic variation, especially in small populations (Rhymer and Simberloff, 1996).

Hybridization poses a large concern in that it can lead to the destruction of coadapted gene complexes, which, in turn, leads to decreased fitness of the hybrids (Rhymer and Simberloff, 1996). Essentially, multiple genes that have evolved together (as a unit) can be broken apart by hybridization.

The destruction of these gene complexes has been raised as a concern in sea turtle conservation (Carr and Dodd, 1983, Karl *et al.*, 1995, Rhymer and Simberloff, 1996). There are seven species of sea turtle (Cheloniidae; Carr and Dodd, 1983) and five of these hybridize (Karl *et al.*, 1995). All of these turtles are listed by the IUCN as threatened or endangered (IUCN,1993), all are protected by CITES (Appendix I; CITES, 1997), and little is known about their biology (Carr and Dodd, 1983). The following hybrids have been confirmed using single copy nuclear DNA analysis: *Caretta caretta X Lepidochelys kempi, Caretta caretta X Eretmochelys imbricata, Caretta caretta X Chelonia mydas,* and *Chelonia mydas X Eretmochelys imbricata* (Karl *et al.*, 1995). The hybrid *Chelonia mydas X Lepidochelys olivacea* has been reported on morphological grounds, but not confirmed at the molecular level (Karl *et al.*, 1995). *C. mydas X E. imbricata* hybrids are more susceptible to lung infections than are the parent species (Karl *et al.*, 1995). It has been suggested that hybrid turtles may have reduced fitness due to the mixing of gene pools adapted to different environments (Carr and Dodd, 1983). Human intervention with sea turtles has led to an increased incidence of hybridization (Karl *et al.*, 1995). It has been argued that hybridization should be avoided at all costs because it jeopardizes species, hinders biological research, and because ethically, people do not have the right to destroy species (Carr and Dodd, 1983).

The potential for detriment due to hybridization in conservation is well illustrated with the Headstart Project implemented to save the Kemp's Ridley (*Lepidochelys kempi*) from extinction. This project was initiated in 1978 due to a decline in Kemp's Ridley populations from over 40000 nesting females in 1947 to less than 500 in 1978 (Bowen *et al.*, 1994). Eggs from the single n ing beach of this turtle in Tamaulipas, Mexico were incubated in captivity and then the hatchlings were reared for nine to twelve months before release on Padre Island, Texas beach, where they were transplanted (Fig. 3, Bowen *et al.*, 1994, Karl *et al.*, 1995). During the fourteen years of the project, over 18000 hatchlings were released (Karl *et al.*, 1995). At hatching, young turtles were allowed to run down the beach on Padre Island in an attempt to allow them to imprint on it, thus establishing another nesting beach for the species (Bowen *et al.*, 1994). In 1992, Kemp's Ridley nests were documented on beaches in North and South Carolina (United States), about 2000 km north of the historical

range of the species (Bowen *et al.,* 1994). The Headstart Project has raised much criticism and many concerns. Captive reared turtles are now known to behave differently than wild ones (Carr and Dodd, 1983), and the lower temperatures in the Carolinas lead to a male-biased sex ratio (Bowen *et al.,* 1994). The concern relevant to this paper is that the breeding range of the Kemp's Ridley has been expanded and now overlaps to a greater degree with that of the loggerhead (*Caretta caretta*), resulting in increased incidence of hybridization (Karl *et al.,* 1995). In fact the hybrid *Caretta caretta X Lepidochelys kempi* used in Karl *et al.*'s (1995) study was caught in the Carolina area. From this example, it should be noted that wildlife managers must address the potential for human-facilitated hybridization before implementing conservation projects (Karl *et al.,* 1995).

A second example of hybridization used in conservation illustrates how hybridization can aid conservation efforts. A population of *Vipera berus* in Smygehuk, Sweden has been isolated from other populations for about a century due to infringement of agricultural land (Madsen *et al.,* 1996). Three other, non-isolated populations were also studied elsewhere in Sweden (Genarp, Pard, and Lovon). Both the Smygehuk and Genarp populations consist of about thirty adult individuals (Madsen *et al.,* 1996). Due to skewed sex ratios, non-reproducing adults, and varying litter sizes, effective population size at Smygehuk was greatly reduced – as little as 2.67 individuals in a given year (Madsen *et al.,* 1996). It was found that high rates of inviable offspring were not due to pesticide or heavy metals, or food availability (Madsen *et al.,* 1996). Homozygosity was highest in the Smygehuk population (Madsen *et al.,* 1996). When ten males from non-isolated populations were introduced to the Smygehuk population, viability of offspring increased dramatically and it was concluded that previous poor viability was due to inbreeding depression (Madsen *et al.,* 1996). In this case, human-facilitated hybridization occurred due to the introduction of *Vipera berus* from one population ' another, resulting in a greater probability of persistence of the inbred population.

Conclusions and an outlook on human activities

The above discussion attempts to objectively present the costs, benefits, and implications of human-facilitated hybridization without analysing to any great extent what humans should be doing. This is something that people must decide now that these arguments have been presented. With the current trend of producing hybrids in herpetoculture, people involved in the hobby must address the issue based on the facts. With an increased pace of human activities such as habitat modification, fragmentation,

and the introduction of species, problems induced by hybridization will worsen (Rhymer and Simberloff, 1996). The fields of herpetoculture and conservation are interconnected in that they involve people that generally do care about biodiversity. Conservation should be one of the goals of herpetoculture. From this statement, and from the above discussions, it seems that if one does care about the persistence of animals both in the wild and in captivity, then human-facilitated hybridization is difficult to justify at best.

It has been argued by some that hybridization in herpetoculture is both irresponsible and damaging (Ross and Marzec, 1990). From the above discussions, there seems high potential for detriment to species due to hybridization. Therefore, it is my position that hybridization must be practiced in a controlled, careful and responsible manner in herpetoculture. Responsible hybridization is another issue for discussion and I will only briefly address it here, with the intention of supplying a starting point for these discussions. The microchipping of hybrids to permanently identify them as such is a worthwhile endeavor, as has been practiced by Bob Clark. The breeding of mutations such as albinism into hybrid lines would help to ensure poor extra-terrarium survivorship. Education of hybrid buyers is important, allowing them to understand the potential risks of owning a hybrid as well as inciting them to keep hybrids in an informed and responsible manner. It is also essential that hybrid animals be always sold as what they are. The producer of such animals must be completely honest and supply the scientific names of the parent species. This criterion for responsible production and management of hybrids is the most important, but perhaps the most difficult to implement. There are always some people who refuse to do things properly and responsibly, despite little cost to them and extreme detriment to the rest of the world. Finally, it would be a great service to herpetoculture and herpetology if hybrids that are produced were registered and published in journals. This has been implemented in horticulture, where the Royal Horticultural Society receives registration of hybrids' parentage and provenance and publishes lists of these data. In an attempt to begin the implementation of this in herpetoculture, I have compiled a list, as complete as I could make it, of reptile and amphibian hybrids produced in captivity (Appendix 1). Information sources and parentage information is supplied where available. If hybridization is not practiced in a responsible manner, such as that described above, then it is my position that hybridization should not be done at all.

In conservation, it is imperative that possible outcomes of human-facilitated hybridization be evaluated. One must consider the possibility for unnatural hybridization resulting inadvertently from conservation projects. One must be aware that species can become extinct through hybridization (Mallet, 1995). Also, the gene pool of a population

will change over time even without human intervention by gene flow, mutation, selection, drift, etc. (Rhymer and Simberloff, 1996). As a result, conservation and preservation are not synonymous. Hybridization may be a valuable tool in conservation (*e.g.* as in *Vipera berus*, above), but must be used with extreme caution to prevent further damage to the taxon being conserved or to other taxa. Communication and cooperation between local fish and wildlife authorities, conservation groups, and universities would act as a system of checks and balances against ultimately detrimental conservation efforts.

Finally, governments play increasing roles in conservation, management and regulation of flora and fauna. Laws and other regulations governing these issues must be consistent with biology and reality. Many hybrids are natural, perhaps essential, and must be preserved (Mallet, 1995). Currently, the Endangered Species Act of the United States does not protect hybrids, even natural ones (Bookes, 1999). In the management of other species, governments must make efforts to conserve natural hybrids, just like pure species. Furthermore, stringent measures must be taken to remove the results of human-facilitated hybridization (with the exception of that resulting from successful conservation efforts) from nature. These measures are important to take, even if they mean the eradication of these potentially dangerous hybrids (despite ethical dilemmas associated with such practices), as these hybrids may be extremely detrimental.

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Appendix 1: Listing of hybrids produced in captivity. Compiled by July 7, 2000.

This listing of hybrids is organized taxonomically and attempts to list both parents, a contact, and additional notes for each cross. Although the sex of each parent species is not available for many of these hybrids, (but see note*, below), this is a worthwhile piece of data to record. It is suggested that a convention be adhered to, where the parent of one gender always be listed first and the other second, for consistency. It must be noted that people listed under contacts are NOT the producers in all cases. However, they are all people that are closely associated with the hybrids they are listed next to. I have gone to significant efforts to ensure the reliability of all sources of information, (see contact, below), and am reasonably confident in the accuracy of these data (but note that reliability may be compromised where contacts are without names or any contact information).

Parent 1	Parent 2	Contact ^	
Testudines			
Chrysemys rubriventris	Trachemys scripta scripta	Ron Daniel	
Sauria: Eublepharidae			
Eublepharis macularius	Hemitheconyx caudicinctus	Craver Shugart	*
Sauria: Varanidae			
Varanus pilbarensis	Varanus glauerti	Frank Retes	x
Varanus panoptes	Varanus flavirufus	Frank Retes	x
Serpentes: Crotalidae			
Crotalus adamanteus	Crotalus horridus articaudatus	Trevor Scott	
Serpentes: Boidae: Boinae			
Corallus caninus	Corallus .ortulanus	Dan Mendez	
Serpentes: Boidae: Pythonidae			
Antaresia stimsoni	Antaresia childerni	S. Kortlang	x
Antaresia stimsoni	Antaresia maculosa	S. Kortlang	x
Liasis macklotti	Morelia spilota mcdowelli	Kevin McCurly	*,x
Morelia spilota spilota	Morelia spilota cheynei	J. Brad Lichtenhan	
Morelia spilota cheynei	Morelia amethystina	Royal Melbourne Zoo and Raymond Hoser	*
Morelia spilota cheynei	Liasis fuscus	Royal Melbourne Zoo and Raymond Hoser	*
Morelia spilota mcdowelli	Morelia spilota metcalfei	Matt Hingley	x
Morelia bredli	Morelia spilota metaclfei	"Buxton Zoo, Australia"	
Morelia viridis	Morelia spilota cheynei	Dr. Frankenstein's Creations	

Python sebae	Python molurus bivittatus	Pete Nieffer	*
Python reticulatus	Python molurus bivittatus	Kevin McCurly	*
Python reticulatus X P. molurus bivittatus	Python reticulatus	Kevin McCurly	*
Python reticulatus X P. molurus bivittatus	Python molurus bivittatus	Bob Clark	x
Python reticulatus X P. molurus bivittatus	Python sebae sebae	Kevin McCurly	*,x

Serpentes: Colubridae

Elaphe

Elaphe guttata guttata	Elaphe obsoleta obsoleta	Dwight Good	
Elaphe guttata guttata	Elaphe guttata emoryi	Dwight Good	

Lampropeltis

Lampropeltis alterna	Lampropeltis mexicana mexicana	Wes & Vicki Green	
Lampropeltis alterna	Lampropeltis mexicana thayeri	Dave Thomas, Henry Dean	
Lampropeltis alterna	Lampropeltis pyromelana pyromelana	Todd Smith & Glenn Fankhauser	x
Lampropeltis alterna	Lampropeltis pyromelana X L. mexicana "greeri"" X L. ruthveni X L. alterna	Brent Green, Henry Dean	
Lampropeltis alterna	Lampropeltis ruthveni	Henry Dean, Steve Osborne, Exceptional Quality Reptiles, Wes & Vicki Green"	
Lampropeltis alterna	Lampropeltis triangulum sinaloae	Henry Dean	
Lampropeltis getulus californiae	Lampropeltis triangulum sinaloae	Brent Green, Henry Dean	
Lampropeltis getulus holbrooki X L. alterna	Lampropeltis pyromelana X L. mexicana "greeri"" X L. ruthveni X L. alterna	Brent Green, Henry Dean	
Lampropeltis mexicana "greeri"	Lampropeltis pyromelana knoblochi	Wes & Vicki Green	
Lampropeltis mexicana mexicana	Lampropeltis pyromelana pyromelana	Todd Smith & Glenn Fankhauser	
Lampropeltis pyromelana pyromelana	Lampropeltis pyromelana pyromelana X L. ruthveni	Steve Osborne	x
Lampropeltis pyromelana X L. mexicana ""greeri"	Lampropeltis ruthveni X L. alterna	Brent Green, Henry Dean	*

Lampropeltis ruthveni	Lampropeltis mexicana "greeri"	Todd Smith & Glenn Fankhauser
Lampropeltis ruthveni	Lampropeltis mexicana mexicana	Exceptional Quality Reptiles
Lampropeltis ruthveni	Lampropeltis mexicana thayeri	Henry Dean
Lampropeltis ruthveni	Lampropeltis pyromelana knoblochi	Steve Osborne
Lampropeltis ruthveni	Lampropeltis pyromelana pyromelana	Steve Osborne
Lampropeltis ruthveni	Lampropeltis pyromelana X L. mexicana "greeri"" X L. ruthveni X L. alterna X L. triangulum campbelli"	Brent Green, Henry Dean
Lampropeltis ruthveni	Lampropeltis triangulum campbelli	Steve Osborne, J. Brad Lichtenhan
Lampropeltis triangulum campbelli	Lampropeltis pyromelana X L. mexicana "greeri" X L. ruthveni X L. alterna	Brent Green, Henry Dean
Lampropeltis triangulum campbelli	Lampropeltis triangulum sinaloae X L. triangulum hondurensis	Henry Dean
Lampropeltis triangulum hondurensis	Lampropeltis getulus floridana X L. getulus californiae	Henry Dean
Lampropeltis triangulum hondurensis	Lampropeltis triangulum campbelli	Larry Kellar, Henry Dean
Lampropeltis triangulum hondurensis X L. triangulum campbelli	Lampropeltis pyromelana X L. mexicana "greeri" X L. ruthveni X L. triangulum campbelli"	Henry Dean
Lampropeltis triangulum sinaloae	Lampropeltis pyromelana X L. mexicana "greeri"	Henry Dean
Lampropeltis triangulum sinaloae	Lampropeltis triangulum nelsoni	Wes & Vicki Green

Elaphe X Lampropeltis

Elaphe guttata guttata	Lampropeltis getulus californiae	Todd Smith & Glenn Fankhauser
Elaphe guttata guttata	Lampropeltis mexicana mexicana	O/U - %
Elaphe guttata guttata	Lampropeltis getulus niger	Dwight Good

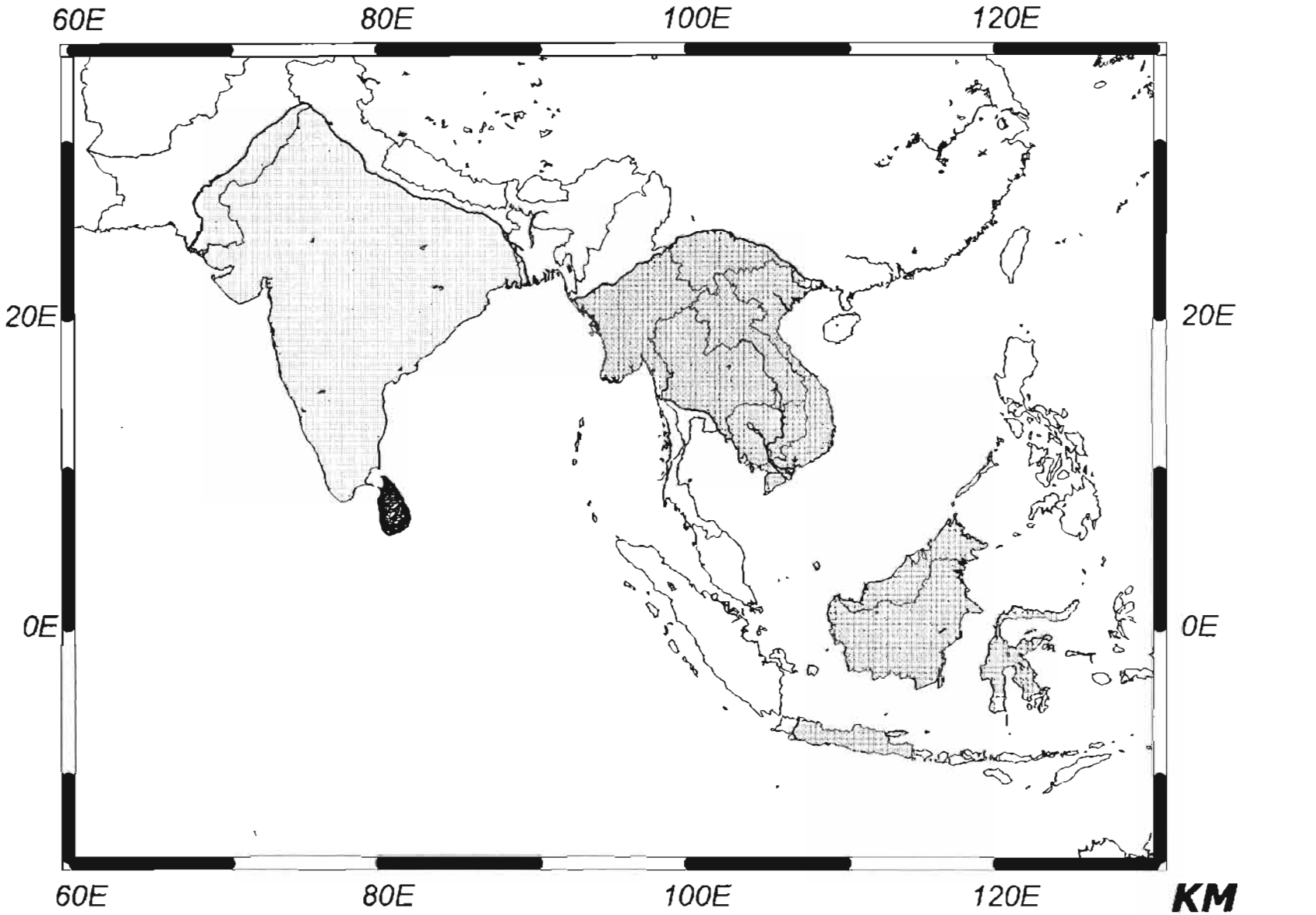
	Elaphe guttata guttata X Lampropeltis alterna	Lampropeltis pyromelana X L. mexicana "greeri" X L. ruthveni X L. alterna	Brent Green, Henry Dean
Elaphe X Pituophis			
	Elaphe guttata guttata	Pituophis catenifer catenifer	Mike Bradshaw *
	Elaphe guttata guttata X Lampropeltis getulus californiae	Elaphe guttata guttata X Pituophis catenifer catenifer	

* "Sexed - Male is P1, Female is P2."

x No picture seen.

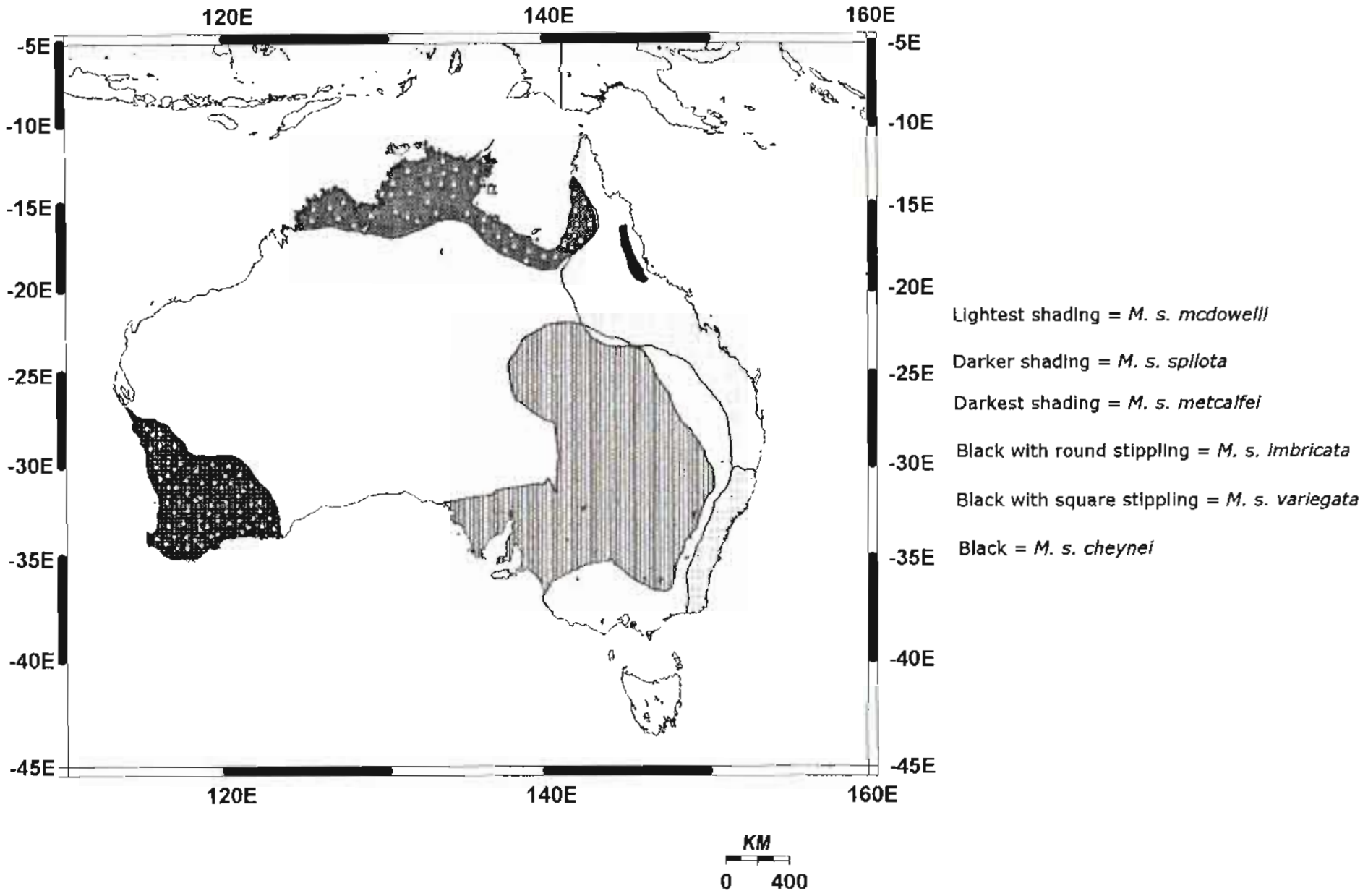
% O/U = Originator unknown.

^ Bob Clark bob@bobclark.com http://www.bobclark.com/Hybrid.html
Brent Green lostinsnakes@hotmail.com email
"Buxton Zoo, Australia" adder@smuggled.com http://www.smuggled.com/hybpyt3.htm Herptile 24 v (2): 61-67. 1999.
Craver Shugart Revracsnakeman@aol.com email
Dan Mendez Urbnjnglz@aol.com http://www.corallus.com/urbanjungles/
"Dave Thomas, Henry Dean" henry_dean@hotmail.com,http://www.geocities.com/~henrydean/hybrid.html
Dr. Frankenstein's Creations chondro@nethere.com http://www.chondroweb.com/DrFrankenstein/hybrids.htm
Dwight Good dgood@kih.net http://www.kingsnake.com/obsoleta/hybrids.htm
Exceptional Quality Reptiles britt@webzone.net http://www.britt2.com/exceptional/eqs/prices.htm
Frank Retes http://www.kingsnake.com/forum/monitor/messages/38679.html
Henry Dean henry_dean@hotmail.com http://www.geocities.com/~henrydean/hybrid.html
J. Brad Lichtenhan lich@prismnet.com http://www.kingsnake.com/snakedoctor/
Kevin McCurlytheundead@mindspring.comemail
"Larry Kellar, Henry Dean" henry_dean@hotmail.com http://www.geocities.com/~henrydean/hybrid.html
Matt Hingley adder@smuggled.com http://www.smuggled.com/hybpyt3.htm Herptile 24 (2): 61-67. 1999.
Mike Bradshaw mike@albany.net http://www.albany.net/~mike/page0.htm
O/U Reptodude228@aol.com http://www.captiveherp.com/hybrids/colubrids.html
Pete Nieffer Pnieffer@aol.com email
Ron Daniel rondaniel@mindspring.com http://www.mindspring.com/~i20west/turtle/orangeslider.htm
Royal Melbourne Zoo & Raymond Hoser adder@smuggled.com http://www.smuggled.com/hybsna1.htm Litteratura Serpentium 8(3): 134-139. 1988.
S. Kortlang adder@smuggled.com http://www.smuggled.com/hybpyt2.htm Herptile 16(3): 110-115. 1991.
Steve Osborne probrdmt@digisys.net http://www.probreeders.com/price.html
Todd Smith & Glenn Fankhauser aspidites@aol.com http://hometown.aol.com/aspidites/yknot.html
Trevor Scott http://www.captiveherp.com/hybrids/others.html
Wes & Vicki Green classicrep@yahoo.com http://www.elitereptiles.com/htm/indexI2.htm

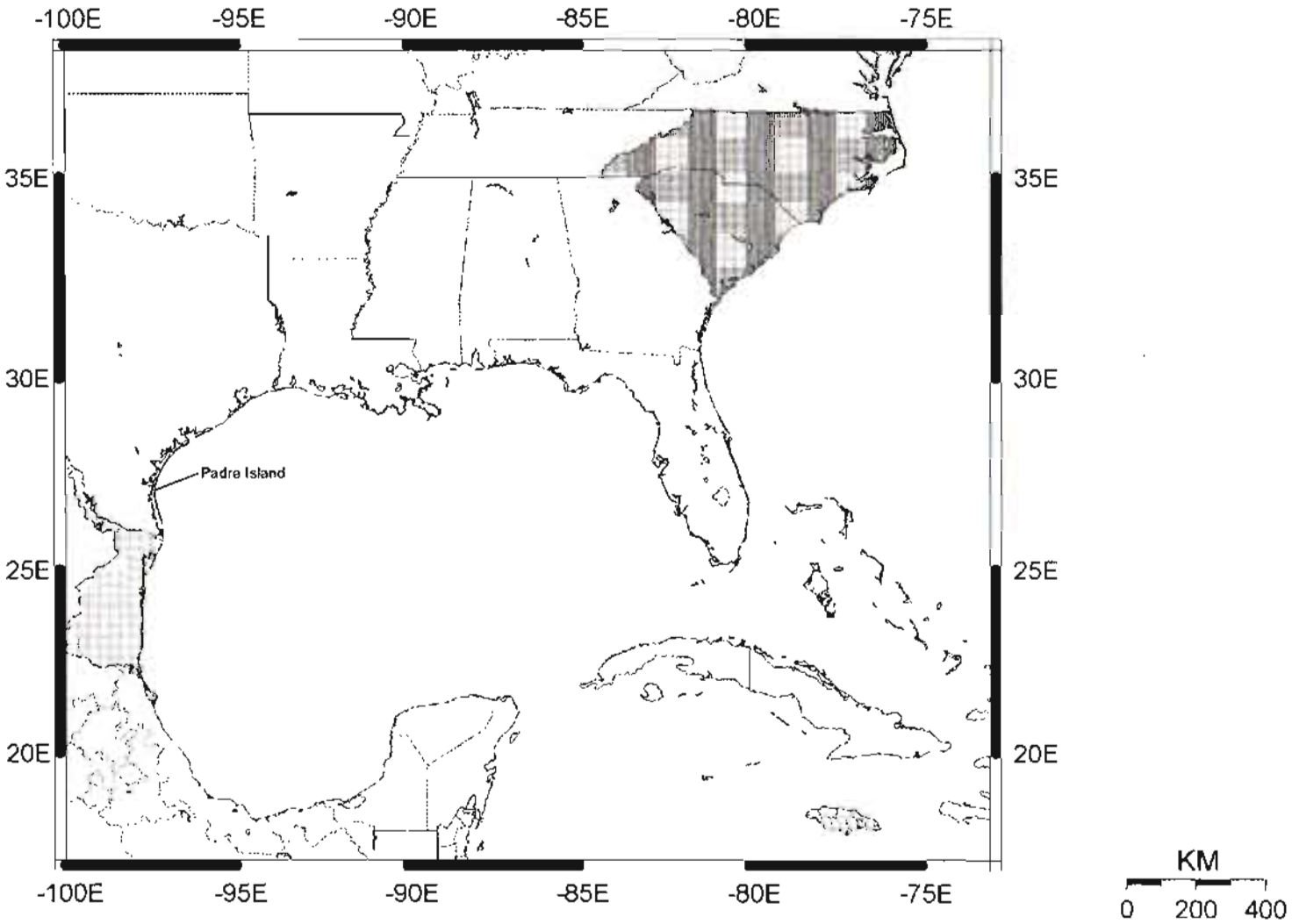


Bergmann Figure 1. Distribution of the subspecies of the python *Python molurus*.

Light shading = *P. m. molurus*
Medium shading = *P. m. bivittatus*
Dark shading = *P. m. pimbura*



Bergmann Figure 2. Distribution of the subspecies of the python *Morelia spilota*.



Light shading = Tamaulipas, Mexico, historical nesting sites.

Dark shading = North and South Carolina, USA, nesting activity observed after Headstart Project completed.

Padre Island labeled - site for Headstart Project.

Bergmann Fig. 3. Nesting beaches of the Kemp's Ridley sea turtle, *Lepidochelys kempi*

It is best referred to as *Emydura subglobosa worrelli*. *Emydura subglobosa subglobosa* is found in the Jardine River at the tip of Cape York and is widespread in the southern flowing rivers of the island of New Guinea. The Northern Yellow-faced Turtle, *Emydura tanybaraga*, is widespread across northern Australia. All three species of *Emydura* are found in the Daly River.

Australian Snappers

The species of *Emydura* are all very closely related, differing at most by few fixed allozyme differences, and are presumably a recent radiation. This is not the case for the genus *Elseya* – the Australian Snappers. What was until recently regarded as a single widespread species, the Northern Snapping Turtle *Elseya dentata*, is now known to be a series of highly divergent allopatric species (Georges and Adams 1996). They are river turtles and largely herbivorous. *Elseya dentata* is restricted to the northern rivers west of, but not including, the Alligator Rivers region of the Northern Territory. A distinct undescribed species occurs in the Alligator Rivers region and the rivers flowing north from the Arnhem Land plateau (*Elseya* sp. [Sth Alligator] of Georges and Adams, 1996). The Gulf Snapping Turtle, *Elseya lavarackorum*, is poorly known, but its distribution is thought to extend from the Roper River of the Northern Territory in the west to at least as far east as the Gregory-Nicholson drainage in Queensland. There is an undescribed species in the Johnstone Rivers region near Cairns, *Elseya irwini* restricted to the Burdekin, and there is a third undescribed species in the Mary, Burnett and Fitzroy Rivers of south-eastern Queensland (Georges and Adams 1996). A related form, the New Guinea Snapping Turtle *Elseya novaeguineae*, is widespread in New Guinea. *Elseya branderhorsti* is found in the southern rivers of New Guinea. It is likely that many more species will be discovered there (Rhodin and Genorupa, 2000; Samedi and Iskandar, 2000) and in the Kimberley region (Cann, 1998).

Saw-shelled Turtles

A second lineage of carnivorous and omnivorous species is currently grouped within *Elseya*. They tend to be most abundant in the upper reaches of rivers and their tributaries. The Common Sawshell, *Elseya latisternum,* is the most widespread. It occurs in the coastal rivers from the Richmond River of northern New South Wales, to the Jardine River on the tip of Cape York, in the rivers discharging into the Gulf of Carpentaria, and in the

headwaters of rivers that discharge from the Arnhem Land plateau. Other species in this group are very restricted. The Bellinger River Turtle, *Elseya georgesi*, and the Manning River Turtle, *Elseya purvisi*, are restricted to the coastal New South Wales rivers that give them their common names. They are of particular interest because they are a sibling or cryptic species pair, morphologically difficult to distinguish on external examination, but deeply divergent genetically (Georges and Adams 1996). Once thought to be a single species, the genetic examination prompted a closer look at their morphology and revealed that *Elseya purvisi* has well-developed series of exposed neural bones, consistently lacking in *Elseya georgesi* (Thomson and Georges 1996). Neural bones in most chelid turtles are reduced subsurface bony elements of the carapace lying immediately above the vertebral column (Thomson and Georges 1996). A fourth species in this group, *Elseya bellii*, is found in the granitic headwaters of the Namoi, Gwydir and Severn tributaries of the Darling River in inland New South Wales. Those from the upper reaches of the Severn have small but distinctive morphological differences from the Namoi/Gwydir populations, and may prove to have a similar relationship to that between *Elseya purvisi* and *E. georgesi* (Cann, 1998).

Snake-necked Turtles

Australia is well known for its snake-necked chelid turtles, genus *Chelodina*, because their necks can be spectacularly long in relation to their bodies, an innovation rare among the cryptodiran turtles that dominate the turtle fauna of the Northern Hemisphere. Their long necks have evolved through the benefits of attenuated strike and gape feeding that enables these animals to secure fast-moving prey not available to their short-necked cousins. When feeding, the head and neck are thrust out against the inertia of the body. At the same time, the floor of the mouth is lowered causing an in-rushing of water to suck in the prey.

Species of *Chelodina* fall into three sub-generic groups (Burbidge, Kirsch et al. 1974). *Chelodina longicollis* and *C. steindachneri* of Australia, *C. pritchardi* and *C. reimanni* of New Guinea, *C. mccordi* of Roti and *C. novaeguineae* of Australia and New Guinea belong to Group A. They are carnivorous foragers with relatively narrow heads, shorter thinner necks and broader plastrons (Goode 1967; Rhodin 1994; Rhodin 1994). *Chelodina expansa, C. burrungandjii* and *C. rugosa* of Australia, and *C. siebenrocki* and *C. parkeri* of New Guinea belong to Group B are ambush predators with relatively broad heads, longer thicker necks and narrower plastrons (Goode 1967; Rhodin and Mittermeier 1976). *Chelodina rugosa* and *C. siebenrocki* are indistinguishable using allozyme electrophoresis,

and are morphologically very similar. We regard them as a single taxon, *Chelodina rugosa*.

Chelodina colliei of southwestern Australia (formerly C. oblonga, Thomson 2000) is superficially similar to species of the Group B, and has often been placed in that group (Goode 1967; Legler 1981).

However we follow Burbidge et al. (1974) and place it in a third sub-generic group, Group C. It is distinguished from other described *Chelodina* by a consistent set of well developed of neural bones (Burbidge, Kirsch et al. 1974; Thomson and Georges 1996).

Monotypic Genera

The remaining genera are monotypic. *Rheodytes leukops* is restricted to the Fitzroy-Dawson drainage, *Elusor macrurus* is found only in the Mary River of coastal Queensland, and *Pseudemydura umbrina* is restricted to coastal swamps near Perth. The cryptodire, *Carettochelys insculpta*, is found in the Victoria River, Daly River and Alligator Rivers region of the Northern Territory.

Natural Hybridisation

Hybridisation presents particular problems for any species concept, as substantial gene flow between taxa acts against their divergent evolution and blurs their separation as discrete entities. Traditionally, hybridisation is interpreted as contributing to a final stage in speciation, whereby introgression leads to reduced fitness and positive selection for traits limiting further hybridisation (Dobzhansky 1940; Dobzhansky 1970). When two diagnosable taxa are in long-standing allopatry, the possibility exists that despite substantial genetic divergence, reproductive incompatibility may not be fully effected, with the final stage of reproductive character displacement requiring a period in sympatry. Recent studies soon to be published demonstrate that reproductive compatibility, a pleisiomorphic trait by definition, can persist for substantial periods in a phylogeny derived from morphological and molecular data. *Chelodina rugosa* (Fig. 1) and *C. novaeguineae* (Fig.2) are distant phylogenetically, and may soon be placed in separate genera (Legler 1985), yet they hybridise in the Gulf region of Queensland with evidence of introgression (Georges, Adams et al. submitted). *Chelodina longicollis* (Fig. 3) and *C. novaeguineae* are not sister taxa, yet they hybridise in central coastal Queensland. Strict application of the Biological Species Concept (Mayr 1969) would have us regard these as single species, but in practice, all species concepts must be relaxed to include the possibility that species can form natural hybrids (Arnold 1997).

When the hybrids from central coastal Queensland were found, it was clear that cross-breeding was taking place on the boundary of the distributions of the two parent *Chelodina novaequineae* and *C. longicollis* (Cann, 1998). Not so with the hybrids (Fig. 4) between *C. novaeguineae* and *C. rugosa*. They were initially thought to be a new species, and a description was being prepared (Cann, 1998). They were found in a dam made for mining over 80 years ago, which gathers water only in the tropical wet. This dam is toxic, with warnings on water use, so it is interesting to speculate whether this has in some way interfered with the normal barriers to reproduction between the two species. High on the list of research questions then is whether this hybridisation is more widespread. Does it occur in the Gilbert River proper, some 6 km away? To what extent is backcrossing occurring and is there persistent gene transfer between the two fairly distantly related species?

Conclusion

The current Australian turtle fauna appears to comprise a series of distinct lineages, each of considerable antiquity, and possibly relicts of a more diverse fauna that existed when wetter climes prevailed. Half of the extant genera are monotypic, and many species are restricted to single drainage basins. The recent work on taxonomy will allow a more reasoned analysis of the conservation status of freshwater turtles in Australia and will allow us to identify hotspots of biodiversity and endemism that deserve special management attention (Georges and Thomson, 2001).

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Fig.1. *Chelodina rugosa* from the Gilbert River, Gulf Country, Northern Territory, Queensland. All photos by the authors.

Fig. 2. *Chelodina novaeguineae sp.*

Fig. 3. *Chelodina longicollis*

Fig. 4. A fertile hybrid between *C. rugosa* and *C. novaeguineae sp.*

Fig. 5. A collection of shells from central coastal Queensland where *C. longicollis* and *C. novaeguineae sp.* meet.

Fig. 6. Top to bottom: *C. rugosa, C. novaeguinaea sp,* and *C. hybrid.*

HERPING IN USAMBARA MOUNTAINS, TANZANIA

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In March of 1997, I undertook a photographic trip to Tanzania to document as many species of reptiles and amphibians as possible. I was fortunate to have met Joe Beraducci the previous year at the San Antonio IHS whereupon he invited me to visit him in northern Tanzania. Joe has a phenomenal animal facility where he maintains, and even breeds many of the 31 taxa of indigenous chameleons. When he collects new chameleon stock from the wild, he releases numerous captive-bred juveniles of the same species, thereby ensuring a continued healthy population.

While waiting to rent a *trustworthy* vehicle, I took a side trip to the northern region of the country to explore the Serengeti. Here, I came across the typical animals that so characterize the African plains: elephants, rhinos, zebras, elands, storks, eagles, as well as wildebeests by the hundreds of thousands. Reptiles were also seen; leopard tortoises, colorful endemic agamas (*Agama mwanzae*), puff adders, and even a pair of the rare, brilliantly-colored, green and gold Hanang hornless chameleons (*Bradypodion uthmoelleri*).

When I returned to Arusha, our starting point, Joe had a vehicle ready for us to take to the Usambara Mountains. These mountains are actually divided into two separate ranges, the eastern and western Usambaras. Our first destination was the eastern range. Just before ascending the road up this mountain, we came upon a juvenile, four-foot-long African rock python (*Python sebae*) lying in the middle of the road. While removing it, it became very agitated and struck wildly at the slightest movement. (We were thankful it wasn't a 15 foot adult.)

As we climbed higher into the mountain, we noticed a dramatic change in habitat from that of typical forest to cloud forest. The temperature now had dropped into a comfortable mid 70s (25 C). Before reaching the top, we stopped at a small village where Joe suggested we pay a visit to the local Chief. The Mzee (village leader) welcomed us and was quite willing to assist us in any way he could. We explained to him that we wanted to collect and photograph as many different reptiles and amphibians as we could find. Together with several of the natives, the Mzee took us on a brief walk through the surrounding forest. Here we caught the tiny, leaf-mimic chameleon (*Rhampholeon brevicaudata*). Fully grown, these two inch-long lizards are nearly impossible to detect amongst the leaf litter of the forest floor. At a nearby stream, I found an endemic species of toad, *Bufo brunai.*

Although it was not very colorful, it was nonetheless a species which occurred only in this small region of the mountain.

At the top of the mountain was a modest research station that had several rooms to rent. Included in the rental fee were three meals per day. This was most advantageous as it allowed us to spend most of the day out searching for herps, then returning to a well-prepared meal at our convenience.

Joe informed me that there is an endemic species of caecilian found only here in the Usambara and Magrotto Mountains. Tanzania has a high number of endemic reptiles (50 +) as well as amphibians (35 +) scattered mostly in the various disconnected mountain ranges around the country. The caecilian species here, *Boulengerula boulengeri*, is a 7-10 inch-long amphibian that spends most of its life underground where it feeds on worms and other soft bodied invertebrates. After many "false alarms", we managed to catch several of these pink and purple creatures, including a three inch-long juvenile.

The forests of this paradise habitat are home to nearly a dozen chameleon species. Finding one during the day is almost impossible (at least it was for me). However, the natives here have a very keen eye and are able to locate even the most cryptic species amidst the entanglement of bushes and trees. The largest chameleon here is the Fisher's chameleon, of which two of the three subspecies are found only in the Usambaras. (The third subspecies is found in the Uluguru Mountains, located in the central-eastern part of the country.) We had much better luck finding these elusive animals at night when our flashlight beams could concentrate just on a small piece of vegetation at a time. The eastern Usambara two-horned chameleon, *Bradypodion f. fisheri*, is 8-10 inches long and has a row of spines that extend from behind its head to halfway down its back. Males have a large nasal projection which is absent in females. At night, the coloration was much more dramatic than during the day. Some males were lime-green with yellow and pink spots along their sides. During the day, their overall coloration tends to be dark brown with light tan stripes on the sides.

One of the smaller species of chameleon, the Usambara soft-horned chameleon (*Bradypodion tenue*) was common among the low growing shrubs and bushes in the gardens surrounding the research station. At night, while they slept, (typically with their heads facing the ground), their three-inch-long bodies were brown with the head and nasal appendage being bright orange. Upon capture, they quickly turned a pale grayish-silver color and their spiny, nasal protuberances were bright green! There were also bright blue spots along the sides of their bodies. These were truly a spectacular looking species.

Also present in the trees at night were many exquisite species of frogs. As soon as the sun set, more than half a dozen species began to call. Several of the frogs were

endemic to just a few surrounding mountains, notably the gaudy Amani tree frog, *Leptopelis vermiculatus*, which was bright green with black spots and silver eyes. Another gorgeous tree frog was the "red-eyed" frog (not related to the frog of Central America with the same common name), *Leptopelis parkeri*. The males of this species had bright red, oversized eyes, a light green overall body coloration, and small yellow spots scattered on their backs. Interestingly, this species is sexually dimorphic and the females were larger (2-3 inches) and were also light green with larger yellow splotches on their backs. Their eyes however, were very dark red, almost like the color of blood, and their venters were pale, opalescent blue!

After a few days in the eastern mountains, we decided to check out the western side. Although the distance between them was short (the two mountains were only a few miles apart), the journey took most of the day to complete. Again, we were fortunate to find accommodations here as there is only one place where visitors can find room and board. After checking into our modest rooms (essentially each room just had a bed, and there was only one communal bathroom with no running water), we went out to explore the surrounding habitat. In minutes, we found a most unusual gecko under a pile of logs, the "scansor-tailed" gecko, *Urocotyledon wolterstorffi*. This lizard has, under its tail, what many gecko species have on their toes; adhesive pads. This enables the gecko to use its tail like a "fifth" foot. The specimen we caught was a hatchling but what was really unusual was that this species has not been reported from the western Usambaras, only the eastern Usambaras. (Range extension.)

Under a dead fallen tree I collected an adult black "garter" snake (*Elapsoidea nigra*). The common name is somewhat misleading as this is an elapid and not related to the colubrid garter snakes of the U.S. (*Thamnophis* sp.) This species is rather small, adult size is only 15-20 inches, and there is a pronounced ontogentic pattern change from juvenile to adult. Adults are dark gray and black banded, whereas juveniles have light beige bands alternating with dark blue bands. (They look very similar to banded sea kraits – *Laticauda colubrina*.) Immediately after catching the adult, it regurgitated a recently eaten unidentified skink.

Searching the buttresses of the large trees yielded a few colorful lacertid lizards, the blue-tailed tree lizard, *Heliobolus guentheri*. These are a small, colorful species whose tail is vibrant blue, and like most lizards, it will break off easily if molested or handled roughly.

In a short bush, one of our guides found an adult male boomslang, (*Dispholidus typus*) wrapped tightly around two branches. With a long-handle set of tongs, I tried to

extricate it from amidst the bush, taking care not to get bit by this potentially dangerous snake. After a brief struggle, I was victorious and managed to capture it unharmed.

But perhaps the catch of the entire trip came only minutes before we were ready to leave the Usambaras. While walking down a narrow trail, one of the guides yelled: "Snake, snake, up there in the bush!" All of us gathered around the bush and the other two guides were nodding in approval of the discovery of this animal. I kept asking where it was, as I could not see it from where I stood. Despite their diligence in pointing the snake out to me, I still could not locate it at all. I did end up aiming my camera in the general vicinity of the "snake" and took a picture in the hope that when I developed the film, I would finally be able to see it. Everyone tried to rush the snake and grab it before it escaped, but since it was in a tall, thorny bush it was completely protected and inaccessible. Joe finally decided to endure the pain of the thorns and got underneath the snake with a large pillowcase hoping it would drop into the bag if it were disturbed. His theory worked, and a moment later he captured the Usambara horned bush viper, *Atheris ceratophorus*. Quite a nice way to end a magnificent herping expedition in Tanzania.

USE OF ENDOSCOPY IN HERPETOLOGICAL MEDICINE

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Endoscopy has been used for many years in both human and veterinary medicine. Only recently, however, has endoscopy been used to any extent in reptiles or amphibians. Endoscopy involves the use of a fiberoptic lens system or camera system to visualize the internal structures of the patient. Endoscopy is favored because it is minimally invasive, does not involve large incisions, and can be used to obtain tissue biopsies.

In herpetological medicine, the veterinarian is often faced with a very stoic patient. Reptiles have the ability to appear quite normal externally, while actually being extremely ill internally. As a result, diagnostic testing is often necessary. Blood testing, including cell counts, blood chemistry values, and antibody levels to specific diseases, is often helpful but is equally often unhelpful. It is possible to have a completely normal blood result in a very ill reptile. Similarly, radiographs and ultrasound images are sometimes useful, but only provide an indirect, limited view of organs. Because of these limitations, veterinarians may now favor endoscopy to allow direct visualization and evaluation of reptile and amphibian patients.

There are numerous areas where endoscopy may be useful (1). Coelioscopy, or internal examination of the coelomic cavity, provides direct view of the liver, lungs, kidneys, heart, spleen, bladder, gastrointestinal tract, pancreas, and gonads. This technique can be used to evaluate these organs for abnormalities including organ enlargement, abscesses, tumors, bleeding, etc. Visualization of the gonads can be used to determine the gender of individuals of sexually monomorphic species or juveniles of dimorphic species. Fieldwork on juvenile desert and Galapagos tortoises, and hellbenders, has demonstrated the utility of endoscopy for gender identification (2,3,4,5). Endoscopy can also be used in reptiles to look into the trachea and bronchi to evaluate cases of respiratory disease. It can be used to retrieve foreign bodies from the gastrointestinal tract (eg., coins swallowed by crocodilians). Finally, and perhaps most importantly, endoscopic instruments allow the veterinarian to obtain tissue biopsies of diseased organs. By obtaining biopsies, it may be possible to provide a more precise diagnosis and prognosis than previously available through other diagnostic testing.

For example, based on blood work an animal may be said to have a liver problem; but with endoscopy, a more definite diagnosis such as a "moderate chronic active fungal hepatitis" may be made, thus allowing precise treatment for the precise problem.

Several types of endoscopes are useful for reptiles. For chelonians, lizards, and for some procedures in snakes, the rigid 2.7 mm Hopkins telescope is most useful. This telescope system generally is equipped with a sheath to allow introduction of biopsy forceps and endoscopic surgical instruments. Endoscopic scissors are often required to incise through the coelomic membrane or capsule of organs such as the chelonian kidney prior to biopsy. Flexible endoscopes are most useful in snakes for evaluation of the digestive and respiratory tract. To sterilize scopes for coelioscopy, cold sterilization products or gas sterilization may be used. For insufflation, a simple aquarium air pump may be used to provide very gentle pressure. Care must be taken to prevent over-inflation leading to cardiorespiratory depression and severe subcutaneous emphysema.

In general, a small incision (about one cm) must be made in the body wall under general anesthesia. In lizards, the incision for coelioscopy is generally made in the lateral body wall just caudal to the last rib. In chelonians, the incision is made in the center of the pre-femoral fossa. In snakes, the incision is made at the junction of the ventral and lateral scales at a site along the body where the organ of interest is expected to be. The skin incision is generally made with a scalpel, while incision of the coelomic membrane and muscle may be made bluntly with hemostats or sharply with endoscopic scissors.

Veterinarians and herpetoculturists should be aware of the availability of endoscopy and consider seeking a referral veterinarian that can provide this service if other diagnostic options have been unrewarding.

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The Captive Maintenance and Propagation of the Ornate Monitor, *Varanus ornatus* (Daudin, 1803) and Mertens' Water Monitor, *Varanus mertensi* (Glauert, 1951) at the Wildlife Conservation Park (Bronx Zoo)

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The ubiquitous Nile monitor, *Varanus niloticus*, has been featured in nature documentaries as well as many natural history books. After the savannah monitor, it is probably the next most frequently purchased monitor lizard in the pet trade. Unfortunately, it is often purchased on impulse, and not much thought is given to the large size it attains or to its husbandry needs (Faust and Bayless, 1996). Less frequently imported is the ornate Nile or rainforest monitor, *Varanus ornatus*, a form recently elevated to a full-species on the basis of significant morphological and ecological differences (Böhme and Ziegler, 1997).

One of the many specialized varanids in terms of morphology and habitat use is the Mertens' water monitor, *Varanus mertensi* (Shine, 1986). Glauert named the species after the late herpetologist Robert F. Mertens (1894-1975), well known for his contributions to varanid taxonomy and morphology. This article focuses on the husbandry and reproduction of these species maintained at the Wildlife Conservation Society Park (Bronx Zoo)*.

* The first *Varanus ornatus* breeding occurred at the author's residence in 1998.

INTRODUCTION: DESCRIPTION

The Nile monitor was first described by systematist Carolus Linnaeus (1707-1778) in 1766 as *Lacerta niloticus*. A second form was described by Francois-Marie Daudin (1774-1804) in 1803 as *Tupinambis ornatus* based on external morphological differences (Bayless, 1992; Bennet, 1998). *Varanus ornatus* (Photo 1.) can be distinguished from the common Nile monitor through several morphological characters. Ornate Nile monitors generally have a dark olive to black background skin color with cream to bright yellow contrasting stripes on the jaw and head region. These break into a row of three to four chevrons running down the neck; and right before the insertion of the forelegs, they form light crossbands of spots and/or ocelli posteriorly. These rows are arranged from four to six in *V. ornatus*. Light-colored complete tail bands number from nine to twelve. Colors may fade as the animal matures, but the pattern remains prominent. *V. niloticus* has a similar color scheme, but the rows of ocelli between the limb insertion points range from six to eleven, and the tail bands range from ten to eighteen. The ornate Nile also has a light-colored to pinkish tongue, whereas the common Nile's tongue is bluish-black in color (Mertens 1942a-c; Naclerio, 1993; Faust and Bayless, 1996. Bennett (1998) lists various

average and record sizes for the common Nile monitor, which has been recorded at sizes of over 6 ft. TL (182 cm). Sprackland (1992) states that the common Nile is slightly larger than the ornate Nile. Haacke and Groves (1995) report a record size for a female common Nile monitor from Pretoria, South Africa at 7 ft., 11-1/4 in. (243 cm). However, the record skull size comes from a preserved ornate monitor originating from Ureca, Bioko Island (a.k.a. Fernando Poo). Böhme and Ziegler (1997) state that between similarly sized specimens of *V. ornatus* and *V. noloticus*, the ornates have comparably larger and bulkier skull with greater curvature of the jaw.

Scale pattern is similar in both species, but the scale rows are higher in number about mid-body in *V. ornatus*. Also, it should be noted that the genital morphology of the two species differs; the details of which can be found in Böhme and Ziegler (1997). The hemibaculae of male *V. niloticus* are not ossified (Card and Kluge, 1995), and this is probably the case with V. ornatus.* For those who do not know the sexes of their ornate Niles, ultrasonography can be a safe, non-invasive method. It has been successfully performed with *Varanus albigularis*, *V. exanthematicus*, *V. komodoensis*, V. mertensi, *Heloderma horridum*, and *H. suspectum* (Sainsbury and Gili, 1991; Wright and Pugh, 1995; Morris and Alberts, 1996; Lee and Friedman, 2000).

Mertens' water monitor, *Varanus mertensi*, was described to science in 1951 by L. Glauert, based on the holotype collected on the Moola Bulla Cattle Station near Halls Creek, East Kimberley. This lizard is mostly light to dark olive on the dorsum with small whitish specks and spots on each scale, casting it a gold-bronze hue (Bustard, 1970). The head scales are large, smooth, and irregular. Scales are relatively uniform in size on the dorsum. Body scales are smooth, convex, and small, but become lengthened posteriorly and slightly keeled on the tail. The ventral surface and throat are a light cream color with several dark crossbars on the thoracic region. There is some grayish striping and mottling on the lower jaw (Storr, 1980), and adult males may develop blue hues on the throat (Sprackland, 1992). The nostrils are positioned on top of the snout rather than directed to the sides as in most varanids (Glauert, 1951; Cogger, 1959; Bustard, 1970).

According to Shine (1986) in his study on four sympatric species of monitors in the Jabiru region, Northen Territory, males ranged from 13-16.2 in. (33.0-41.0 cm) SVL and were sexually mature at 13 in. (32 cm) SVL (n=19), while females ranged from 12.2-18.1 in. (31-46 cm) SVL and were sexually mature at 11 in (28 cm) SVL (n=14). Christian and

*The sexually mature male *V. ornatus* in the collection did not present ossified hemibaculae upon radiographic examination.

Garland (1996) found a mean SVL of 15.5 in. (39.4 cm) from five preserved museum specimens. Bustard (1970) gave a TL of 3.5 ft. (106.6 cm) and a weight of 6 lbs. (2.72 kg) for adults. Storr (1980) gave a maximum SVL of 19 in. (47.5 cm) and 44.5 in. (113 cm) TL for a lizard from Western Australia. In captivity, Eidenmüller (1990) reported the TL of long-term captives as 31.5 (80 cm) and 33.5 (85 cm) for male and female, respectively.

INTRODUCTION: DISTRIBUTION

The range of *Varanus ornatus* encompasses ten West African countries including Senegal to Cameroon longitudinally, south to Cabinda (Faust and Bayless, 1996). According to Bayless (1992) ornate monitors do not come from the central-east African country of Burundi, although they are frequently advertised as "Burundi Niles." This most likely reflects the origin of exportation. According to locality data of preserved specimens in British and German museums, ornate Nile monitors are distributed along the Upper Guinean and the western Lower Guinean forest block. Sympatric overlaps of the two species have been recorded in places such as Liberia, Ghana, Nigeria, Gabon, and Southwest Zaire (Böhme and Ziegler, 1997). Schmidt (1919) recorded *V. niloticus* as occurring in the Belgian Congo rainforests and borders. However, despite having collected thirty-one (31) specimens of Nile monitors during the American Museum of Natural History's Congo expedition of 1909-1915, no tongue color or body pattern descriptions were published. Broadley (1998) assumes that these were indeed ornate Nile monitors that Schmidt's crew had observed and captured, and a cursory examination of these particular specimens by the author supports this assumption (AMNH#R-10496, R-10498, R-10505, R-10508, R-10509, R-10520, R-10521 and R-10523).

Common Nile monitors inhabit most regions of Africa except for Mediterranean Africa, arid deserts, tropical rainforests and elevations over 4,265 ft. (1300 m) above sea level. Ornate monitors are restricted to the ever-shrinking equatorial rainforests, the Tierra Templada, and to large swamplands with dense forest close by (Bayless, 1997; Faust and Bayless, 1996).

The range of *Varanus mertensi* (Photo 2) lies in the northern-most region of the Australian continent. It is found in Western Australia to western Queensland, the western side of the Cape York Peninsula, as well as on Groote Eylandt (Cogger, 1959; Gow, 1981). These lizards prefer reservoirs, stream margins, creek-fed pools, and occasionally venture out to Billabong floodplains (Shine, 1986).

INTRODUCTION: NATURAL HISTORY

The ornate Nile monitor is secretive by nature, but many specimens were seen in Korup National Park as they were captured in snares set by farmers. Adults and juveniles were found in and near moderately-sized streams, and were quite arboreal. Juveniles have been found on the roofs of village homes, and adults were observed scaling tree trunks up to a height of approximately 98 ft. (30 m) (D. Lawson, pers. comm.).

An analysis of stomach content from five specimens captured in the Belgian Congo revealed land snails, crabs, small fish, a small water snake, mantid and orthopteran remains, slugs and a small frog (Schmidt, 1919). Dentition and skull structure in both the ornate and common Nile monitor undergo ontogenetic changes from juvenile to adult forms to accommodate a durophagous diet (Lonnberg, 1903; Mertens, 1942).

Varanus ornatus inhabits regions where rainfall averages over 5.2 ft. (1.6 m) annually (Bayless, 1997). In Cameroon annual rainfall can exceed 13.1 ft. (4 m) (D. Lawson, pers. comm.) Ornate monitors inhabit regions of high heat and humidity; and, therefore, many populations do not aestivate like non-equatorial populations of *V. niloticus* (Cowles, 1930; Cissé, 1971). However, even though there are marked wet and dry seasons, conditions remain moist and humid in forested areas. In Cameroon, the rainy season lasts from February through October, peaking in rainfall July through September. In November, the transition from wet to dry occurs abruptly and lasts until February (Lawson, 1993). Mean annual maximum and minimum temperatures measured in the shade at the southwest end of Korup National Park are 86.4 F. (30.2 C.) and 75 F. (23.7 C.) (Lawson, 1993). Small juveniles can be observed in great numbers in southwest Cameroon around September-October (D. Lawson, pers. comm.). In contrast to *V. niloticus,* reproductive events have rarely been recorded for *V. ornatus* (see Bayless, 1992 for a review of the literature).

Mertens' monitor is a sleek and active lizard, capable of exploding into a high-speed chase after small fish and crustaceans. It keeps its eyes open and actively tongue-flicks while foraging under water (Swanson, 1976). Its long, laterally compressed tail is directly related to its aquatic lifestyle (Bedford and Christian, 1996), and it is similar to crocodilians in having dorsally positioned valvular nostrils (Cogger, 1959). Research conducted by Losos and Greene (1988) demonstrated the preference of these monitors for aquatic invertebrates, namely freshwater crabs, shrimp, crayfish, and amphipods. Frogs, beetles, and other insects were found to round out the diet. In 1981 Hermes described

an interesting account of a Mertens' monitor using its body and tail to herd a small school of fish trapped in a pool. Shine (1986) compares this behavior to that of the huge saltwater crocodile, *Crocodylus porosus*, a successful sympatric predator of crabs and fish. This lizard is a predator of several species of juvenile Australian turtles and their eggs (Cann, 1998).

Varanus mertensi inhabits a temperate region where temperatures remain between 59-91.4 F. (15-33 C.); however, a wet-dry season occurs in this region and appears to play a major role in the nesting behavior of this species. Christian et al., (1996) recorded climatological data taken at Bennet Lake, Northern Territory. The area underwent a wet season, December through March, and a dry season, May through September. The mean annual maximum and minimum air temperatures recorded were 87 and 67 F. (30.4 and 19.3 C.) in July, and 92 and 77.5 F. (33.1 and 25.3 C.) in November. In the wild, breeding occurs between January and March, and oviposition occurs between April and June (Shine, 1986; Greer, 1989). Gravid females may dig a tunnel complete with a terminal nesting chamber in which they deposit their eggs (Irwin, 1986; Hoser, 1989).

INTRODUCTION: CONSERVATION STATUS

Varanid lizards are one of the most commercially important and, consequently, most heavily exploited reptile species in the world. Trade in skins, consumption of meat, and use of lizard parts for traditional medicine take a large toll on populations of Nile and ornate monitors. Exportation of live animals for the pet trade is a smaller yet significant pressure they also endure (Luxmoore and Groombridge, 1988; Buffrenil, 1992). *Varanus ornatus* faces threats such as hunting by humans and possible niche competition and genetic mixing with *V. niloticus*. *V. ornatus* is listed as a vulnerable species according to the IUCN Mace-Lande status listing; and further distribution, habitat survey, and taxonomic and husbandry research is recommended by the Varanid CAMP Taxon Advisory Group (Hudson, et al., 1994).

Hudson, et al., (1994) also listed populations of *Varanus mertensi* as stable and made recommendations for zoos to improve upon husbandry techniques and breeding efforts for management of captive populations. With the Australian government's great vigilance for its wildlife, few specimens have left the continent. However, cane toads (*Bufo marinus*) have been implicated in preying upon juvenile Mertens' monitors, while adults may die from attempts to eat small cane toads. Population declines have been noted especially in Mt. Isa at the Queen Elizabeth River dam area (J. Cann, pers. comm.).

MATERIALS AND METHODS: *Varanus ornatus*

The author (SML) purchased a male ornate monitor on 16 January 1996. It weighed approximately 7 lbs. (3.2 kg), and his SVL and TL measurements were 19.7 in. (50.4 cm) and 50 in. (127 cm), respectively. Full hemipenal eversion was observed. The female was adopted on 9 February 1998. Her weight was approximately 4-1/2 lbs. (2.0 kg), and her SVL and measurement was 15-1/2 in. (39.4 cm). At the time of this writing, the male weighed 19-1/2 lbs. (8.8 kg) and the female, 11-1/2 lbs. (5.5 kg).

Each lizard had a different number of light-colored bands on the tail, which we used as identifying characters. For the purposes of this paper, the female was named F9 and the male, M11. Weights were obtained using a HOMS® tubular 50 kg capacity spring scale, and measurements were obtained using a standard tape rule. Their morphometrics and estimated ages (given by previous owners) are given in Table 1.

These lizards displayed various levels of defensive behavior towards humans, but eventually adjusted to a daily routine. The male, M11, was the most defensive of the two; sometimes it stood up in a threatening tripodal stance. It calmed down when I sat down at face level. F9 quickly grew accustomed to my presence and, eventually, became quite docile. Both lizards took food readily from forceps.

HOUSING AND THE PHYSICAL ENVIRONMENT

The two wooden cages used to house these lizards were kept in a secluded room, providing the lizards with a great deal of privacy from human activity. One cage, housing the male, measured 6 ft. long by 3 ft. wide by 2 ft. high (183 cm L x 91.4 cm W x 60.9 cm H) and was constructed of 3/4 in. (19 mm) thick plywood and studs. A basking shelf large enough for two monitors was installed. Indoor reflector spotlights, 75 and 90 watt, were used in conjunction with two 20 watt Verilux® and Vitalite® (Durotest) fluorescent bulbs above the basking shelf, along its long axis. The female's housing was similar but slightly smaller.

Both cages rested on wooden platforms. Large Rubbermaid® dishpans were used for water, and inverted pans with holes cut in them served as hide boxes. Some wire and plastic foliage pieces were added to the lids of the cages as a visual barrier to give the lizards a sense of security. A nest box was provided after the female had shared living quarters with the male for more than a month. This was an 18 gal. (68 l.) Rubbermaid® storage box filled with a mixture of sand, coconut mulch, and sphagnum moss. The sub-

strate used for both cages was primarily eucalyptus mulch and pine bark mini-nuggets. When the pair was brought into the zoo collection in August 1998, they were housed separately, the male in a large galvanized metal tub measuring 120 in. long by 36 in. wide by 22-3/4 in. high (30 x 91.5 x 57.5 cm) and the female in a 96 in. by 31 in. by 31 in. (244 x 79 x 79 cm) Neodesha® cage.

The lizards experienced seasonal ambient temperature and humidity changes while at my residence. During the late spring to early fall, the ambient high temperatures ranged from 68-92 F. (20-33.3 C.). In the winter, the ambient high temperatures ranged from 55-72 F. (22.2-12.7 C.). Basking lamps were kept on except for during the hottest days in July. Basking site temperatures ranged from 90 to 100 F. (32.2-37.7 C.) year-round. Cages were misted several times weekly; and in April and May, misted several times daily. The room that the enclosures were kept in had a large North-facing window and underwent a photoperiod corresponding to Plainview, NY. Additionally, the lights were kept on timers to allow for a photoperiod adjustment of 9L:13D from November to February, increasing to 14L:10D by early June. At the zoo, the lizards were kept at more optimal thermal conditions (ambient temperature ranges from 77-88 F. [25-31 C.] under skylights and artificial lighting set at 12L:12D.

HUSBANDRY AND FEEDING

When the lizards were accessioned into the zoo collection, they went through a quarantine period consisting of fecal analyses and diagnostic blood tests. They were found to be in good health and did not require treatment.

These captive ornate monitors were fed three or four times a week. Their diet consisted of rodents (rats and mice of various sizes and ages), fish such as minnows and shiners (*Notamegonus* sp.), and invertebrates; and, listed in order of frequency offered, included crayfish (*Cambarus* sp.), night crawlers (*Lumbricus terrestris*), land and water snails (*Helix* and *Pomacea* sp.), super mealworms (*Zoophobas morio*), crickets (*Acheta domestica*), and strips of squid (*Loligo* sp.). Calcium supplements were offered weekly, and increased to twice-weekly for the female once she appeared gravid.

The monitors regularly defecated in the water, which facilitated cleaning. Feces were spot-cleaned from the substrate, although the substrate was completely changed approximately three times annually, at which time all cage furnishings were cleaned and disinfected with a dilute mixture of Nolvasan®. The lizards were captured and held in

large snake bags inside trash barrels for the duration of these procedures, which were opportune for giving them physical examinations and trimming overgrown claws.

BREEDING AND NESTING EVENTS

F9 (Photo 3) was introduced to M11 in the larger cage on 11 March 1998, but as of 22 March the male had shown no interest in the female. On 9 April 1998, M11 was observed investigating F9's head and neck region while "head-weaving." At 6:00 A.M. both animals were on the basking shelf, and the male was observed mounting F9 from her left side. Copulation events continued until 15 April 1998, and the male was observed copulating with the female from both sides. By 19 April 1998, F9 displayed mildly aggressive behavior toward M11 during and after feeding sessions. On 24 April 1998, F9 was transferred to her own nesting enclosure. A 60 watt Pearlco® ceramic element heated the nest box from above, 24 hours daily.

On 7 May, F9 ate only one of two small rats offered. This was unusual for her and was a good sign of impending nesting. On May 9 and 10, F9 was digging inside the nest box at 6 P.M., and later at 1:30 A.M. Nocturnal nesting activity has been documented for other varanid species as well (Irwin, 1996). I was out of town between May 11 and 16, having left my mother in charge of caring for my monitors. She reported that while I was gone F9's digging activity knocked off the nest box lid. She then observed F9 using her forelimbs to toss cage floor substrate 12 in.(30.5 cm) upward into the open next box, and then spending time on top of the nest box substrate beneath the ceramic bulb.

I returned home on 17 May and rushed in to find F9 lying on top of the open nest box. I scooped her up without her displaying signs of agitation or defensive behavior. Her pelvis and tail base were noticeably thin. There was a pile of fresh feces on top of the substrate in one corner of the nest box. I removed the feces and began digging in that spot. A total of 16 white eggs were piled on top of each other beneath 2-3 in. of relatively dry substrate. I immediately set-up the eggs in moist sphagnum moss for transport to the zoo the next day. The nest site temperature was around 82 F. (27.7 C.). I hypothesize that feces may have been deposited on top of the clutch for any of several reasons. It could have resulted from the physical stress of egg-laying itself, or instinctive behavior because the substrate needed more hydration or to protect the eggs from predators with stool odor.

The second breeding occurred at the zoo in 1999. The lizards were paired on 24 March 1999, and copulation had ensued by 5 April. The pair was separated one week later,

and the male was moved to a display in the new Congo Gorilla Forest exhibit (Photo 4.). On 13 May 1999, F9 laid twenty-three eggs in the nest box.

The pair was introduced again during 1999 with near disastrous results. They were on exhibit and were observed in the pool, where they were biting and wrestling in a manner typical of two combating Nile monitors. We let this go on for several minutes until F9's head was nearly engulfed in M11's massive jaws. They were separated quickly after that episode.

RESULTS: INCUBATION

On 19 May 1998 the first clutch of 16 eggs laid by F9 were taken to the Reptile House for incubation. They were measured with Fowler® dial calipers and weighed with an OHAUS® triple-beam balance. The eggs were split into two groups of eight each. Those in the first group (Group A) were incubated using a medium of vermiculite and water in a 1:1 ratio by weight; however, an additional handful of moist, hand-squeezed sphagnum moss was placed on top. Above this was a dry layer of moss, and eggs 1-8 (Group A) were placed on top of it. The second group (Group B) was incubated in perlite and sphagnum moss. The perlite was soaked for five minutes, drained without squeezing, and placed in a plastic box. A layer of moist, hand-squeezed sphagnum moss was placed on top of the perlite, and eggs 9-16 (Group B) were placed on top. Both groups were incubated in Rubbermaid® 13 quart (53 l.) capacity containers, measuring 14-3/4 in. long by 10-1/2 in. wide by 6 in. high (37.5 cm x 26.7 cm x 15.2 cm). The eggs were buried up to one-third their width in a transverse fashion to facilitate water exchange in both liquid and vapor phases (Packard and Packard, 1988; Phillips and Packard, 1994). The containers were placed in a Cagemaster® incubator, controlled with a Helix® thermostat at a setting of 86.4-86.7 F. (30.1-30.4 C.). All of the eggs were candled, and they all showed a high level of vascularization.

Throughout the incubation term the eggs were checked and ventilated daily. Temperature and humidity were monitored with a Raytek® Raynger ST2 infrared emission-detecting hand-held thermometer gun and a Radio Shack™ indoor/outdoor LCD thermometer, as well as HOBO® humidity and temperature loggers programmed to record at random intervals. Water was added to the egg containers whenever a deficiency was indicated.

On 3 August 1998 the eggs were weighed and measured again to chart growth and development, revealing that they had become shorter, yet wider and heavier. For all eggs the average deficit in length was .25 in. (6.5 mm), and the average increase in width and weight was 1.4 in. (3.5 cm) and .25 oz. (7.2 g), respectively. On average, the eggs in Group B were longer and heavier than those in Group A.

On the morning of 18 August 1998, after 125 days, the first neonate was observed pipping through the eggshell. There were several close, parallel, longitudinal slits in the eggshell, leading me to suspect that the neonate (Photo 5.) was using its claws rather than an egg tooth to make these tears. Each hatchling had a small, pink nub of yolk plug on its abdomen, and these either fell off or were absorbed within the first twelve to twenty-four hours of its life. By 24 September, after 129 days, fifteen more neonates had emerged on their own. Incubation length ranged between 123 and 131 days. Each lizard was weighed and measured with respect to which group it was from, and then was placed into one of two aquarium tanks contained within another incubator set at 84-85 F. (28-29 C.).

Two neonates hatched with slight dorsal kinks in the spine just anterior to the pelvic girdle. Two had "squiggly" tail tips (the last inch [2 cm] or so), but the rest were devoid of such anomalies. I attribute the deformities to a fairly high incubation temperature and possible temperature spikes, which may have occurred during the initial days of incubation before the thermostats were replaced by Helix® proportional controllers. It has been shown that for some varanid species incubation of eggs at the lower end of the acceptable temperature range and at relatively high humidity levels produced the most robust hatchlings (Phillips and Packard, 1994). Thermal and hydric conditions found in wild *Varanus ornatus* nests have yet to be documented. The hatchlings from Group A were on average longer in SVL and TL, and were also heavier than those from Group B.

The eggs from the second clutch began to hatch on 23 September 1999, after 134 days. On 4 October, after 144 days, egg 17 hatched. Six were lost during incubation due to dehydration. A regression analysis illustrates the relationship between length of incubation and weight (Figure 1) and weight and snout-to-vent length in the two clutches (Figure 2). Approximately half of the hatchlings fell within the 95% confidence intervals in each graph. In Figure 1, it appears that heavier hatchling weights correspond closely with longer incubation periods.

CARE OF JUVENILES

Neonates were kept both on, and off, display at the Bronx Zoo's Reptile House Nursery.

They were housed communally in 20 gal. tanks with several low-wattage spot lamps and full-spectrum lighting. Basking temperatures were recorded at 95 F. (35 C.). The average ambient temperature of the nursery remained at 82 F. (27.7 C.). The set-up was moist coconut husk and eucalyptus mulch for substrate, with rocks, branches and cork hollows. Water pans were provided with small pieces of cork bark afloat to offer escapes for both the lizards and any crickets that ventured into the pan.

Within three to five days post-hatching, the lizards eagerly accepted crickets dusted with a calcium supplement, and soon accepted pinky mice, minnows, earthworms and wax worms as well. At three weeks of age, several of the lizards at the zoo exhibited dominant behavior, particularly during feeding. Chasing, biting, and pinning were observed during those times. One lizard managed to kill a smaller conspecific and was promptly isolated.

HOUSING AND THE PHYSICAL ENVIRONMENT: *Varanus mertensi*

The Department of Herpetology acquired several Mertens' monitors from a dealer 27 June 1994. They were captive-hatched offspring originating from the Miami Metro Zoo and Glades Herp. Four juveniles (2.2) were also obtained in July of 1995 from Bernd Eidenmüller of Frankfurt, Germany.

The lizards were set-up in two separate quarantine rooms. High and low ambient temperatures of 85-80 F. (29.4-27 C.) were established. They were housed in deep, spacious plastic Neodesha® tubs, which were plumbed and secured with screened-top lids. Several branches were propped up for arboreal basking sites, while large bricks were kept on the tub bottom for traction and to serve as a supplemental haul-out site. We used Verilux® full-spectrum fluorescent lamps combined with 75 and 150 watt incandescent spotlights. Basking temperatures averaged 100 F. (37.7 C.). Water temperatures remained 1-2 degrees below ambient temperature. Photoperiod was kept at a 12L:12D cycle.

A large galvanized metal tub measuring 120 in. long by 36 in. wide by 22-3/4 in. high (30 cm x 91.5 cm x 57.5 cm) served as an enclosure for the breeding trio. This tub was equipped with a metal screen top with a hinged door for easy access. Originally, half of the tub space served as a 6-8 in. (15-20 cm) deep pool equipped with a drain, while the remaining half served as a land site for basking and nesting and to provide shelter. Eventually, a stout wooden platform was installed inside the tub. The shelf supported two nest boxes, subsequently opening up more swimming space for the lizards. Several cork

hollows provided refuge, and stout branches offered climbing and basking sites. A male that is not part of the breeding group is kept in a semi-aquatic exhibit that measures 52 in. long by 36 in. wide by 40 in. high (132 cm x 91.4 cm x 102 cm). It has a gravel bed, branches overhanging the pool, and a small waterfall. We used the same lighting scheme as was described for the quarantine rooms.

Temperatures on land and in water were taken randomly, using a HOBO® Stowaway Tidbits®, as well as a Raytek® ST2 hand-held infrared temperature gun. The average basking, ambient, and water temperatures were 100 F.(37.7 C.), 82 F.(27.7 C.), and 78 F. (25.5 C.), respectively. From the study of body temperature, water flux and energetics of this species, Christian, et al., (1996) found mean maximum body temperatures of 85.5-93.2 F. (29.7-34 C.) in the wet season and 78-92 F. (25.4-33.3 C.) in the dry season.

The young monitors were fed four to five times weekly. Prey items consisted of gut-loaded crickets, fuzzy mice, minnows and shiners, krill, and crayfish. The crickets were gut-loaded with Tetra Min™ fish flakes and orange slices for two days prior to being fed out. Live fuzzy mice were offered until the lizards accepted pre-killed mice, but the fish and invertebrates were offered alive to offer enrichment and exercise. Food items were occasionally dusted with either a mixture of pure limestone ($CaCO_3$) and Reptocal® in a 1:1 ratio by weight, or with Repcal®. Dusted crickets were offered inside a large crock bowl so water would not wash away the supplements. Adult lizards are currently fed three times a week, year-round. Adults refuse crickets, earthworms and giant mealworms, a phenomenon noted by other keepers of captive Mertens' monitors (R. Schuster and J. Friedman, pers. comm.).

SEXING AND REPRODUCTION

Enlisting the cooperation of the veterinarians at the Wildlife Health Center, we used ultrasonography to detect the presence of follicular and testicular structures in the body. On 27 January 1998 we confidently determined the sexes of these lizards, as testicular and follicular structures were observed in good detail. We commenced our propagation project using the two females from this group and an unrelated older male. Table 2 provides data on the breeding trio.

Since Mertens' monitors do not have variable patterns like many other lizard species, the most accurate way for us to differentiate between siblings was to use passive-integrated transponder (PIT) tags for identification. A small transponder was implanted in the left

inguinal cavity of each lizard. This allowed us to read discrete alphanumeric codes by passing a transponder reader over individual lizards.

For the purposes of this article, the male will be hereafter referred to M61; and the two females, as F69 and F72. The trio was first introduced on 29 January 1998. By mid-afternoon the male was exploring the enclosure. The male commenced stereotypical varanid courtship displays, as described by Auffenberg (1981) and by Green and King (1993). Most of this behavior occurred in the water and continued well into early March, with a peak of activity in February. Courtship was never observed to include biting. By late March both females were visibly rotund, especially in the posterior region. Both females had been observed digging shallow pits under the cork hollows on land. At that time an 18 gal. (68 l.) Rubbermaid® tote box, with a 4 in. (10 cm) diameter hole cut in the lid, was provided for the females. It consisted of a damp sand, mulch, and a sphagnum moss mixture.

At 8:30 A.M. on 6 April 1998, we observed F72 digging inside the nest box. This female appeared very thin around the base of the tail, her lateral folds were large, and her pelvic bones were very prominent. She was scooped out of the nest box without incident. Buried in one corner of the box, under 3 in. (7.6 cm) of nest material, were eight eggs. They were very white and turgid. The eggs were carefully removed from the nest box and transferred to incubators in the Reptile House Nursery. It should be noted that egg deposition occurred before 8 A.M., the time at which zoo staff begins their workday. Irwin (1996) observed *Varanus mertensi*, in captive situations, engaging in nocturnal nesting behavior.

F69 did not appear gravid until 29 April 1998. Three shelled but infertile ova were discovered in the enclosure on 4 May 1998. One ova was on the platform just outside the nest box, and two were found lying on the bottom of the pool. There were no signs of fertility in these eggs and all were flaccid, greenish, and foul-smelling.

Multiple-clutching within a short time frame has been documented in large species of captive varanids such as *Varanus gouldii* and *V. olivaceus* (Card, 1994). For the health of the females involved, it is vital that plenty of food with an adequate calcium content be offered throughout their reproduction period.

RESULTS: INCUBATION

Mertens' monitor eggs incubated at 84.2-86 F. (29-30 C.) took 182-217 days to hatch, according to Brotzler (1965), while those kept at 86-90 F. (30-32 C.) took 265 days

(Irwin, 1986). Depending on the substrate type and substrate to water ratio, ten different clutches of eggs hatched at anywhere from 193 to 317 days at 81-82.4 F. (27-28 C.) for Eidenmüller and Wicker (1995).

The eight eggs laid in F72's first clutch were weighed and measured before placement into egg containers, four eggs per container. They were set-up in a Rubbermaid® 13 quart (53 l.), 14-3/4 in. long x 10-1/2 in. wide by 6 in. high (37.5 cm x 26.7 cm x 15.2 cm) capacity plastic container with a 1:1 ratio of vermiculite and water by weight and volume. The eggs were then placed into an incubator set at 82 F. (27.7 C.) and maintained as ornate monitor eggs had been.

On 28 September 1998 (day 124), one container of four eggs was transferred to an incubator maintained at 86.4-86.7 F. (30.2-30.4 C.). Later, that group was transferred to the high temperature incubator, 87-88 F. (30.5-31.1 C.); and the other group of four eggs was moved to an incubator with a steady temperature of 85 F. (29.4 C.).

By day 258 two eggs were greatly dimpled. Whereas movement inside those two eggs had previously been observed through candling or by touch, there was no response to either manipulation. Radiographs of the entire clutch were taken to examine bone quality and skeletal development, and they indicated excellent skeletal development. We feared that some of the young might have developed fully, but lacked the strength to emerge on their own. Three of the most dimpled and brownish eggs were manually slit on days 258, 262 and 278. There was a viable hatchling in each egg, and they had a good amount of yolk left (approximately .14-17 oz. (4-5 g). The veterinary staff ligated the yolk stems with suture string and snipped off the yolks to prevent the lizards from inadvertently slicing open blood vessels with their claws, thereby bleeding to death or becoming septic. The first two monitors were tube-fed a slurry mixture of Science Diet® A/D and Reptomin® to replace lost energy that would have been derived from the yolk. The remaining five monitors hatched from their eggs on their own in the ensuing weeks, the last two emerging on 20 January 1999 (day 289). Their body sizes are summarized in Table 4. The single egg laid on 1 June 1998 hatched on 23 March 1999 after a period of 295 days. It weighed .92 oz. (26.8 g) and measured 5 in. (129.2 mm) and 12 in. (306.2 mm), SVL and TL, respectively.

Out of 29 eggs incubated from clutches laid between 1998-2000, a total of 22 monitors hatched successfully. Seventeen were offspring from F72 and five were from F69. Due to the low demand by other zoos, many fertile eggs were intentionally destroyed. Sometimes the male and non-nesting female robbed the eggs of the nesting female before

the staff was able to retrieve them. Over a period of several days following such a raid, partially digested eggs would be discovered in the tub.

A regression analysis illustrates the relationship between length of incubation and weight in Figure 4, and that of weight and snout-to-vent length in Figure 5. In Figure 4 it appears that heavier hatchling weights correspond closely with longer incubation periods. Figure 5 reveals quite a number of outliers, indicating a high variability in the relationship between SVL and weight. This can probably be attributed to the fact that these points represent twenty-two lizards from four different clutches.

CARE OF HATCHLINGS

The hatchlings in both collections were initially housed in 30 gal. aquariums with half of the tank containing water maintained at 78-86 F. (26-30 C.). For the first two months, the lizards were fed daily; and then were fed every other day. Their diet consisted of minnows, pinkies, krill, and crickets. It took several weeks before pinkies were accepted regularly. All food items except the krill were dusted with powdered reptile minerals and vitamins for the first few months. Lighting included a combination of Vitalite® (Durotest) and Verilux® fluorescent bulbs, and incandescent flood and spotlights.

Juveniles are excellent swimmers and climbers. To date, there have been no extremely aggressive territorial conflicts as seen in the ornate monitor groups. Individuals will occupy the same basking or sleeping site without triggering aggressive behavior; however, the largest animals do appear to intimidate the smaller ones during feeding. The smaller individuals often will not feed until the larger members of the group have either stopped feeding or are no longer actively foraging. When kept in groups, these monitors may bite each other during a feeding frenzy. Several of the juveniles in the WCS collection have demonstrated what Hermes (1981) described as "prey-herding" behavior; and they have also exhibited piracy against one another, in a manner described by Horn (1999). Also, a pirating strategy observed in the zoo groups included lizards using all four legs to clamp around a feeding lizard in water, thus preventing it from swallowing or even surfacing. Only after the lizard released its prey, would the pirate aggressor release the other animal and eat the hard-won meal (S.Lee, pers. obs.).

MISCELLANEOUS NOTES

V. mertensi is sensitive to water-borne pathogens. Subsequent illnesses, traceable to water-borne pathogens, have been averted through improved husbandry techniques and

better filtration systems. Observations indicate that *Varanus mertensi* appears to be somewhat social, and sexually mature males can co-exist in a single enclosure for short periods of time. Ritualistic combat between males, without the males biting each other, has been observed in the WCS collection. Females F69 and F72 mounted each other, in addition to mounting the male. Both sexes exhibited the stereotypical head-weaving and rapid tongue-flicking, but the males exhibited this behavior more frequently. It appears that in captivity, *Varanus mertensi* displays a wide range of behaviors associated with establishing dominance - without resorting to violent combat. However, this is pure speculation derived from observations on one captive population; and it should not be projected to all individuals of *V. mertensi* , and especially not to other varanid species such as *Varanus ornatus*.

During her nesting period F69 appeared to defend the nest box site in a strange manner. She did not try to bite F72 or M61 when they tried to enter the nest box; however, if all three lizards were in the water and F69 saw the other two climb towards the nest box, she rushed the transgressors, mounted their backs, and using her forelegs to form a tight grip, attempted to pull them back into the water. We observed this behavior on several occasions. Other interesting behaviors documented for this species involved interspecific confrontations between a captive Mertens' monitor, specimens of three different species of rock iguana (*Cyclura* sp.), and a Gould's monitor sharing one enclosure at the Dallas Zoo (Murphy and Lamoreaux, 1978).

One of the Mertens' monitors hatched in 1999 has a foreleg anomaly resembling that of its sire. The incubation parameters were stable as far as the staff was able to observe, so the author suspects the anomalous trait could have been inherited.

The female ornate monitor displayed the usual behaviors while she was gravid in 1998. F9 was basking, when she suddenly swung her left forelimb back and forth as if she were digging. She tongue-flicked her leg and dorsum to investigate this seemingly involuntary movement. The female repeated this at least six times in total, alternating this motion with both forelegs. Just after nesting in 1999, after the eggs and nest box were removed from the enclosure, F9 continued to use her front limbs to throw substrate over the nesting site; and this behavior continued for approximately twenty minutes.

CONCLUSION

It is hoped that the information derived from the author's experiences with these species of monitors will help herpetologists, zookeepers and hobbyists who study and keep varanid lizards. These animals have proven to be excellent exhibit species and are crowd favorites.

Mertens' monitors are fecund monitors that offer great potential for ethological and physiological study.

Since ornate monitors inhabit ever-shrinking forest zones where bush meat is a premium and money is in short supply, fewer of them may be available in the future unless further captive propagation efforts are successful.

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Table 1. Morphometrics and age of breeding pair of *Varanus ornatus*

Monitor	Age	Introduction Date	TL	SVL	Pre-laying Wt	Post-laying Wt	Date Eggs laid/found	Clutch size
M11	3y+	9 April 1998	127.0 cm	50.4 cm	3.95 Kg.			
F9	3y+	9 April 1998		39.4 cm	2.10 Kg	1.54 Kg	12-15 May 1998	n=16
M11	4y+	24 March 1999			~5.5 Kg			
F9	4y+	24 March 1999			~3.0 Kg	2.1 Kg	13 May 1999	n=23

Table 2. Morphometrics and age of *Varanus mertensi*

Monitor	Age	Introduction Date	TL	SVL	Pre-Laying Weight	Post-Laying Weight	Date Eggs Laid	Clutch Size	Number of surviving hatchlings
Male (M61)	4y+	29 Jan 1998	79.0 cm	37.3 cm	1044.5 g		28 Jan 1998		
Female (F72)	2y+	29 Jan 1998	87.0 cm	36.0 cm	973.0 g	820.0 g	6 April 1998	n=8	8
Female (F69)	2y+	29 Jan 1998	78.0 cm	35.5 cm	965 g	739.0 g	4 May 1998	n=1 (slugs)	0
F72	"	29 Jan 1998	87.0 cm	36.0 cm		886.5 g	1 June 1998	n=5	1
F69	"	29 Jan 1998	78.0 cm	35.5 cm		814 g	28 June 1998	n=5 (predated)	0
F72	3y+	26 Aug 1998			1038 grams	750 g	4 Dec 1998	n=8	7
F72	3y+	24 Feb 1999					7 April 1999	n=2 (slugs)	0
F69	3y+	7 Mar 1999			993 grams		16 May 1999	n=8	6

Table 3. Breeding summary for *Varanus ornatus*

1.1 breeding pair first bred in April, 1998. Female oviposited ~16 May 1998.
Min. SVL and weight for female's first clutch: 105 cm & 3.6 kg
Total number of clutches to date: 2
Max. number of clutches per female per year: 1
No. eggs per clutch: 16 & 23; mean = 17
Avg. success hatching rate: 87%
Mean egg dimensions: Length = 55.6 mm, Width = 32.7 mm, Weight = 35.1 grams
Incubation length: 126-144 days; mean = 133.8 days
Mean hatchling morphometrics: TL= 305 mm, SVL- 115.7 mm, WT= 24.4 g
Total number of hatchings to date: 33

Table 4. Breeding summary for *Varanus mertensi*

1.2 breeding trio first bred in March, 1998. 0.1 first oviposited on 6 April 1998.
Min. SVL and weight for females' first clutches: 36 cm & 865 g
Total number of clutches to date: 16 (8 per female)
Max. number of clutches per female per year: 3
No. eggs per clutch: 6-8; mean = 5.6
Average success rate: 76%
Mean egg dimensions: Length = 66.7 mm, Width = 30.8 mm, Weight = 38.4 grams
Incubation length: 257-344 days; mean = 287days
Mean hatchling morphometrics: TL=291mm, SVL= 123 mm, WT= 25.3g
Total number of hatchlings to date: 22

Figure 1. Incubation length (days) vs. weight (g) for *Varanus ornatus*

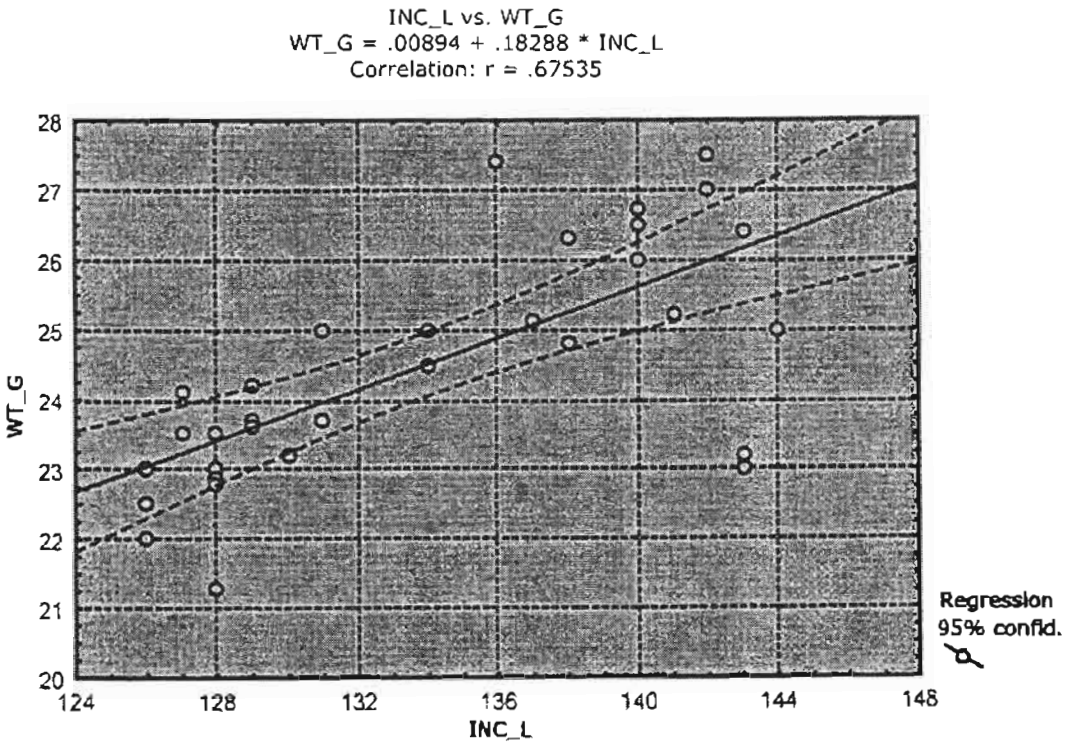


Figure 2. Weight (g) vs. snout-to-vent length (mm) of *Varanus ornatus* (n=23)

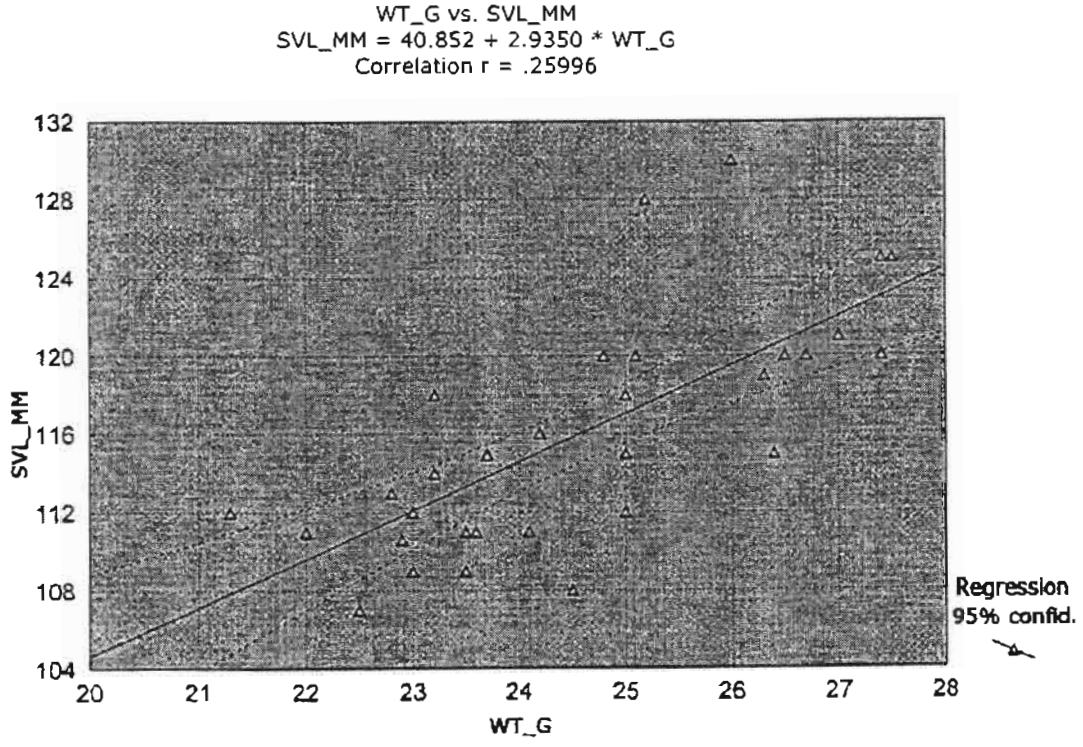


Figure 3. Frequency of oviposition by 0.2 *Varanus mertensi* from 1998 – 2000

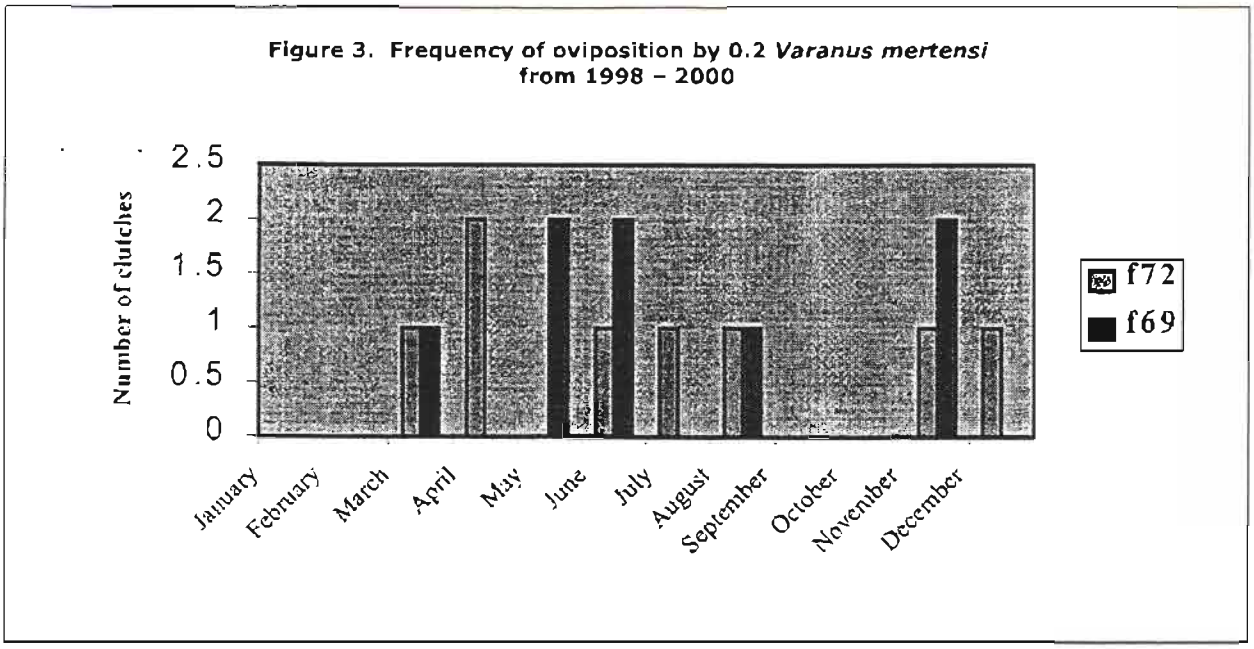


Figure 4. Incubation time (days) vs. weight (g) for *Varanus mertensi* (n=22)

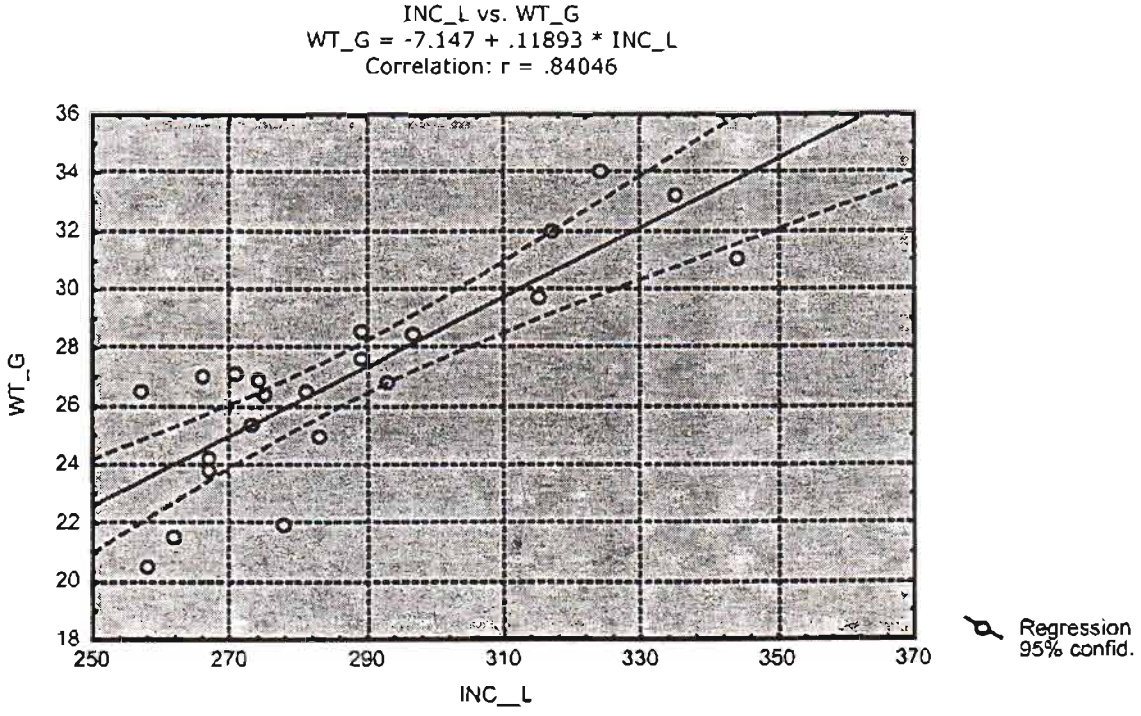


Figure 5. Weight (g) vs. snout-to-vent length (mm) of *Varanus mertensi* (n=22)

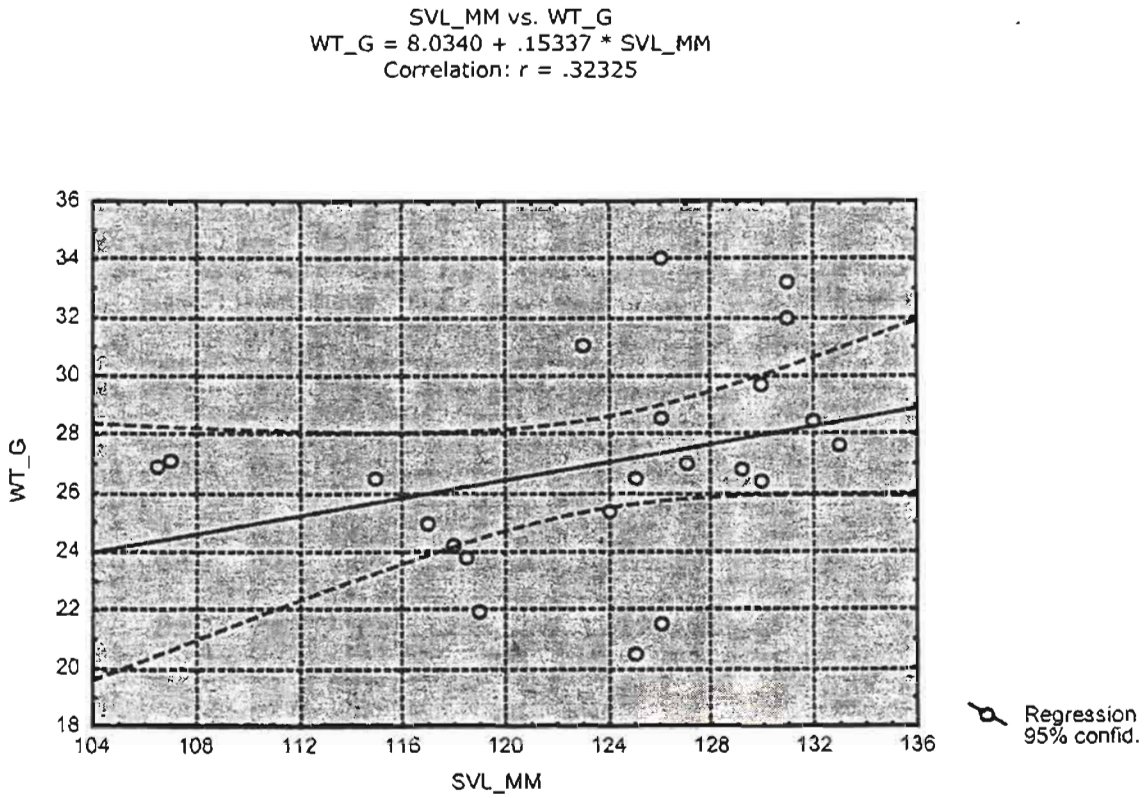


Photo 1. Ornate Nile monitors are indigenous from forested regions of western and central Africa. Photo by D. Demello.

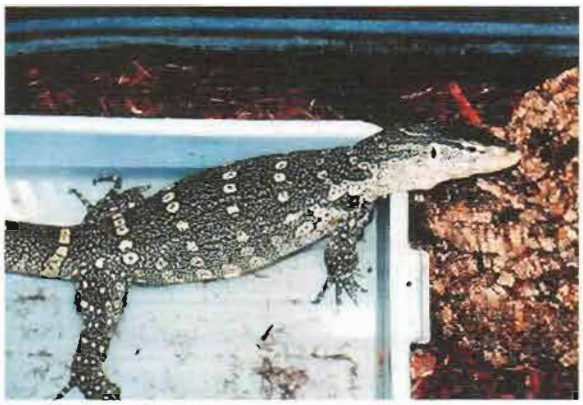


Photo 3. F9, the breeding female ornate monitor spends much of her time soaking in water. Photo by S. Lee.

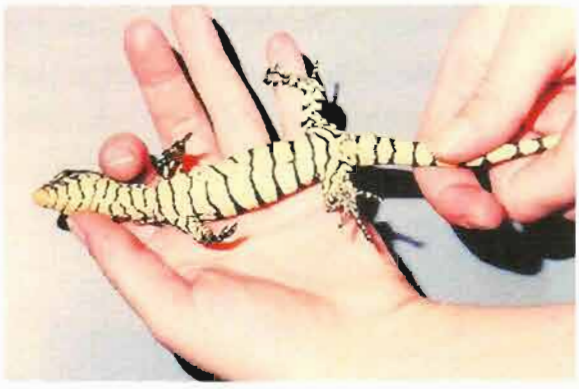
Photo 5. *V. ornatus* hatching in September, 1998. Photo by S. Lee.

Photo 7. Ventral view of a juvenile ornate monitor. Photo by S. Lee.

Photo 2. A young adult specimen of *Varanus mertensi* basking. Note the streamlined head and vertically oriented nostrils. Photo by J. Friedman.

Photo 4. M11, the male Ornate monitor on display at the Congo Gorilla Forest exhibit. Photo by S. Lee

Photo 6. A male *Varanus mertensi* on exhibit at the Bronx Zoo. Photo by D. Demello.



THE NATIONAL AMPHIBIAN CONSERVATION CENTER - A NEW WINDOW ON A WET WORLD

Andy Snider, Curator of Herpetology and **Kevin Zippel**, Curator of NACC
Detroit Zoological Institute, Royal Oak, MI

The Detroit Zoological Institute (DZI) has a long history with amphibians. When the Holden Museum of Living Reptiles (HMLR) opened to the public in August 1960, amphibians were already a part of the collection. The first amphibian breeding, Columbian giant toads (*Bufo blombergi*), occurred the following year. In 1969, our first caecilian was born, an upper Amazon caecilian (*Nectocaecilia petersi*), and the first of many clutches of axolotls (*Ambystoma mexicanum*) was produced and reared shortly thereafter. In 1990, for the 30th anniversary of the Museum, the name of the facility was officially changed to the Holden Museum of Living Reptiles and Amphibians (HMLRA) to acknowledge the importance of this class. Since 1994, increased emphasis has been placed on amphibian husbandry and conservation, and many significant species have been reproduced. These include: emperor newts (*Tylototriton shanjing*), for which we won an AZA "Significant Achievement" award in 1998 for long-term propagation; Anderson's newts (*Echinotriton andersoni*), bred in 1999 for the first time in a U.S. zoo; Wyoming toads (*Bufo baxteri*), extremely endangered, for which we shared an AZA "Conservation" award in 1998; and golden mantellas (*Mantella aurantiaca*), an IUCN "Vulnerable" species which we now produce by the hundreds for breeding programs at other institutions.

In 1997, experts from around the U.S., Canada, and Europe gathered at the DZI to discuss the potential for an amphibians-only facility. These amphibian aficionados were chosen from diverse backgrounds (academia, veterinary science, education, conservation, zoos, aquariums, etc.) to allow for differing views on how best to design and build this unique facility. The meeting was a tremendous success, and many of the ideas brought forth were incorporated into the National Amphibian Conservation Center (NACC), the first facility in the world designed, constructed, and interpreted specifically for amphibians.

It should be noted and acknowledged that the NACC is NOT the first amphibians-only facility in the U.S. The Columbus Zoo maintained a small, renovated amphibian house into the mid-1980s, and the San Antonio Zoo opened "The Pad," a cleverly renovated amphibian facility in 1998. Although the Columbus facility no longer exists, San Antonio's continues to educate the public and contribute to ongoing amphibian husbandry and conservation challenges.

The setting for the NACC was a critical element in its design. A concrete-rimmed lake in front of the HMLRA was renovated into a 2-acre clay-bottomed naturalistic wetland habitat, and the NACC was placed on the opposite shore from the reptile building. Five different wetland habitats were recreated with approximately 60,000 plants, including cedar swamp, quaking bog, sedge meadow, urban wetland, and lake edge. These areas are interpreted for the public with graphics partially written and designed by the Michigan chapter of The Nature Conservancy.

The NACC consists of a $6.4 million 12,000-square-foot facility dedicated to saving amphibians and shaping public attitudes toward these threatened and valuable animals. Nearly half the facility is off-exhibit space, comprising holding and breeding rooms, quarantine and isolation areas, offices, and research facilities. A live-feed breeding room is also included, as is a breeding facility for *Partula* snails, the only SSP-program currently in existence for an invertebrate species.

The outdoor entry to the building features a fountain consisting of three bronze water-spouting frogs and a beautiful giant red salamander. An artificial-wood boardwalk made of recycled plastic leads the visitor to the entryway. The entry foyer includes a beautiful tile mosaic commissioned by DZI from local artist Gretchen Kramp. The public area is broken into distinct areas including: the entry corridor ("What is an Amphibian?", "Evolution," and "Metamorphosis") and its 24-ft. flowing wall of water; the Orientation Gallery, which shows a 12-minute film commissioned by DZI from Academy-award-winning producer Sue Marx; the Ecosystem Gallery, with its 22-foot-long underwater-viewing tadpole tank; the Conservation Gallery, with an 18-foot-long cut-away stream for Japanese giant salamanders (*Andrias japonicus*) and 8-foot-long hellbender (*Cryptobranchus alleganiensis*) tank; the Kid's Cave, which highlights cave-dwelling amphibians; the Diversity Gallery; Culture Corner, which shows man's long-time associations with amphibians through the ages; the Immersion Gallery, a walk-through changing-exhibits gallery currently highlighting the Peruvian Amazon; and the Michigan Gallery. The public then exits the building on a boardwalk through a recreated marsh.

Graphics and other interpretive elements were designed to meet the needs of a variety of patrons, from young children to adults who might wish for more detailed information. Interactive elements are also present, ranging from matching the frog and its call, to matching amphibian feet and the specific habitats for which they're adapted.

Brochures from the Declining Amphibian Populations Task Force are available to the public in the Conservation Gallery. In addition, our "Amphibian Ambassadors" (docents with

advanced training in amphibian biology and husbandry) are available throughout the facility to answer questions, point out animals, and supplement our educational program.

Individual exhibits were designed to meet the needs of the animals, the staff, and zoo patrons. Exhibits are constructed of fiberglass and acrylic, and concrete rockwork is included in many as a major design element. The bottoms of most exhibits begin approximately 30-32 inches from the floor, making it relatively easy for small children to see inside. Most exhibits are accessed from the rear, allowing keepers to work with animals at any time of the day. A small, hidden service door is provided for daily servicing of inhabitants, and removable top-access panels are available on most exhibits for moving in/out large props. Many and varied types of filtration equipment are provided for all aquatic and semi-aquatic exhibits, and lighting is provided by fluorescent, incandescent, and metal halide lamps. A misting system is available on most exhibits, as a means of providing the high humidity necessary for successful husbandry and reproduction. Chilled water is available both on and off exhibit for cool-dwelling species. Live plants are used wherever possible to simulate natural habitats, and make the animals comfortable while on exhibit. Within the first two months of operation, four species of frogs successfully bred on exhibit, and three other species laid eggs.

Specimens for the NACC were chosen based on criteria such as exhibitry needs (size, color, story line, etc.), conservation need, and scientific merit. Both SSP amphibian species, the Puerto Rican crested toad (*Peltophryne lemur*) and the Wyoming toad (*Bufo baxteri*), are on exhibit. Many species are kept strictly off exhibit, to concentrate our efforts on reproductive needs at this time. The DZI has been a lead player in "Proyecto Rana Dorada," ("Project Golden Frog"), a program designed to aid the Panamanian government in its attempt to protect their national animal, the golden frog (*Atelopus zeteki*), from extinction. A number of these frogs will soon be arriving in the U.S. as a hedge against extinction due to a fungal pathogen that has devastated many amphibian species in North, South, and Central America, as well as other areas of the world. In addition, the DZI will soon be receiving a large number of Kihansi spray toads (*Nectophrynoides asperginis*) at the request of the Tanzanian government, because of a threat to their habitat from a recently built hydroelectric dam.

Four to five staff members are present to care for the day-to-day needs of the animals and plants and to support breeding and research programs. It is expected that within the first year of operation, the facility will contain nearly 100 species of amphibians, and over 1000 specimens. In addition, other animals are present in varying numbers, including fish, invertebrates, birds, and reptiles.

The goals of the NACC are:

1. *To educate*. The NACC will present millions of visitors and students with live animals and exhibits that inspire a sense of appreciation and public stewardship for amphibians and their habitats. Through interpretive graphics in and around the building, distance-learning programs, and educational amphibian "kits" distributed to elementary schools, the NACC strives to shape public attitude and provide creative ways for citizens to understand and take responsibility for these animals and their environment.

2. *To save*. The NACC will provide an ex-situ site for the maintenance and breeding of rare and endangered amphibians to complement in-situ conservation programs. The facility provides physical space for maintaining genetic reservoirs of endangered species in the event that wild populations become extinct, and to hold wild animals and their offspring until a time when they can be reintroduced into their native habitats or transferred to other zoo conservation programs. NACC staff will also work cooperatively with field research and conservation programs in an attempt to study and reverse unnatural amphibian declines. Furthermore, provision of captive-bred animals to the zoo community will help alleviate some of the stress on wild populations caused by over-collection.

3. *To study*. The NACC will serve as a resource for academic, governmental, and other conservation-oriented amphibian biologists from around the world. The facility will provide a controlled environment for amphibian observation and non-invasive research on all aspects of biology, from basic husbandry requirements to reproductive behavior and embryology/development. Video and audio recording equipment with computer-analyzing programs, and microscopes with digital downloading capabilities will facilitate these studies.

An Endowed Chair of Amphibian Conservation will support top researchers from around the world for three-month terms to complement the continuous research programs of permanent staff. The NACC will also provide logistic and financial support for field studies of amphibian ecology, both locally and globally. The facility will further serve as a database of knowledge regarding amphibian biology and conservation. In addition, Froglog, the international publication of the Declining Amphibian Populations

Task Force, is now published through DZI, and discussions are currently underway with the U.S. Fish and Wildlife Service (USFWS) to provide an off-exhibit addition to the facility which will complement current and future USFWS projects.

4. *To pioneer.* The NACC will bring together cutting-edge techniques of education, conservation, and research, providing a model for future conservation facilities around the country and the world.

The NACC provides a unique environment for the celebration of an often-overlooked group of animals. Through conservation-oriented education and research, we are striving to change public attitudes and address widespread declines in an effort to ensure that amphibians will persist into the future.

HERPETOFAUNA OF THE KALAHARI DESERT

Karl H. Switak
Santa Rosa, California

The Kalahari Desert of southern Africa harbors a great diversity of herpetological presence. It is also a region of climatological contrast, exemplified by summer temperatures the likes of hell, followed by winter months when the mercury often drops below freezing. Mix into this a combination of dust and sand storms, precipitation via torrential downpours (summer months) plus the occasional hail storm, and I give you the Kalahari.

A difference of opinion exists as to the origin of the term "Kalahari." However, the greatest percentage of researchers seem to agree that the Kgalagadi or Makgalagadi people were responsible for naming this region. The Kgalagadi word "Makgadikgadi" refers to salt pan. In due course, perhaps due to a difficult spelling and pronunciation, the whites must have changed it to the more romantic echo, Kalahari.

Some authorities call this region a desert, others refer to it as an arid savannah or semi-desert. Whatever the case, this massive piece of real estate boasts a continuous mantle of sand that stretches from the Orange River in South Africa to the equator in the north. Much of its reddish substrate lies below ground, but in a large region of Botswana and adjacent South Africa/Namibia it is visible from horizon to horizon and best known throughout the world as the Kalahari Desert.

To format the presence of every amphibian and reptile species that frequents the confines of the Kalahari would be a monumental task, certainly greater than space allows here. Therefore, I am restricting my findings to a region known as the Kalahari Gemsbok National Park, located in the extreme northwestern tip of South Africa's Cape Province. Immediately adjacent, to the east, lies Botswana's Kalahari Gemsbok Park. In April of 1999 a treaty was signed between these two countries, combining both parks into a single entity (NO fences) and appropriately called the Kgalagadi Transfrontier Park. In total it comprises some 38,000 square kilometers!

My very first visit to this region took place in April of 1983, followed by numerous safaris that provided not only memorable sightings, but also a magnetic force from which I cannot escape. My very latest sojourn took place in February of 2000, with yet another return visit planned for November 2000. Here I am reminded of what a young lass (then residing in the park) once wrote to me..."it is very hot today, but it is still paradise."

Although amphibians do occur in the Kgalagadi Transfrontier Park, they are by no means common nor often seen by visitors. With rain being the magic ingredient for amphibian activity, but often a long time in the coming, only a handful of species have evolved here to cope with extremely adverse weather conditions. My South African safari partner, Rod Patterson, and I have encountered the following varieties, all of the family Ranidae: Dainty frog, *Cacosternum boettgeri;* Tremolo sand frog, *Tomopterna cryptotis* (Fig. 1.); and African bullfrog, *Pyxicephalus adspersus* (Fig. 2.).

We are told that at least one species of toad (*Bufo*) and one species of rainfrog (*Breviceps*) can also be found here, but these have hitherto eluded our own research. However, Passmore and Carruthers (1995) do not show these species to occur in the Park, but it wouldn't be the first time for range maps to be incorrectly formatted.

In March 2000 a sizeable emergence (hundreds) of African bullfrogs, *P. adspersus*, took place at Lijersdraai just to the west of the normally bone-dry Nossob River and well within the South African section of the Park.

Three species of chelonians, representing three genera, frequent the region. These are *Geochelone pardalis* (Fig.3), *Psammobates oculifer* (Fig.4) and *Pelomedusa subrufa*. For those who believe that *G. pardalis* is represented by two varieties, then the one found in the Kalahari would be *G. p. babcocki*. Although it has often been written (including this author) that tortoise activity in many parts of the continent is directly associated with the arrival of rain, my colleague, Rod Patterson, and I cannot say this for the Kalahari populations. We have found more leopard tortoises and Kalahari tent tortoises, *P. oculifer*, during dry spells than during rainy periods.

Finding the helmeted terrapin, *Pelomedusa subrufa*, in the Park is a rare sighting indeed. The occurrence of this species is definitely associated with the onslaught of rain, and plenty of it!! We have observed this chelonian at Cubitje Quap waterhole, at the edge of the Kwang Pan north of Nossob camp, and near Rooikop. However, many years have passed since our last sighting, even though copious amounts of rain have fallen several times.

Tortoise activity is most often encountered during the morning and late afternoon hours. *P. oculifer* seems to be more common in the central dune region, while *G. pardalis* roams the fringes of both the Auob and Nossob rivers (usually bone dry); of course, exceptions exist. Leopard tortoise females tend to grow much larger than the males. We've observed attempted mating in January of 1994 (Kalahari's mid-summer). Lizards in the Kalahari are not only conspicuous by their great numbers, but also by the diversity of species.

They can be found running across the fine dune sand, scurrying from one driedoring bush to another and tactfully scaling those magnificent camelthorn acacia trees. Many of the diurnal species fall prey to a score of raptors, bat-eared and Cape foxes, suricates and various members of the serpent clan - just to mention a few. Nocturnal varieties, specifically geckos, are easy prey for several owl species, yellow mongoose, African wildcat, black-backed jackals, plus other opportunistic scavengers.

The following families are represented (number in parentheses indicates approximate number of varieties known to occur here): Amphisbaenidae (5), Scincidae (8), Varanidae (1), Agamidae (2), Chamaeleonidae (1) and Gekkonidae (8).

One of the most common lizards in South Africa's section of the Kgalagadi Trans-frontier Park is the black tree skink, *Mabuya striata sparsa*. On cool mornings hundreds can be observed thermoregulating on the rough bark of camelthorn acacias. At such times the reptile's skin is indeed jet black, covered with a fluorescent sheen. Males are territorial, always bickering over the best location on any given object.

Another common variety, especially along the course of the Nassob River, is the ground agama, *Agama aculeata aculeata* (Fig. 5.). "Ground" agama is somewhat misleading, as many are found atop diredoring bushes and on the trunks of camelthorn acacias. When summer daytime temperatures reach hellish proportions, these lizards thermoregulate by climbing to the highest branches of driedoring bushes, at which time they are easy prey for pale chanting goshawks, kites, falcons, etc.

The largest of the Lacertid lizards is *Nucras tessellata*, the most colorful is *Heliobolus lugubris* (neonates), and the two speed demons are *Meroles suborbitalis* and *Pedioplanis namaquensis*.

Perhaps the most noteworthy lizard in the region is the barking gecko, *Ptenopus garrulus* (Fig. 6.). It is a ground-dwelling species and very common throughout its domain. At or near sunset they begin what can best be described as a "reptilian serenade." Males sit at the entrance of their burrows and emit a quick sequence of clicking sounds, much like hitting two stones together. Each sequence consists of five to seven clicks. When performed by hundreds of these three-inch-long geckos (TL), which is often the case around Nossob camp, the night is indeed filled with music to one's ears.

The two rarest lizards in the region must be *Varanus albigularis* and *Chamaeleo dilepis*. Up to this point in time, they've remained elusive during all my Kalahari safari
The serpents that abound in the Kalahari are many, but most are seldom seen by visitors. Members of the families *Typhlopidae* and *Leptotyphlopidae* are primarily fossorial and

nocturnal, at least during the hot summer months (December-March). Although African rock pythons, *Python sebae natalensis*, have been recorded from the Kgalagadi Transfrontier Park, they must be considered one of the rarest species. A photo on record shows a large individual crossing the dirt road at Bedinkt waterhole north of Nossob.

The family Colubridae is represented by at least ten species, of which the sand snake (*Psammophis*), the mole snake (*Pseudaspis*), and the dwarf beaked snake (*Dipsina*) are among the most common. All three varieties are primarily diurnal, especially so during early spring. Sand snakes are genuine speed demons, much like our own racers/whipsnakes, and often seen via a "blurred" image only. Mole snakes in the Park reach a total length in excess of three to four feet, often move across the Kalahari substrate in bright daylight (full sun), go through a pattern/color dimorphism from neonate to adult, and are represented by two natural color variants - one being shades of gray, light brown or even tan; the other, jet black. Dwarf beaked snakes seldom reach a total length greater than 14 inches; and, like the mole snake, are often found crossing a dirt road during full sun. They can be easily confused with young mole snakes due to a similarity in color/pattern.

The most spectacular snake in the Park, without equal, is the gaudily-colored Cape cobra, *Naja nivea* (family Elapidae). This extremely venomous species, averaging some four feet in total length, is often encountered crossing the dirt roads during bright daylight, especially so along the Auob and Nossob rivers, but we have found them deep within the dune system also. They are excellent climbers, often raiding the nests of social weaver birds some 20 feet aloft. Most Cape cobra specimens in the Park display a bright yellow coloration, some with minuscule speckling of black or dark brown. One large individual we encountered north of Kousant waterhole radiated shades of deep lemon yellow with a tinge of subdued orange dorsally. My colleagues and I considered this almost five-foot-long beauty the most gorgeous serpent ever to slither across planet Earth.

Cape cobras yield high quantities of potent neurotoxic venom. Maximum yield per adult snake averages about 250 mg, only 15-20 of which is fatal for humans. It is considered by many the most toxic cobra in Africa.

During the spring *Naja nivea* slithers across the open ground (in bright sunlight) without obvious concern for dangers from above. The snakes often fall prey to a variety of raptor species (tawny eagle, Martial eagle, bateleur, etc.). While crawling along, often with considerable speed, the snake investigates rodent holes, climbs into driedoring bushes,

and closely scrutinizes the bottom circumference of camelthorn acacias. Once we came across a specimen, again in bright sunlight, that was in the process of devouring a very large ground agama. Also in attendance was pale chanting goshawk. Our timely arrival probably saved the cobra, too busy to notice danger, from becoming avian prey. Also found in the Park are puff adders, *Bitis arietans*, horned adders, *B. caudalis* (difficult to locate), and a score of other Colubrid and Elapid species. It is said that black mambas, *Dendroaspis polylepis*, occur in the far northwest corner of the Park where the countries of South Africa, Namibia and Botswana meet. But, like the African rock python, flap-necked chameleon and white-throated monitor, I'm quite certain that this, too, constitutes a rare species here.

Acknowledgments

First and foremost I wish to thank the following individuals from the Kalahari Gemsbok National Park for their help in our efforts to observe, photograph, and otherwise record the herpetological presence in so magnificent a park. They are Elias le Riche, Martin Engelbrecht, Giel and Emmerentia De Kock, Daleen Ras and several bushman game rangers.

Others who were influential along this avenue of pursuit include Anthony Bannister, Dave "Yebo" Hewett, the late Paul Olsen, and of course my unofficial brother, Rod "Skipper" Patterson. His patience in putting up with this writer's impetuous attitude stretches far beyond the real of infamy. All of my safaris into the Kalahari have been with Rod, using his vehicles and equipment, and I cannot imagine what it would be like traveling to this region without him along.

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Fig. 1. *Tomopterna cryptosis,* like *Pyxicephalus,* emerge with the arrival of the rainy season. In soft substrate they can disappear from sight very quickly. All photos by the author.

Fig. 2. Adult *Pyxicephalus adspersus* stay above ground only long enough to breed and to fatten up for the next "lengthy" stay below a parched substrate.

Fig. 3. *Geochelone pardalis* is most often encountered in the Kalahari during the early morning and late afternoon hours. This adult female was found north of Nossob in the a.m.

Fig. 4. *Psammobates oculifer*, the Kalahari tent or serrated tortoise, is a "very fast" walker. Pictured here is an adult female from the central dune region.

Fig. 5. *Agama aculeata aculeata* is very common in the park, especially so along the outer fringes of the usually dry Auob and Nossob rivers. This adult male is thermo-regulating atop a driedoring bush some four feet off the ground.

Fig. 6. An adult male *Ptenopus g. garrulus* is caught here in the act of emitting his "clicking" serenade. It is a common species in the park, but difficult to locate.

HERPETARIUMS AND HERPETOGICAL COLLECTIONS IN MEXICO

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The maintenance and study of reptiles in Mexico is ancient. Even before the Spanish conquered America, the indigenous people already had a wealth of knowledge about these animals and were already practicing captive maintenance. In prehispanic cultures such as the Maya, Aztec and others, the flora and fauna of the region performed vital roles in the development of the mythology and the political and social structures of these indigenous cultures.

Snakes and other reptiles had a religious influence and they played an important role in native traditions and culture. They associated them with different gods and deities, and in this way they represented the days and months of the year. The people also made stone sculptures of these deities and molded their images onto their pottery. The most well known gods who are linked to these animals are: Quetzalcóalt, the plumed serpent, Xiuhcóatl, the fire serpent, Mixcóatl, the cloud serpent, Coatlicue, the hill serpent and Cihuacótl, the serpent woman.

When the Spaniards arrived at the city of Tenochtitlan, they were astonished to find such an organized civilization and were amazed to discover an extremely modern and diverse zoo for the period. This zoo was the property of the emperor Moctezuma and in it were maintained all sorts of animals such as birds, large cats, crocodiles and snakes. The Aztecs enjoyed imposing their power against their enemies and perhaps for that reason, the emperor ordered the construction of a zoo that would house all sorts of natural oddities, including deformed and albino people.

Original historical narratives by different historians and Spanish conquistadors, like Bernal Díaz del Castillo, Francisco Hernández, Francisco Javier Clavijero and Hernán Cortes himself comment that, "...there existed two great buildings, one was called the house of birds and the other the house of beasts, and in the latter were large jugs. Some contained feathers and others were lined with earth and contained a variety of snakes, some of which had a thing on the tail which sounds like a bell, these were the most venomous of all."

These people also mentioned that there existed large pools where large lizards were kept and that all the animal enclosures were maintained in conditions which existed in nature. It was the responsibility of approximately 300 men to care for and feed these animals as if they were in the wild.

It is important to emphasize that thanks to these accounts, we are able to say that in 1519 it was known that the first herpetarium existed in Mexico and perhaps throughout all the Americas. However, many years would pass before an interest in creating a place to study and maintain reptiles and amphibians would return to Mexico. In the Republic of Mexico there are about 80 zoos, but not all have herpetariums. Only 11 have these facilities, and another 10 have put together exhibitions, but they are by no means herpetariums.

Zoos That Maintain Reptiles (No Herpetariums)

1. Zoologico San Juan de Aragón, Edo. México, D.F.
2. Promotora Zoofari, Cuernavaca, Edo. Morelos
3. Zoologico de Cholul, Mérida, Edo. Yucatán
4. Zoologico Africam, Puebla, Edo. Puebla
5. Parque Zoologico Wameru, Querétaro, Edo. Querétaro
6. Parque Zoologico de San Luis Potosi, Edo. San Luis Potosi
7. Parque Arqueoecologico Xcaret, Edo. Quintana Roo
8. Promotora Xelha, Edo. Quintana Roo
9. Yumka, Edo. Tabasco
10. Parque Zoologico Tamatan, Edo. Tamaulipas

In the country today there are approximately 30 herpetariums, of which only a few were constructed specifically for that purpose. The majority are buildings that have been remodeled in order to function as herpetariums. Of these 30, 10 belong to universities, 11 to zoos, 1 to the National Institute of Health and Hygiene, and 8 belong to miscellaneous private organizations.

Herpetariums in Mexico

1. Herpetario del ZOOMAT, Chiapas
2. Herpetario del Zoologico de Chapultepec
3. Herpetario del Zoologico de Zacango, Zacango, Toluca
4. Herpetario del Zoologico La Pastora, Monterrey, Nuevo León
5. Herpetario del Zoologico de Culiacán
6. Herpetario del Zoologico de Santiago, Baja California Sur
7. Herpetario del Zoologico el Centenario, Mérida, Yucatán
8. Herpetario del Zoologico Yumká en Villa Hermosa, Tabasco
9. Herpetario del Zoologico de León, Guanajuato
10. Herpetario del Zoologico de Morelia
11. Herpetario del Zoologico Guadalajara
12. Herpetario de la Universidad Veracruzana en Xalapa, Veracruz
13. Herpetario de la Facultad de Ciencias de la UNAM, D.F.
14. Herpetario de la ENEP Plantel Iztacala, Edo. De México
15. Herpetario de la Facultad de Ciencias de la Universidad Autónoma de Nuevo León
16. Herpetario del Centro Ecológico de Sonora
17. Herpetario de la Universidad de Tijuana, B.C.N.
18. Museo Vida Animal, Puebla, Puebla

19. Herpetario Canamaite, Xalapa, Veracruz
20. Herpetario La Nauyaca, Parque Jungla Mágica, Cuernavaca, Morelos
21. Herpetario Reptilmex, Tepoztlan, Morelos
22. Herpetario de Reino Aventura, D.F.
23. Herpetario del Instituto Nacional de Higiene de la Secretaria de Salud, D.F.
24. Herpetario UNIVERSUM, Museo de la Ciencia, UNAM
25. Herpetario de Córdoba Veracruz
26. Herpetario de la Universidad de Puebla
27. Herpetario del CEAMISH
28. Herpetario SIGNOS, Guadalajara, Jalisco
29. Herpetario Tlajomulco de Zuñiga, Jalisco
30. Herpetario particular Daniel Cañibe

In many cases these herpetariums are not suitable for maintaining specimens in prime breeding condition and function only as display facilities. Recently however, thanks to the efforts of people like Don Miguel Alvarez del Toro, who founded the herpetarium that now carries his name (ZOOMAT of Chiapas), the study of living reptile collections was achieved, and not just preserved animals as had been the tendency. In fact, in Mexico there exists little more than 19 scientific herpetological collections in educational institutions and an unknown number of private collections. It is worth noting that even in Mexico, the first herpetologists preferred working with preserved animals rather than living specimens.

Herpetological Collections in Mexican Institutions

1. Instituto Politécnico Nacional
2. Instituto de Biología de la Universidad Nacional Autónoma de México (UNAM)
3. Museo Alfredo Duges
4. Instituto de Historia Natural de Chiapas
5. Universidad Autónoma de Nuevo León
6. Facultad de Ciencias (UNAM), Museo de Zoología
7. Universidad Michoacana de San Nicolás de Hidalgo
8. Universidad Autónoma del Estado de Morelos, UAEM
9. Universidad Autónoma de Aguascalientes
10. Universidad Autónoma de Guadalajara
11. Instituto Nacional de Investigaciones Sobre Recursos Bioticos, INIREB
12. Escuela Nacional de Estudios Profesionales, Iztacala, UNAM
13. Universidad Autónoma de Baja California Sur
14. Centro Ecológico de Sonora
15. Facultad de Estudios Superiores, FES, Zaragoza, UNAM
16. Facultad de Ciencias Biológicas y Agropecuarias, CUCBA
17. Benemérita Universidad Autónoma de Puebla
18. CIIDIR, Oaxaca
19. CIIDIR, Durango

Herpetology in Mexico has undergone a great expansion in the last 20 years. However, there are still not enough institutions conducting scientific investigations of reptiles and amphibians and many researchers have even left UNAM which is one of the few educational institutions offering courses and seminars in herpetology in the country. As a result, the handful of students that enroll in these courses are unskilled in the maintenance and management of reptiles in captivity and in herpetarium design. This fact is reflected by the few constructed in the country.

Mexican Institutions with Developed Herpetological Activities

1. Instituto de Biología UNAM
2. Instituto de Ciencias del Mar UNAM
3. Instituto de Investigaciones Biomédicas UNAM
4. Instituto Nacional de Pesca
5. Instituto de Ecologia
6. Instituto Nacional de Higiene
7. Instituto Nacional de Investigaciones sobre Recursos Bioticos
8. Instituto de Ecología, Centro regional Durango
9. Instituto Biotec, UAEM
10. Instituto de Ecología A.C. Jalapa Veracruz
11. Universidad Autónoma de Sinoloa
12. Universidad Autónoma de Nuevo León
13. Universidad de Nuevo León, UdeNL
14. Universidad Autónoma de Guadalajara, UAG
15. Universidad de Guadalajara, UdeG
16. Universidad Autónoma de Baja California, Fac. De Ciencias
17. Universidad Autónoma del Estado de México, CIEARB. Fac. De Ciencias
18. Universidad Autónoma Metropolitana, Iztapalapa y Xochimilco
19. Universidad Autónoma de Querétaro
20. Universidad Juárez Autónoma de Tabasco
21. Universidad Michoacana de San Nicolás de Hidalgo
22. Universidad Veracruzana
23. Universidad Autónoma de Puebla
24. Estación de Biología Tropical, Los Tuxtlas, UNAM
25. Estación de Biologia Chámela, UNAM
26. Centro de Investigaciones Pesqueras
27. Centro de Investigaciones para la Conservación de Especies Amenazadas Tabasco, CICEA
28. Centro de Educación Ambiental e Investigación Sierra de Huautla, CEAMISH
29. CIIDIR; Oaxaca
30. CIIDIR; Durango
31. SEDESPA; Tabasco
32. Colegio de la Frontera Sur Chiapas
33. Colegio de la Frontera Sur, Chetumal, Quintana Roo
34. Fundación Ecológica, Cuxmala A.C.
35. ENEP – Iztacala UNAM
36. Facultad de Ciencias UNAM
37. Facultad de Medicina UNAM
38. Museo de Historia natural, Chiapas
39. Escuela Nacional de Ciencias, IPN
40. Facultad de Estudios Superiores, FES

Among the herpetariums of Mexico that fulfill the requisites for keeping animals are, ZOOMAT, the first modern herpetarium in Mexico. Constructed in 1942, it maintains a collection of solely regional animals. Likewise, the E.N.E.P. Iztacala has only regional animals and contains 33 terrariums and 55 exhibits of 40 different species.

The herpetarium of the Institute of Hygiene of the Health Secretary follows in seniority. Antivenom is produced at this facility. Another important facility, known for education and research, is the herpetarium of the Science Faculty of UNAM. Also, the herpetarium of the Chapultepec Zoo, promoted by Doctores Oscar Flores Villela and Oscar Sanchez, is well known for the large number of visitors it has each year. This herpetarium has been temporarily closed for unknown reasons.

In the state of Morelos are found 2 magnificent herpetariums, Reptilmex and the Nauyaca. The first has a collection of more than 250 specimens of 114 different species in 200 terrariums, and is well recognized for its work in rehabilitating and releasing sick or injured animals. The herpetarium of Nauyaca is known for its high standards of husbandry and practical maintenance of its exhibits. Their collection contains 200 specimens of 50 species in 73 terrariums.

In the Morelia Zoo exists a small herpetarium of considerable importance. It is a horseshoe shaped wooden building that first opened in 1998. It contains only 17 terrariums of varying sizes, in which are kept 5 species of amphibians and 16 species of reptiles. The emphasis at this facility is on public education and carefully maintain placards in front of each exhibit contain a wealth of information beyond that normally seen at public exhibitions. Another interesting aspect of this herpetarium is the curator, Laura Briseño Cazares. She is one of only two herpetarium curators in Mexico that are women, and in a very short time, has done much with this facility.

However, the herpetarium of the Guadalajara Zoo is known to be one of the best facilities in Latin America. It is of a good size (800 sq. meters) and is outstanding in exhibit quality, husbandry, education, research and conservation. Our herpetarium is a round building with a large circular atrium. Entering from the east into the atrium, the public encounters a large riverine exhibit housing American crocodiles, green iguanas and assorted species of aquatic turtles. Continuing up a spiral ramp along the edge of the atrium, you arrive at the main exhibit corridor. The circular shaped exhibit hall is divided into endemic and exotic species and contains 49 exhibit terrariums of varying sizes. Our collection consists of more than 300 specimens of 100 different species and subspecies of reptiles, amphibians, and arthropods.

Among the more exotic species we maintain are: *Bipes biporus*, *Crotalus scutulatus scutulatus*, *Crotalus enyo cerralvensis*, *Crotalus durissus tzabcan*, *Crotalus michelli*, *Crotalus pusillus*, *Crotalus polystictus*, *Crotalus enyo furvus*, *Sistrurus ravus ravus*, *Crotalus basiliscus*, *Bothrops asper*, *Heloderma horridum horridum*, *Drimarchon corais erebemus*, *Naja naja kaouthia* (albino), *Ophiophagus hannah*, *Clamidosaorus kinjii*, *Varanus salvadori*, and *Geochelonea gigantea*.

The species that we have successfully bred since the opening of the institution 10 years ago are: *Crocodylus moreletti*, *Ambystoma mexicanum*, *Scaptochelys berlandieri*, *Iguana iguana rinolopha*, *Boa constrictor imperator*, *Lampropeltis triangulum nelsoni*, *Pituophis deppei deppei*, *Pituophis deppei jani*, *Elaphe guttata emoryi*, *Elaphe guttata guttata*, *Crotalus atrox*, *Crotalus scutulatus salvini*, *Crotalus aquilus*, *Bothrops asper*, *Agkistrodon bilineatus bilineatus*, *Naja naja kaouthia* (albino), *Bitis gabonica rhinoceros*, *Boiga dendrophila melanota*, *Epicrates cenchria maurusy*, and *Python molurus bivittatus*.

The majority of our exhibits contain snakes, which has been the trend since the facility opened in 1988. All the exhibit cages at the Guadalajara herpetarium are landscaped to conform to the natural habitat of the species inhabiting them, including live plants which are changed once or twice a year. All the exhibit cages contain their own illumination and watering system independent of the others in order to prevent cross contamination.

In addition to the exhibit space, we also maintain a large reserve area which we use for the quarantine of sick and newly acquired animals. We also use a separate section of this area to maintain healthy animals which can be used to replace exhibit animals which are lost through normal attrition.

In spite of being one of the best herpetological institutions in Mexico, the Guadalajara herpetarium is deficient in a number of areas. Among these are a lack of continuing scientific research, a lack of good equipment (e.g., incubators, heating & air conditioning, lighting), and a lack of a trained and motivated staff of professional herpetologists.

Our hope is that the next generation of herpetologists in Mexico will continue the construction of more state of the art herpetariums and place more emphasis on the study of reptiles and amphibians in Mexico and the world.

Translation by Joseph P. Marek, Jr., IHS Treasurer.

COVER PHOTO CREDITS

Front Cover:

Top Left: *Naja nivea* in the park exhibits a number of color and pattern variants. This adult individual was found deep in the central dune system. Photo and caption by Karl H. Switak

Top Right: *Chelodina novaeguineae sp.* Photo by John Cann

Lower Left: *Varanus mertensi*. Photo by Kim Carmody

Lower Right: *Pyxicephalus adspersus*. Photo by Karl H. Switak

Rear Cover:

Top: An adult *Naja nivea*, perhaps the most radiating serpent ever to cross my path, surveying its domain atop a driedoring bush. In the spring they are primarily diurnal, as are a multitude of rodents. Latter scurry about in bright daylight without obvious concern for a score of opportunistic predators. Photo and caption by Karl H. Switak

Center: *Pseudaspis cana* can deliver a painful bite. It is a live bearer, powerful constrictor, and almost completely diurnal during early spring. Photo and caption by Karl H. Switak

Bottom: A young ornate monitor should be handled frequently if it is to become docile. Photo and caption by Sam Lee