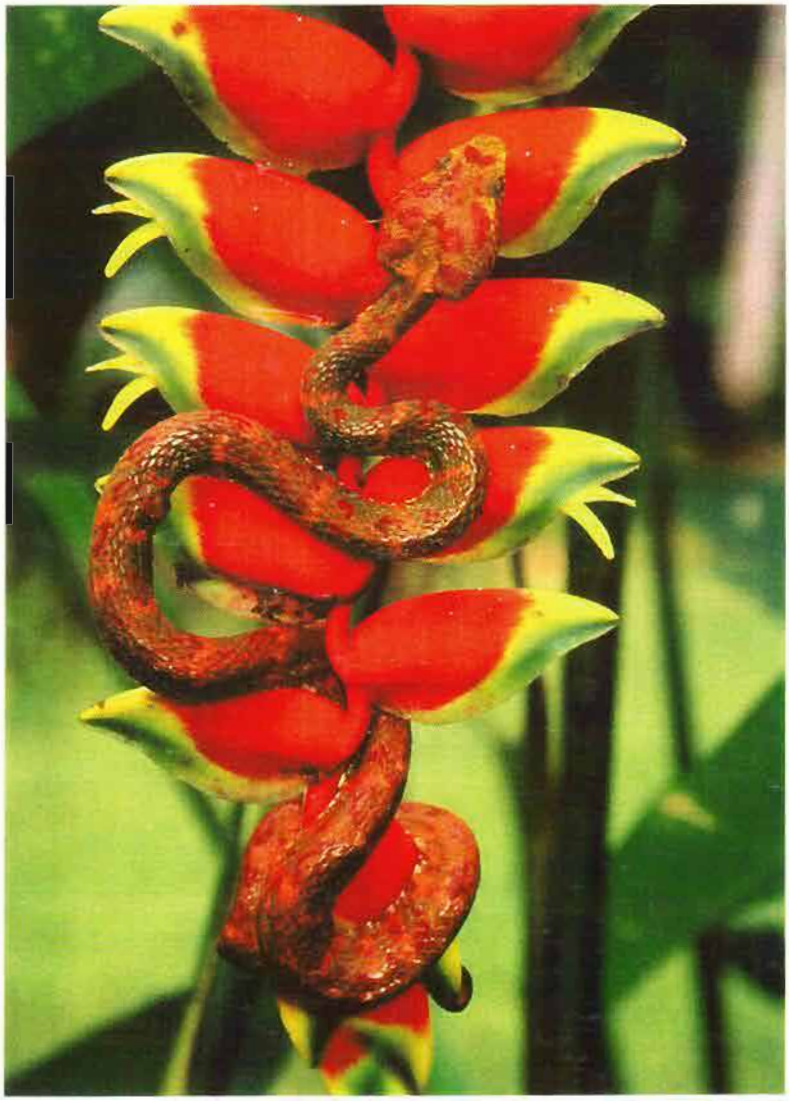
PROCEEDINGS OF THE

25th INTERNATIONAL HERPETOLOGICAL SYMPOSIUM ON CAPTIVE PROPAGATION & HUSBANDRY



Detroit, Michigan, USA
July 14 - 17, 2001

Edited by
WILLIAM E. BECKER

PROCEEDINGS OF THE

25th INTERNATIONAL HERPETOLOGICAL SYMPOSIUM
on
CAPTIVE PROPAGATION and HUSBANDRY

Hosted by
The Detroit Zoological Institute
Detroit, Michigan USA

July 14 - July 17, 2001

Edited by

William E. Becker
President
International Herpetological Symposium, Inc.

May 2002

25th Anniversary Meeting of the

International Herpetological Symposium

Hosted by

The Detroit Zoological Institute
Detroit, Michigan USA

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Program and Abstracts

INTERNATIONAL HERPETOLOGICAL SYMPOSIUM
25TH ANNUAL MEETING

PROGRAM

Saturday, July 14th

5:00 - 8:00 p.m.	Registration - Hotel Pontchartrain
7:00 p.m. - ?	Ice Breaker – Hotel Pontchartrain

Sunday, July 15th

8:00 a.m. - 5:00 p.m.	Open Registration - Hotel Pontchartrain
8:00 - 8:15 a.m.	Opening Remarks & Introduction
8:15 - 9:00 a.m.	**Dr. Robert Wilkinson** Hellbenders: Past and Present
9:00 - 9:45 a.m.	**Nathan Dunstan** Management of a Taipan, *Oxyuranus scutellatus*, Colony for Venom Extraction
9:45 - 10:00 a.m.	*Break*
10:00 - 10:45 a.m.	**Kelly Bradley** The Husbandry and Reproduction of the Cuban False Chameleon, *Chamaeleolis chamaeleonides*
10:45 - 11:30 a.m.	**Dr. Edward A. DeGrauw** Behavioral Ecology and Captive Management of Arboreal Alligator Lizards (Genus: *Abronia*)
11:30 a.m.- 12:15 p.m.	**Gerard T. Salmon** Mexicana Complex Kingsnakes: New Insight from Captive Breeding and Field Work in Mexico
12:15 - 1:45 p.m.	*Lunch Break*

1:45 - 2:30 p.m.	**Patrick Baker & Dr. William McCord** Conservation Breeding of Turtles: With Special Emphasis on Asian Box Turtles of the Genus *Cuora*
2:30 - 3:15 p.m.	**Kurt Buhlmann** Implementing Solutions to the Turtle Crisis in Asia
3:15 - 4:00 p.m.	**Robert T. Zappalorti** The Ecology, Conservation, and Management of the Timber Rattlesnake (*Crotalus horridus*), Corn Snake (*Elaphe guttata*), and Northern Pine Snake (*Pituophis melanoleucus*) in New Jersey Pine Barrens
4:15 - 5:15 p.m.	**WORKSHOPS** Asian Turtle Husbandry: **Patrick Baker & Dr. William McCord** **David T. Roberts** Natural History Photography Techniques

Monday, July 16th

8:00 a.m. - 12:00 p.m.	Open Registration
8:00 - 8:15 a.m.	Remarks and Announcements
8:15 - 9:00 a.m.	**Allen Repashy** Commercial Scale Aquaculture System for Amphibians
9:00 - 9:45 a.m.	**Peter Taylor** The Matchbox Croc: What Captivity has Taught Us About Cuvier's Dwarf Caiman, *Paleosuchus palpebrosus*
9:45 - 10:00 a.m.	*Morning Break*
10:00 - 10:45 a.m.	**Bob Myers** The American International Rattlesnake Museum
10:45 - 11:30 a.m.	**Charlie Painter** The Ecology of the Chihuahuan Ridge-Nosed Rattlesnake

11:30 a.m.- 12:15 p.m.	**Eugene Bessett** The Dream
12:15 - 1:45 p.m.	*Lunch Break*
1:45 - 2:30 p.m.	**Louis W. Porras** Rattlesnakes of the Colorado Plateau
2:30 - 3:15 p.m.	**Richard Hudson** Rock Iguana Conservation
3:15 - 4:00 p.m.	**Dr. Edward A. DeGrauw** The Behavioral Ecology and Captive Management of the Neo-Tropical Lizard, *Xenosaurus*
5:00 - 9:00 p.m.	**Detroit Zoo Field Trip and Hosted Dinner**
5 p.m.	Shuttle Buses to Detroit Zoo for Field Trip and Hosted Dinner
9 p.m.	Shuttle Buses Return to Hotel

Tuesday, July 17th

8:00 - 8:15 a.m.	Remarks and Announcements
8:15 - 9:00 a.m.	**Dr. Scott Stahl** Herpetological Obstetrics
9:00 - 9:45 a.m.	**Greg Lipps & Andrew Odum** The Struggle to Save the Wyoming Toad, *Bufo baxterii:* A Case History in Captive Propagation and Conservation
9:45 - 10:00 a.m.	*Break*
10:00 - 10:45 a.m.	**Bryan L. Starrett** Biogeography of Herpetofauna in the Grand Canyon
10:45 - 11:30 a.m.	**Alan Botterman** The Pet Industry and Herpetoculture

11:30 a.m. - 12:15 p.m.	**Jon Coote** The Early History of Herpetoculture, Up to the Year 1900
12:15 - 1:45 p.m.	*Break*
1:45 - 2:30 p.m.	**Tim Nias** Captive Propagation and Double Clutching of Inland Taipans, *Oxyuranus microlepidotus*
2:30 - 3:15 p.m.	**Jim Harrison** Observations and Consequences of Exotic Snake Envenomation
3:15 - 4:00 p.m.	**Jim Pether** The Giant Lizard of Gomera, *Gallotia gomerana*
4:15 - 5:00 p.m.	**John Tashjian** Mystery Herp Quiz (Winner receives free registration to the 2002 IHS)
6:00 p.m.	Banquet Dinner - Hotel Pontchartrain
	Dr. Jay Savage, Banquet Speaker Costa Rican Herping - Then and Now: 40 Years as a Tropical Herper
	Presentation of the Joseph Laszlo Memorial Award
	Closing Remarks
	Auction (Proceeds benefit next year's IHS!)

ABSTRACTS

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Conservation Breeding of Turtles: With Special Emphasis on Asian Box Turtles of the Genus *Cuora* (Geoemydidae)

In response to the global decline in turtle populations, the importance of captive breeding by zoos and private breeders cannot be overstated. Unsustainable human consumption and habitat destruction have pushed many species, especially those from Asian countries, to the brink of extinction. The future survival of many affected species depends upon the establishment of successful captive breeding groups both inside and outside range countries, as well as in situ conservation efforts. In this talk and in an informal workshop session, we will discuss our methods for the care and captive breeding of a wide variety of turtles with diverse habitat requirements and other special needs.

Although currently given nominal protection under CITES Appendix II, the turtles of the genus *Cuora* are among the most endangered of all Asian turtles. The southeast Asian box turtles are tropical and live in semi-aquatic habitats. From India they range to the east throughout southeast Asia; north to China, Hainan Island, Taiwan, and the Ryuku Islands; south to Indonesia and the Philippines. As a result of low reproductive output and complex habitat requirements, Asian box turtles are especially vulnerable to extinction. Many species were first discovered in the food and medicine markets of southern China, however, the status of wild populations is still unknown. In addition to the pressures applied to other species, the three-striped box or golden coin turtle (*Cuora trifasciata*) has been identified in Traditional Chinese Medicine as a "cure" for cancer and is highly sought after for that trade. An overview of the genus *Cuora* will be presented, along with an introduction to each species. Their captive husbandry, including habitat requirements, feeding, veterinary care, breeding, egg incubation, and the rearing of hatchlings, will be discussed.

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The Dream

"The Dream" in my mind's eye is a worthy goal or process that adds value to other peoples' lives. The thin thread of "The Serpent" has interwoven so many relationships and opportunities to enable a select few who are willing to accept a life of passionate pursuit in this so often misunderstood fascinating world of the reptile. An overview of the process of events, which many people, will either like or dislike, regarding how society is embracing reptiles as a "main stream" part of the family unit. Where is it heading? How can we further continue to be a significant part of establishing what future generations to come will be able to observe or posses? Change is constant, so we must be also. Many questions to be asked but, together those interested people of like-mindedness can ensure a viable world for the "Living Reptiles".

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The Pet Industry and Herpetoculture

In the early 1990's, reptiles became very popular in the pet sector. Many pet shops jumped at the opportunity to increase their sales, even if they had no prior experience or knowledge of reptiles.

On the rare occasion that a pet shop had trained staff and a legitimate reptile section in their store, there just weren't the products available on the market to support this fast-growing category.

In fact, in 1993, approximately 1,000,000 iguanas were imported for the pet trade into the United States alone; and there wasn't even a prepared diet for iguanas available on the market for pet shops to sell. With this obvious market demand facing the pet shops, as well as the lack of support products for a reptile hobbyist to succeed, I started T-Rex Products. I wasn't the only entrepreneur who recognized the potential market. By 1997, 15 companies produced an iguana diet for the pet trade. The pet industry had never seen such an explosion in a category before the reptile proliferation. At its peak in 1996, the frenzy for reptile products produced hundreds of companies worldwide who manufactured, re-packed, or somehow marketed products for reptiles to the pet trade. Today, the pendulum has swung back toward the centerline. There are a few core companies who have remained committed to the reptile market. With the market stabilized at approximately 3,000,000 households owning reptiles, it proves to be a very competitive category amongst the pet trade manufacturers.

It is in my opinion however, that the so-called fad of keeping reptiles for pets has not pinnacled, but is experiencing a tremendous bottleneck in the availability of quality livestock. It is my contention, that with the development of the captive breeding of appropriate pet trade reptiles, we could be on the verge of another growth spurt in the reptile pet industry.

T-Rex is actively supporting the efforts of captive breeders to supply quality reptiles to pet shops. This strategy will ensure a sustainable reptile market for the pet industry.

KELLY A. BRADLEY

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The Husbandry and Reproduction of the Cuban False Chameleon *Chamaeleolis chamaeleonides*

Cuba is home to over 90 species of lizards, including the Genus *Chamaeleolis*. This distinctive genus of anoline lizards is comprised of five taxa. *Chamaeleolis chamaeleonides* has one of the widest distributions among this group. Until recent years, this species was not represented in US collections due to political constraints; hence captive management techniques were unknown. In an effort to establish general husbandry protocols for large anoline lizards, the Fort Worth Zoo received a single pair of captive hatched adults in 1992 from the Czech Republic. This program has proven to be very successful, and to date the Fort Worth Zoo has produced more than 30 specimens, including second generation offspring. All aspects of this group's husbandry will be discussed, especially environmental requirements, diet, propagation, and neonate husbandry.

KURT A. BUHLMANN

Coordinator for Amphibian and Chelonian Conservation (Conservation International) and Deputy Chair of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group
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Implementing Solutions to the Turtle Crisis in Asia

At this point in time, there are few sectors of the conservation and herpetological communities that have not heard of the crisis facing Asian freshwater turtles and tortoises. The documentation of the unsustainable commercial exploitation of chelonians for the food and traditional medicine is convincing and undeniably real. Feelings of hopelessness have at times been nearly overwhelming. However, over the past year, substantial progress has been made towards achieving action on the behalf of beleaguered turtle species. International conservation organizations, zoos and aquariums, private turtle hobbyists, government authorities, and university research scientists have begun to work together on this problem. Fund-raising efforts are beginning to bear fruit. Long-range efforts are being launched on several fronts including support for education programs and law enforcement efforts in the range countries, identification of proposed and "protected" natural areas within range countries, field research and surveys to identify original distributions, habitats, and life histories of Asian turtle species, and the establishment of range country rescue centers. Of perhaps greatest

immediate importance is the progress being made to establish genetically viable populations (Assurance Colonies) of every species of exploited chelonian and to house them in long term captive or semi-wild conservation programs. The Turtle Survival Alliance (TSA), a new working group of the IUCN, has been formed to facilitate action in this direction. Through collaborative efforts with the institutions and individuals referred to above, many of these "Assurance Colonies" will be established in the United States and hopefully in range countries through collaboration with international government authorities. They will be stocked primarily through the confiscations of illegally traded turtles. Should the combined education and enforcement efforts prove not effective in time to prevent the extinctions of turtle species in the wild in Asia, Assurance Colonies will "keep the pieces" and provide future reintroduction options.

JON COOTE
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The Early History of Herpetoculture, up to the year 1900

Although the world's first reptile keepers may have been Mexican, historical data suggests that the beginnings of herpetoculture were primarily a British endeavor during the nineteenth century. This is indicated by the world's first chelonian building around 1820; the first zoo reptile house in 1849; and the first book, in English, on herpetoculture, 'The Vivarium', published in1897. The huge increase of individual's wealth, as a result of the British industrial revolution, provided the means, and the leisure, for many individuals to indulge themselves in the increasingly fashionable study of natural history, including herpetology. Increasing knowledge, higher expectations, and improved technology, contributed to the success of their captive care. The data available outlines some of the pioneering attempts of these, mostly forgotten, early herpetoculturalists to provide us with the foundations of the knowledge and skills that we enjoy today. Early captive breeding successes were more frequent than generally supposed. For at least one snake species it's captive breeding still remains to be repeated to this day. It is also possible to speculate, from available data, on the exchange of information between at least one of these early British pioneers and his colleagues in North America.

EDWARD A. DEGRAUW, Ph.D.
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Behavioral Ecology and Captive Management of Arboreal Alligator Lizards (Genus: *Abronia*).

The lizard genus, *Abronia*, is currently comprised of twenty-eight recognized species, more than half the species of the gerrhonotine anguid lizard diversity. This genus is found within a geographic region extending from southern Tamaulipas, Mexico to northeastern El Salvador and southern Honduras. Within this area the distribution of *Abronia* is restricted to the pine-oak and cloud forests of the highland regions (from 800->2,800 meters). *Abronia* are omnivorous, ovovlviparous, arboreal lizards with strongly prehensile tails. Like other anguids the tail is easily autonomized, which affects their suitability for arboreal existence and the ability of being allowed to copulate. They are active thermoregulators with preferred body temperatures ranging from 22-28°C and an upper thermal limit of 33-35°C. They have a well-developed chemosensory ability that they use in tracking of prey, which consists of a wide variety of vertebrates and invertebrates. Chemosensory ability allows recognition of conspecifics by sex and reproductive status. The lizards are somewhat solitary and intraspecific aggression is common, particularly between males. With the exception of females and their own offspring, adults have been known to eat neonates. Breeding within this genus generally occurs in September-October with birth of young in May-June. Litter sizes range from 1-17. Neonates are 30-40 mm SVL with weights ranging from 2.5-5.0 g. They are hardy in captivity, but successful breeding of this genus requires high UVB radiation and active management of temperature on a daily and annual basis.

EDWARD A. DEGRAUW, Ph.D.

The Behavioral Ecology and Captive Management of the Neo-Tropical Lizard, *Xenosaurus*

The lizard genus *Xenosaurus* consists of at least six species of crevice-dwelling lizards found from Tamaulipas, Mexico south to Alta Verapaz, Guatemala. The species within this genus are found in a variety of habitats ranging from tropical to nearly xeric. Most of the species are thermoconformers (22-25° C) that exhibit no basking behaviors with an upper thermal limit of approximately 37°C. They are suited to a crevice-dwelling lifestyle with varying degrees of flattened body and head morphology and choose crevices with a height approximately 0.75 times the length of their head. The skin of these lizards allows water to be drawn by capillary action anterior along their body to the corners of their mouth for drinking. Food consists primarily of Orthopterans and Lepidopteran larvae, which are found within the crevices the lizards inhabit. The species within this genus are solitary, with varying degrees of aggression displayed toward conspecifics and the degree of aggression changing with reproductive status. Some members of the genus demonstrate parental-neonate associations lasting up to 55 days which are adaptive to the offspring, while in other species the young disperse immediately to avoid the cannibalistic behavior of the adults. The lizards are hardy in captivity and captive husbandry and breeding requirements are minimal. Care must be taken with groupings of some species to avoid potentially damaging aggressive encounters.

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Management of a Taipan, *Oxyuranus scutellatus*, Colony for Venom Extraction

The taipan, *Oxyuranus scutellatus*, is a large elapid with highly toxic venom, which occurs in the northern coastal regions of Australia and is used widely for venom production for antivenom and medical research. Venom Supplies currently has 38 taipans ranging from juvenile to adults for the purpose of venom extraction. Here we report the care and maintenance required to manage taipans to a Good Manufacturing Practice (GMP) venom production over a period of 2 years from 1999 to 2001.

In the study period we there were 44 records of milkings and achieved an average yield of 868 mg per milking. We found that a minimum fortnightly milking frequency was adequate recovery time for the snakes with an average of 20 milkings per year.

The snakes are kept between a minimum of 31 deg C and a maximum of 32 deg C. Special attention to heating has had a positive effect on the temperament.

Minimal health problems were experienced with the snakes. Some of the problems were an infected fang sheath, protozoan infection and there was 1 death due to a lesion of the liver. Particular consideration to hygiene, minimized health problems. Despite their deadly potential, generally these snakes were easy to handle, good-natured and are good venom producers.

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Observations and Consequences of Exotic Snake Envenomations

Over the past several years there has been an increase in the captive breeding and keeping of venomous reptiles, and an increase in envenomations by exotic snakes has been observed. Several case histories of exotic envenomations by Elapidae and Viperidae in the U.S. will be discussed, including observations of systemic and local effects of venoms, and reactions to antisera. Post-bite consequences of necrosis, surgery, and rehabilitation will be addressed.

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Conservation and Recovery Efforts for West Indian Iguanas

The iguanas of the West Indies comprise two genera, *Cyclura* (eight species) and *Iguana* (two species), with 18 recognized taxa. These large herbivorous lizards inhabit fragile island ecosystems and most populations have suffered substantial declines largely due to the activities of man. Their tropical dry forest habitats have been eliminated or altered by human development and they are particularly sensitive to the negative effects of introduced mammalian species (feral exotics). As a group these iguanas represent the most highly endangered lizards in the world and recent IUCN Red List assessments rank nine taxa as Critically Endangered, four as Endangered, and four as Vulnerable. Several species are at high risk of extinction and are not predicted to survive without conservation intervention. This paper will review the natural history and conservation status of Caribbean iguanas, and discuss some of the research and recovery programs that have been initiated to prevent their extinction. Zoos have played a leading role in the implementation of these programs and these efforts will be highlighted.

BOB MYERS
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The Rattlesnake Museum

Private reptile exhibits come and go. What makes one succeed and the next dwindle from existence? Is the formula for success measured in well planned and researched details, or is it just a matter of common sense? Are there other characteristics to the equation that may be a bit more elusive? In this presentation you will learn the path taken by a former biology teacher, Bob Myers of the American International Rattlesnake Museum in Albuquerque, New Mexico. The Rattlesnake Museum just concluded its tenth year and doesn't seem to be losing steam. The Museum has been featured on National Geographic Explorer, the Discovery Channel, Good Morning America, Good Morning Television (in Europe), Reptile Magazine, Amphibian and Reptile Hobbyist Magazine, and scores of additional local, regional, national and international television shows, radio programs, magazines, newspapers and travel guides. And, while the Museum's logo T-shirts don't quite rival the numbers of Planet Hollywood's or Tommy Hilfiger's, they are increasingly recognized by reptile enthusiasts around the world. And yet, with all the hype, the Museum's primary concept remains, education. Visitors are willing students in this Crotalid classroom. Myths are explored, phobias cured, mysteries revealed and respect gained for these curious reptiles, and surviving students to this "striking" exhibit leave with a diploma, their "Certificate of Bravery!"

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Captive Propagation and Double Clutching of Inland Taipans *Oxyuranus microlepidotus*

Inland taipans inhabit a very arid part of Australia and little is known about the ecologies. This paper reports on breeding this species in captivity over a period of 5 years at Venom Supplies Pty Ltd. There were 11 clutches with a total of 120 eggs produced in this period from which there were 57 males, 58 females and 5 unsexed offspring. Mean egg widths for both male and female were 34mm and mean lengths for males were 67mm and 69mm for females. The mean egg weights were 47gm for males and 49gm for females. For both egg weights and egg

widths, most of the eggs were in the lower half of the range whereas the egg lengths were evenly distributed through the range.

There were a higher number of females with mid range snout vent lengths (SVL) than males, with the mean SVL for males 400mm and 397 for females. Tail lengths were evenly distributed through their ranges for both males and females with means of 67 for males and 63 for females. Copulations varied between early September through to mid January. Ovipositions varied between late November to end of March. The mean gestation period was 67 days. Hatching varied between late January to early June. The mean incubation time was 73 days. The mean copulation plus incubation was 140 days.

GREG LIPPS *and* **R. ANDREW ODUM**
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The Struggle to Save the Wyoming Toad *Bufo baxteri*: A Case History in Captive Propagation and Conservation

The Wyoming toad, *Bufo baxteri*, is perhaps the most endangered amphibian in the North America. It became extinct at its last remaining wild refuge in the early 1990s and its recovery has been entirely based on captive reproduction and repatriation from a small captive nucleus. Unfortunately the captive population has been plagued with challenges and sporadic breeding, which has hindered repatriation efforts. Many husbandry protocols at different institutions were tested with different successes. What factors were important for successful reproduction were not readily apparent so a program was established to quantify relationships between numerous husbandry variables and reproduction. Factors that were examined included length of hibernation period, age of animal, mass of animal, temperature of hibernation, length of time between hibernation and breeding, inbreeding coefficient of resulting offspring, and number of hormonal injections. Factors that showed significant relationships to successful reproduction included: number of injections of hormones, length of hibernation period, mass of females, and age of animal. This presentation will discuss the history and challenges of the Wyoming toad conservation efforts, as well as efforts to quantify husbandry parameters necessary for successful reproduction.

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Status and Ecology of the New Mexico Ridgenose Rattlesnake, *Crotalus willardi obscurus*

On 24 January 1975, the New Mexico ridgenose rattlesnake, *Crotalus willardi obscurus*, was listed as Endangered by the New Mexico Department of Game and Fish. On 4 August 1978, the species became the first rattlesnake listed as Threatened under authority of the federal Endangered Species Act. Limited habitat and the potential for overcollecting were given as the primary reasons for these listings. Since that time numerous investigators: Klauber, Degenhardt, Altenbach, Applegarth, Painter, Barker, and Holycross have explored the Animas and Peloncillo mountains of southwest New Mexico and southeast Arizona and the Sierra San Luis of northern Sonoran and Chihuahua, Mexico and have added considerably to the understanding of this unique montane rattlesnake. The earliest studies concentrated on the distribution and habitat use, while an emphasis on systematics, ecology, natural history, and conservation have dominated the later studies. Most of the data in this presentation were collected by Painter and Holycross. We worked in the Animas Mountains (New Mexico) from 1994 - 1999, the Peloncillo Mountains (Arizona and New Mexico) from 1995 - 1998, and in the Sierra San Luis (Sonora and Chihuahua) in 1998. Field teams dedicated 1,355 "person-days" searching for *C. w. obscurus* over the course of the study. 206 individual *C. w. obscurus* (160, Animas Mountains; 17, Peloncillo Mountains; 29, Sierra San Luis) were marked during these studies.

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The Giant Lizard of Gomera, *Gallotia gomerana*

The Canary Island archipelago situated close to the coast of Morocco, although poor in herpetofauna is rich in endemisms. Of the 17 species of reptiles and amphibians in the Canary Islands, 14 are endemic, the other three being introduced species. In the last 25 years three new species have been rediscovered, two in the last 5 years including *Gallotia gomerana* from the island of Gomera.

G. gomerana was first described in 1985 by a German mammalogist (Hutterer), also ancient documents from the 16th century mention a large lizard on Gomera.

A team of biologist rediscovered a relict population of these lizards in 1999 on the cliffs of La Merica in the municipality of Valle Gran Rey. A total of six lizards, three males and three females, were captured over a period of six months. The lizards are to be the founder group for a captive breeding program run by the Department of the Environment of the Canarian Government. Captive breeding may be the only salvation for these extremely rare lizards. A provisional census has shown a wild population of only five lizards and it is calculated that a maximum population of only twenty may exist. This makes *G. gomerana* among the most endangered vertebrate in the world.

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Rattlesnakes of the Colorado Plateau

The Colorado Plateau is a physiographic region of southwestern North America that encompasses most of northern Arizona and eastern Utah, parts of western Colorado, and extreme southwestern Wyoming. The area is drained primarily by the Green and Colorado rivers, and is characterized by broad plateaus, ancient volcanic mountains, and deeply dissected canyons. The Colorado Plateau is one of the most scenic regions in the world. The western rattlesnake (*Crotalus viridis*) has long been recognized as the most widespread and phenotypically variable rattlesnake in North America and has been partitioned into nine subspecies based on scalation, size, color, pattern, and geographic distribution. The Colorado Plateau is pivotal to our understanding of the evolution of the C. *viridis* group, as six members potentially contact one another at or near the Grand Canyon. Recent molecular studies investigating specific regions of mtDNA do not support monotypic status for the group but rather indicate two major lineages (Douglas et al., *in press*). An overview of the rattlesnakes of this region is presented, and aspects of their natural history and evolutionary relationships are discussed.

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Commercial Scale Aquaculture System for Rearing Amphibians

Sandfire Dragon Ranch became the name associated with Bob Mailloux in 1992, after he developed the beautiful red color morph of the Inland Bearded Dragon *Pogona vitticeps*. Bob had been working extensively with Reptiles and Amphibians for approximately 35 years at that point, with his primary emphasis on amphibians. Bob and I became friends in the early nineties when our paths crossed through the trade. We quickly became friends and exchanged ideas, shared techniques, and discussed our long-term goals. We soon began discussing ways to combine Bob's years of knowledge, and my strong business background, to create a new facility directed at large scale propagation of Herps for the pet trade. In about 1996, we began pooling our resources, and developed methods and refined techniques to successfully produce select species of frogs and lizards on a commercial scale

for the pet trade.

A brief over view of our lizard propagation techniques will be presented. I will mainly focus on our amphibian propagation. The methodology to reproduce frogs began as a "green house style" style set up with manipulation of environmental cues at the appropriate time of year. This type of production has remained fairly constant, only the scale had to be changed. Rearing methods to achieve the large numbers of specimens for commercial production has changed significantly. Details on the development of an intensive aquaculture system to optimize this production will be discussed. Observations on the effects of water quality, pheromones, nutrition, temperature and density on the survival and growth rates will be provided. In developing these methods my opinion on health problems and deformities such as "spindle leg" syndrome will be provided. These methods were primarily developed for several species of Old World tree frogs in the genus *Litoria*. The process has been a learning experience, it has answered many questions and generated many more.

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Mexicana Complex Kingsnakes: New Insights from Captive Breeding and Field Work in Mexico

Confusion regarding natural history and taxonomy has plagued this group of kingsnakes since the discovery of each of the species (currently recognized as *Lampropeltis alterna*, *L. mexicana* and *L. ruthveni*). Due to their secretive nature and difficulty in collecting specimens, captive breeding of specific locality founders has shed light on the colors and patterns possible in these often polymorphic snakes. Recent work in Mexico has yielded new information on their geographic distribution and microhabitat preferences. Gerry has been working on this species group for more than 15 years and has done extensive research in museum collections and in the field. This talk will highlight some of the information that is a work in progress and several papers are due to be published in the near future.

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Reptile Obstetrics

Complications with laying eggs or giving birth to young are common sequelae of breeding reptiles. Veterinarians treating reptiles in practice will often be presented with reptiles with dystocia. Dystocia in reptiles can be multifactorial and may be the result of inappropriate nesting sites, stress, dehydration, malnutrition, obesity, salpingitis, obesity, malformed eggs and abnormal reproductive anatomy. This presentation will discuss the general clinical presentation and commonly used medical and surgical options for the treatment of dystocia in snakes, lizards and chelonians.

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Biogeography of Herpetofauna in the Grand Canyon

While the geographic distribution of herpetofauna throughout most of North America is well understood and extensively represented in the literature, the biogeography of Grand Canyon amphibians and reptiles (particularly viperids) remains poorly known, and published indices are scarce. The Grand Canyon lies within the Colorado Plateau region and extends nearly 278 miles from Lake Powell at the Utah border to Lake Mead, Nevada encompassing 1900 square miles. The dearth of knowledge regarding occurrence and distribution of herpetofauna is due largely to the enormity and remoteness of habitat. Miller et al (1981) identified 39 reptile and 7 amphibian species in *Checklist of the Reptiles and Amphibians of the Grand Canyon Area*, and in *Amphibians and Reptiles*

of the Grand Canyon (1982). Eleven taxa were identified as "Problematical Species", some of which are unlikely to occur naturally in the vicinity of the Grand Canyon. The author and other individuals participated in a series of river trips through most of the Inner Gorge of the Grand Canyon from 1991 to 1999. The occurrence of some species previously considered rare is frequently documented. Of particular interest is *Crotalus mitchelli* and *C. viridis* occurring sympatrically and syntopically. Much confusion exists regarding identification, and hence, distribution of these species in the Canyon. Herein we elucidate the distribution of these and other viperids in the Grand Canyon.

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The Matchbox Croc: What Captivity has Taught Us About Cuvier's Dwarf Caiman, *Paleosuchus palpebrosus*

This paper will accomplish several objectives. First, it will give a description of Cuvier's Dwarf Caiman, *Paleosuchus palpebrosus*, and its place within the Crocodilia relative to other species. Notes on its congener, Schneider's Dwarf Caiman, *P. trigonatus*, and on an ecological analog, the West African Dwarf Crocodile, *Osteolaemus tetraspis*, will further define its ecological niche and taxonomic position.

Because of the paucity of wild observations of such basic events as nesting and feeding, much captive information will be brought to bear. Mastery of captive management is a desirable goal in itself. Additionally, some details of zoo husbandry and reproduction can complement and support that which has currently been observed in nature. The comparatively robust status of this species from a population and conservation standpoint should create a reasonable time buffer for these investigations to take place in the future.

A life history problem that has been addressed by other investigators is the lack of environmentally available heat for nest incubation in forest crocodilian species. It has been demonstrated that *P. trigonatus* will exploit ground termite species and their heat generating mounds for warming nests. This has not been seen in wild *P. palpebrosus*. Captive data points toward *P. palpebrosus* having at least lower end thresholds for hatching young and concomitantly reducing temperatures required to produce gender modes. Implications are that the tolerance for less sunny pastures of "cool crocs" broadens available ecological space within the order.

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Hellbenders: Past and Present

Missouri populations of the long-lived hellbender, *Cryptobranchus alleganiensis*, were censuses in 1998-1999. These data were compared to data from previous studies from the 1970's and 1980's. The hellbender populations appear to have declined in all rivers sampled. This decline is characterized by an increase in average body size, due to an apparent lack of recruitment of young into the population. Hellbenders from all rivers, except the Niangua, tended to be in better body condition in the 1998-1999 sample than they were in the past. It is not known whether the population decline for hellbenders has a single cause of whether each population has experienced independent declines.

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The Ecology, Conservation, and Management of the Timber Rattlesnake *(Crotalus horridus)*, Corn Snake *(Elaphe guttata)* and Northern Pine Snake *(Pituophis melanoleucus)* in the New Jersey Pine Barrens

Herpetological Associates, Inc. conducted surveys for corn snakes *(Elaphe guttata)* and pine snakes *(Pituophis melanoleucus)* from 1977 - 1997 for the New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Endangered and Nongame Species Program (NJDEP), the Trust for Public Land, the New Jersey Conservation Foundation, and The Nature Conservancy. Evaluations of potential suitable habitats were made within the historic known range in southern New Jersey. Critical habitat for corn snakes *(e.g.,* such as winter dens and nesting areas) were confirmed at 14 sites in Burlington County, 2 sites in Cumberland County, and 5 sites in Ocean County. Critical habitat for the northern pine snake was also found; 9 sites in Atlantic County, 16 sites in Burlington County, 1 in Camden County, 1 in Cape May County, 3 sites in Cumberland County, 1 in Gloucester County, 1 in Monmouth County, and 10 in Ocean County. Methods to capture and observe these snakes are provided in order to determine presence or absence along with the biology and important life history notes. Radio-telemetry was used to determine habitat selection, activity range size, seasonal movements, nesting sites, and winter hibernation sites. The average home range of 21 northern pine snakes was 50.10 hectares (125.29 acres), whereas the average home range of 5 corn snakes was 18.30 hectares (45.23 acres). Likewise, between 1984 and 1986, radiotelemetry was used to monitor the movements, foraging strategy, and habitat use of the timber rattlesnake (*Crotalus horridus*) in southern New Jersey. Movement patterns of males and non-gravid females consisted of constantly shifting, non-overlapping activity areas. In most cases these snakes moved in a looping pattern during the active season and returned to the same hibernation site from which they departed. Males generally exhibited the largest activity ranges *(N* =7, mean 48.6 hectares, range 3.5 to 123.5 hectares), and the sizes of their ranges were positively correlated with the number of days the snakes were monitored. This was not true for gravid or non-gravid females. Gravid females exhibited more static, overlapping activity areas and shorter migratory distances *(N*= 7, mean 9.9 hectares, range 1.8 to 20.4 hectares) from hibernacula. Whereas non-gravid females moved farther from overwintering sites *(N* = 6, mean 17.3, range 5.4 to 46.4 hectares) than gravid females, but not as far as males. Typical habitat consisted of pitch pine and Virginia pine mixed with black, post, scarlet, scrub, and white oaks. These upland forests often have intermittent stream corridors, *Sphagnum* bogs, or grassy savannahs interspersed within them. Pine Barrens rattlesnakes used underground rodent burrows and natural spaces under the root-systems of cedar, sour gum, and red maple trees along stream edges for winter refuge. The ground surface at hibernacula is often covered with a thick carpet of *Sphagnum* moss, in densely vegetated Atlantic white cedar stands. Early in April 1995, an extensive forest fire burned an estimated 20,000 acres (8,094 hectares) of Pinelands. Approximately 90% of the forest area used by rattlesnakes during the previous study was burned. In an attempt to learn about changes in habitat selection, activity range size, or behavioral shifts following a major forest fire, follow-up radio telemetry studies to Reinert and Zappalorti's (1988a) earlier studies have been initiated. This included foraging sites, gestation sites, and hibernating sites. Fortunately, at the time of the fire, the rattlesnakes were still underground. When they emerged from hibernation, only two individuals had minor facial burns which subsequently healed after shedding. This massive fire-induced alteration of the structural environment surrounding the overwintering habitat of rattlesnakes provided an opportunity to examine responses of snakes to infrequent natural disaster. Data collected after the fire provided a direct comparison for pre-burn and post-burn habitat disturbance. Preliminary results of this investigation include the first observation of two neonate *C. horridus* hibernating in an artificial den, similar to the type described in Zappalorti and Reinert (1994). This was the first time Pine Barrens rattlesnakes were observed hibernating in an upland situation. One of the two individuals was radio-tracked for two successive years. In the fall of 1995, it shifted to a more typical situation at the stream-edge of the cedar swamp, and returned to the same location in the winter of 1996. Another first-time observation involves the shift from one overwintering stream to another by a postpartum female in the winter of 1996. After emerging from

her overwintering burrow in the spring of 1995, she moved south through the burnt forest about 1.6 km to a trash-pile on the edge of a sand road. She remained there for about one month, then moved 25 meters east to a field-edge mound. After giving birth to 12 young, the female moved 0.5 km, towards a stream where she overwintered in 1995. This was the first time we observed a Pine Barrens rattlesnake shifting stream corridors to hibernate. Such behavior has important implications because it demonstrates non-fidelity to a particular stream corridor and suggests that Pine Barrens timbers may be more pioneering in surrounding available habitat than previously thought. In 1995 the snake's hibernaculum was engulfed by the fire, whereas her location on the new stream had not been burned. Several other radio-monitored rattlesnakes moved to unburned sections of the den-stream, while a few returned to partially burned sections. Shifting overwintering sites may be beneficial to the survival of a population, especially if the habitat becomes radically altered by natural or human causes. Thanks to funding provided by The Nature Conservancy and the Trust for Public Lands, we have completed 5 years of this comparative radio-tracking study in the burned acreage of the Pine Barrens. The information obtained will not only provide answers to basic ecological questions, but it will also generate invaluable insight useful to the NJDEP and other wildlife conservation groups who are interested in the management of these 3 declining species.

NOTES

Preface

More than 25 years have past since the 1st Annual Reptile Symposium on Captive Propagation and Husbandry was held in July 1976, at Hood College in Fredrick, Maryland. The International Herpetological Symposium (IHS) evolved from this meeting. The primary purpose of the IHS is to provide a forum for the dissemination of information and results of research pertaining to the natural history, conservation biology, captive management, and propagation, of amphibians and reptiles. The articles contained in this publication represent the ongoing effort of the IHS to promote the sharing of information between zoologists, herpetologists, and herpetoculturists at all levels.

Acknowledgements

We would like to thank Host Committee Chairman, Andrew T. Snider, Curator of Herpetology at the Detroit Zoological Institute. Andy, you did an excellent job of coordinating all of the local organizations and making arrangements for the interesting and pleasurable evening at the Zoo. Special thanks to the Detroit Zoological Institute for providing the manpower and resources to make the Symposium a success, and for providing us access to one of the most outstanding amphibian collections in the world.

Thanks must also go to Don Boyer, Curator of Herpetology at the San Diego Zoo and the 25th IHS Program Coordinator, for developing the excellent program of speakers. Few can appreciate the effort required to assemble a well-balanced program for an organization with such diverse subject matter, and to coordinate the itineraries of local, national, and international speakers.

Special thanks go to Emily Draper, Stan Draper, Joe Marek, Phil Samuelson, Vince Scheidt, and Andy Snider for reviewing the papers for this publication.

William E. Becker
President
International Herpetological Symposium

2002

25th International Herpetological Symposium
July 14-17, 2001
Detroit, Michigan USA

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An Overview of the Genus *Cuora* (Geoemydidae) with Techniques for Breeding Semi-Aquatic Turtles

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Human consumption, coupled with habitat destruction, has pushed many Asian turtle species to the brink of extinction. Captive breeding programs will play an increasingly important role in the success of both *in situ* and *ex situ* conservation efforts for the recovery of impacted populations. The species of the genus *Cuora* endemic to China are among the most vulnerable to extinction. An overview of the genus with regard to taxonomy, distribution, morphology, and reproduction is presented along with husbandry techniques for semi-aquatic turtles that have proven to be successful.

Introduction

Large-scale human consumption, coupled with habitat destruction, has pushed many Asian turtle species to the brink of extinction. Rapid growth in the international turtle trade has been driven largely by the Chinese markets for food and medicine (Thorbjarnarson et al. 2000). While habitat preservation and *in situ* conservation are the preferred methods of conservation biologists for stemming the global decline in turtle populations (Seigel & Dodd Jr. 2000), the importance of captive breeding by zoos and private individuals should not be overlooked. The future survival of many impacted species depends upon the establishment of successful breeding groups, as well as *in situ* conservation in range countries (Pritchard 1995).

In addition to providing a refuge for threatened and endangered species, *ex situ* breeding programs, 1) act to propagate an endangered species until conditions for repatriation are favorable, 2) educate visitors on the causes of declining turtle populations, 3) generate baseline data on diet, behavior, and reproduction, and 4) provide direct or indirect support for *in situ* conservation programs (Wiese & Hutchins 1994). Additionally, distributing captive-bred offspring among private breeders may reduce pet trade collection pressure from wild populations.

Although currently given nominal protection under Appendix II of the Convention for International Trade in Endangered Species (CITES), the semi-aquatic turtles of the genus *Cuora* are among the most endangered of all Asian turtles. The low reproductive output and complex habitat requirements of semi-aquatic turtles render them especially vulnerable to extinction. Several species were first discovered in the food markets of southern China during the 1980s, and the status of wild populations is unknown. In this paper we review the species of the

genus *Cuora* and provide detailed husbandry techniques which may be useful to conservation organizations and private individuals establishing breeding groups of semi-aquatic turtles.

Overview of the genus

The Malayan box turtle, *C. amboinensis* (Daudin 1801), was originally described in the genus *Testudo*; later this species was designated as the type for the genus *Cuora* (Gray 1855). The "amboinensis complex" consists of four subspecies: *C. a. amboinensis*, *C. a. cuoro* (Schweigger 1812), *C. a. kamaroma* (Rummler and Fritz 1991), and *C. a. lineata* (McCord & Phillipen 1998). The range of *C. amboinensis* extends from the Nicobar Islands, Bangladesh and Assam, India, across southern Asia to Indonesia (Iverson 1992). The type locality for *C. a. amboinensis* is the island of Ambon in the Moluccas, and the range includes the Philippines and Sulawesi. *Cuora a. cuoro* is restricted to the islands of the Indonesian archipelago with the exception of Borneo and Sulawesi, while *C. a. kamaroma* is distributed from Borneo to the mainland of southeast Asia (Rummler & Fritz 1991). *Cuora a. lineata* has been collected in Kachin Province in northern Myanmar and may range to southern Myanmar as well.

The lateral head pattern of three parallel longitudinal yellow bands against a black background is consistent for each of the subspecies. The first band runs from the tip of the nostril to the dorsal margin of the tympanum; the other two run from the nostrils through the orbit to the neck. The carapace (up to 23 cm long) of the mainland species are typically high domed, while specimens from the island populations have a more depressed tricarinate carapace. *Cuora a. lineata* can be distinguished from the other subspecies by a pale mid-dorsal stripe that runs along the vertebrals and by the lateral stripes that are typically present on the second and third costals. The strongly hinged plastron allows the shell to be closed tightly. Mainland specimens have a distinct black blotch toward the outer margin of each plastral scute, whereas a variable dark plastral pattern is found in the island subspecies. The posterior lobe of the plastron is rounded and usually without a notch (Ernst & Barbour 1989). The anal seam is usually present in adults. Consistent with the observation that this species inhabits aquatic and semi-aquatic habitats in nature, the digits are distinctly webbed. Males are slightly smaller and can be distinguished from females by a concave plastron and a larger, thicker tail with the vent posterior to the carapace margin. The elongate and brittle-shelled eggs measure 40-48 mm x 30-34 mm (McCord & Philippen 1998; Smith 1931).

Cuora flavomarginata was designated as the generotype for the genus *Cistoclemys* (Gray 1863). Although there is little variation in outward appearance, the "*flavomarginata* complex" consists of three subspecies: *Cuora f. flavomarginata*, the nominate form from Taiwan; *C. f. sinensis* (Hsü 1930), found on the mainland and restricted to China; *C. f. evelynae* (Ernst & Lovich, 1990) from the Ryukyu archipelago of Japan. Using discriminant analysis of morphological features, researchers found the mainland subspecies to be significantly different from the two island subspecies, which could not be sufficiently distinguished from one another (McCord & Iverson 1991). The Ryukyu population is characterized by having more yellow coloration on the scute

areolae than the other subspecies (Ernst & Lovich 1990).

In contrast to the gray-green dorsal surface, the lateral head markings include a pair of bright yellow bands with black borders running posteriorly from the orbit. The tympanum is light brown to orange, but never yellow (McCord & Iverson 1991). The hooked upper jaw is yellow and the chin may be pink or yellow. The dark brown carapace (up to 19 cm long) is high domed with a prominent keel and a distinct yellow stripe along the midline (Ernst & Barbour 1989). The scutes on the carapace are well-sculptured with growth annuli (Pritchard 1979). The dark plastron is strongly hinged, such that the shell can be tightly closed. The posterior lobe of the plastron is wide and without a notch, and the anal seam may not be present in adults. The digits of this mostly terrestrial species (Lue & Chen 1999) are minimally webbed. Males are slightly smaller than females and are distinguished by a moderately concave plastron and a larger, thicker tail with the vent posterior to the carapace margin. *Cuora flavomarginata* is capable of producing several clutches of 1-3 somewhat elongate eggs (41-53 mm x 20-27mm) each spring (McCord & Baker, in prep). Similar data has been reported for eggs from a wild population of *C. f. flavomarginata* from northern Taiwan (Chen & Lue 1999). Hatchlings generally emerge after an incubation period of 71-80 days (Schaffer & Felsner 2000).

Bourret (1939) described *C. galbinifrons* from specimens acquired in Indochina and placed this species in the genus *Cistoclemys*. The "*galbinifrons* complex" consists of three subspecies: *C. g. galbinifrons* (Bourret 1939), *C. g. bourreti* (Obst & Reimann 1994), and *C. g. picturata* (Lehr, Fritz & Obst 1998). Head coloration in *C. g. galbinifrons* is variable, but can be a spectacular combination of red, black, orange and yellow. This terrestrial species ranges from northern Vietnam, southern China and Hainan Island. Carapace and plastral patterns are highly variable within and among the subspecies (Obst & Reimann 1994). *Cuora g. bourreti*, from central Vietnam and Laos, is intermediate in both coloration and pattern between *C. g. galbinifrons* and *C. g. picturata*, but is distinguished from both by a wide, dark brown median band on the carapace, reaching the anterior margin of the shell in its entire width (Lehr et al. 1998b). *Cuora g. picturata*, which is found in southernmost Vietnam and Cambodia, is easily distinguished from the other subspecies by a primarily yellow head adorned with fine gray vermiculations (Lehr et al 1998a).

The high-domed carapace of this medium-sized turtle (up to 20 cm long) is unkeeled with a wide medial band and a yellow line along the vertebrals. The plastron of *C. galbinifrons* is strongly hinged and the shell can be closed tightly. The posterior lobe of the plastron is rounded and without a notch, the anal seam is generally absent in adults, and the digits are weakly webbed. Although comparable in size, males can be distinguished from females by a larger, thicker tail with the vent posterior to the carapace margin. *Cuora g. bourreti* lays three clutches of one egg or a single clutch of two eggs during the spring (Fiebig & Lehr 2000). The eggs average 55.4 mm x 30.0 mm and hatch after 85-117 days of incubation.

The serrated box turtle, *C. serrata* (Iverson & McCord 1992), was originally

described as a subspecies of *C. galbinifrons*, but was later elevated to full species status (Fritz & Obst 1997). This terrestrial species has been collected in central Vietnam and Hainan Island. The posterior margin of the high-domed carapace is serrated. The plastron is strongly hinged and the shell can be closed tightly. The posterior lobe of the plastron is rounded and without a notch, the anal seam is usually present, and the digits are weakly webbed (Iverson & McCord 1992). Males can be distinguished from females by a concave plastron and a larger, thicker tail with the vent posterior to the carapace margin. In captivity, a clutch of 2-4 large, elongate eggs (42-44 mm x 29-31 mm) is produced annually (McCord & Baker, in prep).

The three-striped box turtle, *C. trifasciata* (Bell 1825) was once common throughout its range of Laos, northern Vietnam, and southern China, including Hainan Island and Hong Kong. Also known as the golden turtle or golden coin turtle, it has been identified as a "cure" for cancer in traditional Chinese medicine. This species is highly sought after for the commercial trade and is aggressively collected for the high price it commands (Timmins & Khounbouline 1999).

The coloration of the head is highly variable, ranging from a vibrant yellow in northern China to olive-green in southeast Asia. A broad black post-orbital stripe enclosing an elongate yellow to olive-brown bar extends beyond the tympanum. The domed to slightly depressed carapace is orange-brown with three black longitudinal stripes. The plastron is almost entirely black with yellow edges. The posterior lobe of the plastron is notched and the anal seam is usually present in adults. The digits are webbed, and the natural habitat may range from high mountain streams to shallow muddy lakes and rice fields (Pritchard 1979; Timmins & Khounbouline 1999). In captivity, *C. trifasciata* may be maintained in a range of water depths, but is less aggressive toward other turtles when kept in shallow water. This species frequently buries in the soil provided for nesting. Males are slightly smaller (up to 20 cm long) than females (up to 28 cm long) and can be distinguished by a flatter carapace, a slightly concave plastron, and a larger, thicker tail with the vent posterior to the carapace margin. One or more clutches of one to four elongate eggs (45-61 mm x 25-29 mm) are laid annually (McCord & Baker, in prep).

Cuora aurocapitata (Luo & Zong 1988) is endemic to China and known only from Anhui Province. The lemon-yellow head and dark eyes distinguish this species from *C. pani* which is similar in appearance and size (Luo & Zong 1988). The depressed carapace is reddish brown. The plastron has irregular black blotches and streaks on a yellow background. The posterior lobe of the plastron is notched and the anal seam is usually present in adults. The webbed digits indicate an aquatic habit, but in captivity this turtle exhibits a preference for shallow water. Males (up to 11.9 cm long) are much smaller than females (up to 16.4 cm long) and can be distinguished by a flatter carapace, a slightly concave plastron, and a larger, thicker tail with the vent posterior to the carapace margin. A clutch of three elongate eggs (39-46 mm x 18-24 mm) is produced annually (de Bruin & Zwartepoorte 1994). This species has been observed to excavate a much deeper nest cavity than has been observed for other *Cuora* (Jim Barzyk, pers. com.; WPM, pers. obs.). An incubation period of 66-67 days has been reported (de

Bruin & Zwartepoorte 1994).

Pan's box turtle, *C. pani* (Song 1984), is endemic to China, with widely separated collection localities in Shaanxi (Song 1984) and Yunnan Province (Ernst & McCord 1987). Although morphologically similar, *C. pani* is immediately distinguished from *C. aurocapitata* by an olive-green head coloration with two yellowish-green stripes behind the light colored eye (McCord & Iverson 1991). The depressed carapace is brownish black. Melanism progresses with age to create a bold, black, seam-following pattern against a yellow background (Ernst & McCord 1987). The posterior lobe of the plastron is notched and the anal seam is usually present in adults. Although the digits are distinctly webbed, this species prefers shallow water in captivity. Males (up to 14.3 cm long) are smaller than females (up to 15.6 cm long) and can be distinguished by a flatter carapace, a slightly concave plastron, and a larger, thicker tail with the vent posterior to the carapace margin.

Cuora yunnanensis (Boulenger 1906) was originally described in the genus *Cyclemys*, but recent reviewers have consistently placed it in the genus *Cuora*. This species is most similar to *C. pani* and *C. aurocapitata*, but it is distinguished from all other *Cuora* by a distinctive cream-colored pattern on the chin (Ernst 1988b). The head is brown with a narrow yellow stripe extending from the nostril to the eye (Ernst 1988b). The depressed carapace is brown with dark seams. The plastron is yellow or brown with dark seams and the posterior lobe is notched. The anal seam is usually present in adults. Males (up to 12.5 cm long) are slightly smaller than females (up to 13.8 cm long) and can be distinguished by a slightly concave plastron, and a larger, thicker tail with the vent posterior to the carapace margin. This turtle was discovered at high altitudes near Kunming, Yunnan Province; however, no reliable specimens have been collected since the type series. Unfortunately, this unique species, endemic to mainland China, is believed to be extinct.

McCord's box turtle, *C. mccordi* (Ernst, 1988a), is endemic to the Kwangsi and Yunnan provinces of western China. The head is yellow with an orange black-bordered temporal stripe. The moderately domed carapace is reddish brown. The plastron is yellow, with a distinctive black pattern that covers the majority of all but the humeral scutes. The posterior lobe of the plastron is notched and the anal seam is usually present in adults. In captivity, this turtle exhibits a preference for shallow water and both sexes have been observed to bury themselves in the soil provided for nesting. Males (up to 13 cm long) are slightly smaller than females (up to 15 cm long) and can be distinguished by a flatter carapace, a slightly concave plastron and a larger, thicker tail with the vent posterior to the carapace margin (Ernst 1988a). A clutch of one to three elongate eggs (45-48 mm x 23-24 mm) is produced annually (McCord & Baker, in prep).

Zhou's box turtle, *C. zhoui* (Zhao, Zhou & Ping 1990), was originally described from market specimens (Zhao et al. 1990), but is believed to be endemic to Yunnan Province, China (McCord & Iverson 1991). The pale green head has a narrow yellow line with a dark border that extends from the nostrils, through the eye, to the cream colored tympanum. The dull brown carapace (up to 18 cm long) is moderately domed. The plastron is mostly black with a central, yellow blotch

which varies in size. The posterior lobe of the plastron is notched and the anal seam is usually present in adults. Males are slightly smaller than females and can be distinguished by a flatter carapace and a larger, thicker tail with the vent posterior to the carapace margin.

Methods

The *Cuora* breeding facility is located in a large climate-controlled room. Natural light from windows and skylights provide a seasonal change in day length. The breeding enclosures are adapted from 3 m x 2 m x .5 m fiberglass tanks designed for the lobster industry. Each tank is factory fitted with a 6 cm drain in one corner and set on a slight angle to ensure proper drainage. The enclosures are divided into four zones; nest boxes, rinse tubs, courting area, and a pool. These enclosures are large enough to accommodate a breeding group of up to 3.10.

Females are acclimated to the breeding enclosures for approximately one year before males are introduced. Although the presence of multiple males can lead to difficulty in assigning parenthood, there is increased competition for females which seems to stimulate breeding activity. Alternatively, successful breeding of *Cuora* and other semi-aquatic turtles can be achieved by isolating males from females, briefly introducing them for mating, and then separating them again (Meier 2000).

Nest boxes are filled with moistened peat moss to a depth of 13 cm. Drainage holes in the bottom of each nest box prevent excess water from collecting. Two nest boxes, elevated a few centimeters above the water by a wooden platform, are positioned at the shallow end of the enclosure opposite the drain. These boxes may also function as a refuge, as several species have been observed to bury themselves in the soil provided for nesting.

The rinse tubs, identical in size to the nest boxes, are filled with water and positioned adjacent to the elevated nest boxes, such that turtles must pass through them to wash off any adhering peat moss before entering the courting area. Ribbed plastic mats, clay bricks, natural rock, and quartered logs are used to create ramps that assist turtles entering and leaving the rinse tubs. Two full-spectrum fluorescent bulbs are positioned 22-25 cm above the nest boxes and rinse tubs.

The water in the courting area is shallow (5-8 cm) and has several quartered logs for sight barriers. Courting is most often witnessed immediately following a water change. Although courtship patterns are species-specific, they can be generalized as reciprocal head-bobbing displays followed by attempted copulation (Harding 1989). These interactions can be aggressive in some *Cuora* species (de Bruin & Zwartepoorte 1994; Ernst & Barbour 1989).

A pool constructed from a large plastic tub is placed in the deepest end of the enclosure. Water depth is approximately 10-12 cm and is refilled as needed. Bricks and logs are placed adjacent to the pool to facilitate entry and exit. Courtship and copulation has occasionally been observed in the deep water.

The turtles are fed twice each week: one feeding of pelleted trout chow (AquaMax, Purina Mills, St. Louis, MO) and a second feeding of fresh fruits and vegetables. Occasionally, turtles are fed worms and pinky mice. The enclosures are thoroughly cleaned after each feeding and as needed. Nest boxes are manually excavated at regular intervals to inspect for eggs. Routinely mixing and moistening the peat moss in the nest boxes appears to stimulate nesting behavior. Turtles rarely lay eggs in dry peat moss, and eggs laid in moss that is too moist may not develop.

Although freshly laid eggs are less sensitive to injury during transport, every egg should be handled with care not to rotate or jostle a developing embryo. The brittle shelled eggs are partially buried in 8 cm of moistened peat moss or vermiculite in a plastic incubator box. The box is labeled with the species name and date of oviposition and placed in an incubator (Helix Controls, San Diego) chalking usually proceeds from the center towards one end at first, but eventually covers 90-100% of the egg. By periodically candling the eggs, the formation of blood vessels and ultimately an embryo can be observed in a fertile egg. Infertile and undeveloped eggs often become moldy and are removed as necessary. Incubation is usually completed in 60-90 days.

Depending on the condition of the external yolk sac, hatchlings are removed from the incubator 1-2 days after emerging from the egg. Each individual is inspected and placed in a separate tub of moistened sphagnum moss for 10-14 days. The carapace of the egg-shaped neonate quickly expands to the circular, tricarinate form characteristic of hatchlings from this genus. During this period the umbilicus is examined to ensure that the external yolk sac has been completely absorbed. After one week the hatchling is offered live black worms (Tubifex sp.) every other day. Once the hatchling is feeding regularly, it is placed in a large rearing enclosure with 6-7 hatchlings of similar size. The water in the enclosure is shallow (3-4 cm max) and barely covers a thick layer of leafy sphagnum moss. In order to maintain a water depth gradient, the hatchling rearing enclosures are kept on a slight incline. A flat rock with a heat lamp is positioned at the shallow end for basking and several artificial caves are placed throughout the enclosure. The enclosures are exposed to full-spectrum light from fluorescent bulbs. Hatchlings are fed live black worms at first, and then ReptoMin (Tetra, Blacksburg, VA) two out of every three nights for the first two years. Water and sphagnum moss are changed as needed.

Discussion

Captive breeding programs will play an increasingly important role in an integrated program for the recovery of many critically endangered Asian turtle species. A tremendous international effort will be necessary to preserve the diversity of turtles in Asia, especially the species endemic to China, involving the cooperation of the governments of range states and countries with ex situ breeding programs, conservation organizations, and the previously untapped resource of private breeders. While the ultimate goal of repatriation of captive bred turtles to the wild is unlikely in the near future, the short term goals of captive breeding programs are attainable: maintaining viable populations; raising public awareness of the issues involved in turtle conservation; recording

previously unknown data on reproduction, behavior, and diet; and supporting conservation programs in range countries.

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The Dream
(Abstract Only)

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"The Dream" in my mind's eye is a worthy goal or process that adds value to other peoples' lives. The thin thread of "The Serpent" has interwoven so many relationships and opportunities to enable a select few who are willing to accept a life of passionate pursuit in this so often misunderstood fascinating world of the reptile. An overview of the process of events, which many people, will either like or dislike, regarding how society is embracing reptiles as a "main stream" part of the family unit. Where is it heading? How can we further continue to be a significant part of establishing what future generations to come will be able to observe or posses? Change is constant, so we must be also. Many questions to be asked but, together those interested people of like-mindedness can ensure a viable world for the "Living Reptiles".

Husbandry and Captive Reproduction of the Cuban False Chameleon (*Chamaeleolis chamaeleonides*)

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Cuba is home to over 90 species of lizards. The Genus *Chamaeleolis* is a distinctive genus of anoline lizards, and is comprised of five taxa. *C. chamaeleonides* has one of the widest distributions among the group. Until recent years, this species was not represented in US collections due to political constraints, hence captive management techniques were unknown. In an effort to establish general husbandry protocols for large anoline lizards, the Fort Worth Zoo received a single pair of captive hatched adults in 1992 from the Czech Republic. This program has proven to be very successful, and to date the Fort Worth Zoo has produced more than 30 specimens, including second generation offspring. All aspects of this group's husbandry will be discussed, especially environmental requirements, diet, propagation, and neonate husbandry.

Introduction

Chamaeleolis chamaeleonides, the Cuban False Chameleon, is one of the strangest lizards in the Caribbean. Currently there are five recognized species (*C. agueroi, C. barbatos, C. chamaeleonides, C. guamuhaya, and C. porcus*) all endemic to Cuba (Leal and Losos, 2000). There is some conflict as to whether *Chamaeleolis* should be recognized as a distinct genus or put into *Anolis* (Frost and Etheridge, 1989, Hass et al., 1993). For the purposes of this paper, the author will continue to use *Chamaeleolis.*

Chamaeleolis chamaeleonides is a large anole lizard. Male snout-vent length typically measures about 146.9 mm, with females measuring slightly smaller at 139.8mm (Rodriguez Schettino, 1999). The color varies from light gray to dark brown and is correlated with temperature or stress levels. The genus does have independent eye movement, though it is not as developed as it is in true chameleons.

There is not a lot of sexual dimorphism for this species. Males are larger, with a slightly larger head. However the most obvious difference is adult males have two enlarged scales just below the vent; this enlargement is hard to see in small specimens.

Chamaeleolis chamaeleonides has the widest distribution among all the species, and can be found in all provinces in Cuba (Garrido and Schwartz, 1967). The habitat for *Chamaeleolis* spp. is contiguous forest, but it has also been sighted in fruit and coffee plantations. *Chamaeleolis* spp. are arboreal lizards that are usually found approximately 4.2m above ground under the shade of vegetation (Rodriguez Schettino, 1999).

The typical locomotion of this species is very much like the slow and deliberate pattern seen in Old World chamaeleontids (Garrido and Schwartz, 1967). Leal and Losos recently reported that *C. porcus* remained stationary for 63% of the time it was observed in the wild (2000). These lizards rely heavily on their cryptic coloration and behavior to avoid predation; if sighted the lizard will squirrel around its perch. Another distinct aspect of this lizard's natural history is its specialized diet of snails and slugs.

The Fort Worth Zoo acquired a single pair of adults in February of 1992 from what is now the Czech Republic. These animals were part of the zoo's effort to establish a large anoline program. The Fort Worth Zoo has gone on to produce more than 30 offspring, including five second-generation specimens. The original pair is still alive and represents a longevity record of ten years.

Methods

The adult lizards were kept in a twenty-nine gallon long aquarium. There were two wooden branches used for perches. The diameters of the perches were approximately one and one half to two inches. The branches were arranged so they would provide horizontal perches. Moist sphagnum moss was used as the substrate for the enclosure. The moss was approximately two inches deep, and covered the entire floor of the enclosure. This set up allowed for feces to be easily picked out of the tank.

Two fluorescent black lights (Sylvania 350BL) were mounted approximately four inches above the cage. A fifty-watt spotlight was provided. The photoperiod corresponded with the photoperiod of north central Texas.

Chamaeleolis will sometimes drink from a water bowl. However, they prefer to drink form a slow dripping water source. An I.V. drip system with a valve that controlled the water flow was used. This drip bottle was filled an emptied once a day. The lizards quickly became conditioned to this system and would readily move to the water source. The substrate helped to soak up extra water, and a small hole was drilled into the bottom of the tank so the excess water would drain out.

We also used plastic gallon milk containers with a small hole punched into the bottom. Both the I.V. drip system and the plastic bottles were washed out once a week with a disinfectant to prevent bacteria from growing in the watering system. We found it was very important to keep these lizards well hydrated. If not, they showed the typical signs of dehydration common to other lizards such as sunken eyes and lethargy. A water bowl can be provided, but it is more important to offer a dripping water source at least once a day.

Chamaeleolis are specialized feeders and this was taken into consideration when forming the lizards' diet. The Fort Worth Zoo acquired a source for land snails from California, where they are considered a pest. Single live snails were offered on forceps to the lizards. Most of the lizards at the Fort Worth Zoo readily ate snails from tongs. The lizards were also fed crickets, and pinkie mice. The lizards were offered mealworms, and earthworms, but these food items were not typically

accepted. The feeding schedule for the adult lizards was two snails twice a week, and seven to ten crickets once a week. The crickets were offered on tongs, and sometimes left loose in the cage. If crickets were left in the cage, small pieces of carrots were also left in the enclosure for the crickets to eat.

It was important to keep males in separate enclosures. They also needed to have visual barriers between enclosures. Visually connected males would constantly display and become dark brown and very stressed. We taped pieces of black plastic trash bags to the side of the aquariums. This worked well because the material could get wet without falling apart.

The Fort Worth Zoo had very few medical problems with *Chamaeleolis*. The problem of swollen eyes always responded well to antibiotic drops. Two nematode species, *Travassozolaimus travassosi* and *Cyrtosomum longicaudatum* have been documented in *Chamaeleolis chamaeleonides* (Rodriguez Schettino, 1999).

No special actions were taken to induce reproduction of *Chamaeleolis* at the Fort Worth Zoo. The adult lizards were kept together year round. Copulation was seen during each month of the year. The female readily laid eggs in the sphagnum substrate during each month of the year. The female never showed any clear signs of being gravid. However, a behavioral cue was the female sitting on the bottom of the cage. The author saw her on the floor of the enclosure only prior to finding an egg.

Results

The eggs were typically found about 2cm below the surface of the substrate. Single eggs were laid approximately every thirty days; although one female reached a peak of one egg every ten days. The average egg length was 25.18mm and the average mass was 4.17g. The temperatures at which the eggs were incubated ranged from 78-82° (Table 1). The average incubation time was sixty-seven days. The average measurements for neonates were 44.64mm for snout-vent length, and average mass was 2.75g (Table 2).

Neonate lizards were kept very similar to the adult lizards. The enclosures were two-gallon glass aquariums. Small twigs were placed in the tanks at approximately a forty-five degree angle across the length of the tank. The diameters of the twigs were about one quarter to one half inch. Single fronds from a plastic fern were also placed in the enclosure to provide visual security for the lizards.

The young lizards were misted once or twice a day with a small spray bottle. In most cases the lizards would not begin to drink immediately, but after about thirty to forty seconds, they would begin licking the perch or the plastic plant. The lizards would then be misted until they stopped drinking.

The neonates were primarily fed two-week old crickets, three times a week. When small snails (about the size of a pea) were available they would also be offered. All the neonates were tong fed. The lizards were lightly tapped on the side of the mouth until they opened their mouths in a threat display. Then the food items were placed on their tongues. The lizards would close their mouths and later swallow the food

item. The neonates quickly became conditioned and would attack the end of the tongs in a strong feeding response. Small mealworm and wax worms were occasionally offered but were not as readily accepted by the young lizards.

Conclusions

Chamaeleolis chamaeleonides proved to be a great species to work with. The lizards require very little space, and as long as their basic needs are met, they thrive with little specialized attention. The Fort Worth Zoo has been very successful with *Chamaeleolis chamaeleonides*, and other large anole, such as *Anolis smallwoodi*. The keys to Fort Worth's success in maintaining and reproducing this species are the drip system used for hydration, and providing the lizards with their natural diet, snails.

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Table 1

Egg Data for *Chamaeleolis*	
Average Egg Length	25.18mm
Average Egg Width	17.29mm
Average Egg Mass	4.17g
Incubation Temperature Range	78-82°F

Table 2

Chamaeleolis Hatchling Data	
Average Incubation Tine	67 Days
Average Snout-Vent Length	44.64mm
Average Total Length	83.88mm
Average Mass	2.75g

Implementing Solutions to the Turtle Crisis in Asia

(Abstract Only)

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At this point in time, there are few sectors of the conservation and herpetological communities that have not heard of the crisis facing Asian freshwater turtles and tortoises. The documentation of the unsustainable commercial exploitation of chelonians for the food and traditional medicine is convincing and undeniably real. Feelings of hopelessness have at times been nearly overwhelming. However, over the past year, substantial progress has been made towards achieving action on the behalf of beleaguered turtle species. International conservation organizations, zoos and aquariums, private turtle hobbyists, government authorities, and university research scientists have begun to work together on this problem. Fund-raising efforts are beginning to bear fruit. Long-range efforts are being launched on several fronts including support for education programs and law enforcement efforts in the range countries, identification of proposed and "protected" natural areas within range countries, field research and surveys to identify original distributions, habitats, and life histories of Asian turtle species, and the establishment of range country rescue centers. Of perhaps greatest immediate importance is the progress being made to establish genetically viable populations (Assurance Colonies) of every species of exploited chelonian and to house them in long term captive or semi-wild conservation programs. The Turtle Survival Alliance (TSA), a new working group of the IUCN, has been formed to facilitate action in this direction. Through collaborative efforts with the institutions and individuals referred to above, many of these "Assurance Colonies" will be established in the United States and hopefully in range countries through collaboration with international government authorities. They will be stocked primarily through the confiscations of illegally traded turtles. Should the combined education and enforcement efforts prove not effective in time to prevent the extinctions of turtle species in the wild in Asia, Assurance Colonies will "keep the pieces" and provide future reintroduction options.

The History of Western Herpetoculture Before the 20th Century

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Although the world's first reptile keepers may have been Chinese, Egyptian or even Mexican, historical data suggests that the beginnings of herpetoculture, as we understand it, was primarily a British and European endeavor during the 19th Century. This is indicated by the first known specialist Chelonian building constructed in 1820, the first zoo reptile house in 1849, and the first book, in English, on herpetoculture: *The Vivarium*, published in 1897. The huge increase of individual wealth, as a result of the British industrial revolution and its empire, provided the means and the leisure for many privileged individuals to indulge themselves in the then increasingly fashionable study of natural history, including herpetology. Increasing knowledge, higher expectations and improved technology contributed to the success of their captive care. The data available outlines some of the pioneering attempts of these, mostly forgotten, early herpetoculturists to provide us with the foundations of the knowledge and skills that we enjoy today. Early captive-breeding successes were more frequent than generally supposed. For at least one snake species, captive breeding has not been repeated to this day. It is also possible to speculate, from available data, on the exchange of information between at least one of these early British pioneers and his colleagues in North America.

Earliest Records

The early documented history of keeping exotic species, including reptiles, in captivity has always been an indication of both sufficient wealth and civilization. Also it would appear that the skills required to keep reptiles and amphibians successfully have been gained and then lost many times through the course of human history. Early evidence of the keeping of captive reptiles is very sparse. The relatively few facts are both tantalizing and frustrating, because there is not more information. It is not until we get to the 19th Century that we begin to find significant data and observations on captive care.

Not surprisingly, the first to keep exotic species in captivity were monarchs and emperors, having both the necessary wealth and time to indulge themselves. Only much later would wealthy private individuals attempt to emulate them. Perhaps the earliest record of the keeping of wild animals, including reptiles such as cobras and crocodiles, is from the pictographs and hieroglyphs of 2500 BC found at the Saqqara cemetery near Memphis in Egypt. These show that the Egyptians of the time kept a wide range of exotic species, including those that were most holy to them, and used them in religious ceremonies. The Egyptians are also the first documented race to have sent out an expedition to collect wild animals. Queen Hatsheput, daughter of Thutmose I of the Eighteenth Dynasty, sent an expedition to the "Land of Punt," probably Somalia, to bring back a wide range of species. In addition to this, the Egyptian kings both received and gave a bewildering variety of exotic animals in the form of tributes to other nations.

Ptolomy I of Egypt (323 - 285 BC) was particularly interested in animals and founded a great zoo in Alexandria. His successor, Ptolomy II Philadelphus, enlarged this zoo and staged one of the world's largest animal processions in history, on the Feast of Dionysus in the year 285 BC, which included snakes such as Cobras, and large crocodiles. Ptolomy II was also the recipient of a huge python that was the primary objective of a privately coordinated expedition to the Upper Nile sometime between 282 - 246 BC. This huge python was a principal exhibit in Ptolomy II's personal collection of exotic and rare animals.

To the east, the kings of Ur kept wild animals from about 2000 BC in large walled gardens which in the Babylonian region of Persia later became known as *paradeisos*, from which is derived the word paradise. The first recorded tribute in the region, from one king to another, was that sent to the Assyrian king Tiglath-Pileser I around 1100 BC. The pharaoh of Egypt sent him a gift of a large crocodile, a hippopotamus and several "strange fish of the sea." This tribute of giving rare and exotic animals to presidents and kings continues even to this day, such as the Pandas and Komodo dragons exchanged between different countries.

In China, a 900-acre walled "Park of Knowledge" was constructed some time around 1150 BC for the use of the Emperor Wen Wang in the province of Henan (located between Beijing and Nanjing), though deer and fish were the main inmates. Subsequent emperors of China constructed similar parks until the Middle Ages, including Kublai Khan in the thirteenth century at Shang-tu. In 1417, Yung-lo, a Chinese Ming dynasty emperor, sent an expedition from China to Africa to bring back a live giraffe. He already had a zebra and other African animals. It is inconceivable that this same expedition would not have returned to China without the addition of many smaller species, including reptiles.

The ancient Greeks never had large royal animal collections, though wealthy individuals from the seventh century BC onwards developed more serious and inquiring attitudes toward the exotic animals that they kept. This resulted in the first written information concerning a wide range of species, including reptiles. By the second century BC, wealthy Romans were keeping private collections of animals including snakes. As early as 186 BC, a wide range of exotic animals began to be imported to fuel the gladiatorial games, including crocodiles and large snakes from Africa and other species from Northern Europe and Asia. These animals came as gifts and tributes from the governors of roman colonies, foreign dignitaries and monarchs, but also from animal traders.

In Rome, extensive animal holding facilities were constructed called "vivaria," usually in association with the arenas. In the third century AD, one was located just outside the Praenestine Gate. This vivarium was 440 yards long and 70 yards wide, with one long wall adjacent to the city wall. Although mainly a holding facility, it is thought that the public were allowed in to view the inmates.

Each Roman emperor strove to outdo his predecessor in terms of triumphal processions including exotic animals and exhibitions of animals being killed in the arenas. At the beginning of the Christian era between 29 BC and 14 AD, the

Roman emperor Octavious Augustus had more than 3,500 wild and tamed exotic animals from his vivaria killed in 26 exhibitions, including 420 tigers, 260 lions, 36 crocodiles, and a snake recorded as 25 yards long.

Medieval Period

In 1519, Hernando Cortés and his soldiers arrived at Tenochtitlan, the Aztec capital, now known as Mexico City. There, they discovered probably the world's largest royal menagerie maintained by the Aztec emperor, Montezuma. Amongst the proliferation of wildlife kept there, and described by Diaz del Castillo, were "vipers and poisonous snakes which had on their tails things that sound like bells. These are the worst vipers of all, and they keep them in jars and great pottery vessels...and there they lay their eggs and rear their young."

The Aztecs revered snakes as important religious symbols, which is probably why they kept so many of them. They also used many animals, including snakes, as sacrifices to their gods, and this may have been the main reason for the existence of the menagerie. However, Montezuma is perhaps the first successful herpetoculturalist to be recorded in human history. Others almost certainly have previously existed in ancient history but without any surviving record.

Dial del Castillo went on to suggest that Montezuma's reptiles were not only fed on "deer, fowls, dogs and other things" that the Aztecs hunted, but also wrote "I have heard it said that they feed them on the flesh of the bodies of the Indians who have been sacrificed." This confirms their religious significance in Aztec society, and the possible use of some method of force-feeding. This important and impressive imperial menagerie was totally destroyed following the conquest of the Aztecs by the invading Spanish.

Quetzalcóatl, whose name means "feathered serpent" (cóatl meaning snake), was a very important Aztec god. He was previously a god of the Toltec people who were conquered by the Aztecs, but adopted by them into their religion. Aztec legend has it that Quetzalcóatl was originally a human being who taught the Toltec's to work metals. He was respected as a good and wise leader but was defeated by the Aztec god Tezcatlipoca, escaping into Yucatan. From there he headed east promising to return. It is for this reason that the Spanish were welcomed when they arrived, as the Aztecs considered them to be Quetzalcóatl's returning party.

As a special cult object, Quetzalcóatl was perceived as the god of wind and both the morning and evening stars. He was credited with creating the world, creating humanity and providing it with corn, and also, more bizarrely, with inventing the calendar. He was one of the few Aztec deities that did not require human sacrifice. Sacrifices to him were generally confined to snakes, birds and butterflies.

In Europe during the Middle Ages, the requirement for large numbers of exotic animals diminished with the decline of the bloody Roman spectacles, and once more it was royalty and wealthy merchants who indulged their passion for unusual pets. Henry I of England, the youngest son of William the Conqueror, in

about 1100 established the first recorded Royal menagerie in England at Woodstock. Later, King John (1199 - 1216) continued the tradition during the Crusades, and at the time of Robin Hood. In 1243, a William de Botton became the first recorded animal keeper of the Royal Menagerie. It became normal for a nobleman to assume this position in the collection's earliest years.

In 1231, the Holy Roman emperor Frederick II von Hohenstaufen, leader of the Fifth Crusade, had established the first great European menagerie of wild animals at his court in southern Italy. In 1250, Frederick sent his brother-in-law, Henry III of England, a gift of three leopards. A manuscript of the time at the College of Arms says, "Since the arrival of three leopards in London in 1250 there are constant records of payment made for maintenance of the animals at the Tower." The payment was six pence per Leopard per day (three cents) and three halfpence per day for the keeper (less than half a cent). These three leopards have become forever immortalized in the royal coat of arms of the kings and queens of England since that time. In 1252, Henry III transferred the animals at Woodstock, established by his predecessors, to the Tower of London. In 1255, he desired the Sheriffs of London to build a house for an elephant at the Tower. It was sent as a gift to him from Louis IX of France. He issued the following decree: "We command you that, of the farm of our city, to cause, without delay, to be built at our Tower of London, one house of forty feet long, and twenty deep, for our elephant."

The 19th Century

So began the 735-year history of the famous Royal Menagerie, which lasted until 1835. In the 15th Century, both the 13th Earl of Oxford and Sir Robert Brakenbury served as keepers, continuing the tradition of noblemen in this position. During the 16th and 17th Centuries, the management of the collection was undertaken by commoners, namely successive generations of the Gill family from Essex.

All English monarchs appeared to enjoy the menagerie and provide it with their full support, except for Oliver Cromwell, who took power after the English Civil War and the execution of Charles I for treason. He became known as Lord Protector, having refused to be crowned as King. Cromwell tried to close the menagerie but failed. He did, however, stop much of the excessive baiting of the animals that had taken place previously. By 1831, most the tower's inmates had been transferred to the newly formed Zoological Society of London, the Dublin Zoological Garden, the United States, and the Exeter 'Change.

Visitors to the Tower of London today can still see the site of this ancient menagerie. In front of the middle tower, at the entrance to the Tower of London, you can see the foundations of a semi-circular building. A plaque informs that this recently excavated site was once the location of the famous Lion Tower, the original menagerie of the Kings and Queens of England.

In its later years of existence, the Tower of London maintained an alligator, which was fed once a week on raw beef, and a pair of probably Burmese pythons, which subsequently bred and laid 14 eggs after two years in the collection, but

unfortunately failed to successfully incubate them. This is perhaps not surprising when you consider that the tower comprised of stone-built and metal-barred enclosures designed for large mammalian carnivores. Probably these would have been difficult to heat adequately at the best of times.

The tower was also recorded as having a collection of over 100 rattlesnakes! They were described as being between 4 to 6 feet in length and differing considerably in color and markings. Unfortunately, no other information about this fascinating snake collection appears to have been recorded. This data does perhaps indicate that their keeper, a Mr. Alfred Cops, was surprisingly successful at keeping reptiles in less than ideal facilities.

As described above, the animals at the tower were mostly transferred in 1831, on the instruction of King William IV, to the Zoological Society of London. A female American crocodile, *Crocodylus acutus*, recorded as alive in the gardens in 1831 and the first individual of this species to be received by the society, may have been the tower "alligator." Similarly, Burmese pythons, *Python molurus bivittatus*, were recorded as first received before 1833 and could also have been those previously kept, and unsuccessfully bred, at the tower. There is no record of the collection of over 100 rattlesnakes going to the Zoological Society of London or anywhere else. The zoo's earliest record of receiving one is that of a timber rattlesnake in either 1842 or 1843. We can perhaps assume that their keeper, Alfred Cops, left with them in his possession.

Chunee, the famous elephant, shot by a firing squad in 1826, lived at the Exeter 'Change in the Strand, and was looked after by the same Alfred Cops. Cops, however, left this position in 1822 to take charge of the Royal Menagerie at the Tower of London, as indicated above. He transformed and improved this collection and became a useful contact and animal supplier for visiting American showmen, who frequently stayed with him while in London, including one who went on to marry his daughter in 1841. It is interesting to speculate if it was this close contact with the Americans that led to the intriguing collection of 100 rattlesnakes at the tower, mentioned above.

It was also Cops who came close to successfully breeding the Burmese pythons at the tower. At the same time, he had a large snake described as an "Anaconda, from Ceylon, which in no way differed from the Burmese python though of a lighter color." This is an accurate description of the Ceylonese python, *Python molurus pimbura*. This snake nearly killed Cops when it grabbed his hand when being fed. It was at the time "almost blind from the approaching change of its skin." It managed to get two coils around Cops' neck, and he had to be rescued by an assistant keeper.

It is interesting to speculate about what became of Mr. Alfred Cops. After the tower menagerie finally closed in 1835, an Englishman from London, named Cops, is known to have arrived in the United States, complete with what was perhaps the first mobile USA reptile show. With such an unusual surname, and his previous dealings with American showmen, surely this must be the same Alfred Cops. If it was, he would certainly have taken his knowledge and husbandry

techniques with him, and perhaps even the rattlesnake collection. This would also provide a more realistic opportunity for one of his American showman friends to become his son-in-law six years later, as described above.

If this account is true, this could be one of the first transfers of the technology of herpetoculture from Europe to the United States. It would be most likely that Alfred would have shared his knowledge and experiences with at least his son-in-law. It is also probable that he shared his expertise with those who purchased reptiles and other animals from him, both in London and later in the United States.

Due to my historical research, it surprises me less to discover that something we thought was a recent invention or technique in herpetoculture is something that has been developed or invented in the past but then mostly forgotten again. It makes you speculate just how much we may have tragically lost and forgotten forever.

An example that is fortunately not lost and forgotten is the interesting tale of the pinky pump. I had previously considered this invaluable device for force-feeding hatchling snakes to be the original invention of a friend of Seattle herpetoculturist Ernie Wagner's in the late 1970s, who, I believe, was named Scott.

I was able to obtain an original pinky pump from another friend of Ernie's, named Warren Jones, during a visit to Ernie in 1980. On returning to England I believed this to be the first mechanical device in the UK to assist with the force-feeding of snakes. From this example, a number of UK herpetoculturists had additional pinky pumps made, and so it became an important tool for practically all serious captive breeders of colubrid snakes in the UK during the 1980s.

The design is simply based on that of a hypodermic syringe constructed of stainless steel and PTFE plastic for hygiene and durability. The principle of the pump's use is to introduce a dead pinkie mouse into the barrel with the plunger removed. The plunger is then replaced and depressed with some force to expel the pinkie through the small offset holes in the end of the cannula. This effectively liquefies the pinkie in one operation. This liquefied material is then replaced back into the barrel and the process repeated until the material passes through the pump with a smooth consistency and all bone is reduced to a size small enough to readily pass through the cannula. Once this has been done, the material is once more placed back into the barrel and the plunger depressed until the material can be seen as a dark shadow to fill the cannula to the tip with no air spaces. The spoon-shaped end of the cannula is then used to gently pry open the mouth of the hatchling snake, which is restrained in one hand. The cannula is passed down the throat of the snake, and the finger and thumb moved back to restrict the snake's neck around the penetrated tip of the cannula. The plunger is slowly and smoothly depressed, expelling the macerated pinkie deep into the snake's gullet. If the finger and thumb are not used to restrict the snake's throat around the end of the cannula then there is the risk of the material flowing back up and out of the snake's mouth, rather than all going down its throat. Raw egg can be used to lubricate the tip of the cannula if this is thought to be necessary.

The pinky pump, as I described above, is definitely an improvement on what follows below. However, it is nonetheless very interesting to realize that something so similar in principle was available to UK herpetoculturists, and apparently possibly even earlier to USA herpetoculturists, back in the late 19th Century. It is also interesting to speculate, was it Alfred Cops who took this husbandry technique to the USA when he emigrated there from the UK in 1835?

Below is reproduced verbatum the relevant text from the Reverend Bateman's 1897 book, *The Vivarium*, published by L. Upcott Gill, 170, the Strand, London, from page 289 to page 293 inclusive.

> No animals, in their manner of taking food, are more capricious than snakes. Sometimes their desire to feed is so great, that they will eat a meal out of all proportion to their size; and, sometimes, without any apparent cause, they will refuse food, even the most suitable, until they die of starvation. As a rule, these creatures cannot be persuaded to seize any prey that is not natural to them. For example, a snake which lives upon frogs will not under any account, as a general thing, take lizards, though the latter may be as nourishing to the Ophidian as the former, and possibly even more so, nor will a lizard-eating snake be tempted to swallow a newt.
>
> Even if snakes did never refuse their natural food, the supplying of it is not always convenient, nor is it, to most people, pleasant. Young mice and rats, frogs and lizards are not continually at hand, and it is not, by any means, an attractive sight to see a Snake, at evident discomfort to itself, swallowing a live animal or one recently constricted or poisoned.
>
> One of the drawbacks therefore, perhaps the only important one, to the keeping in confinement of these interesting reptiles is the feeding of them. This drawback, however, in a great measure, may be overcome by supplying the Snakes with their food artificially. Generally this means of feeding is very successful and satisfactory. The Snakes thus get sufficient food regularly; and, if properly administered, the discomfort to the reptile, I believe, is not nearly so great as it is when it takes its food in a natural way. I think that most people, after they have watched the two operations, will be disposed to agree with me in this respect.
>
> As far as I can see, no Snake is deprived of any pleasure by being fed artificially. For many reasons it is fairly safe to conclude that Snakes have little or no sense of taste whatever. Many of my own Snakes would have been dead long ago, had I not fed them forcibly, and so prevented them from starving themselves to death. Almost invariably when a Snake has been so treated it has recovered its appetite, and when given the opportunity, taken food of its own accord.

I believe many keepers of reptiles in Zoological Gardens adopt, to a greater or lesser extent, the artificial system of feeding their charges. The largest snake in the Reptile House, Regent's Park, London, and which is also perhaps the largest snake in captivity anywhere, has been hand fed for the last three years at least, and is in splendid condition, weighing probably something like 18 stones (252 lb or 114.3 kg). This snake, the Reticulated Python (*Python reticulatus*), receives its food regularly once a week.

The forcible giving of food does not interfere in the slightest degree with a snake's becoming tame. Indeed, I think that this extra handling tends towards that desired end.

There are several methods of administering food to snakes. For example (1) some snakes will swallow a dead animal, or even a piece of meat, when it has been simply placed between their jaws. (2) The snake's mouth is forcibly opened, and a small dead animal, dipped in milk, is pushed down the throat, and then worked down the gullet by the manipulation of the fingers outside the snake's body. (3) Pieces of meat, or portions of animals, dipped in milk, are pushed sufficiently far down the opened mouth of the snake by means of a smooth stick. (4) A tube is filled with food, and passed down the gullet of the reptile, and then the contents of the tube are discharged by means of a piece of cane used as a ramrod.

This last method I have generally adopted. I was told, a few months ago, by the keeper at the Reptile-House, that tubes were used for the purpose of artificially feeding snakes in the Zoological Gardens in America. Until I received this information I was under the impression that I was the only one who employed tubes in the forcible administration of food for these Reptiles.

The tubes, which should be of glass for small Snakes, and of india-rubber for the larger Reptiles, may be filled with dead animals, portions of dead animals, or butchers' meat cut into pieces, minced or scraped.

Anyone who has a taste for anatomy may like to fill the tubes with parts of dead animals. This, of course, is most suitable, but those who do not care for this kind of work should use butchers' meat instead, together with a few feathers, bits of fur, and the like. The butchers' meat, which may be employed, is the liver of bullocks, calves, sheep, and pigs for the larger Snakes, and beef-steak (which can be scraped) for the smaller reptiles. If the employment of raw meat be found to be unpleasant to some people, cooked meat may be substituted.

The tubes can be filled easily and quickly in the following ways: (1) Raw meat when cut up into pieces, just small enough to go down the

tube chosen, should be inserted in the tube by means of a pair of forceps, such as those used for dissecting purposes. Each piece of meat, as it is taken up by the forceps, ought to be dipped into milk and then placed in the tube, and being thus lubricated, and so the tube is filled with meat from end to end, if necessary. (2) When raw meat, such as beef steak, is scraped into very tiny parts by means of a sharp knife, a dry tube may be filled very rapidly with it, by placing the scraped meat in a mass on a board, and by dabbing quickly and repeatedly one end of the tube into the mass of meat. Under these circumstances, if the interior of the tube be quite dry, the meat is readily gathered up, and the tube soon becomes full from end to end. (3) When cooked meat is used, it may be prepared for the tubes by being passed two or three times through a mincing machine. When thus prepared, it should be treated as already suggested for the scraped meat. In both cases care ought to be taken that the meat does not become too closely packed, or it will not slip out of the tube sufficiently easily, and consequently it will enter the Snake in so compact a mass that the reptile will very likely get rid of it by disgorging. A snake will seldom disgorge - I think less seldom than when it has swallowed prey naturally - if the food has been gently and loosely deposited within it. (4) A common metal squirt, having an aperture of its nozzle slightly enlarged, is a very convenient instrument for quickly filling the tube with minced meat.

The tube should be of such a diameter that it will easily pass down the throat of the snake for which it is used. For example, for a snake 4 ft long and of stoutish build, glass tubes having a diameter of about 1/2 in. and about 1 ft. long should be used, the tube as a rule being filled full of meat.

For snakes of less than 2 ft. in length, tubes, such as those sold by chemists at 1/2d (half of an old UK penny) each for babies' feeding bottles, may be employed. These tubes are strong, and have, for their size, a large interior. They are, also, perfectly smooth at the ends. According to the needs of the snakes, one or more tubes full of meat can be inserted into the gullet of each reptile.

For snakes less than a foot in length, a specially prepared tube (Fig. 76) should be used. The tube receives its desired shape by being heated in a hot flame, and then drawn out to the necessary length and slenderness. This tube is easily filled with scraped raw meat, according to the directions already given, the larger end (A) of the tube being dabbed down into the meat. This larger part (Fig. 76) should hold just about sufficient meat for a meal for one small snake. A small ramrod, which exactly fits the broad part, is used to push the meat out of the lower part (B) into the gullet of the snake. Of course, the narrow portion of the tube always remains full of meat until, when all the feeding is done, it is emptied by means of a piece of wire. Young

snakes may be reared from the egg or from birth by such a contrivance as this tube.

A snake can be fed with the help of a tube in the following way: The reptile is taken gently, just behind the head, with the left hand, and its mouth is opened very carefully with a small paper-knife or some similar article. When this has been done the end of a filled tube, having been dipped in milk, is inserted into the opened mouth by an assistant. The tube is then, by the holder of the snake, gently passed into its gullet, and as soon as it is there, the assistant, by means of a ramrod, discharges the contents of the tube into the interior of the reptile. The animal is now fed, and should be returned to its vivarium, where it will lie and quietly digest its food. After a very little practice the whole operation may be performed quickly and with hardly any trouble. The very small snakes should have their mouths opened with a smooth piece of wire, such as the end of a hairpin. The tubes ought to possess no sharp edges, and be kept very clean. When a snake is so large and strong as to be likely to break a glass tube, an india-rubber tube must be substituted.

Snakes, when fed artificially, should be so fed regularly once a week. These reptiles, when fed by hand for the first time or two, sometimes disgorge.

So there we have it. I wonder how many times "the wheel" has been reinvented in herpetocultural terms. There is clearly much that we can learn from the past that is still relevant to how we keep our reptiles today.

In the 17th and 18th Centuries, the Dutch East India Company was the main supplier of reptiles and other exotic livestock into Europe through the port at Amsterdam, where they constructed special holding facilities. They also constructed a depot and holding facility at the Cape of Good Hope in South Africa, which operated until 1832. This was clearly additional to their more important trade in traditional dry goods. Other reptiles would have arrived as the speculative initiative of ship owners or even individual seamen. It is perhaps most likely that such a seaman was the source of the two escaped 2 ½-foot-long green lizards which caused such alarm to the villagers of Woscot and Penbury, in rural Worcestershire, England, in 1741.

The Exeter Exchange, previously mentioned, was a famous indoor menagerie at 287 the Strand, London. Established in the 1770s, it lasted until 1829. As its name suggests, it was also an important supplier of exotic species, including reptiles. Soon known to all simply as the Exeter 'Change, it was in reality an early shopping mall or arcade housing a variety of retail shops and market stalls. One section, the 'Change, was rented by a George Pidock. He used it as the headquarters for his summer traveling menagerie. On his death in 1810, the Exeter 'Change was purchased at auction by a Mr.S.Polito. He added several large snakes to the collection, plus the title 'Royal' in the name.

Within only seven years this gentleman sold out to a Mr. Edward Cross who quickly expanded the collection and now called it the Royal Grand National Menagerie, perhaps to more successfully compete with the nearby, and previously discussed, Tower Menagerie. Cross became an important animal dealer supplying other menageries and dealers both in Europe and the USA. In 1820, Cross published a guide called *The Companion to the Royal Menagerie, Exeter 'Change.* It included details of the most famous inhabitant there: an elephant named Chunee. This elephant was first exhibited on the stage at Covent Garden in 1810, and had by then apparently doubled his size to 10 feet at the shoulder and a weight of 5 tons. The unfortunate animal was shot by firing squad, on March 2, 1826, as previously described. It had refused poison placed in its food when it became intractable due to an infection in a damaged tusk. The only reptile listed in this guide to the collection was the "Boa Constrictor, the Giant Serpent of Tara." An old poster of the time, however, advertises the "Enormous Serpent of Java, which regularly swallowed six large fowls with their feathers at a meal" which appears to refer to a reticulated python. Also advertised was "the Spectacled or Hooded Serpent," clearly an Indian cobra, *Naja naja*, from the description of the spectacle marking on the back of its hood.

A Harry Richardson, who previously worked at the Exeter 'Change, later owned a traveling menagerie of snakes and other reptiles known as "Richardson's Menagerie of Reptiles." Records show that he exhibited these at the Bristol Fair in September of 1825 and again in 1828. In August of the same year, he is recorded as exhibiting at Camberwell Fair in London a collection including "the Boa Constrictor Serpent, the Anaconda Serpent, six live Crocodiles, a pair of Alligators, and a beautiful Circassian lady. The association is remarkable as a lady is seldom found in such company..."

This association was to become almost obligatory with future similar exhibits. Cyril Bloor recalls a travelling menagerie at Ashton-under Lyne, UK, in 1931 or 1932, called Manders' Lion Arena. The truly magnificent "tilt" (painted and decorated show-front) depicted lions, tigers, leopards, and hyenas leaping and snarling around splendidly uniformed trainers on the two main panels, while over the doorway, a buxom young lady clad in a leotard and Greek sandals blithely wrapped huge pythons around her ample curves. Bloor goes on to describe the actual show: "when a suitably big enough number of people was assembled, a young women in a leotard covered by a cloak drew our attention to the case from which she took the Python, placing it on her shoulders whilst she gyrated and posed." As late as 1970 I recall visiting a reptile side-show at the famous Goose Fair in Nottingham. It comprised an illuminated glass case containing a wide range of pythons, boas, and large lizards crawling over a young lady in an inadequate bikini. My main recollection of the event was how dirty the young ladies canvas shoes were!

A more detailed experience of a reptile show from Cyril Bloor recalls his visit to one in Stretford in 1936, in the UK. It was called Parry's Reptile Wonders and had a very ornate "tilt" with a gilded walk-up to allow paying viewers to look over the top of three sides of a 6-foot-tall wooden walled pit. The pit was floored with thick coconut matting and divided into four sections, each containing various types of

snakes; boas and pythons in one; venomous snakes in another; monitor lizards, etc. in another. There was no performance as such but a fellow in a compartment overlooking the pit pointed out various specimens with the use of a long forked stick. The exhibit was very brightly lit, perhaps to provide sufficient heat as well as illumination.

A Mr. Kendrick, an animal dealer who also sold reptiles in London, had premises in Piccadilly in the early 1800s and seems to have been fond of telling his customers that "it" came from Brazil! One of his regular reptile customers was Sir Robert Heron, at one time Member of Parliament for Peterborough, who had an estate at Stubton in Lincolnshire, where he kept an extensive private menagerie. In 1808, he was breeding goldfish, originally supplied by Kendrick, in an aquarium, and by about 1819 Heron describes some terrapins received from the same dealer: "About 4th June, I received from Kendrick three Brazil Tortoises, two and three quarter inches in the greatest length of the shell; the flesh green and yellow striped, the shell of a dingy green, brown and red. They delight in the warm water of the aquarium, but when the sun shines, sit basking on a pot, a stone or gravel. They will eat insects, small fish, and almost any animal food; they are active and tame; and in three months have grown three quarters of an inch." This description could be for the Central American ornate slider, *Trachemys scripta ornata.* The London Zoo had to wait until 1838 before it received a specimen of the same species, presented by a Dr. Harlan.

Robert Heron also wrote about a chameleon that he purchased in 1820:

> On Tuesday 28th March, a Chameleon was sent me, about eleven inches in length, tail included. It came in a wicker basket, covered with flannel; it was then entirely of a light yellow. I had it put into the pine stove. The next morning I found it on the stem of a vine; it was then entirely of a bright green, like the leaves of the vine. These colours, however, are not from reflection, as they do not change immediately on arrival. I have since always found it green, but, sometimes, with broad perpendicular stripes of a dark brown. Once, on being repeatedly molested, I saw the bag of the under jaw swell to an enormous size, and become yellow, whilst the rest of the body was covered with multitudes of spots, yellow and brown, completely circular.
>
> The house adjoining it's abode being painted so I moved it (the Chameleon) into the house for forcing cherries, but in the night it suffered so much from cold, that the next morning it seemed to be expiring. On being restored to its former residence, it soon recovered; it was, however, three days without recovering it's appetite. It now eats freely, and even voraciously, all flies, bees, etc., put within its reach: when apparently dying it did not change colour. I do not know the country from whence it came.
>
> The crown of the Chameleon does not differ from Buffon's (this Frenchman's book on Natural History described previously)

description: the only points in which the animals differ are, that the openings of the membranes which covers the eyes are perfectly circular, and that I have not found any grey colour upon it. The Chameleon continued in perfect health until this morning (22nd June 1820), when a stupid under-gardener destroyed him by hastily closing one of the lights on which he had climbed. He was brought from Brazil (chameleons as we know do not occur in the Americas). During a journey of six months no food was given him, and it was a month longer before he recovered his appetite. His brother, who travelled with him, is at the Exeter 'Change.

In about October of 1825 Robert Heron wrote of another Chameleon: "A Chameleon I brought down with me from London, in March, died this month. It had appeared healthy lately, when it's appetite fell off, and it appeared restless and generally on the ground. It was perhaps looking for a place in which it could repose itself for the winter; but it must be always very difficult in this country to provide it with an hibernacle sufficiently cool for it's purpose, and yet warm enough to preserve it's life."

Chameleons do not generally hibernate, so was this a female searching for somewhere to lay her eggs perhaps?

Finally, in 1827, he wrote: "Mr. Reid, near York, has two Water Tortoises brought over from the Siege of Belle Island, which commenced in 1761; one of them having wandered, was missing for 16 years, when it was found on cleaning out another pond. After 66 years both are alive, and very tame."

These were probably painted turtles, *Chrysemys picta*, as the Siege of Belle Island took place between Newfoundland and the Canadian mainland, as part of the Seven Years War, when the British were at war with the French for the possession of Canada.

In Hamburg, Germany, from 1841 until 1863, Carl Hagenbeck Senior, a wholesale fishmonger, had a small pet store devoted to exotic species. Legend has it that this side of his business began with six harbor seals caught in a fisherman's net, who supplied him. The 1860s were a boom period for the supply and sale of wild animals, and zoological gardens became established in Europe at the rate of almost one a year with a similar increase in interest from private keepers. In 1863, Hagenbeck's animal business became independent of his wholesale fish business and was located on Spielbudenplatz, or Gaming Booth Square, in the heart of the red-light district, as it is today.

The shop had two sections onto the street devoted to the sale of monkeys and parrots, respectively. In a courtyard at the back amongst stacked cages of birds were wooden tubs of water containing seals. An 80 x 30 foot barn at the back housed larger mammals, including elephants and rhinoceroses. It was here also that crates housing boas and pythons were located, lined up along the center aisle. In 1866, Hagenbeck Senior passed on the animal business to his son Carl Hagenbeck Junior. Within ten years he had become the largest dealer in exotic

species in the world. In 1874, he relocated the business to a two-acre site in Neur Pferdemarkt, or New Horse Market, a mile and a half north of his previous premises. Here, he constructed special buildings to display his animals to the public, including a reptile house. This "zoo" was stocked to overflowing with the rarest and most valuable specimens. It was the first to exhibit a wide range of new species. Hagenbeck supplied animals, including reptiles, to the USA, to both animal dealers and zoos. He also supplied animals for exhibition at two World Trade Fairs, first in Chicago in 1893 and again in St. Louis in 1904.

Dante Gabriel Rossetti, miserable after the death of his wife in 1862, moved to 16, Cheyne Walk, Chelsea, London, close to the banks of the Thames river. Here, he was to live for the rest of his life. There was almost an acre of garden, which became more and more overgrown. In the garden he established a menagerie of bewildering variety, much to the despair of his neighbors. He is recorded as keeping a chameleon, green lizards and salamanders. A local cook was shocked to discover an armadillo burrowing through the floor of her kitchen, and another became enraged at a racoon that stole her eggs. Amongst other animals were two kangaroos, the mother subsequently being killed by her son, peacocks, one of which had its tail stamped off by the deer, and a Brahmin bull. This animal, on its first day with Rossetti, charged through the house and out into the garden. On the second day it charged back through the house and out onto the street with Rossetti in hot pursuit. He even tried to buy an elephant to clean his windows, but wombats were always his favorites, which spent most of their time sleeping inside hanging lamps.

The earliest public aquariums were established in the second half of the 19th Century, following the invention of the glass aquarium in the UK in the early 1700s. Many of these housed aquatic reptiles and amphibians, including the Berlin Aquarium in Germany, which opened in 1869 and was the first facility in the world to exhibit the Chinese alligator. Today, it continues to house reptiles, concentrating on endangered species breeding programs, including one for Komodo dragons.

The Calcutta Zoological Gardens were first established in 1875. In 1876, they employed a remarkable young Indian from Bengal called Ram Bramha Sanyal, who was to become the most influential person in the development of this zoo. His contribution to the captive care of wild animals, including reptiles, was outstanding. This culminated in the publication of his book, in March 1892, called *A Handbook of the Management of Animals in Captivity in Lower Bengal*. For this he was honored as a "Corresponding Member" by the London Zoological Society in England. Between 1895 and 1896, Sanyal conducted a whole series of valuable experiments into the action of reputed antidotes to snake venom. These and other studies led to him being sent to Europe in June 1898 to get experience from the various zoological collections there, and to attend the Fourth International Congress of Zoology at Cambridge in August of the same year.

By the early 1830s, a constant stream of new reptile specimens was arriving at the new London Zoo. These included those from the Tower Menagerie mentioned earlier. The first reptile arrived at the Zoo in June 1828. It was an Aldabran giant

tortoise, which, unfortunately, lived only until 2nd December of that same year. The first Galapagos tortoise, of unknown species, was presented to the Zoo on 22nd October of the same year. This was by a Mr. Stuge, of 8 Newington Butts, Elephant & Castle, London. What intrigues me about this is that there was a specialist retail reptile shop at 8 Newington Butts exactly 150 years later, run by John Picket and Graham Ruthven, from were I purchased several reptiles.

In 1834, a Mr. John R. Reeves presented a Reeves turtle, *Chinemys reevesii*, to the zoo; the species having been previously named after this gentleman by J. E. Gray in 1831. Gray based his description of this new turtle species on a drawing of a specimen sent to him by John R. Reeves, who lived in Macao and worked in Canton for the Dutch East India Company, previously mentioned. Reeves presented the Zoo with a number of other specimens of Chinese turtle species at the same time, including the four-eyed turtle or Beale's box turtle, *Sacalia bealei*, and the big-headed turtle, *Platysternon megacephalum*. An Australian snake-necked turtle, *Chelodina longicollis*, was kept in the private collection of Dr. Thomas Bell, a well-known herpetologist who wrote his book, *A History of British Reptiles*, in 1839. There is no record of this species at the zoo until 9th January 1861, when one was presented by a Mr. P. Joske.

A Jamaican land iguana, *Cyclura collei*, was presented to the zoo on 31st July, 1849, by Dr. Andrew Smith. It died on 29th December 1852, having lived in captivity for 3 years, 4 months and 29 days. This species may be the rarest lizard species in the world today. Its population on Jamaica crashed following the introduction to the island of the Indian mongoose in 1872. In 1940, a total of 22 specimens were brought into captivity to try to save the species from extinction. The last one of these died 6 years later with none of them ever reproducing. Apart from a dead male found in 1970, there were no more sightings until 1990 when a small breeding population was discovered. It is still under considerable threat of extinction, though head starting of hatchlings and other conservation methods may yet save it.

The first veiled chameleon, *Chameleo calyptratus*, to reach the zoo was caught in Aden, in South Yemen, on 15th March 1885 and presented on 3rd June 1885 by Lt.-Col. J. W. Yerbury, R.A.

One of the reasons why so many reptiles arrived at the London Zoo in such good condition, particularly lizards, may be explained by an early document surviving from those times instructing those who were shipping animals: "Correspondents should engage some individual of the ship's company to take charge of the animals on board and guarantee him a handsome recompense on bringing them safely to their destination..." Food was also important for reptiles on the long sea journeys and correspondents were advised: "ants eggs, which are abundant in tropical climates, may be preserved in a jar, well tied down and with the addition of the Blattae or cock-roaches so generally obtainable on board in all their stages of growth, and of meal worms, which are equally abundant in the bread room..."

In June 1849, the London Zoo opened the worlds first known specialist reptile house. The building, in truth, had first been designed for and housed carnivorous

mammals, and was built in the then popular "chalet" style. Once the famous Terrace was constructed for big cats it became available for conversion for reptiles. It was less than ideal for reptiles, being described as very unhygienic. It was said that the cockroaches, which bred freely in the high humidity of the steam pipes beneath the dens, became a useful source of food for the lizards.

On the 4th December, the first pair of alligator snapping turtles, *Macroclemmys temmincki*, at the zoo were presented by a Mr. G. Hagenbeck. This gentleman was perhaps related to the more famous Hamburg animal dealer Carl Hagenbeck Junior.

The cage design in this first reptile house left much to be desired, servicing from the front being accessed by hoisting the plate glass fronts up with a system of chains and pulleys. The fact that this was not particularly secure is born out by a story of an 18-foot anaconda recently introduced into one of the cages from close confinement in a large wooden tub used as its traveling container. This snake, simply by stretching its coils when wedged between a tree trunk and the front of its new cage managed to push out the whole front plate glass. This would have fallen and broken had it not been for the quick reaction of a Mr. Frank Buckland, who caught the frame and held it in place until it could be properly secured. The den into which this anaconda had been placed already contained another two plus a large python and was weakened by age and damp. This anaconda subsequently proved to be a female. She produced a number of fully developed but, unfortunately, dead, young. It was thought that she had retained her progeny too long, this due to her long sea journey in close confinement. Later, described as showing signs of disease, she, unfortunately, had to be destroyed.

In this first reptile house, painted turtles, *Chrysemys picta*, presented by a Dr. Harlan in 1838, were bred for the first recorded time in the UK between 1860 and 1861. The first New Guinea blue-tongued skinks. *Tiliqua gigas*, purchased on 17th June 1852, subsequently led to this species producing 27 babies in the period between 1866 and 1893. Rattlesnakes produced young on 9 th November 1867, and boa constrictors producing young on 30th June 1877.

Two live hybrid babies were produced from the pairing of a male pale-headed boa (Cuban Boa), *Epicrates angulifer*, and a female yellow boa (Puerto Rican boa), *Epicrates inornatus*, on the 9th September 1871. The same pair produced three more hybrid babies, 7 years later, on 30th August 1878. Captive longevity and breeding successes were being achieved even with what we would today consider to be inadequate facilities.

Water moccasins, presented by a Mr. Odo Russell in 1858, were recorded as breeding between 1860 and 1861. A pair of seven-banded snakes, *Tropidonotus septemvittatus,* perhaps more easily recognized today as North American queen snakes, *Regina septemvittata*, purchased on 6th August 1872, produced 48 young between 1872 and 1880. It is perhaps fortunate that this species will also accept small fish, frogs and newts in captivity, as well as its preferred diet of freshly molted crayfish, which may have been an unlikely snake food resource for the early reptile keepers at the zoo. In his book *Snakes of the United States and*

Canada, Keeping them Healthy in Captivity, published by Krieger in 1992, John Rossi had no knowledge of the queen snake ever having been bred in captivity.

All of these captive-bred snake species produce their young alive, so there is not the problem of successfully incubating eggs. However, it is still a sobering thought that as early as 1872 an apparently difficult snake species, the queen snake, was being bred regularly in captivity, which has apparently never been repeated in modern times.

Until 1903, keepers at the London Zoo were not forbidden to trade in surplus animals to the general public, and they jealously guarded this valuable perk. They became an important source of reptiles and amphibians to an increasingly large and interested circle of amateur British herpetoculturists. The best known of these is the, previously mentioned, Reverend Gregory Climenson Bateman, who once purchased a pair of tuataras from the Zoo for the sum of £2.00 ($3.00).

Bateman, at the age of 43, committed his previous 30 or so years of experience keeping reptiles and amphibians to print in his book *The Vivarium*. This book was probably first published on 28th July 1897, by L. Upcott Gill, of the Strand, London. Copies of *The Vivarium* exist which are undated, and could therefore either be earlier or later editions. (A brass cross on the chancel wall of his church, in Bratton Clovelly, Devon, England, commemorates "Gregory Climenson Bateman," rector of this parish, 1899 - 1909, at rest, June 25th 1909, aged 55 years.) This, the first book in English on herpetoculture, provides a fascinating insight into the care and availability of species during the latter part of the reign of England's Queen Victoria (1837 to 1901).

Bateman's most useful invention was his system of a miniature hot water boiler, heated by the chimney of a paraffin lamp. Additionally he proposed the use of felt covers and curtains to retain the heat produced. By placing the boiler between two stacked cages, the upper one had its floor heated for terrestrial species, and the lower one had its ceiling heated, which was more suitable for arboreal species. Although some private individuals had access to coal gas at this time, only a few progressive businesses had access to electricity. We can only be amazed at what they achieved in keeping their animals successfully without the benefits of electricity. He also advocated the use of a small thermometer in every reptile cage, which he said could be purchased for 6 pence (about 10 cents).

Bateman describes vivaria with gravity-fed fountains, natural plants, and a variety of construction methods to suit various different species. He particularly advocated the use of canvas as a covering for the sides and tops of cages, and especially for those designed to house snakes in the summer. For this idea he gratefully acknowledged the series of articles on "The Treatment of Snakes in Captivity," by Dr. Stradling, published in the *Zoologist* for 1882-1883. Another innovative idea was to use a length of wire attached to a piece of bark, used as a hide, and passed up through the top of the cage. The hide could then be gently lifted, without opening the cage, to view the inmate inside.

The smallest dimensions that he suggests for a chameleon's cage seem a little small at 14 inches long, 12 inches wide and about the same height. However, this would most likely be for the common chameleon of Europe and north Africa, which is a relatively small species.

Construction of all-glass vivaria is discussed, in advance of the invention of silicone adhesives. The method used in their construction involved drilling small holes, at least 1 inch into the corners, in the glass panels to allow them to be subsequently wired to each other. It was suggested that the top and base could be of wood instead of glass. Also aquariums are discussed, suitable for amphibians, constructed of slate and glass panels held together with iron rods.

Bateman's suggestions for live plants for use in decorating the vivaria are limited to various fern species and aquatic plants for use with the amphibious species. The keeping and display of ferns was a huge interest of the general population, as it was with Batemean initially. It was this interest that subsequently led to his interest in reptiles and amphibians. He constructed an aquarium to fit into the window of the room he rented at the time. Unfortunately, his construction techniques were a little lacking, as the aquarium leaked badly. This led him to reconfiguring the use of the aquarium into a fern case. The lack of movement within this prompted him to add some lizards, soon followed by some slow worms and then some terrapins.

With regard to chelonians, Bateman discusses how European species of tortoises may be bred in England, with the observation that the eggs hatch within 8 to 10 weeks if incubated at a temperature of 75oF, but not greater than 90oF. He observed that the eggs of freshwater turtles take much longer to incubate. Artificial incubators designed for chicken eggs were commercially available and adapted for use with reptile eggs. It was understood that incubation temperatures needed to be relatively high (up to 96oF), for most species, and that moisture was important. Eggs were recommended to be set-up in damp moss to prevent them from shriveling.

Crocodiles may not have been bred at that time, but Bateman records successful incubation, including the interesting notion that their eggs may be hatched either under a hen or in an incubator. An egg from a saltwater crocodile was brought from the ditch at the fort at Vellore in India, to be incubated by an individual named Walter Elliot. The crocodile was eventually hatched in the Government House compound, and in eight years had increased in size from 8ft to 9ft, becoming so powerful as to capture a full grown antelope that came to drink at the tank where it was housed. Female alligators were known to take their young into their mouths for protection from danger and transport tham to water from the hatching area.

Lizards described as breeding frequently in captivity included many *Lacerta* species, blue-tongued and other species of skinks, slow worms, chameleons, and geckos. Frequently bred snakes included grass or ring-necked snakes, and garter snakes and other live-bearing colubrid snakes.

Insectivorous reptiles and amphibians were satisfied with collected live food, including moths and spiders. Fly larvae, generally known in England as maggots, were commercially available, as they were used as bait for fishing, as they still are today. Glass fly traps were frequently used in many homes of the time, and provided a steady supply throughout the warmer months of the year. Mealworms, being a pest of grain stores and flour mills, were easily collected and were also commercially available, especially for those who kept birds in captivity. Cockroaches could be found in most homes, providing an additional resource. Special traps to catch these insects were also commonly used. Ants eggs (actually pupae) were collected and used directly as food for aquarium fish, or hatched and then used for baby lizards. Aphids were also recommended for baby lizards.

In California, a Dr. Stradling, reported that horned lizards may be commonly seen in the houses there. These were not kept in cages but rather secured with a long, narrow, brightly colored ribbon. During the day they could catch flies and spiders, then burrow into a box of sand at night, provided especially for that purpose.

Providing water to chameleons is not easy, as they will not usually drink from a bowl. Bateman solved the problem in an ingenious way. He discovered that if you syringed the cage periodically with water, a chameleon would take maybe a drop here and there, but the cage would become very damp and generally unsuitable for the inmate. He placed a small bottle of water on the top of the cage; a tiny stone is tied to the end of a piece of coarse string, of a length three times that of the bottle. The stone was then dropped into the bottle, and thus, one part of the string being in the bottle and two-thirds out, a kind of slow-running siphon is formed. The bottle in this way is then emptied drop by drop. Each drop generally hangs for some time at the end of the string. The string is passed through a small hole in the top of the cage. A small container on the floor of the cage catches any drops that are not consumed, preventing excess dampness. He readily found that chameleons drank the water droplets suspended from the end of the string.

The prices of live reptiles and amphibians, referred to in the *The Vivarium* book, make for an interesting comparison with those of today. Small monitor lizards could be purchased for a sum as little as 5 shillings (38 cents), while common tegus were about £2.00 ($3.00), with red tegus fetching as much as £3.00 to £8.00 ($4.50 to $12.00) depending upon size. Bearded dragons fetched 10 shillings to £1.00 (75 cents to $1.50). Green anoles could occasionally be had for so low a price as half-a-crown (16 cents). European chameleons cost 3 shillings and 6 pence to 7 shillings and 6 pence (30 to 65 cents). Common lizards, a British indigenous species, could be bought in London and other large towns during the summer months for sums as little as 4 to 6 pence each (6 to 9 cents).

Diamond pythons were recorded as costing between 10 shillings and £3.00 (75 cents to $4.50). African pythons of approximately 4 feet long cost anywhere from 25 shillings ($1.88) to £3.00 ($4.50). Bateman considered ball pythons to be more suitable vivarium inmates, as "they are gentle and handsome, and not by any means large for a Python." They could be purchased for the same price as other pythons as, although rarer, they were not so impressive in size and

therefore not so attractive to showmen. Anacondas were expensive, costing as much as £30.00 each ($45.00).

Bateman advocated the use of a forked stick to pin a snake then the use of a strap stick to capture it. He was unimpressed with the use of tongs or grab sticks as he considered that snakes were far to easily injured when these were used in their capture.

Substrates suggested included gravel, but also felt, cut to the size of the cage floor. Two pieces were advocated so that one could always be available clean. Hides were considered essential, either as boxes or pieces of cork bark. Moss was suggested to be placed within the hide to provide more comfort. Hide boxes could be attached to the outside of the cage and the inmate trapped within them while cage cleaning operations were undertaken.

Batemen describes the technique of getting a snake to eat either more food or food of a different kind by tying the additional food to a prey item that the snake either will eat or is actually eating at the time.

With regard to snakes shedding their skins, Bateman knew that the inability to do so in one piece was likely to indicate old age, ill health, large size or insufficient moisture. He suggested bathing snakes in warm water to assist them with shedding their skins. He also recorded his observation that hatchling snakes shed their skins for the first time when six to ten days old, and that frequently they would not feed until they complete this operation.

During the French Revolution in June 1793, Europe's first classical zoological park, the Jardin des Plantes of the Muséum National D' Histoire Naturelle, was established in the Quartier Latin in Paris. It began with animals from the former royal collection and was free of charge to the visiting public. The museum's predecessor was the Jardin de Roi, the garden of the king, renamed during the Revolution as the Jardin des Plantes. Here more than 6,000 species of living plants were established but few live animals. What animals there were had previously been kept at the estate at Montbard of a man called Buffon, who is today immortalized by having the street outside the Muséum named after him, Rue Buffon. He established his place in the history of zoology by publishing his *Histoire Naturelle*. The volumes of this devoted to reptiles and fish were written by his colleague Bernard-Germain-Etienne de Lacépède, who was considered the natural successor to Buffon. He was expected to succeed to one of the two newly established chairs at the new Muséum National D' Histoire Naturelle. Unfortunately, Lacépède was of noble birth and was forced to flee from Paris in 1793. It is interesting to speculate on the contributions he might have made to the captive care of reptiles if he had been able to stay in Paris.

It was in this zoo in Paris that the first evidence of pythons incubating their eggs was discovered. On the 6th May 1841, a female Burmese python laid a clutch of 15 eggs three months after an observed mating. She arranged these eggs into a cone shape and coiled around them for the next 56 days, only leaving them for two days in total during this period. Her temperature between her coils was

regularly taken and observed to always be higher than the surrounding air in her den. During the incubation, she ate nothing and eventually succeeded in hatching 8 of her eggs successfully. She was fed raw meat which she accepted both before and after the incubation, a fasting period totaling four months. The 8 hatchlings shed their skins at 10 days of age after which all successfully constricted and fed on live sparrows.

A less successful confirmation of a python's incubation of its eggs was at the London Zoo in 1862. A female African python, *Python sebae*, laid upwards of 100 eggs and tried to incubate them for seven weeks. During this time she was continually disturbed by the cleaning of her den; feeding the male housed with her; the overflow of her water tank; the shedding of her skin on day 53; and the insertion of a thermometer between her coils at frequent intervals. The majority of her eggs were later determined to have been fertile. Temperatures taken on the body surface of both the male and the female and within the den produced the following results in degrees Fahrenheit:

Date	Temperature at Body Surface		Temperature between Coils		Temperature in Den
1862	Male	Female	Male	Female	
Feb. 12th	70.2	73.0	74.8	81.6	58.6
Feb. 23rd	71.8	75.0	74.0	83.2	65.4
March 2nd	71.6	84.0	76.0	96.0	60.0
March 9th	72.8	79.5	Not Taken	86.5	61.0
March 16th	72.4	77.6	77.6	86.0	66.0

This pair of African pythons were set up on a bed of moss each and covered over with a blanket. The male showed no interest in the female's efforts despite the fact that she was very aggressive towards all disturbances. The use of blankets to try to keep these snakes warm would have helped the female to loose less heat less quickly, though the background temperature to her den, we now know, was woefully inadequate. We must remember that this was long before access to electrical heating and control.

Today the Jardin de Plantes is interesting to visit purely on an historical perspective as it has two separate buildings devoted to reptiles. The most interesting dates from the Victorian era, while the "new" one looks as if it was constructed in the 1930s. The Victorian building still retains and uses the original ornate legged, glass-fronted, mahogany reptile cases and marble-walled crocodile pits. To see the reptile cages here is to step back in time and view the first dawning of modern herpetoculture.

Historical Tortoises

It is probable that the European land tortoises were the first reptiles that the British ventured to keep in confinement and treat as pets. In fact, the earliest pet reptile recorded in England is a European tortoise from 1601, as described below. Their popularity increased to such an extent that by the 17th and 18th Centuries they were being imported into England in the thousands, and were relatively inexpensive. One dealer in London in 1850 headed his advert with the announcement "10,000 tortoises". Incidentally, the term "tortoise" comes from

the twisted appearance of their front legs and is derived from the French word for twisted, tortis.

William Laud purchased a spur-thighed tortoise, *Testudo graeca*, in 1625. In keeping with his position as Bishop of London, he at first kept the tortoise at the Palace of Fulham. Eight years later, he succeeded to the top clerical position in England as the Archbishop of Canterbury. So the tortoise moved with him to Lambeth Palace, across the river Thames from the Houses of Parliament. Here, the tortoise lived for another incredible 120 years. In 1753, its long life was literally cut short when an under-gardener accidentally cut off its head. The shell of this earliest English pet reptile was preserved and is still kept today in the library at Lambeth Palace. Its original owner, Archbishop William Laud, fared no better, as he supported King Charles I in his belief in the divine right of Kings. This put him on the loosing side in the subsequent Civil War of 1642, leading to his trial for treason and a sentence to death in 1645. He was imprisoned in the Tower of London, close to the famous tower menagerie described previously, before his execution by beheading, the same fate that befell his pet tortoise 108 years later.

An even earlier clerical tortoise, or more likely succession of tortoises, was the pet of a succession of seven Bishops of Peterborough in England recorded from as early as 1601 until the death of the last in 1821, a period of 220 years. This data is from a document belonging to the archives of Peterborough cathedral called the "Bishop's Barn." The last of these pet tortoises was recorded in 1818 to eat endive, green peas and leeks, be partial to oranges, but to reject asparagus, parsley and spinach. In the early part of the year its preference was for the yellow flowers of dandelions and lettuce. From the end of June onwards it looked for fruit including currants, raspberries, pears, plums, apples, peaches and nectarines—the riper the better—but refused cherries. It was particularly fond of strawberries, for which its shell was perforated, in order to attach it to a tree, to limit its ravages among the strawberry borders. Also fond of gooseberries, it refused any root vegetables, including carrot and turnip, as well as all animal food. It was never observed to drink, and would shake leaves dry if wet. At the beginning of each October to end of September, it would dig itself into a particular part of the garden at a steep angle. The depth that it dug being apparently significant with the severity of the forthcoming winter, up to a maximum depth of two feet. It would refuse all food a month before its hibernation and on its emergence around the end of April it would not accept food for another two weeks. This tortoise was recorded as weighing 13.5 pounds, which raises speculation as to its exact species, being probably too heavy for the European species except perhaps a very large marginated tortoise, *Testudo marginata*. It was recorded as being able to move, with apparent ease, though pressed by a weight of 18 stone (252 lb.).

The most famous early pet tortoise in England is one called Timothy. It was kept, closely observed and recorded by Gilbert White, a village curate. He discusses it in detail in his book, *The Natural History of Selbourne*. This tortoise was originally purchased for half a crown (15 cents) by his Aunt, a certain Mrs. Snooke, who bought it from a sailor in Chichester, Sussex, in 1740. He assured her that it

came from Virginia and was born in 1734. It was actually a Greek tortoise, *Testudo graeca*, of large size, and therefore probably originating from the coast of Algeria. It came into the possession of Gilbert White following the death of his Aunt, Mrs. Snooke, in 1780. She had left it to her nephew in her will. It was March at the time, and he had to dig it out of its winter hibernaculum, to which it expressed its displeasure by hissing at him. To transport it home, he packed it in a box full of soil. It was then carried the 80 miles to his home in a series of horse-drawn poste chaises. The rough journey unsettled it, causing it to walk twice down to the bottom of his garden when released, before re-burying itself in some loose-leaf mold.

The last detailed account of Timothy by White was entitled, "More particulars respecting the old family tortoise":

> Because we call this creature an abject reptile, we are too apt to undervalue his abilities, and depreciate his powers of instinct. Yet he is, as Mr. Pope says of his lord, "Much too wise to walk into a well, and has so much discernment as to not fall down a haha (a sunken fence or ditch used in garden design to provide an unimpeded view, but prevent livestock entering the garden), but to stop and withdraw from the brink with the readiest of precaution."
>
> Though he loves warm weather, he avoids hot sun; because of his thick shell, when once heated, would, as the poet says of solid armor, scald with safety. He therefore spends the more sultry hours under the umbrella of a large cabbage leaf, or amidst the waving forest of an asparagus bed. But as he avoids the heat in summer, so in the decline of the year, he improves the faint autumnal beams, by getting within the reflection of a fruit wall; and, though he never has read that planes inclining to the horizon receive a greater share of warmth, he inclines his shell, by tilting it against the wall, to collect and admit every feeble ray.
>
> Pitiable seems the condition of this poor embarrassed reptile, to be cased in a suit of ponderous armour, which he cannot lay aside; to be imprisoned, as it were, within his own shell, must preclude, we should suppose, all activity and disposition for enterprise. Yet there is a season of the year (usually the beginning of June) when his exertions are remarkable. He then walks on tiptoe, and is stirring by five in the morning, and, traversing the garden, examines every wicket and interstice in the fences, through which he will escape if possible; and often has eluded the care of the gardener, and wandered to some distant field. The motives that impel him to undertake these rambles seem to be of the amorous kind: his fancy then becomes intent on sexual attachments, which transport him beyond his usual gravity, and induce him to forget for a time his ordinary solemn deportment.

Mrs. Snooke also had two North American box turtles, as described in a note by White in 1774. She kept their shells following their deaths in "a room over the Hall."

White examined his tortoise Timothy's droppings, recorded what it ate, weighed it regularly (average 6.5 pounds), tested its hearing, and if it could swim, and generally did a pretty good job of looking after it until his death on the 15th June 1793. Timothy followed his master in death the following spring at an estimated age of 60. His carapace was preserved and became the property of White's great niece, a Mrs. Christopher, in 1836. She presented it to the British Museum (Natural History) in April 1853.

Perhaps the oldest living European tortoise in the UK today, also called Timothy but established as being a female in 1926, is one living at the 60-room Powderham Castle. This castle is located above the estuary of the river Exe, in Devon, and has been home to the Earls of Devon since 1325. This tortoise weighs about 11 lb. and is described as 5 in. tall. The current Earl, the 18th, is Lord Hugh Rupert Courtenay, whose ancestors fought at the battles of Crecy and Agincourt, provided three Latin Emperors of Constantinople during the 13th Century, and included one who was a founder member of the Knights of the Garter in 1384. The Courtenay family were welcomed to England by King Henry II in 1147. This followed Renaud de Courtenay's quarrel with King Louis VII of France, after they had both recently returned from a Crusade to the Holy Land.

This tortoise was originally found onboard a captured Portuguese pirate ship in 1854. The pirate ship was captured by Captain John Guy Courtenay Everard, of Her Majesty's Ship (HMS) Queen, a relative of the 10th Earl of Devon. The Portuguese pirate ship was captured in the Mediterranean, and Timothy, thought to be very young, perhaps only hatched around 1850, was apparently part of the cargo. She served as the captain's ship mascot throughout the Crimean War and remained on board during the British and French bombardment of the Russian naval base at Sevastopol in 1855.

Following the end of the Crimean War, Captain Everard and Timothy transferred first to HMS Princess Charlotte, and subsequently to HMS Nankin. On these two ships they both saw service in the East Indies and China Sea. This included the occupation of Peking by the British and French forces in 1860.

On returning to England in 1890 Timothy was left at Southampton whilst his master sailed on to Antarctica. Two years later, the tortoise found a home with the captain's family at their home, in Honiton, Devon. She lived there for the next 22 years before being finally relocated to Powderham Castle in 1914.

Still alive in 2001, this tortoise is believed to be at least 148 years old. Her rescuer, Captain Everard, died in 1931 at the very respectable age of 101 but failed to outlive her. Eight Earls of Devon have cared for this tortoise, which even exceeds the seven Bishops of Peterborough's tortoise-keeping efforts. This venerable old tortoise has never been kept indoors and hibernates each winter in

a deep layer of Wisteria leaves. All attempts to mate her with a suitable male have failed.

An unusual building called the "Tortoise House" was built between 1820 and 1830. It is located in the southwestern corner of the grounds of Wotton House, in Surrey. This is the home of the Evelyn family, which has what is thought to be the first Italian garden in England, created by the 17th Century diarist John Evelyn. The family always maintained an extensive menagerie of exotic animals. This menagerie is also recorded as one of the first to ever successfully breed chameleons, though there are no details as to which species.

The building, built by either George Evelyn, or his son William John, has a tall, black-and-white, marble-floored Ionic portico of four bays on the ground floor, with niches on which fragments of statuary still remain. This surrounds a center courtyard with a deep pool fed by one of the tributaries of the nearby Tillingborne river. An open upper floor once supported a "summer-house" from which visitors would take tea and watch the terrapins swimming in the deep pool below. The building was reminiscent of a Chinese tea house and is believed to be the first ever dedicated building for reptile use known. Sadly, this building is now in a ruinous state and is unlikely to ever be restored.

Galapagos tortoises are known to live to a great age if they receive proper care. The most interesting one, alive at the time of this writing, is a female Santa Cruz tortoise, *Chelonidis nigra porteri*, called Harriet, kept at the Queensland Reptile Park, Beerwah, near the Sunshine Coast of Queensland, Australia, first described by her pet name in 1870. This tortoise was collected with two others by Charles Darwin on 17th August 1835 on the Galapagos Island then called Charles Island (now Islas Santa Maria or Floreana), and taken back with him on his ship, the Beagle, to England, arriving in 1836. This island was where the colony's main settlement and prison was established. As a result, tortoises from a number of different islands were kept there, and, as noted by Darwin, the three tortoises were probably of different subspecies. Captain Fitzroy, of the Beagle, recorded these tortoises as being 11 inches long in 1835, which would indicate a hatching date sometime in 1830.

The first lieutenant of Darwin's ship under Captain FitzRoy was a John Clements Wickham, who himself later became captain of the Beagle. Wickham subsequently became First Government Resident of Moreton Bay in Australia on his retirement from the navy in 1841. He brought with him to Australia three of these Galapagos tortoises, even though he himself had never been to Galapagos. They were kept at his residence, Newstead House, Brisbane. These young tortoises were previously left in Wickham's care in England by Darwin himself. Wickham subsequently left Australia for France in about 1860, at which time the three tortoises were presented to the Brisbane Botanical Gardens.

Of the three tortoises one subsequently died in 1893 in the Great Flood of Brisbane, when the city was deluged under a depth of up to 20 feet of water. The two survivors, now known as Harriet and Tom, are recalled to have been at the Gardens in 1922. Tom died in 1929. He was preserved in spirit at the Queensland

as to what species it actually belonged to. At least until the end of the 18th Century giant tortoises were known to exist on many of the Seychelles islands, and to be of both huge size and closely related to the Aldabran species. Long thought to be extinct, two species continue to survive, including a domed species, *Dipsochelys hololissa*, and a saddle-backed species *Dipsochelys arnoldi*. I would like to believe that Dr. Gunther's huge tortoise was one of these.

The re-discovery of these two species of Seychelles giant tortoise is one of the reptile success stories of the 1990s. Believed hunted to extinction by the 1840s, recent DNA analysis has confirmed that a number of captive giant tortoises, previously regarded as Aldabran, are, in fact, survivors of these two distinct species. Hotels and individuals actually on the Seychelles islands kept most of these captives. Since 1997, efforts have been made to collect them together at the Seychelles Giant Tortoise Protection Trust based on Silhouette island and run by the Nature Protection Trust of the Seychelles.

In 1998, the first Seychelles tortoise were discovered outside of the Seychelles. The first *Dipsochelys hololissa* discovered was a large male, called Darwin, housed with a female Aldabran at the Blackpool Zoo in England. Darwin was purchased from an animal dealer in the 1970s but his actual origin is unknown. The first Arnold's tortoise, *Dipsochelys arnoldi*, a male called Hugo, was found at the Dresden Zoo in Germany. He too had been purchased from an animal dealer on 28th July 1971, but his previous history is also unknown.

The oldest verifiable tortoise is that referred to as Marion's tortoise. In 1766, the Chevalier Marion du Fresne gave it, along with four others, to the French governor in Mauritius. Marion had organized an expedition to explore the then little-known Seychelles islands. This Seychelles expedition was the first to document details of the natural history of the islands and collected a number of tortoises, primarily as a food supply. The five presented to the governor were an unusual form of Aldabran tortoise, *Dipsochelys dussumieri* sumeirei. They were collected on a return journey to Mauritius, from the Farquhar islands, by a Captain Lampériaire, on his ship *La Curieuse*.

In 1810, when the British captured Mauritius from the French, the tortoises were all still alive and living at the artillery barracks. Shortly before 9th July 1833, one was presented to the London Zoo by Lieutenant-General Sir Charles Colville, but died soon after arrival. This specimen was a male that was reported to weigh 285 lb. A few years later, a second tortoise from the original five was sent to the zoo but also died after a short period.

Of the three remaining tortoises, one disappeared from the record without a trace, and the surviving two attracted the attention of the great Giant tortoise collector Lord Walter Rothchild around 1900. Believing them to be the sole survivors of the Mascerene giant tortoise, *Cylindraspis indica*, he was disappointed on receiving one of them when it became clear that it was *Dipsochelys dussumieri sumeirei*.

Rothchild's attempts to purchase the last surviving Marion's tortoise were unsuccessful. In 1908, this tortoise became blind, and finally fell off the ramparts of the barracks to its death in 1918. Thus it had lived on Mauritius for 152 years, and was presumably of adult size when collected in 1766.

Hawksbill turtles occasionally are found around the coast of Britain. One was taken in the river Severn in the southwest of the country in 1770. A Dr. Turton records that it was placed in his father's fish ponds where it lived until winter. This is perhaps the earliest record of a sea turtle being kept in captivity.

The earliest record of reptiles on public display in the USA is perhaps that of a menagerie in New York in 1781. This was described as consisting of reptiles, birds and quadrupeds. Eight years later another exhibited a crocodile, snakes and lizards, as well as a tiger, orangutan, sloth, baboon and a buffalo. The traveling American reptile menagerie of the Englishman Cops from 1835 has been previously discussed. It was not until July 1st 1874 that the first American zoo opened in the then cultural capital of the republic, Philadelphia, with 212 animals on display, including eight reptiles. By 1890, the Baltimore Zoo could boast the exhibition of a single alligator, with the opening of the first dedicated alligator farm in St. Augustine, Florida, still three years away, in 1893. In 1896, an aquarium was opened in New York in what had originally been built as a fort in 1807. This aquarium collection was given to the New York Zoological Society in 1902 and was described as having a good selection of amphibians and aquatic reptiles, in addition to fish and aquatic mammals.

In 1828 in his book *The Tower Menagerie*, Mr. E. F. Bennett, Assistant Secretary to the newly formed Zoological Society of London, confirmed the great increase in interest in the natural world, this resulting from both improved wealth and civilization caused by the British Industrial Revolution. He wrote: "But as civilisation advanced and the progress of society favoured the development of the mind, when those who were no longer compelled by necessity to labour for their daily bread found leisure to look abroad with expanded views upon the wonders of creation, the animal kingdom created new attractions and awakened ideas which had before laid dormant. What was at first a mere sentiment of curiosity became a love of science; known objects were explained with more minute attention, and whatever was rare or novel was no longer regarded with a stupid stare of astonishment and an exaggerated expression of wonder, but became an object of careful investigation and philosophic meditation."

Today, with our advanced civilization and society, we have a duty to these early pioneers to continue to change the attitudes of the public towards reptiles and amphibians, and continue to publish the results of our own careful investigations and philosophic meditations.

Additional Reading Resources

The list of references used in the above text is extensive and based on many publications that are invariably long out of print and subsequently difficult to

consult even within specialist and library collections. However, two recently published books contain a wealth of relevant historical data and are listed below.

Hoage, R. J. and W. A. Deiss 1996, New Worlds, New Animals, from Menagerie to Zoological Park in the Nineteenth Century (ISBN 0-8018-5373-7), published by The John Hopkins University Press, Baltomore & London

Kisling, V.N. 2001, Zoo and Aquarium History (ISBN 0-8493-2100-X), published by CRC Press, Baton Rouge, London, New York, Washington D.C.

Behavioral Ecology and Captive Management of Arboreal Alligator Lizards (Genus: *Abronia*).
(Abstract Only)

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The lizard genus, *Abronia*, is currently comprised of twenty-eight recognized species, more than half the species of the gerrhonotine anguid lizard diversity. This genus is found within a geographic region extending from southern Tamaulipas, Mexico to northeastern El Salvador and southern Honduras. Within this area the distribution of *Abronia* is restricted to the pine-oak and cloud forests of the highland regions (from 800->2,800 meters). *Abronia* are omnivorous, ovoviviparous, arboreal lizards with strongly prehensile tails. Like other anguids the tail is easily autonomized, which affects their suitability for arboreal existence and the ability of being allowed to copulate. They are active thermoregulators with preferred body temperatures ranging from 22-28°C and an upper thermal limit of 33-35°C. They have a well-developed chemosensory ability that they use in tracking of prey, which consists of a wide variety of vertebrates and invertebrates. Chemosensory ability allows recognition of conspecifics by sex and reproductive status. The lizards are somewhat solitary and intraspecific aggression is common, particularly between males. With the exception of females and their own offspring, adults have been known to eat neonates. Breeding within this genus generally occurs in September-October with birth of young in May-June. Litter sizes range from 1-17. Neonates are 30-40 mm SVL with weights ranging from 2.5-5.0 g. They are hardy in captivity, but successful breeding of this genus requires high UVB radiation and active management of temperature on a daily and annual basis.

The Behavioral Ecology and Captive Management of the Neo-Tropical Lizard, *Xenosaurus*
(Abstract Only)

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The lizard genus *Xenosaurus* consists of at least six species of crevice-dwelling lizards found from Tamaulipas, Mexico south to Alta Verapaz, Guatemala. The species within this genus are found in a variety of habitats ranging from tropical to nearly xeric. Most of the species are thermoconformers (22-25° C) that exhibit no basking behaviors with an upper thermal limit of approximately 37°C. They are suited to a crevice-dwelling lifestyle with varying degrees of flattened body and head morphology and choose crevices with a height approximately 0.75 times the length of their head. The skin of these lizards allows water to be drawn by capillary action anterior along their body to the corners of their mouth for drinking. Food consists primarily of Orthopterans and Lepidopteran larvae, which are found within the crevices the lizards inhabit. The species within this genus are solitary, with varying degrees of aggression displayed toward conspecifics and the degree of aggression changing with reproductive status. Some members of the genus demonstrate parental-neonate associations lasting up to 55 days which are adaptive to the offspring, while in other species the young disperse immediately to avoid the cannibalistic behavior of the adults. The lizards are hardy in captivity and captive husbandry and breeding requirements are minimal. Care must be taken with groupings of some species to avoid potentially damaging aggressive encounters.

Management of a Taipan, *Oxyuranus scutellatus*, Colony for Venom Extraction.

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The taipan, *Oxyuranus scutellatus*, is a large elapid with highly toxic venom, which occurs in the northern coastal regions of Australia and is used widely for venom production for antivenom and medical research. Venom Supplies currently has 38 (of which 11 were on the program) taipans ranging from juvenile to adults for the purpose of venom extraction. Here we report the care and maintenance required to manage taipans to a Good Manufacturing Practice (GMP) standard of venom production over a period of 2 years from 1999 to 2001. In the study period there were 314 individual records of milkings and achieved an average yield of 169 mg dry per milking. We found that a minimum fortnightly milking frequency was adequate recovery time for the snakes with an average of 20 milkings per year. The snakes are kept between a minimum of 21 deg C and a maximum of 32 deg C. Special attention to heating has had a positive effect on the temperament. Minimal health problems were experienced with the snakes. Some of the problems were an infected fang sheath, protozoan infection and there was 1 death due to a lesion of the liver. Particular consideration to hygiene, minimized health problems. Despite their deadly potential, generally these snakes were easy to handle, good-natured and are high-quality venom producers.

Introduction

The taipan, *Oxyuranus scutellatus*, is a large elapid, which occurs in the northern coastal regions of Australia. The taipans venom is probably the fourth most toxic of all terrestrial snakes in the world, being 12 times more toxic than the Indian cobra *Naja naja* (Mirtschin and Davis 1982).

Prior to antivenom development, apart from a dubious report of an aboriginal survivor, no victim is was thought to survive a taipan bite (Masci and Kendall 1995, Sutherland and Tibballs 2001) and even now with antivenom available, survival is less certain than other Australian snake bites. Even despite acute intensive care, some patients die even after early treatment (see example Cobcroft *et al* 1997). While blood samples tested *in-vitro* with many venoms exhibit spheroechinocytosis (Flachsenberger and Mirtschin 1995), this has only been reported in humans clinically in Australia in *Oxyuranus scutellatus* bites (Arthur *et al* 1991and Cobcroft *et al* 1997).

Specimens have been recorded up to 2.8m in length with an average of 2.0m (Mirtschin and Davis 1992). The venom potency, its size and temperament make it Australia's, and possibly the world's most dangerous snake.

Whilst the venom is highly potent and results in life-threatening emergencies in taipan snake-bite cases, it is highly useful in medical research and diagnostics. Taipoxin, a highly potent presynaptic neurotoxin from taipan venom has been used extensively in neuromuscular research and has aided in a better understanding of pharmacological and neurophysical systems. Moreover the clotting component, a prothrombin activator, has been proposed as a one-stage assay for prothrombin levels (Denson *et al* 1971).

A potent calcium ion channel blocker has been found in 1992 (Possani *et al* 1992).

Materials & Methods

Venom Supplies Pty Ltd currently has 38 taipans of both juvenile and adult sizes. These taipans are kept using two different sizes according to their requirements.

The larger taipans are kept in separate floor cages (see Fig 1). These enclosures are made from wood with fibro-cement flooring sealed for easier cleaning. The floor measurements are 840x600 mm, the front and back walls are 550 mm and 570 mm high respectively. A top opening fly-screen door allows access and visibility.

Each floor cage is provided with a plastic hide box (see figs 1 & 2) for the snake to seek refuge. The hide box is comprised of a box drawer inside a plastic frame. This allows removal of the snake inside the box for cage cleaning. The out side frame measurements are 465x340x220 mm while the inside box measurements are 425x310x180 mm. The hide box has a 90mm diameter hole cut into one end as an entrance. A slide can be inserted in the top of the box at the entrance end in order to lock both the drawer and secure the snake inside. If necessary, this allows the snake to be removed from the cage without handling the snake thus reducing the chances of accident.

The heat source, a thermostatically controlled blue-colored incandescent light bulb, is fixed in top of the cage towards the back, which allows for a heat gradient between the basking spot and the front of the cage giving the snake a choice of temperature. Banks of 4 to 6 cages are linked to a single thermostat. Temperatures are checked periodically with a computerized data logger device which allows downloading on computer (chart 1).

Smaller snakes and juveniles are kept in separate plastic tubs measuring 592x410x328 mm (55 litre) (fig 3). These tubs are also supplied with a hide box. The small tubs do not allow for hide boxes like those in the floor cages so plastic lunch boxes are used. These tubs are heated by convection from the floor cages below. The tubs are positioned in a rack attached to the block of 16 floor cages (fig 4). Plastic flaps are lowed from the top to the bottom which trap warm air and slow down its escape (fig 4).

All cages are lined with paper to allow easier cleaning and provide the snake with a substrate on the floor of the enclosure to assist cleaning. When cleaning, the floor cages are mopped with a 10% chlorine mix (calcium hypochlorite and water) to kill bacteria and some parasites. A brush is also used to remove adherent fecal matter. All tubs and hide boxes (both floor cages and tubs) are sterilized using a 70/30 alcohol and water mix. If it is required to swap snakes between cages, the cages are sprayed with a 100% alcohol mix before the new snake is introduced into the tub.

The collection is also divided into 5 set groups. When cleaning every piece of equipment must be sterilised using the 70/30 alcohol mix so as to not transfer parasites and bacteria from one group to another.

The snakes are milked every fortnight with exceptions being when they are due to shed their skins and if they are taken off the program for health reason.

Results

Temperatures were maintained between 21 and 32°C. Control of temperature in the lower floor cages was easily maintained within target limits but the temperature of the upper tubs has a wider range but was still within expected limits for the species.

The snakes in floor cages can use a basking spot of around 32°C directly beneath the heating light and with the temperatures falling off to 17°C at the front of the cages, this gives a reasonable temperature gradient for these snakes. The colored light bulb reduces the impact of sudden light bursts when the thermostat cuts in and provides a less expensive option over ceramic pig heaters. With these colored lights, the snakes show almost no response to the light switching on or off.

There have been no significant health problems arising from keeping the taipans under these conditions. An adult on the milking program was noticed to have a fang sheath problem. It was removed from the program and started on a course of amoxycillin trihydrate antibiotic (18mg/kg). After the course had been given for 5 days, there was no noticeable improvement. X-rays of the fang showed no loose fang or foreign object (see fig 6) inside the fang sheath. The fang sheath was then treated with hydrogen peroxide on a daily basis and after 2 weeks of this treatment, the problem subsided.

A generalised skin blister problem was observed in another adult comprising small blisters running on both sides of the body. Tests showed no sign of a bacterial or fungal infection and the possibility of abrasion being the cause was ruled out. A temperature data logger in the snakes cage over 3 days showed that the thermostat was incorrectly set. The taipan had a basking temperature of 38.6°C max. Re-setting the thermostat on the correct temperature and a course of cod-liver oil resolved the problem.

A few juveniles have died and their deaths were attributed to protozoan infections (flagellates) but dosing with metranidazole and attention to cleaning practises have controlled any major out breaks. We find small snakes are particularly susceptible to protozoan infections; especially flagellates, whereas, with larger snakes, there is more time to deal with the problem.

The prime reason for keeping the snakes was to obtain a high GMP grade of venom. The results of the milking program are set out below in table 1.

Discussion

The heating system adopted using ordinary household incandescent light bulbs has worked well for most species we keep however, we observed that most taipans housed in the floor cages seemed to flinch a little as the bulbs turned on and off with the thermostat. It was also noticed that during periods when the bulbs turn on and off more frequently for example in colder weather, the taipans seemed more nervous and became agitated easily. A trial was conducted using different coloured light bulbs and it was found that by using a blue coloured globe with a lower light intensity, their reactions to the lights switching on and off was almost eliminated.

Control of temperature, especially high temperatures has been found to cause blister disease in other species. We found that with *Agkistrodon bilineatus*, keeping their temperature below 30°C prevented this problem in that species. In our experience with taipans, in maintaining temperatures below 32°C, we have had no further problems with blister disease.

The published dry venom yield for *O. scutellatus* is 120 mg (Trinca 1969). In our data presented here we report the average dry venom yield to be 169 mg (table 1). The higher yield we experienced may be due to our practice of only using large snakes (over 1 metre) in the milking program and also the snakes are only milked fortnightly. It is unknown what size variation of snakes were used in Trinca's earlier report of venom yield in 1969.

We conclude that keeping taipans at temperature range between 21°C and 32°C, providing a hide box and using low intensity light globes for heating and only milking them each fortnight is a successful way of keeping them for venom extraction.

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Fig. 1. Taipan floor cage showing hide box inside.

Fig. 2. Hide box

Fig. 3. Enclosures for smaller taipans

Fig. 4. The taipan row showing the larger floor cages at the bottom for large snakes and the smaller tubs on the racks for small snakes. Note the lowered plastic flap at the rear.

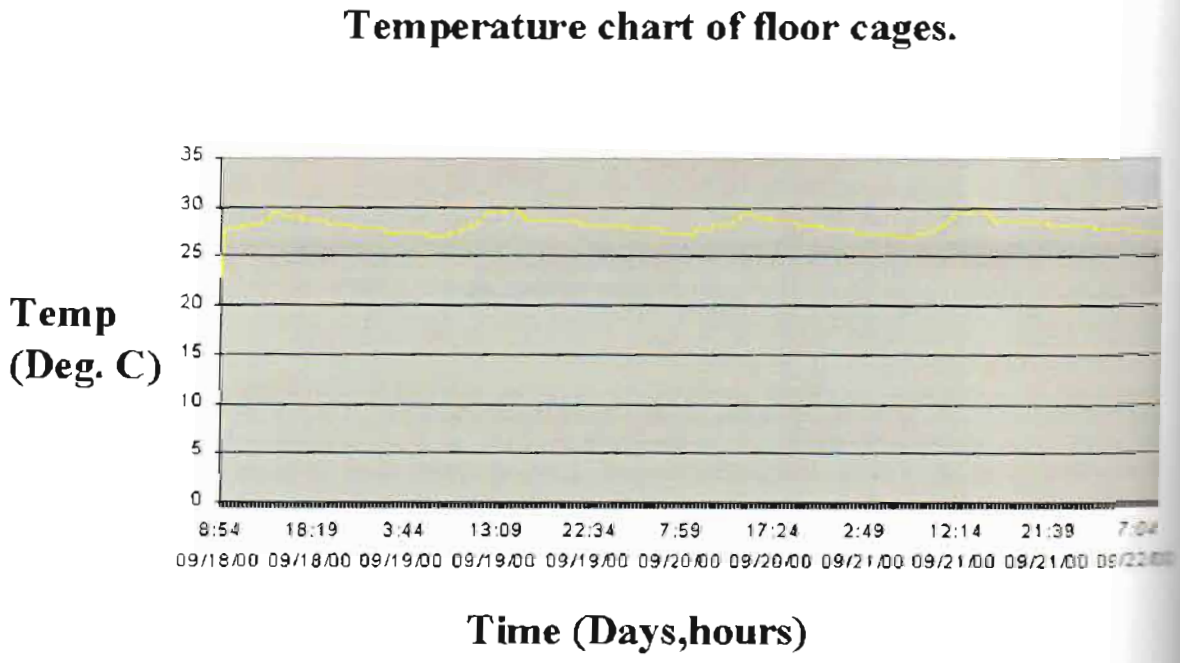

Chart 1. Daily and hourly temperature fluctuations in a typical floor cage.

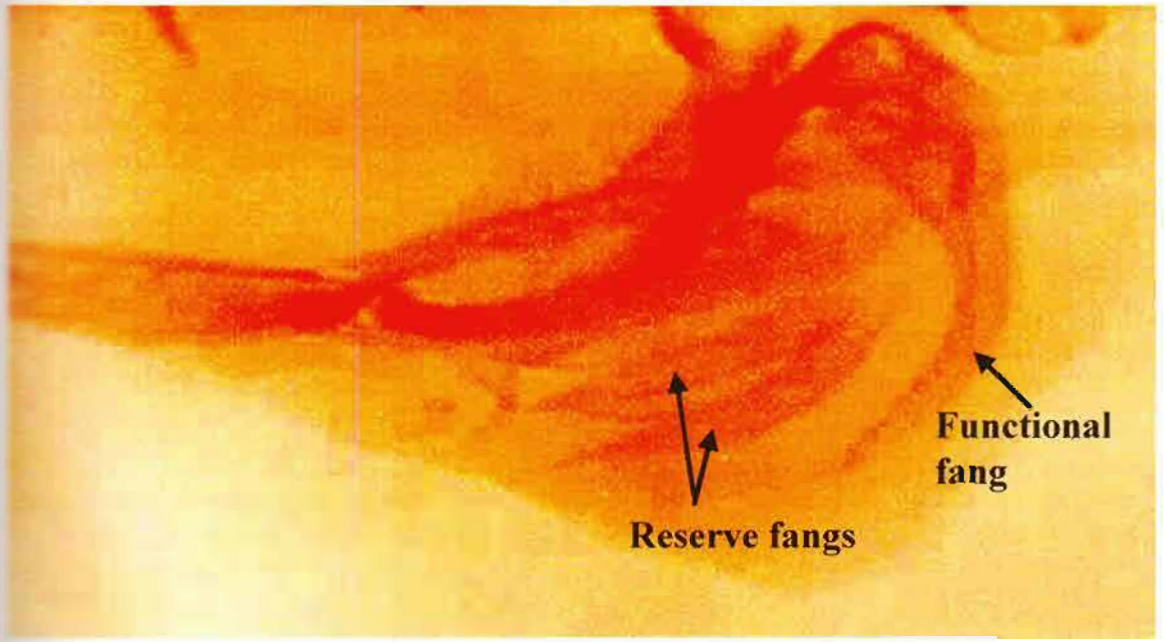

Fig 5. X-ray of taipan fang sheath showing functional fang and reserve fangs but no foreign body or broken fang fragment.

	Wet yield (mg)	Dry yield (mg)
Minimum	53	12
Maximum	2977	772
Average	692	169
	N=314 milkings	
	11 snakes involved	

Table 1. Summary of milking taipans under GMP milking program.

Observations and Consequences of Exotic Snake Envenomations

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Exotic snakebite has been observed with increasing frequency over the last several years. The authors present several case histories of exotic snakebite envenomations, both to private keepers and to the senior author of this paper. Consequences of a lack of appropriate antiserum and protocol are noted. The importance of the keeper having a supply of antiserum for each species kept is emphasized.

Introduction

Over the past several years there has been an increase in captive breeding and keeping of venomous snakes as well as an increase in media coverage of venomous and dangerous animals. One only has to do a quick search on the internet or peruse a recent dealer price list in order to see the wide variety of venomous snakes available today, or turn on a cable television station to see questionable handling techniques portrayed as 'expert' methodology. These factors have led to an increase in envenomations by exotic species. This increase in bites has affected the availability of antisera by putting pressure on zoos and other institutions to supply this medication to private individuals that do not maintain a supply for the animals kept in their collections.

For the purpose of this paper, we have defined an exotic snakebite as any bite caused by a snake not native to the region in which the envenomation has occurred. Thus *Crotalus atrox*, while certainly native to the United States, is not native to Maine and we would consider a bite caused by *C. atrox* in this state to be exotic. This definition is justified by the fact that many Northern states and large metropolitan areas do not have venomous snakes living naturally in the region, and therefore the local hospitals generally do not stock any antisera, leaving private keepers without their own supply of antisera at the mercy of whatever institution with antisera is closest.

Case Histories

We at The Kentucky Reptile Zoo are often called upon to observe or review snakebite cases here in the United States. The following are case histories of several cases we reviewed. Names and locations have been intentionally omitted. We have presented all the information available to us.

Viperidae

1. A 24-year-old male was bitten by a one meter *Crotalus horridus* he was keeping as a pet. The patient had a blood alcohol level of 0.20, twice the intoxication limit for his state. The envenomation occurred when the subject tried to free handle his 'pet' and was bitten on the right hand. Surgeons at the hospital performed a fasciotomy before contacting poison control about antisera usage. The patient lost function of the affected

hand and recently won a large malpractice settlement, as the surgery was ruled to be unnecessary.

2. An 18-year-old male attempted suicide by allowing a *Crotalus atrox* to bite his right forearm. No signs of envenomation developed but the patient was given two vials of Wyeth anti-Crotalidae antisera upon arrival at the emergency room. Following the administration of the antisera, the patient showed signs of anaphylaxis, including a severely swollen tongue. The treating doctor felt the venom had caused this reaction, when in fact it had been caused by the antisera.

Neither of these cases showed signs of necrosis, though one patient lost use of his right hand due to improper surgery. In both of these cases, the patient would have benefited from the on-site doctors contacting poison control before attempting treatment.

Elapidae

1. A 21-year-old male was bitten by a *Naja naja* while attempting to assist the snake in shedding its skin. No antisera was available nearby, and doctors were advised to place the victim on a ventilator until antisera could be shipped in. Instead, the victim was flown to Miami, FL, where the antisera was located. Antisera was then located only a few hours away from the bite location. Transporting a potentially critical patient when not absolutely necessary is a dangerous risk to take. The patient recovered but appeared to not have endured a severe envenomation.

2. A 26-year-old male was bitten twice in one year by his pet cobras. The first bite was by a *Naja kaouthia*. In this case the patient came to the emergency room complaining of abdominal pain. Doctors were preparing to perform an appendectomy when the patient's girlfriend informed them he had been bitten by a cobra. The doctors contacted Dr. Barry Gold about treating the bite. Dr. Gold used neostigmine to keep the patient alive until antisera could be located. Ten vials of Thai Red Cross anti-cobra antisera were located and administered to the victim, who recovered.

   The second envenomation to this man occurred two days before Christmas. He claimed the snake, which was eventually identified by a herpetologist as a black (Pakistan) *Naja naja*, was a cross between *Naja naja* and *Naja melanoluca*. The snake was removed from the victim's home by a friend while the victim was in the hospital because it was illegal for him to possess the snake. However, this meant that it was impossible to identify when doctors were attempting to treat the bite. The treating doctor contacted one of us (JH) about the envenomation. We decided to use SAMIR South African Polyvalent. Ten vials were located at a nearby zoo and administered to the patient, who responded to this treatment and was taken off life support. He recovered with no further complications. It was later discovered the snake was a Christmas present to the victim from his girlfriend.

In all of the cases listed above the people who owned the snakes had no protocol in case of an envenomation, and no supply of antisera. Many of the bites occurred late at night or in the early morning hours when contacting potential antisera sources was extremely difficult, if not impossible. Additionally, many of the victims were uncooperative and withheld information from the physicians and others attempting to help them. These factors, in addition to the fact that the treating doctors are usually faced with a situation they have no experience with, combine to form an extremely dangerous situation for the victim.

The following are case histories of bites to the senior author (JH) of this paper. These cases illustrate how a good protocol and antisera on hand are instrumental in saving the life of the victim. Due to the location of the zoo, the nearest hospital does not contain a trauma unit capable of dealing with a serious snakebite, and so we transport to the larger hospital via helicopter ambulance from the local hospital.

1. A 38-year-old male was bitten on the left thumb by a 1.2 m *Naja nivea* while extracting venom from the snake. The snake was returned to its cage and a compression bandage was placed on the bitten limb per the Southerland technique. The backup person collected the antisera and protocol and drove the victim to the first hospital. Here an IV was started and five vials of antisera were started slow drip. The pressure bandage was removed at this point. The patient was then placed on the helicopter for transport to University of Kentucky Medical Center (UKMC). En route, the IV was somehow interrupted and the patient began feeling cramping in his feet. The cramping progressed up to the abdomen and the patient vomited. His heart rate had dropped to 40 bpm at this point. Ptosis started to occur as the helicopter landed, and the patient was able to tell the treating doctor to follow the protocol before losing consciousness.

   During the next several hours, the patient's heart rate dropped to 10 bpm, and then stopped. He was resuscitated and placed on life support and an exterior pacemaker was used to maintain heart rate. After one night in ICU the patient was sufficiently recovered to return home. Slight necrosis developed in the bitten thumb. Dr. Susan Wermeling treated the necrosis and was able to save the thumb. Treatment to stop further damage included using a gauze drain in the tip (at the bite site) and soaking in Epsom salt solution for 15 minutes twice a day. Surgery was required to remove a small amount of infected bone. During the recovery period, the patent took 500 mg of Cipro and 875 mg of Augmentin twice daily to combat infectious bacteria introduced from the snake's mouth. Though the thumb is scarred, it is fully functional today.

2. The second bite to JH occurred when he was 40 years old. He was bitten on the right hand by an approximately 3m *Ophiophagus hannah*. The bite occurred while he was treating the snake for a respiratory infection. The snake was being held in the left hand and lunged forward to bite the right hand between the first and second metacarpals. At this time the right

hand was being used to swab the snake's throat in an effort to clear the airway. The snake was immediately secured in its cage and again a compression bandage was applied to the bitten limb via the Southerland technique. The backup person (KW) was present at the time of the bite, and she gathered the antiserum, which was Thai Red Cross King Cobra specific. The hospital was notified the victim was on route. Upon arrival at the first hospital, 25 minutes post-bite, an IV and two vials of antiserum were started, and the pressure bandage removed. While this was occurring, the backup person assisted the helicopter staff (who had been called and were present) with packing the antiserum. Then the victim, backup person, and antiserum were transported via helicopter to UKMC. This helicopter trip was uneventful.

Upon arrival at UKMC one-hour post-bite, Dr. Barry Gold, a consultant listed on the protocol, was called by the ER doctor. Dr. Gold recommended administering 13 more vials of antiserum. Shortly after receiving this counsel, a car accident victim was moved into the ER bay we were in, and we were moved to the hall with a portable monitor attached to the patient. The patient was alert and feeling fine when he was moved to the hallway. For the next 15 minutes several staff of the hospital assisted the backup person in reconstituting the antiserum (which is lyophilized.) At this point the victim began complaining of neck and back pain, a strange sensation on the tongue, and tightness in the chest, as well as an overall feeling of drowsiness. These were recognized as neurological symptoms, and the additional antiserum was started and he was returned to the bay, however the severity of the symptoms was not apparent to either the backup person or hospital staff, as JH was not able to clearly articulate exactly how he was feeling. (He later said it felt as if an elephant was sitting on his chest.) Luckily, the antiserum was administered in time, and no further or more severe symptoms were noted. It is important to treat any neurological symptoms as potentially severe and life threatening. Blood work was normal and the victim was able to return home the next morning. No tissue damage at all was caused by this bite.

Five days after the bite, the victim suffered serum sickness, which began with one hive on the back of the right leg and within one hour had progressed to hives all over the body. He immediately started a course of prednisone for seven days. The serum sickness resolved after roughly two days.

3. The most recent bite to the author occurred when JH was 41 years old. This bite was from a *Naja naja* and was to the right small finger. The bite occurred during feeding. The snake was offered a pre-killed rat using tongs. The snake grabbed the rat. The tongs were then used to pour water into the snake's water bowl. The snake let go of the rat, and used the back of the cage to push itself forward, out of the cage, and up the tongs to the victim's hand. The snake did not voluntarily let go, so he pulled it off and returned it to the cage. The backup person (KW) was notified, the constriction bandage was used, and the antiserum (South

African Polyvalent) gathered. The hospital was notified we were on the way. Initial treatment for this bite was essentially the same as for the previous bite. Two vials of antiserum were started at the first hospital approximately 30 minutes post-bite, and the patient, backup person, and antiserum were transported via helicopter to UKMC. Dr. Gold again consulted on the bite. However, the progression of this bite differed from the previous one. Approximately two hours after the bite, and despite the two vials of antiserum already given and 13 more in the IV bag currently running, the patient began to complain of abdominal cramping and tightness in the chest, and about five minutes later his heart rate began to drop. It went from 65 bpm to 28 bpm before adrenaline was used and it began to rebound. At this point the decision was made to put him on a respirator. He remained on the respirator for approximately seven hours with no further complications. It is important to note that the patient went from completely conscious and alert, and showing no systemic symptoms, to a having a heart rate at 28 bpm and dropping within five minutes. If he had still been in transport, or antiserum was not immediately available, the situation could have been much more serious. After being removed from the respirator, no further systemic symptoms were noted and he returned home the next morning.

Five days after the bite gaseous gangrene was apparent in the small finger. Dr. Theresa Levan (a colleague of Dr. Wermeling) debreided the site to remove the dead tissue. Both a cross-finger skin flap, which uses skin still attached to the adjacent finger, and a regular skin graft were attempted, however, neither proved completely successful in repairing the damaged area. However, while the grafts were being attempted, enough scar tissue formed to seal the wound and it was decided to start using the finger again. Several weeks into recuperation, the patient noticed very severe pain in the finger, and returned to Dr. Levan. X-rays showed a fracture in the distal phalange of the little finger. Apparently the venom had weakened the bone, and then as the scar tissue formed and caused a contracture of the finger, the pressure caused the fracture in the bone. Two pins were inserted into the finger to heal the fracture, and remained in place for six weeks. Upon removal of the pins, the pain was greatly reduced. The finger, though scarred, is almost completely functional today.

In at least two of these cases, it is certain that having appropriate antiserum on hand and having a protocol and consultants to assist treating doctors saved JH's life. Certainly in both *Naja* bites the fact that antiserum was immediately available was crucial. The *Ophiophagus* bite did not cause reduced respiration or heart rate, however it is impossible to know how this bite would have progressed without antiserum available and started so quickly.

Conclusion

As we have observed envenomations over the years, the only constant in snakebite is that each bite is different to some degree. It is important to realize many factors are involved in an envenomation. Several problems have become

apparent in recent years due to both the increasing number of people keeping exotic venomous snakes as pets, and the poor handling techniques so frequently apparent in various media.

Many private keepers keep no antiserum, and make no contingency plans in case of a bite. Even minutes lost when trying to locate or properly administer antiserum can lead to life-threatening situations. It is the keeper's responsibility to keep antiserum for each species of snake on hand. Additionally, most physicians in the US are not trained to treat snakebite unless they practice in a state where venomous snakes are frequently encountered. Even in this case snakebite is an infrequent event and doctors are not likely to see many bites over the course of a career. Thus it is always recommended that the treating doctor either call poison control or a known snakebite consultant when faced with a bite, and that the keeper keep a protocol for snakebite with the antiserum at all times.

Photo 1. *Naja naja* bite to the right small finger, approximately 40 minutes post-bite. The next four pictures are of this bite.

Photo 2. *Naja naja* bite, approximately 25 hours post-bite.

Photo 3. *Naja naja* bite, approximately 25 hours post-bite.

Photo 4. *Naja naja* bite, one day after surgical debridement and seven days post-bite.

Photo 5. *Naja naja* bite, contracture in finger due to bone fracture caused by loss of bone density due to the venom. 14 weeks post-bite.

Photo 6. Left arm showing hives due to serum sickness. *Ophiophagus hannah* bite, three days post-bite.

Conservation and Recovery Efforts for West Indian Iguanas
(Abstract Only)

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The iguanas of the West Indies comprise two genera, *Cyclura* (eight species) and *Iguana* (two species), with 18 recognized taxa. These large herbivorous lizards inhabit fragile island ecosystems and most populations have suffered substantial declines largely due to the activities of man. Their tropical dry forest habitats have been eliminated or altered by human development and they are particularly sensitive to the negative effects of introduced mammalian species (feral exotics). As a group these iguanas represent the most highly endangered lizards in the world and recent IUCN Red List assessments rank nine taxa as Critically Endangered, four as Endangered, and four as Vulnerable. Several species are at high risk of extinction and are not predicted to survive without conservation intervention. This paper will review the natural history and conservation status of Caribbean iguanas, and discuss some of the research and recovery programs that have been initiated to prevent their extinction. Zoos have played a leading role in the implementation of these programs and these efforts will be highlighted.

The American International Rattlesnake Museum
(Abstract Only)

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Private reptile exhibits come and go. What makes one succeed and the next dwindle from existence? Is the formula for success measured in well planned and researched details, or is it just a matter of common sense? Are there other characteristics to the equation that may be a bit more elusive? In this presentation you will learn the path taken by a former biology teacher, Bob Myers of the American International Rattlesnake Museum in Albuquerque, New Mexico. The Rattlesnake Museum just concluded its tenth year and doesn't seem to be losing steam. The Museum has been featured on National Geographic Explorer, the Discovery Channel, Good Morning America, Good Morning Television (in Europe), Reptile Magazine, Amphiblan and Reptile Hobbyist Magazine, and scores of additional local, regional, national and international television shows, radio programs, magazines, newspapers and travel guides. And, while the Museum's logo T-shirts don't quite rival the numbers of Planet Hollywood's or Tommy Hilfiger's, they are increasingly recognized by reptile enthusiasts around the world. And yet, with all the hype, the Museum's primary concept remains, education. Visitors are willing students in this Crotalid classroom. Myths are explored, phobias cured, mysteries revealed and respect gained for these curious reptiles, and surviving students to this "striking" exhibit leave with a diploma, their "Certificate of Bravery!"

Captive Propagation and Double Clutching of Inland Taipans *Oxyuranus microlepidotus*

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Inland taipans inhabit a very arid part of Australia and little is known about the ecologies. This paper reports on breeding this species in captivity over a period of 5 years at Venom Supplies Pty Ltd. There were 11 clutches with a total of 120 eggs produced in this period from which there were 57 males, 58 females and 5 unsexed offspring. Mean egg widths for both male and female were 34mm and mean lengths for males were 67 mm and 69 mm for females. The mean egg weights were 47gm for males and 49gm for females. For both egg weights and egg widths, most of the eggs were in the lower half of the range whereas the egg lengths were evenly distributed through the range. There were a higher number of females with mid range snout vent lengths (SVL) than males with the mean SVL for males 400mm and 397 for females. Tail lengths were evenly distributed through their ranges for both males and female with means of 67 mm for males and 63 mm for females. Copulations varied between early September through to mid January. Ovipositions varied between late November to end of March. The mean gestation period was 67 days. Hatching varied between late January to early June. The mean incubation time was 73 days. The mean copulation plus incubation was 140 days.

Introduction

The inland taipan is a large Australian elapid that occurs in South Australia, western and southwestern Queensland, probably the southeastern corner of Northern Territory and northwestern New South Wales. It is also known by several other names; namely the western taipan, small-scaled snake and fierce snake. It is predominantly a diurnal species, found in black soil flood plains, gibber plains, on and adjacent to sand dunes and undulating lands. These regions are extremely arid and harsh areas, thus its movement is restricted to times of the day when the temperature is suitable, usually early morning and sometimes late afternoon. It can sometimes be observed in middle of the day during the winter months.

The inland taipans color varies greatly throughout the year and it undertakes dramatic seasonal changes (Mirtschin 1982). Specimens can be very dark to almost black through winter and a light yellow straw color through summer (Mirtschin 1982, Mirtschin & Davis 1992).

It feeds on mammals, mainly the local plague rat *Rattus villosissimuss* (Covacevich & Tanner (1983) and plains rat *Pseudomys australis* and uses a snap bite release method to quickly subdue its prey (Mirtschin & Davis 1982). It averages 2.0 m in length and a maximum of 2.7 m (Mirtschin & Davis 1982 and Mirtschin & Davis 1992). It also has been known to feed on *Mus musculous* and *Antichinomys sp.* (Mirtschin & Davis 1992).

It is probably the most toxic land snake on earth and while its distribution is mostly in sparsely populated areas, it is found in the tiny townships of Coober Pedy and Birdsville. The only bites so far attributed to this species are to herpetologists either catching them or keeping them in captivity.

Very little is known of the inland taipan's ecology, the only study so far being a study of museum specimens and data supplied by herpetologists carried out by Shine and Covacevich (1983). Little is known of the reproductive characteristics of this species. We report a number of breeding events of this species from 1993 to 1998 in a captive colony held at Venom Supplies Pty Ltd in Tanunda South Australia.

Materials and Methods

The snakes are housed at Venom Supplies Pty. Ltd. At Tanunda in the Barossa Valley, South Australia, and are part of a large collection of snakes used for the production of crude venom.

The snakes are housed in identical vivaria constructed of wood. 850 mm x 600 mm x 550 mm high, they are heated by thermostatically controlled 75 watt globes. They are top opening with wire mesh lids. The cage temperatures are set to maintain 29 degrees maximum directly under the globes. A hide box is placed at the farther end of the cage, the minimum temperature inside averages 22 degrees.

Two males and Four females were used. One male (OM1), was wild caught at Goyders Lagoon South Australia in April 1986, one female (OM4) was also caught at Goyders Lagoon in 1989. 2 females (OM9 & OM10) and the other male (OM6) were from captive breeding (Mirtschin 1990) the other female was from the first successful captive breeding of the 2 wild caught snakes (OM1 OM4) in 1993 reported here.

Eggs were weighed on an electronic balance with accuracy to $\pm$1 mg. Measurements were taken by using Vernier calipers then placed into containers with vermiculite moistened with an equal weight of water.

Juveniles were also weighed on the same electric balance and lengths were measured using a steel metric tape.

The incubator was constructed of wood and heated thermostatically using a broad heat tape and controlled to a set temperature of 29°C. The variation experienced was between 26°C to 31°C.

Mating was attempted in every month of the year by placing a male with the female and observing for courtship. If no courtship was attempted by the male, it was removed. Males display normal courtship behavior with a series of wriggling and jerking movements. Females would respond to these movements by tail flicking, moving away or no movement at all but no particular routine appears to produce a copulation.

On occasions double clutching was attempted, but only if the female was thought to be in good physical condition. Within an hour of finishing oviposition the females

would be offered a rat and if eaten without hesitation, the following morning a male would be introduced to the female.

Results

The summary of eggs produced over the 5 year period is shown in table 1.
Copulations occurred between September and November and ovipositions occurred between November and March.

Gestation varied between 51 and 84 days with a mean of 67.2 days.
Incubation varied between 57 to 78 days with an average 73 days.
Clutch size varied between 4 and 19 eggs with an average of 10.9.

The variation in snout vent length (SVL) is shown in fig 1.
There were a higher number of females with mid range snout vent lengths (SVL) than males with the mean SVL for males 400 mm and 397 mm for females. Tail lengths were evenly distributed through their ranges for both males and female with means of 67 mm for males and 63 mm for females.

The variation in tail length (TL) is shown in fig 2.
The frequency of tail length in males was higher in the mid to upper ranges and frequency of the females tail length was higher in the lower ranges. The averages were 66.6mm for males and 62.7 mm for females.

The variation in juvenile weights is shown in fig 3.
The weights were evenly spread across the range for both males and females. Male average weights were 27.4 gm and females were 27.2 gm.

The variation in egg lengths are shown in fig 4.
The frequency of female egg lengths was greater in both the lower and higher ranges but equal at the mid range. The averages were 67.3 mm for males and 69.2 mm for females.

The variation in egg lengths are shown in fig 5.
There is a greater frequency of females with lower and higher egg widths than males. The averages were 33.9 mm for males and 33.7 mm for females.

The variation in egg weights is shown in fig 6.
The male egg minimum weight was 39.7 gm. and the maximum was 62.0 gm. with an average of 47.3 gm.
The female egg minimum weight was 42.4 gm. and the maximum was 60.0 gm with an average of 49.4 gm.
The number of male eggs that were weighed was 16 with 12 female.

Male combat did occur with the inland taipan in a captive situation. By placing a male with another male during the breeding season the combat would commence immediately and consist of normal intertwining and wrestling 1 male would combat then attempt to mate with the rival male. Biting occurred only once with the smaller male biting the larger. The smaller male would attempt to escape the larger.

Within an hour of finishing oviposition the females would be offered a rat, which were usually eaten without hesitation. The following morning a male would be introduced to the female and courtship would commence. Copulation can be the same day.

Discussion and Conclusion

The copulation, oviposition, gestation, hatching and incubation times were all achieved under artificial conditions. They may shed some light on these times in the wild. The boom or bust nature of the natural environment probably means that inland taipans can only breed when conditions are favorable. Every 2 or 3 years, for much of the inland taipans range, flooding and relative periods of good rainfalls are experienced followed by abundant vegetation growth. The prey favored by inland taipans must also restrict its breeding to these times. *Rattus villosissimus* uses these periods of food abundance to dramatically increase its population (Covacevich and Tanner 1983). Other rat species like *Pseudomys australis* also increase their numbers during these favorable times. It is highly likely, inland taipans double clutch during highly favorable times as we experienced with female OM14 in 1997. Note the first mating in this instance occurred very early in September and is the earliest date recorded for mating in our data. It has been suggested that inland taipans do not breed during droughts and one of the authors (Peter Mirtschin) has seen somewhat emaciated specimens during these times at Goyders Lagoon in South Australia.

Mirtschin and Reid (1982) described one type of refuge site for inland taipans being the deep cavities in flood plains caused by the dissolution of gypsum leaving a labyrinth of tunnels underground. In these thermally insulated refuges, inland taipans can find infinite variable sites to lay their eggs to obtain optimal humidity, temperature range and safety from most predators. We incubated our eggs at an average of 29°C and observed and average of 73 days with a 23 day band-width. We believe that an average of 29°C is possible in this type of habitat and it is possible that the variation would be less in these earthen cavities. When laying her eggs, the inland taipan must balance the incubation temperature requirement with available humidity at a given depth. The humidity and incubation temperature chosen was typical for most snake eggs we use at Venom Supplies Pty Ltd.

The higher average SVL for juvenile males was only marginal and probably not statistically significant however males had higher tail lengths (67 mm vs. 63 mm), which is to be expected. During the 5 year data collection period, male combat in the adult snakes was observed in a number of instances. Shine (1991), has observed that male combat is usually observed in snakes where males are longer than females. In our case juvenile male SVL's were only marginally higher which may not be significant. Shine and Covacevich (1983) recorded a higher SVL for females (132 cm for females vs. 144 cm for males) although their numbers were small (13 males and 6 females).

There were little differences in the juvenile hatchlings of both males and females.

The *Oxyuranus microlepidotus* species is a fascinating species to keep in captivity and keeping them for venom extraction, in relatively large numbers, lends itself to

data collection. Accumulating such data from wild snakes, especially from harsh remote sites of the Australian inland, would be both expensive and tedious therefore our data collected from captive snakes forms a good alternative which may be relevant in forming opinions on the wild snake ecologies. In any case combining both wild observations and captive data, enables quicker conclusions to be drawn.

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Snake	COPULATION	OVIPOSITION	GESTATION	HATCH	INCUBATION	COP-HATCH	NO. EGGS
No.	Date	Date	Days	Date	Days	Days	
OM4	6.11.93	29.1.94	84	27.3.94	57	141	5
OM4	10.10.94	4.12.94	57	20.2.95	78	135	19
OM9	23.9.95	4.12.95	72	19.2.96	77	149	18
OM9	8.10.96	28.11.96	51	11.2.97	75	126	15
OM9	8.9.97	?		21.1.98		135	13
OM10	5.10.95	13.12.95	69	29.2.96	78	147	11
OM10	4.10.96	19.12.96	76	2.3.97	74	150	6
OM10	22.11.97	23.1.98	62	11.4.98	73	135	6
OM14	14.1.97	26.3.97	71	11.6.97	77	148	11
OM14*	2.9.97	26.10.97	54	23.1.98	68	122	4
OM14**	27.10.97	11.1.98	76	25.3.98	73	149	12
							120
Av.			67.2		73	139.73	10.9
			N=10		N=10	N=11	
Min			51		57	122	4
Max			84		78	150	19
	*	1st clutch					
	**	2nd clutch					

Table 1. Summary of inland taipan *Oxyuranus scutellatus*, breeding over a 5 year period.

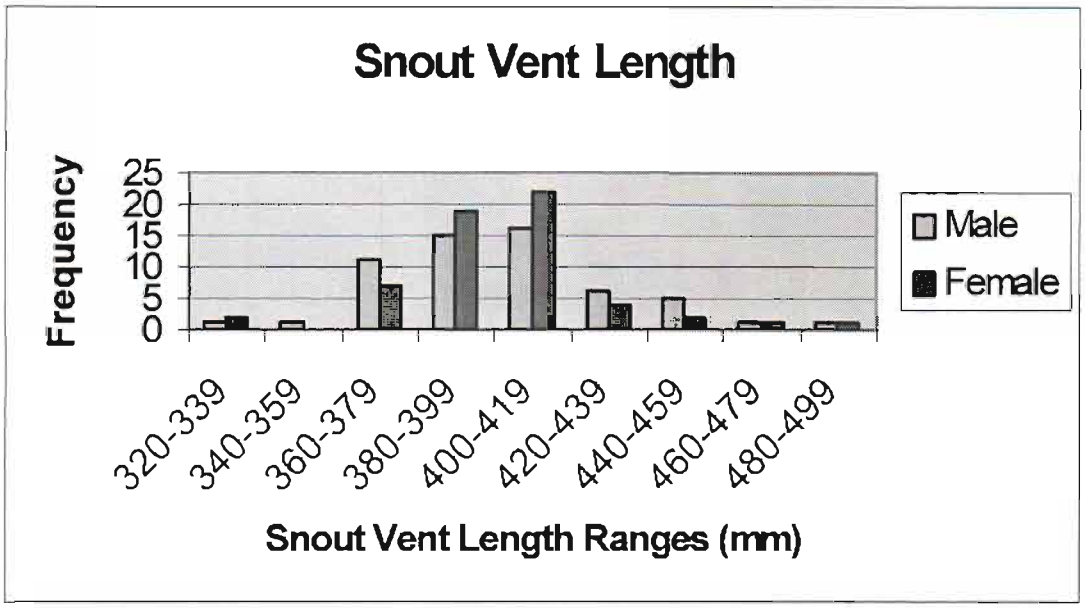

Fig 1. Variation in snout vent length in inland taipan *Oxyuranus microlepidotus* in juveniles hatched in captivity over a 5 year period.

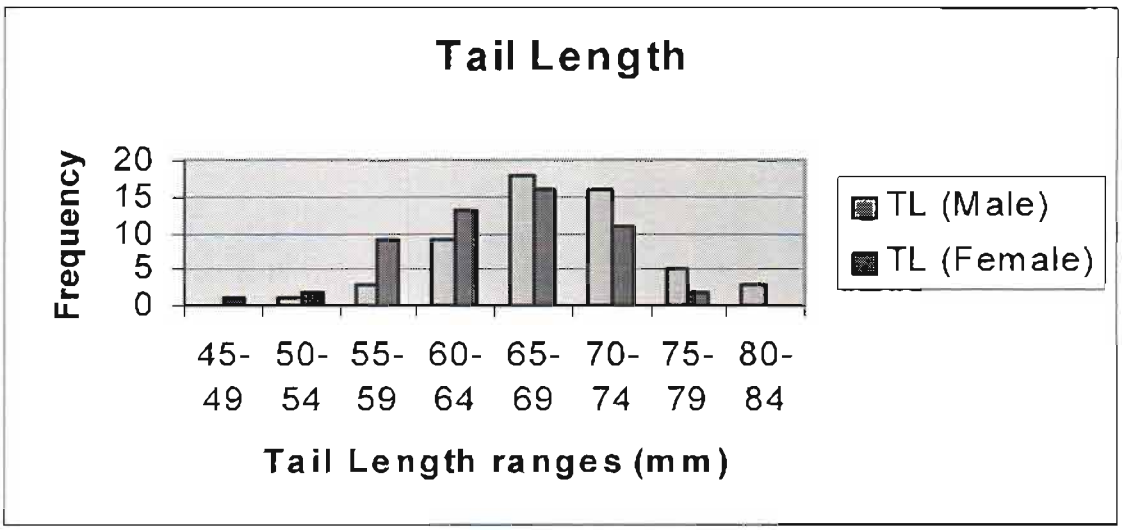

Fig 2. Variation in tail length in inland taipans *Oxyuranus microlepidotus*, in juveniles hatched in captivity over a 5 year period.

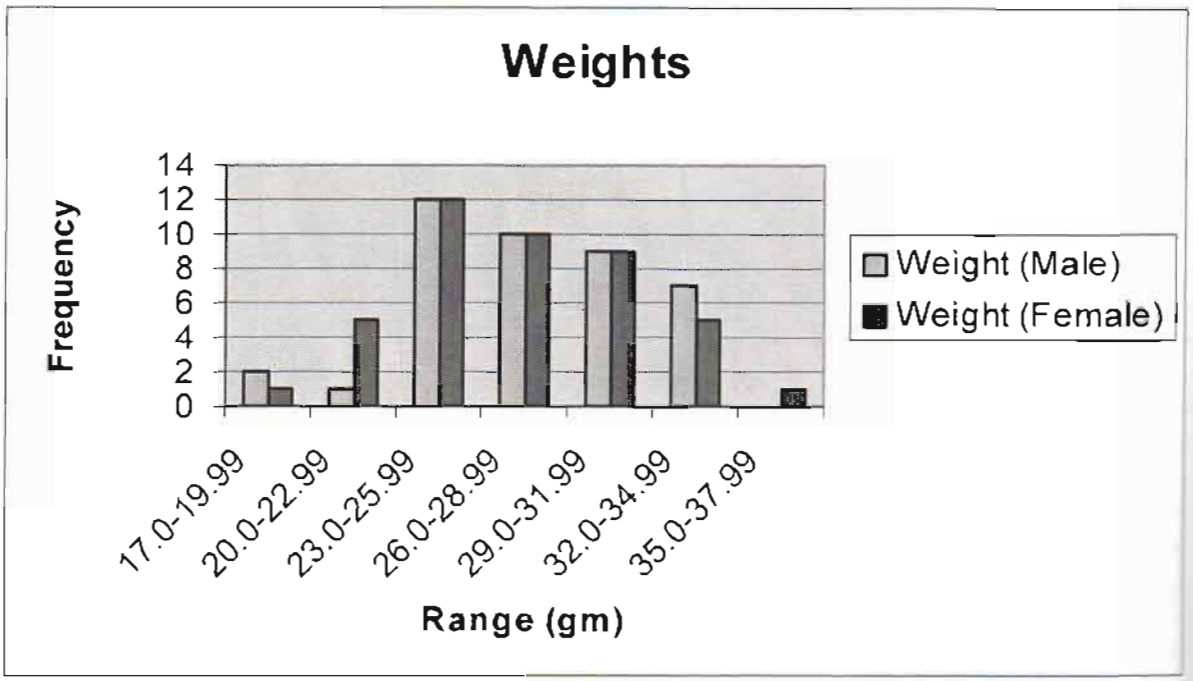

Fig 3. Variation in weights in inland taipans *Oxyuranus microlepidotus*, in juveniles hatched in captivity over a 5 year period.

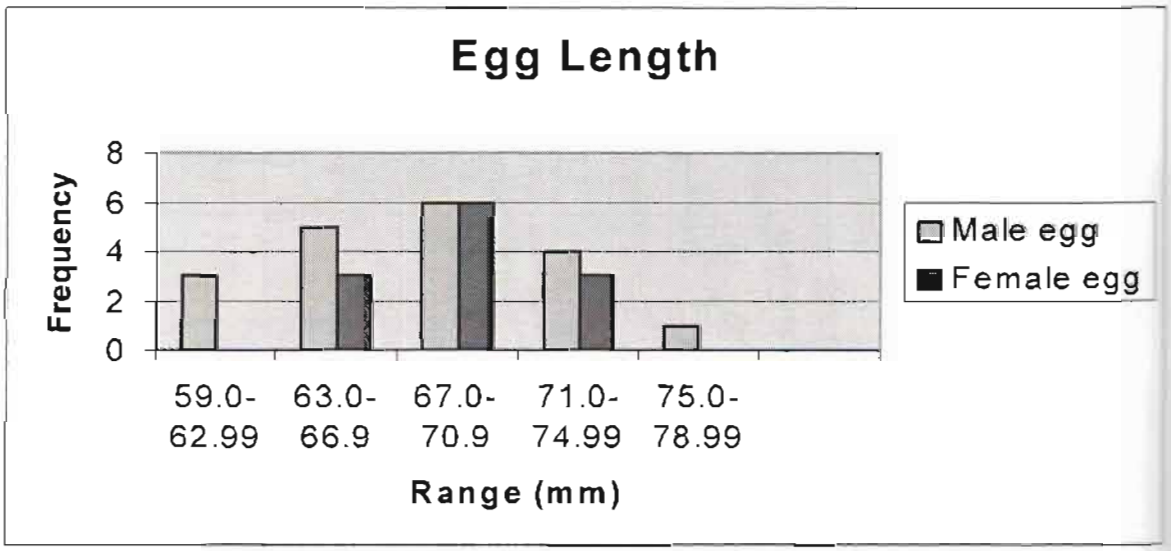

Fig 4. Variation in egg lengths in inland taipans *Oxyuranus microlepidotus*, in juveniles hatched in captivity over a 5 year period.

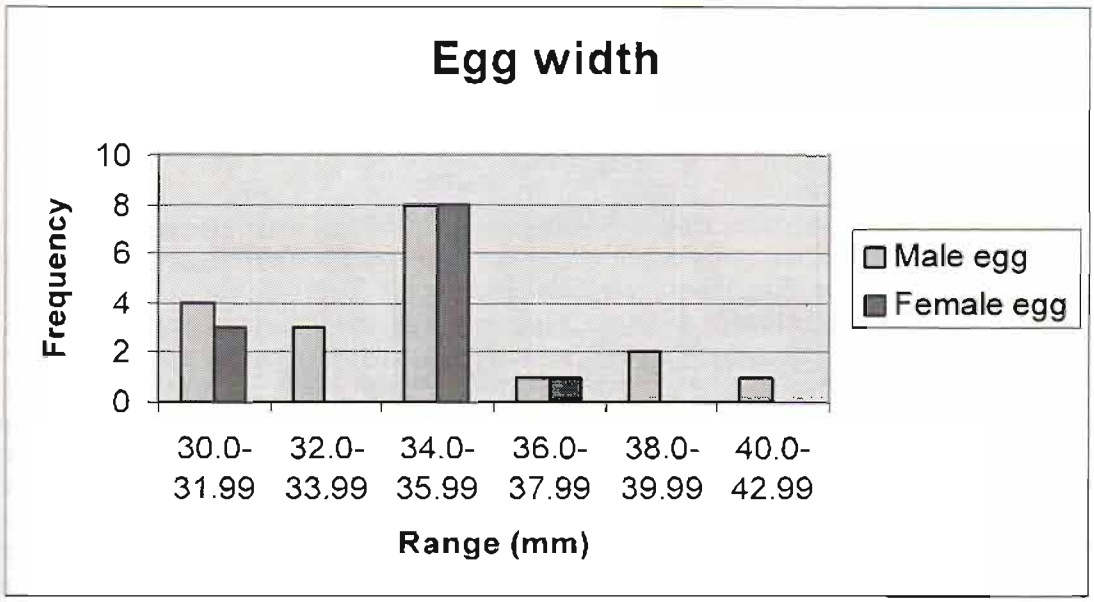

Fig 5. Variation in egg widths in inland taipans *Oxyuranus microlepidotus*, in juveniles hatched in captivity over a 5 year period.

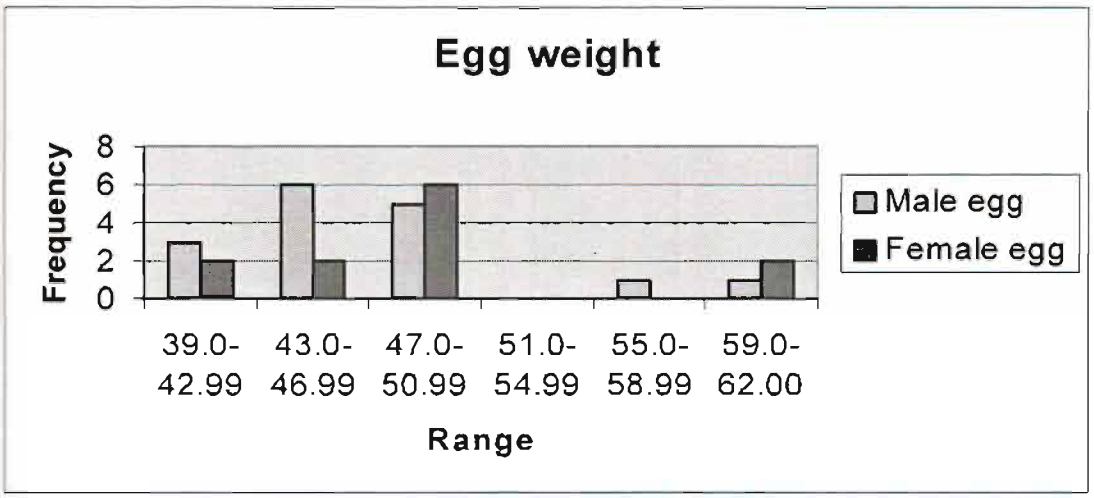

Fig 6. Variation in egg weights in inland taipans *Oxyuranus microlepidotus*, in eggs laid in captivity over a 5 year period.

The Struggle to Save the Wyoming Toad *Bufo baxteri*: A Case History in Captive Propagation and Conservation
(Abstract Only)

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The Wyoming toad, *Bufo baxteri*, is perhaps the most endangered amphibian in the North America. It became extinct at its last remaining wild refuge in the early 1990s and its recovery has been entirely based on captive reproduction and repatriation from a small captive nucleus. Unfortunately the captive population has been plagued with challenges and sporadic breeding, which has hindered repatriation efforts. Many husbandry protocols at different institutions were tested with different successes. What factors were important for successful reproduction were not readily apparent so a program was established to quantify relationships between numerous husbandry variables and reproduction. Factors that were examined included length of hibernation period, age of animal, mass of animal, temperature of hibernation, length of time between hibernation and breeding, inbreeding coefficient of resulting offspring, and number of hormonal injections. Factors that showed significant relationships to successful reproduction included: number of injections of hormones, length of hibernation period, mass of females, and age of animal. This presentation will discuss the history and challenges of the Wyoming toad conservation efforts, as well as efforts to quantify husbandry parameters necessary for successful reproduction.

Status and Ecology of the New Mexico Ridgenose Rattlesnake, *Crotalus willardi obscurus*
(Abstract Only)

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On 24 January 1975, the New Mexico ridgenose rattlesnake, *Crotalus willardi obscurus*, was listed as Endangered by the New Mexico Department of Game and Fish. On 4 August 1978, the species became the first rattlesnake listed as Threatened under authority of the federal Endangered Species Act. Limited habitat and the potential for overcollecting were given as the primary reasons for these listings. Since that time numerous investigators: Klauber, Degenhardt, Altenbach, Applegarth, Painter, Barker, and Holycross have explored the Animas and Peloncillo mountains of southwest New Mexico and southeast Arizona and the Sierra San Luis of northern Sonoran and Chihuahua, Mexico and have added considerably to the understanding of this unique montane rattlesnake. The earliest studies concentrated on the distribution and habitat use, while an emphasis on systematics, ecology, natural history, and conservation have dominated the later studies. Most of the data in this presentation were collected by Painter and Holycross. We worked in the Animas Mountains (New Mexico) from 1994 - 1999, the Peloncillo Mountains (Arizona and New Mexico) from 1995 - 1998, and in the Sierra San Luis (Sonora and Chihuahua) in 1998. Field teams dedicated 1,355 "person-days" searching for *C. w. obscurus* over the course of the study. 206 individual *C. w. obscurus* (160, Animas Mountains; 17, Peloncillo Mountains; 29, Sierra San Luis) were marked during these studies.

Field Conservation and Captive Breeding of the Giant Gomeran Lizard

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The Canary Island archipelago is situated close to the coast of Morocco. Although poor in herpetofauna, is rich in endemic species. Of the 17 species of reptiles and amphibians in the Canary Islands, 14 are endemic; the other three being introduced species. In the last 25 years three new species have been rediscovered, two of those in the last 5 years including *Gallotia gomerana* from the island of Gomera. *G. gomerana* was first described in 1985 by a German mammalogist (Hutterer). Although ancient documents from the 16th century mention a large lizard on Gomera. A team of biologist rediscovered a relict population of these lizards in 1999 on the cliffs of La Merica in the municipality of Valle Gran Rey. A total of six lizards, three males and three females, were captured over a period of six months. The lizards were to be the founder group for a captive breeding program run by the Department of the Environment of the Canarian Government. Captive breeding may be the only salvation for these extremely rare lizards. A provisional census has shown a wild population of only five lizards, and it is calculated that a maximum population of only twenty may exist. This makes *G. gomerana* among the most endangered vertebrates in the world.

Introduction

In June of 1999 a large lizard was rediscovered on the Island of Gomera, one of the Canary Island group. The lizard was first described from fossil remains in 1985 by R. Hutterer as *Gallotia gomerana*, although the taxonomical situation still needs to be resolved. The lizards were temporarily named *Gallotia simonyi gomerana*, this enabled the lizards to be automatically protected in Spain and also listed as CITES Appendix I, due to the existing listing of *Gallotia simonyi* from the neighbouring Island of El Hierro, another large lizard rediscovered in 1976. Another lizard was also found in 1996; *Gallotia intermedia* from the Island of Tenerife.

The Canary Islands are a group of seven small islands and several more smaller Islets. Volcanic in nature, they are between 1 million and 20 million years old, situated close to the west coast of Africa at 28.05N, 17.06W, 3750 miles east of the USA. The Island of Gomera is one of the smallest with 370 sq. kilometres; it is approximately 13 million years old. The last volcanic eruptions were several million years ago, which led to much erosion and the formation of deep valleys. The climate is sub tropical, weather patterns are affected by the trade winds from the Northwest. The north of the islands tend to be more humid, and the south, more arid.

The lizards were discovered in the south west of the island in the municipality of Valle Gran Rey. Working from a tip from locals, a team of biologists searched an area of cliffs known as "La Merica". Large pieces of excrement were found and, after placing traps baited with fruit, a young female lizard was caught. It was noted straight away that this was a species not seen in recent times. Further

trapping produced another 5 lizards in six months. The six were thought to be 2.4 (2 males, 4 females), although 2 smaller lizards were incorrectly sexed as females, later found to be juvenile males. Two adult males were caught. These were distinguished from the females, and other species of Canarian *Gallotia*, by a pure white throat and underarms. The largest animal measured 50cm and was dark-grey-to-black on the dorsum with blue spots along the flanks, with a light belly. Males have larger heads and white throats.

Although the original project was just to look for new and lost species of lizards, no plans had been made for keeping the animals in captivity. The biologist involved thought these lizards were on the brink of extinction and convinced the Canarian government to bring them into captivity. The lizards were sent to Tenerife where they were set up in a small room in separate glass terrariums measuring 6 ft X 2 ft X 1-1/2 ft. The substrate was peat moss with cork hiding places, UV fluorescent tubes, and a heat lamp was placed on the top. The lizards were fed local plant matter and baby food. They were also monitored by CCV cameras. After six months, a political row erupted over the lizards because certain people thought not enough was being done to help the lizards.

It was decided to send the lizards back to Gomera, where a temporary facility had been set up comprised of three outdoor terrariums plus offices. The terrariums are 14 ft X 14 ft X 4 ft high with a natural dirt floor and planted with native shrubs. They are covered with wire netting to protect them from predators. This happened in the end of March 2000. Attempts to breed the lizards that year were unsuccessful due to various factors. The lizards did not adapt well to their new home. Also the altitude of the new terrarium was higher than the natural habitat.

In July, one of the adult males died from a bacterial infection in the spine. In August another male was captured accidentally in a cat trap. Later in the year, a herpetologist was appointed to run the project and a work-plan was drawn up for captive breeding and conservation in the wild. It became clear that this lizard was seriously endangered. It was calculated that a maximum population of only 15 to 20 lizards survived on the cliffs of La Merica. Captive breeding was probably the only hope for this reptile. Also of high priority was the control of predators. Feral cats, rats, and goats were all present in the area. It has long been known that Feral cats are among the largest killers of reptiles, especially on islands where the reptiles have not evolved a natural defence. Cat and rat traps are set everyday, and this has helped to reduce the numbers. A total of 40 cats were eliminated in the first 9 months. Rats have been virtually wiped out and goat herders have been asked not to let their animals graze in the area. A census has been started to gain a more exact census of lizards in the wild. To date there have only been four sightings of wild lizards; one small juvenile was captured, marked, and released. At least one other pair has been identified. Trapping has not been very successful. The lizards are very wary and reluctant to enter the traps, which consist of 6-inch plastic water pipes baited with different fruit. The other species which live in the area, *Gallotia caesaris*, are captured regularly. Over 900 were caught in a 9 month period.

Work is also ongoing to discover new populations. Due to the difficult terrain, two mountain climbers have been contracted to help in the search. This enables us to reach high inaccessible ledges, which may harbour other colonies of lizards. Searching the island has also turned up more fossil evidence. From these findings we can see that the lizards once lived all over the Island. In fact, a German naturist, K.Von Fritsch, who visited the Island in 1863, mentioned in detail the giant lizards. He also found a large jawbone in Agulo in the north of the island. Recently, another German discovered a 14-cm piece of jaw; this would have belonged to a lizard over 3 ft long.

Captive Breeding

One of the first things needed were some adaptations to the outdoor terrariums. Large rocks were placed in the terrarium and heat lamps were installed for basking on cooler days. CCTV is also installed so the lizards can be observed at all times without too much disturbance. After six months, the lizards have adapted to the new installation and have begun feeding normally and gaining weight. Although there was some courtship behaviour in the first year, it seemed the females were not ready to breed. During the winter, the lizards started to lose weight rapidly and there was some concern. I believe this is a natural effect from living in a harsh environment. During late summer and winter there is a limited food supply. Lizards in the wild seem to be almost totally herbivorous and seem to be associated with one plant, the Balo (*Plocama pendula*), which bears small fruits in the early summer. Another plant, Tedera (*Psoralea bituminosa*), is also preferred. Both of these are offered to the lizards in captivity. In the spring, the lizards soon start to recover weight, and at the time of writing (5 June 2001), the lizards are at their maximum weight, and are starting courtship.

On the 29th of June the young female Ramona (Gg1) laid 5 eggs. This was unexpected as it was thought she was too young to breed. Records show she had increased in weight fairly rapidly over the last month. At the time of egg laying she weighed 134 gms, but after oviposition, she weighed 89 gms. She quickly regained 13 gms in the first week after laying. The eggs ranched in size from 26 mm X 12 mm and weighed on average 4 gms each. They have been placed in an incubator at 30°c. The eggs were laid in the late afternoon after several days of digging. All the eggs look fertile and it is hoped they will all hatch in approximately 60 days.

Fortunately, sufficient funds have been allocated by the government to this project. A new specially designed purpose-built breeding facility is soon to be constructed very close to the lizard's natural habitat. This will consist of four large 25 ft x 25 ft natural outdoor terrariums plus smaller ones for juveniles and babies. An office, laboratory, quarantine and incubation room, and a house for the director, is also to be built. This should be finished before the next breeding season in 2002.

Investigation

Although it has been decided to put most forms of investigation on hold until more lizards are found or bred, some work is already in progress. A six- month

study on the behaviour of the lizards was carried out. Also blood has been taken from the lizards to check their health and document normal blood levels. DNA samples have also been taken for taxonomic studies against other species of *Gallotia*, and also to see the phylogenetic relation between individual. ECG levels have also been measured in the lizards to determine normal levels for future use as a diagnostic tool. Data loggers supplies by the Onsett Computer Company have been placed on the cliffs and in the terrariums to give us an idea of the temperature and humidity in the wild and in captivity.

In conclusion *Gallotia simonyi ssp*. is probably one of the most endangered vertebrates in the world, with only 4.2 lizards in captivity, with only one adult reproductive female. We owe it to the lizards to make every effort to try and reproduce them and start a reintroduction project.

I hope that by the time this paper is published, eggs will be incubating, and by the end of 2001 the first offspring will be hatched.

(Editorial note: Three babies were hatched at the Lagartario de la Gomera in August 2001; after the submission of this manuscript.)

Acknowledgements

Jose Antonio Mateo.
Onset Computer Corporation.

Photo 1. Hatching *Gallotia s. gomerana*.

Photo 2. A young *Gallotia s. gomerana* female.

Photo 3. Terrarium at Lagartario de la Gomera.

Photo 4. Lagar 16. An Adult female in the wild.

Photo 5. Veta de Fuente, the only known habitat of the lizard, smaller than a football pitch.

Notes On The Egyptian Tortoise (*Testudo kleinmanni*) in Captivity

E.J. Pirog

In the coastal areas of Libya, Egypt and Israel there lives a small nondescript tortoise commonly called the Egyptian Tortoise. It was originally described in 1869 by Albert Günther and given the specific name of *Testudo leithii*. The type locality, or the area in which it was first discovered, was reported to be Sindh, which is in the area presently called Pakistan (Lovridge and Williams, 1957). There is much doubt that the specimen actually came from this area. The tortoise was later redescribed in 1883 by Louis-Charles Lortet as *Testudo kleinmanni* with a type locality reported as being Alexandria, Egypt (Lortet, 1887). This seemed a little more realistic when compared to the original type locality and present distribution.

Testudo kleinmanni, a relatively small tortoise, is most distinguished from other *Testudo* by the presence of two triangular markings on the abdominal scutes with the apex pointing towards the tail. It has three rows of scales on the forelimbs. The tortoise lacks the presence of spurs on the thighs of the back legs that are usually present in other species of *Testudo*. There are no dark spots in the center of the carapace scutes. The aft plastron is hinged. Deformities in carapace scutes appear to be a fairly common occurrence in the wild population and do not appear to be a temperature-induced malformation that tends to occur in other tortoises during the development of eggs at high temperatures, in general.

There is a definite sexual dimorphism among these tortoises. The females are much larger than the males, with adult females as weighing 250 - 400 grams and measuring up to 130 millimeters straight-line carapace length. The carapace is much higher domed in females than in males. The males are smaller, weighing 175 to 200 grams with a length of up to 105 millimeters. The males also have a noticeably longer tail than the females.

The Egyptian Tortoise ranges along the coastal strip of Northern Africa and Israel, extending from the southern tip of Israel to Western Libya. This range extends roughly 30 to 60 kilometers inland. The prime habitat consists mostly of sandy loam areas which are sparsely vegetated. Average rainfall in this area is between 100 and 200 mm per year (Groombridge, 1982). The average temperature is 20 degrees C (68 F) with a maximum of 30 degrees C (68 F) and a minimum of 12 degrees C (54 F). It is suspected that the tortoises have control over the microenvironment they choose and most likely do not reach the high or low temperatures recorded.

The animals from which this observation is based are maintained in enclosures measuring 24 inches by 48 inches by 16 inches. A 100-watt lamp is provided at one end, 20 centimeters above the substrate, ensuring a temperature gradient of 22 - 32 degrees C from one end of the enclosure to the other. The substrate is crushed oyster shell for the adults and indoor/outdoor carpeting for the juveniles. A shallow water dish is provided to make accessible, clean water available at all times.

During times of warm weather with temperatures above 15 degrees C, the tortoises are maintained outdoors in enclosures having a perimeter of 16 meters. The area is sparsely vegetated with clumps of grass provided for the tortoises to seek shelter under. The ground cover is sand or fine gravel. Where there is more than one male, two large stones are placed in the center of the enclosures to break the line of sight to facilitate escape in the event of a conflict. This allows one of the males, or females, to escape if need be. Aside from the clumps of grass, there are no other provisions for the tortoises to bed down. They usually sleep and nest at the base of the plants. Again, clean water is provided at all times by means of a water dish sunk into the ground. The water is flushed and replaced daily by way spraying with a garden hose. The food provided consists of the following: escarole, endive, romaine and green leaf lettuce, parsley, Italian parsley, cilantro, mustard greens, carrots, water cress, rappini, kale, collard greens, basil and bok choy. Two bunches of each are provided. Cruciferous plants, like the cabbages, are fed sparingly if at all. The food is chopped into 2-centimeter pieces and mixed. This prevents the animals from being too selective and allows them to get a balanced meal. A powdered multiple vitamin (powdered Centrum tablets) is sprinkled on the food weekly. Powdered calcium carbonate is sprinkled on the food daily and whole cuttlebone is available at all times. This appears to keep the beaks and nails trim also, if the tortoises use the cuttlebone. These tortoises are primarily herbivorous, so a diet of high fiber foods is recommended to maintain healthy animals.

Breeding has been observed in the spring, with the earliest observation being 7 May and the latest being 19 September, over a 3 year period. Males will become very aggressive towards both the females and other males. Males would occasionally spar, going about in circles for hours on end, head butting each other - head on. During breeding the males became very vocal producing a cooing sound similar to that produced by a mourning dove. Mating was usually observed in the early morning before noon, or late afternoon after 4 p.m.

Nesting was observed to occur in summer, with the earliest observation being 13 July and the latest being 3 November, over the same 3 year period as the breeding. The females would dig nests at the base of the grass clumps where they usually rested. Nests were located on the south-facing side of the clumps, with deposition of the eggs usually taking place in the early morning or late afternoon. Normally 2-3 eggs were deposited. Occasionally 1 and 4 eggs would be deposited. One to four clutches of eggs were produced per female per breeding season. Two to 11 eggs per female per season were produced. Average egg dimensions are 30.5 x 24.3 mm with an average weight of 10.5 grams. The extremes were a maximum of 33 x 26mm with a weight of 12.75 grams, and a minimum of 27.5 x 24.0 mm with a weight of 8.9 grams. Over the 3-year period of these observations, 7 females produced 68 eggs. Of the 68 eggs produced, 41 hatched. Occasionally nesting would take place indoors. For this a nesting box (11 x 7 x 4 inches) was provided with moist sand 3 inches in depth. The eggs were incubated at 28 - 31C. This fluctuation was intentional to hopefully produce both males and females, going on the assumption that there is temperature-sex determination involved. The average time interval to hatching was 94 days for 33 eggs in 1994. The extremes were a maximum of 126 days and a minimum of 85

days. The eggs were incubated on a dry substrate of vermiculite or sand.

Hatchlings were an average length of 32mm with an average weight of 7.15 grams, out of 24 hatchlings in 1994. The extremes in the hatchlings were a maximum of 36 mm with a weight of 10.6 grams and a minimum of 28.5 mm with a weight of 5.8 grams.

Hatchlings are very hardy. The growth rate can be very fast but is not recommended, so food intake was regulated. It is suggested that hatchlings be fed every other day, paying particular attention to the availability of calcium and water. These should be available daily. It was found that the hatchlings are very susceptible to metabolic bone disease.

These are the observations of one group of *Testudo kleinmanni*. It has been found that a major problem with the care and maintenance of these tortoises is that different groups adapt and seem comfortable in different conditions found in the various areas in which they are kept. This makes it difficult to suggest an exact condition with which to keep these tortoises. The intent of this presentation is to pass on observations that hopefully might help other keepers of this species.

This paper was originally presented at the 1999 IHS in San Diego, CA. Since then, there have been some new developments in the group of *T. kleinmanni* presented here. In the Fall of 2000 two clutches of eggs were produced, one month apart. One clutch consisting of 2 eggs and one clutch consisting of 3 eggs. A long-term wild-caught animal obtained in 1993 produced these eggs. Of the 5 eggs, 4 hatched. One was premature and died soon after hatching. The remaining 3 that hatched were albino. It was later determined that the sire of the hatchlings was an offspring of the female that deposited the eggs. An interesting note is that the male was only 4 years old, and produced viable offspring. This particular male also had a choice of 8 other females in the group and chose to mate with the female that produced it. The female was TK17. The hatchlings were normal in every respect except for the color.

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Breeding Results Through 2000

ID#	Clutches	Eggs Deposited	Eggs Hatched
1993			
Tk03	1	2	0
Tk07	2	4	3
Tk08	1	3	1
Unk	1	5	1
1994			
Tk03	1	3	2
Tk06	4	11	6
Tk07	4	9	9
Tk08	3	6	5
Tk14	2	2	2
Unk	2	4	0
1996			
Tk06	2	6	3
Tk07	3	6	4
Tk17	3	5	4
Unk	3	3	0
1998			
Tk03	1	1	0
Tk06	1	1	0
Tk14	3	4	1
2000			
Tk17	2	5	4

Photo 1. *Testudo kleinmanni* female.

Photo 2. *Testudo kleinmanni* hatching.

Photo 3. Outdoor *Testudo kleinmanni* setup.

All photographs taken by the author.

Photo 4. *Testudo kleinmanni* breeding.

Photo 5. Indoor *Testudo kleinmanni* setup.

Photo 6. Albino *Testudo kleinmanni*.

Rattlesnakes of the Colorado Plateau
(Abstract Only)

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The Colorado Plateau is a physiographic region of southwestern North America that encompasses most of northern Arizona and eastern Utah, parts of western Colorado, and extreme southwestern Wyoming. The area is drained primarily by the Green and Colorado rivers, and is characterized by broad plateaus, ancient volcanic mountains, and deeply dissected canyons. The Colorado Plateau is one of the most scenic regions in the world. The western rattlesnake (*Crotalus viridis*) has long been recognized as the most widespread and phenotypically variable rattlesnake in North America and has been partitioned into nine subspecies based on scalation, size, color, pattern, and geographic distribution. The Colorado Plateau is pivotal to our understanding of the evolution of the *C. viridis* group, as six members potentially contact one another at or near the Grand Canyon. Recent molecular studies investigating specific regions of mtDNA do not support monotypic status for the group but rather indicate two major lineages (Douglas et al., *in press*). An overview of the rattlesnakes of this region is presented, and aspects of their natural history and evolutionary relationships are discussed.

Commercial Scale Aquaculture System for Rearing Amphibians
(Abstract Only)

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Sandfire Dragon Ranch became the name associated with Bob Mailloux in 1992, after he developed the beautiful red color morph of the Inland Bearded Dragon *Pogona vitticeps*. Bob had been working extensively with Reptiles and Amphibians for approximately 35 years at that point, with his primary emphasis on amphibians. Bob and I became friends in the early nineties when our paths crossed through the trade. We quickly became friends and exchanged ideas, shared techniques, and discussed our long-term goals. We soon began discussing ways to combine Bob's years of knowledge, and my strong business background, to create a new facility directed at large scale propagation of Herps for the pet trade. In about 1996, we began pooling our resources, and developed methods and refined techniques to successfully produce select species of frogs and lizards on a commercial scale for the pet trade.

A brief over view of our lizard propagation techniques will be presented. I will mainly focus on our amphibian propagation. The methodology to reproduce frogs began as a "green house style" style set up with manipulation of environmental cues at the appropriate time of year. This type of production has remained fairly constant, only the scale had to be changed. Rearing methods to achieve the large numbers of specimens for commercial production has changed significantly. Details on the development of an intensive aquaculture system to optimize this production will be discussed. Observations on the effects of water quality, pheromones, nutrition, temperature and density on the survival and growth rates will be provided. In developing these methods my opinion on health problems and deformities such as "spindle leg" syndrome will be provided. These methods were primarily developed for several species of Old World tree frogs in the genus *Litoria*. The process has been a learning experience, it has answered many questions and generated many more.

Mexicana Complex Kingsnakes: New Insights from Captive Breeding and Field Work in Mexico
(Abstract Only)

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Confusion regarding natural history and taxonomy has plagued this group of kingsnakes since the discovery of each of the species (currently recognized as *Lampropeltis alterna*, *L. mexicana* and *L. ruthveni*). Due to their secretive nature and difficulty in collecting specimens, captive breeding of specific locality founders has shed light on the colors and patterns possible in these often polymorphic snakes. Recent work in Mexico has yielded new information on their geographic distribution and microhabitat preferences. Gerry has been working on this species group for more than 15 years and has done extensive research in museum collections and in the field. This talk will highlight some of the information that is a work in progress and several papers are due to be published in the near future.

REPTILE OBSTETRICS

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Breeding reptiles for fun and/or profit is becoming commonplace for reptile enthusiasts. Complications with laying eggs or giving birth to young is a common sequelae of breeding reptiles. Veterinarians treating reptiles in practice will often be presented with reptiles with dystocia. Dystocia in reptiles can be multifactorial and may be the result of inappropriate nesting sites, stress, dehydration, malnutrition, obesity, salpingitis, obesity, malformed eggs and abnormal reproductive anatomy (DeNardo, 1996). This paper will discuss the general clinical presentation and commonly used medical and surgical options for the treatment of dystocia in snakes, lizards and chelonians.

Snakes

Dystocia is seen more commonly in the egg-laying (oviparous) snakes than in the live-bearing (ovoviviparous) snakes. *Oviparous snakes* include pythons, colubrids (rat snakes, king snakes, milk snakes, hognose snakes, green snakes) and elapids (cobras, coral snakes, etc.). *Ovoviviparous snakes* include boas, colubrids (garter snakes, water snakes, ring-neck snakes), rattlesnakes, copperheads, and other vipers (gaboon, tree, eyelash)

Historical presentation Oviparous snakes: the snake may have laid a clutch of eggs and the owner notes what appears to be eggs still in the snake. Or the snake has not laid any eggs but is past her due date and the owner can see or feel eggs in the snake. Ovoviviparous snakes: owner may present the snake knowing the snake has been bred, noting that it appears gravid but is well past its due date. Or the snake may have produced an abnormally small clutch size and the owner is concerned there are still babies present. Often with live-bearing snakes owners may not be aware they are gravid and may present them for anorexia or another problem.

Clinical assessment Oviparous snakes: often-retained eggs are palpable on physical examination. They may be distributed unevenly throughout the lower 1/3 of the body or they may be "bunched up" at the cloaca. The eggs may be misshapen on palpation, they may be free to move up and down, or they may be immobile. Use caution when palpating not to force eggs to move. The oviduct is extremely fragile and may tear easily. Radiology or ultrasonography can be used to confirm egg numbers, abnormalities, and comparative egg size but may not be necessary, as eggs are usually readily palpable.

Ovoviviparous snakes: it is much more difficult to palpate developing fetuses in live-bearing snakes and radiology and/or ultrasonography may be necessary for confirmation. Ultrasound can be very useful in determining whether fetuses are alive. In late gestation snakes can be seen moving (in a tight coil) and a heartbeat may be seen. Sometimes determining a true dystocia versus a normal pregnancy is difficult in live-bearing snakes.

Treatment

Medical

There tends to be a small window of opportunity when oxytocin will be effective. If used for a (non-obstructive) dystocia where some portion of the eggs (fetuses) have been laid or obvious nesting or straining is occurring, the oxytocin is best initiated within 48-72 hours of such activity. A dose range of 5- 20 IU/kg IM is used by this author starting with the lower end of the dose range and increasing the dose on subsequent doses if no response is initiated. Dosing can be repeated in 6-12 hours. If 2-3 doses have been given with no response then medical therapy will likely not be effective. Arginine vasotocin, which is the natural reptile oxytocin-equivalent hormone, is likely a more useful drug but it is available only as a research drug at this time.

Egg manipulation

Using general anesthesia with propofol (Rapinovet 10mg/ml; Mallinckrodt Veterinary) at 5-10 mg/kg IV (tail vein or intracardiac) and/or isoflurane eggs sometimes can be gently manipulated toward the cloaca and removed. Another technique is to gently move the retained egg to the cloaca. The egg can then be visualized through the cloaca and may be aspirated. Often the deflated egg will then be easily manipulated out (and the procedure can be repeated for the next egg) or the snake can be allowed to try to pass the deflated egg on its own. Oxytocin can also be used to accelerate the passing of the deflated egg.

If the egg cannot be manipulated to the cloaca, then percutaneous aspiration can be performed. The egg is isolated against the lateral body wall and the area is sterily prepped and a 20-gauge needle is inserted between the first and second row of lateral scales and into the egg. The contents of the egg are aspirated into the syringe using caution to avoid any leakage of egg material into the coelomic cavity. The snake will usually pass the egg within 12-24 hours of aspiration. Subsequent eggs behind the first may also have to be aspirated in turn or they may pass on their own after the first egg is removed. Eggs retained more than several days may not be successfully aspirated as the egg contents may solidify. These eggs will have to be surgically removed.

Surgery

Surgery may be necessary if medical therapy, egg manipulation and/or ovocentesis has failed. After anesthetizing with propofol and/or isoflurane as described above, an incision is made between the first and second row of lateral scales over the retained egg or fetuses. The oviduct is isolated and incised to remove the egg or fetuses. If there is more than one egg or fetus they may be able to be removed from the same incision. However, if they are adhered higher up in the oviduct or in the opposite oviduct multiple incisions may have to be made. The oviduct is closed with a simple continuos pattern using a fine absorbable suture (i.e. 4.0-5.0 PDS). The coelom is closed with an absorbable suture and the skin with a non-absorbable suture in an everting pattern.

Lizards

Dystocia is seen more commonly in the egg-laying (oviparous) lizards than in the live-bearing (ovoviviparous) lizards. Oviparous lizards include iguanas, dragons,

monitors, gila monsters, beaded lizards, anolis, tropical chameleons, many small skinks, uromastyx lizards, most geckos. Ovoviviparous lizards include large skinks such as the bluetongue skink, prehensile tail skink and montane chameleons such as the Jackson's chameleon.

Historical presentation

Owners may or may not be aware that their lizards are reproductively active. Often lizards may develop mature follicles on their ovaries and/or actually ovulate and produce infertile ova without a mate being introduced. Owners often describe their pet lizard as becoming restless in their cage, pacing and climbing, likely looking for potential nesting sites. They may dig in planters or in the substrate in their environment. Appetite and water intake may be greatly reduced or gone.

Owners that are attempting to breed their lizards may present a lizard because the lizard has laid a clutch of eggs but still appears to be have retained some eggs. Or the lizard has not laid any eggs yet (and showing similar signs as above) but is past her due date and the owner can see or feel eggs in the lizard.

For ovoviviparous lizards the owner may bring the lizard in knowing she has been bred, noting that she appears gravid but is well past her due date. Or the lizard may have produced an abnormally small clutch size and the owner is concerned there are still babies retained.

Clinical assessment

It is important to differentiate between pre-ovulatory egg stasis and post- ovulatory egg stasis when lizards are presented to the clinician because treatment for the two syndromes may differ. With both situations weight loss over the tail base and rear limbs may be noticeable, but they will still have a very full appearance to the abdomen.

Preovulatory egg stasis

In captivity, one common scenario is for the ovarian follicles to become static. They may reach a large ovulatory size but still not be ovulated or resorbed. This is known as preovulatory egg stasis. It is unclear why this occurs, but it may be related to inappropriate environmental cues. Generally, the ova will be palpable or very obvious against the body wall of the abdomen. Differentiating ovarian follicles from oviductal eggs can be challenging. It is contraindicated to use oxytocin in lizards with preovulatory egg stasis. Prior to any use of oxytocin, the clinician must be certain the eggs are in the oviduct.

Postovulatory egg stasis

This condition occurs when the ovarian follicles are ovulated into the oviduct, but the eggs are not laid or only a portion of the eggs are laid.

Differentiating pre vs. postovulatory egg stasis

On palpation, ovarian follicles tend to be more dorsal and spherical and not as mobile as oviductal eggs, which are usually more oblong and ventral/caudal in the abdomen. Radiographs may help to differentiate the two as the ovarian follicles are

usually not calcified and are more spherical and dorsal in their location. Ultrasonography can also be useful to differentiate between the two.

Treatment

Medical management
If the eggs are preovulatory or postovulatory and the lizard is normal on assessment, then a nest box can be provided and the lizard may be sent home on NeoCalglucon at 1ml/kg PO BID for 21 days. Surgery can also be pursued at this time if the owner prefers. Postovulatory egg-bound lizards with calcified eggs may present with clinical signs of hypocalcemia, including paresis, tremors, and seizures. These patients are typically critical and must be aggressively treated with fluid therapy and initially calcium at 100mg/kg IM every 6 hours until signs of hypocalcemia resolve.

Medical therapy can be initiated in postovulatory cases to induce oviposition. Calcium at 100mg/kg IM can be given every 6-12 hours followed by oxytocin (approximately one hour after calcium) at 5-20IU/kg IM. The higher dose range is used if there is no response to the lower dose. A nest box should be provided after oxytocin injections. If some but not all eggs are laid, dosing can be repeated. If the eggs are not laid within 48 hours, surgery is recommended (Mader 1996).

Surgical Management
Anesthesia is initiated with propofol at 10mg/kg IV into the tail vein (Divers 1996) followed by intubation and isoflurane. A standard paramedian approach is used by the author to avoid the large ventral midline venous sinus. A large incision for allowing good access and visualization of the gonads is recommended. Caution should be used in entering the coelomic cavity to avoid damaging the potentially large bladder (iguanas), the major blood vessels leading to the paired abdominal fat pads, or the ovarian follicles, if the lizard is in a preovulatory stasis situation. The bladder, fat pads, and intestines should be gently retracted out of the way to expose the paired ovaries located dorsally in the mid coelomic cavity.

Surgical management of pre-ovulatory stasis
If the lizard is in a preovulatory stasis, the large paired ovaries -- which resemble a cluster of yellow grapes -- will be readily apparent. In the preovulatory egg stasis the surgeon should proceed by removing one of the large ovaries. The left ovary is attached to a branch of the renal vein. The left adrenal gland is located between the left ovary and renal vein. The adrenal gland is pink in color, elongated, and is parallel to the ovary. It is important not to remove or damage this organ while ligating the vessels to the ovary. In the preovulatory stasis, the ovary is very large and the vascular supply is easy to expose and ligate.
The vessels are double ligated with suture or vascular clamps. The vessels are then incised between ligatures, laid gently back into the dorsal coelomic cavity and observed for any hemorrhage. The right ovary is attached directly to the vena cava. The right adrenal gland is located on the opposite side of the vena cava than the right ovary, so it is unlikely to be damaged by ligation of the right ovary. The right and left oviducts should be identified but it is not necessary to remove them if both the right and left ovary are removed in the preovulatory egg stasis situation.

Surgical management post-ovulatory egg stasis

In the postovulatory egg stasis the oviducts are filled with oviductal eggs and will easily be identified upon entering the abdomen. One oviduct at a time is gently exteriorized from the cranial end (fimbria) to the caudal extent where the oviduct enters the urodeum.

If the lizard is to be maintained for future breeding a salpingotomy is performed. An incision in the oviduct is made between eggs and warmed saline is infused into the oviduct to allow the eggs to begin to move freely within the oviduct to increase the number of eggs that can be manipulated through the oviduct incision. Several incisions may need to be made in each oviduct to successfully remove all of the eggs from the oviducts. The oviduct incisions are closed with a simple continuous pattern using fine absorbable suture (ex. 4.0-5.0 PDS).

If the lizard is a pet (i.e. green iguana) and the owner is not planning to breed the lizard in the future an *ovariosalpingectomy* should be performed. For an ovariosalpingectomy the fimbria is ligated with suture or a vascular clamp and groups of vessels are ligated together by creating windows in the mesosalpinx and ligating them with monofilament absorbable suture or vascular clamps (Bennett 1996). The caudal end of the oviduct is double ligated with a circumferential and a transfixing suture as close as possible to its junction with the urodeum. The procedure is repeated on the opposite oviduct.

Now, both oviducts and all eggs are removed. This empties the coelomic cavity considerably and allows access to the small inactive ovaries, generally 1-3 inches in length (in the green iguana). The ovaries are held tightly to their vascular supply by a transparent capsule. Caution should be taken when elevating the ovaries because the capsule and vessels may tear and bleed substantially. Windows are made in the capsule material between the vessels with a pair of blunt-blunt scissors and vascular clips or suture is used to ligate the vessels. It is best to ligate all vessels and then go back and cut through them all at the same time to remove the ovary. It is also important not to leave any ovarian tissue attached to the ligated vessels.

It is necessary to remove both ovaries in postovulatory cases (except if performing a salpingotomy) as the lizard may ovulate in the future, which could lead to ectopic ova in the coelomic cavity (Mader 1996). Closure is routine by gently pulling the musculature of the coelom together with a continuous monofilament absorbable suture. The skin (the true holding layer) is closed with an interrupted horizontal mattress suture pattern. Non-absorbable suture (3.0 nylon) or staples can be used to create an everting pattern. Suture removal is recommended in 6 weeks.

Chelonians
All chelonians are egg layers and dystocia is a common clinical presentation.

Historical Presentation
The owner may present the chelonian patient because they know the turtle has been bred, it has been digging and is restless, and may be well past its due date. Or the chelonian may have produced an abnormally small clutch size and the owner is concerned there are more eggs. Often turtle owners may not be aware they are gravid and may present them for anorexia, depression, straining or another problem.

Clinical Assessment
Sometimes eggs are palpable on the physical examination in small chelonians. The turtle is held upright with head pointing to the ceiling and a finger is placed anteriorly into the inguinal fossa. The turtle is gently rocked back and forth and an egg may be balloted against the finger. The technique not as useful for identifying how many eggs are present, and it is not useful for larger chelonians, as their powerful legs will crush the finger of the clinician.

Generally radiology is used to confirm the presence and numbers of eggs any abnormalities in the eggs and comparative egg size. Also the size of the pelvic inlet and any retained eggs may be compared on the radiographs. It may be difficult to tell if eggs present are truly "retained." If eggs appear abnormal in shape or appear too large to possibly pass through the pelvic inlet, or other eggs have passed except those remaining then attempts to remove eggs should likely be initiated.

Treatment
Medical
If radiographs indicate retained eggs are normal in size and shape then medical therapy with oxytocin can be initiated. Generally chelonians respond to much lower doses of oxytocin and there is a much wider window of time when oxytocin can induce oviposition. Calcium at 100mg/kg IM can be given every 6-12 hours followed by oxytocin (approximately one hour after calcium) at 1-10 IU/kg IM for 2-3 doses. The higher dose range is used if there is no response to an initial lower dose. If some but not all eggs are laid dosing can be repeated.

Surgery
If oxytocin is ineffective or eggs are malformed or too large, then surgery may have to be pursued. A plastral approach is a very invasive and healing time is extensive. Although this procedure may have to be performed in some situations a much less invasive procedure for egg removal through a pre-femoral approach is described.

Pre-femoral Coeliotomy
The pre-femoral surgical approach can be used to access the coelomic cavity in chelonians without invading the plastron. Eggs may have to be aspirated or imploded to allow passage through the pre-femoral incision. But the less invasive procedure results in a much more rapid healing time for the chelonian patient.

The chelonian patient is anesthetized (typically with propofol at 12mg/kg IV followed by intubation and isoflurane) and placed in dorsal recumbency. The rear limb is pulled back and secured in place caudally. Surgical retractors or rabbit adjustable dental retractors can be used to increase the opening of the pre-femoral space. The area is then aseptically prepared and draped. An incision is made in the skin midway between the carapace and plastron in a craniocaudal direction within the fossa. The underlying thin musculature is then bluntly dissected to reveal the coelomic membrane. The membrane is carefully incised and the coelom is entered. Placing stay sutures in the incision layers can be useful to help identify them for proper closure.

Once the coelom has been entered an endoscope can be used to assess the entire coelom. A spay hook works well to retrieve the oviduct. The oviduct is then gently retracted into the small pre-femoral window for inspection. Typically, the oviduct with egg is brought to the incision but cannot pass through. Thus an incision is made in the oviduct and the egg is aspirated to collapse it or grasped and broken apart. Caution must be used to avoid leakage of egg contents into the coelomic cavity. The oviduct is then closed in one layer with a simple interrupted absorbable suture. The coelom and muscle layers are closed in a simple, interrupted, pattern with absorbable suture. The skin is closed with a non-absorbable suture in an everting pattern such as a horizontal mattress. Sutures are removed in 6-8 weeks.

References available from author upon request.

BIOGEOGRAPHY OF HERPETOFAUNA IN THE GRAND CANYON

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While the geographic distribution of herpetofauna throughout most of North America is well understood and extensively represented in the literature, the biogeography of Grand Canyon amphibians and reptiles (particularly viperids) remains poorly known, and published indices are scarce. The Grand Canyon lies within the Colorado Plateau region and extends nearly 278 miles from Lake Powell (at the Utah border) to Lake Mead, Nevada, encompassing 1900 square miles. The dearth of knowledge regarding occurrence and distribution of herpetofauna is largely due to the enormity and remoteness of the area. Miller, *et al* (1981) identified 39 reptile and 7 amphibian species in the Checklist of the Reptiles and Amphibians of the Grand Canyon Area, and in Amphibians and Reptiles of the Grand Canyon (1982). Eleven taxa were identified as "Problematical Species", some of which are unlikely to occur naturally in the vicinity of the Grand Canyon. The author and others participated in a series of river trips through most of the Inner Gorge of the Grand Canyon from 1991 to 1999. The occurrence of some species previously considered rare was frequently documented. Of particular interest is *Crotalus mitchelli* and *C. viridis* occurring sympatrically and syntopically. Much confusion exists regarding identification, and hence, distribution of these species in the Canyon. Herein, we attempt to elucidate the distribution of these and other viperids in the Grand Canyon.

Introduction

The Grand Canyon (the Canyon) of northwestern Arizona is arguably one of the last frontiers with regard to our understanding of U.S. herpetofaunal distribution. The Canyon is a vast, remote area, occupying approximately 4921 sq. km (1,900 sq. mi.) of the Colorado Plateau, and extending from 35° 90' to 36° 45' latitude, and 111° 40' to 112° 50' longitude. The Colorado River winds 470 km (292 mi.) through the Canyon from the Glen Canyon Dam to Lake Mead - 448 km (277 mi.) are within Grand Canyon National Park (GCNP). Depth and width of the Canyon vary, but average a vertical 5,000 feet from the South Rim to the Colorado River and over 6,000 vertical feet from the opposing North Rim. The width of the Canyon ranges from 16 to 29 km (10-18 mi.). From Canyon rim to the Colorado River, a diversity of biotic communities exists equivalent to that seen on a trip from Canada to Mexico. While Montane Conifer Forests dominate the rim country, the Inner Gorge and River are covered by arid scrublands. The Rio Colorado of the Grand Canyon is essentially a desert river traversing biotic communities representative of the Great Basin, Sonoran, and Mohavean Deserts, while dropping over 1900 feet from the Glen Canyon Dam to Lake Mead (Carothers and Brown, 1991). Sonoran Desert scrub spans 12 degrees of latitude, from 23° to 35° (Brown, 1994), and is generally not represented as far north as the Colorado Plateau. However biotic components representative of the Sonoran Desert can be found between river mile 39 and Havasu Canyon in the River Corridor. These suggest a disjunct portion of this desert community occurs here.

While the river ecosystem of this region has become one of the most thoroughly studied, the occurrence and distribution of its herpetofauna remains unclear, and corresponding literature is sparse. Only a handful of amphibian and reptile

inventories have been published. McKee (1930), McKee and Bogert (1934), Dodge (1938), Tomko (1975), and Miller and Young (1981) produced brief checklists of species occurring in GCNP. Both Stevens (1983) and Carothers and Brown (1991) published inventories of the herpetofauna of the Colorado River Corridor in the Canyon. The most comprehensive account of Grand Canyon herpetofauna to date was compiled by Miller, *et al.* (1982). The enormity and harshness of the Grand Canyon does not lend itself to casual investigation - cataloging indigenous biota in such an environment is demanding and time consuming. Historically, workers collected data by (1) investigation of observations and records from GCNP staff, visitors, etc., (2) examination of museum specimens, (3) reviewing scientific and popular literature, and (4) making field observations from Canyon rim to river by means of established foot trails or float trips down the Colorado River. The most current published inventory identifies six amphiblans and thirty-four reptiles from GCNP, with an additional eleven taxa considered "Problematical Species" (Miller et al., 1982). Although few new reptiles or amphibians have been documented from GCNP since this account was published, the distribution of many species remains poorly known. Herein, I discuss some factors that regulate the distribution of herpetofauna in and around the Grand Canyon, and submit observations on the distribution of *Crotalus mitchelli* and *Crotalus viridis*.

Methods

Data was obtained by collecting live specimens and examining photographic vouchers. Museum specimens were examined and relevant literature (including GCNP records) was reviewed. A series of Colorado River float trips were conducted by Glen Canyon Environmental Studies (GCES) and GNCP to assess the effects of the Glen Canyon Dam on the ecology of the River Corridor. Between 1991 and 1999, we participated in several of these trips, initially to collect live specimens of *Crotalus viridis* for the Phoenix Zoo, but also to make general herpetological observations and conduct other biological research.

Results and Discussion

- The Grand Canyon is biologically diverse given its northern latitude. While the Canyon occupies less than 1.5% of the Colorado Plateau's 336,674 sq. km (130,000 sq. mi.), it contains 58% of the Plateau's 80 amphibian and reptile species. It is a place of dramatic physiographic barriers and radical topography. As a result, the distribution of herpetofauna is affected in three ways;- as a **refugium**, harboring endemic species within the Canyon; as a **barrier**, preventing cross-Canyon or up-river dispersal, and; as a **corridor,** facilitating the dispersal of desert-adapted species into the Canyon from west to east (Stevens, 1983). Four of the seven Life Zones that comprise the Northern Hemisphere proposed by C.H. Merriam (1890) are found in the Grand Canyon:
- **LOWER SONORAN LIFE ZONE** - from the River to 4,000 feet. Climatic conditions similar to that at sea level in northern Mexico.
- **UPPER SONORAN LIFE ZONE** - 4,000 to 7,000 feet. Climatic conditions of south-central U.S.
- **TRANSITION ZONE** - 7,000 to 8,000 feet.
- **WOODLAND** - climatic conditions of northern U.S.

Some species are highly adaptable habitat generalists, occupying some or all Life Zones within the Canyon (e.g.: *Sceloporus magister*, *Crotalus viridis*), while others are habitat specialists (e.g.: *Crotalus mitchelli pyrrhus*, *Heloderma suspectum*), inhabiting specific niches. Most of our investigations were concentrated within the xeric Colorado River Corridor, hence we encountered primarily arid-adapted species.

We obtained permits for the collecting of *Crotalus viridis abyssus* from 1988 to 1993. During this period, we noted, when interviewing commercial river guides, park personnel, and biologists regarding their observations of the Grand Canyon Rattlesnake, the sobriquet "Grand Canyon Pink" was frequently used in reference to the often salmon-colored rattlesnake. This strongly suggests the confusion with respect to the identity of the rattlesnakes found in the Canyon.

The distribution of *Crotalus mitchelli pyrrhus* and *C. v. abyssus* in the Canyon are poorly understood primarily due to the paucity of vouchered locations and probable misidentifications. Prior to our investigation, *C. m. pyrrhus* was documented from a single specimen collected at Emery Falls (RM 274.5) at the extreme west end of the Canyon. Tomko (1975) states "Previously, I was thought that *C. viridis abyssus* was the only crotaline inhabitant of the Grand Canyon". Consequently, most workers considered *C. m. pyrrhus* "rare" and limited to the far west end of the Canyon (Miller et al., 1982). During a brief visit to Diamond Creek (RM 225) in July 1995, three "pink" *C. mitchelli pyrrhus* were observed in riparian vegetation on the river beach. Although Miller, *et al.* (1982) showed the distribution of *C. v. abyssus* throughout the Canyon to Lake Mead, and stated that C. *v. abyssus* is "common ... [at] Diamond Creek" (but do not reference specimens), we observed none. Our observation of three *C. m. pyrrhus* in this part of the Canyon suggest that previous reports/sightings of *C. v. abyssus* were based on probable misidentifications. An examination of numerous museum specimens and photographic vouchers produced additional misidentifications. All specimens examined were keyed to C. *m. pyrrhus,* having been incorrectly identified as *C. v. abyssus* from the west half of the Grand Canyon. This will be discussed in a forthcoming publication (Starrett, in prep). It appears likely that *C. m. pyrrhus* and *C. viridis abyssus* are almost entirely allopatric in the Grand Canyon. *C. m. pyrrhus,* an arid-adapted rattlesnake, is found to at least Havasu Canyon (RM 157), having dispersed eastward from lower elevation, xeric habitats into the Canyon. *Crotalus viridis* is a more ecologically diverse species (although avoiding extremely arid regions), probably dispersing into the Canyon via the Colorado River drainage to the northeast, and from numerous tributaries feeding the Colorado River to the north and south. Specimens of *C. v. abyssus* have been found westward into the more arid reaches of the River Corridor to at least Tuckup Canyon (RM 164.5), producing an overlap between *C. m. pyrrhus* and *C. v. abyssus* of approximately seven river miles. While *C. v. abyssus* occurs from the Canyon rims to the River, *C. m. pyrrhus* is known only from the River Corridor in the western half of the canyon, never far from the river itself. These species seemingly avoid direct competition and partition available resources by inhabiting separate parts of the Canyon. Their distributions in the Canyon are largely defined by elevation, habitat selection, and to some extent, competition - *C. v. abyssus* generally does not occur

below 1,800 feet, avoiding the most xeric habitats, and being largely restricted to the eastern half of the Canyon. *C. m. pyrrhus* does not commonly exceed an elevation of 3,500 feet in the westem western portion of the Canyon.

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"The Matchbox Croc"

What captivity has taught us about *Paleosuchus palpebrosus*

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The paucity of nesting observations among wild *Paleosuchus palpebrosus* increases the value of captive observations obtained at the Bronx Zoo and Saint Louis Zoo. While mastery of captive management is a desirable goal in itself, details of zoo husbandry and reproduction complement and expand what has been observed to date in nature. For example, it was found that when captive nests are not sequestered from parents and nests are left relatively undisturbed, previously cryptic behaviors could be better understood, such as the roles of males and females during nesting events.

A life history problem that has been addressed by other investigators is the lack of environmentally available heat for nest incubation in forest crocodilian species. It has been demonstrated that *P. trigonatus* will exploit ground termite species and their heat generating mounds for warming nests. This has not been seen in wild *P. palpebrosus*. Captive data points toward *P. palpebrosus* having lower-end thresholds for hatching young and concomitantly reduced temperatures are required to produce gender modes. Implications are that the tolerance for less sunny pastures among "cool crocs" broadens ecological space in the order.

Introduction

The title of this paper refers to the fact that this species, the South American *Paleosuchus palpebrosus* or Cuvier's dwarf caiman, may be the smallest living crocodilian. A possible rival is *Osteolaemus t. osborni*, a subspecies (or full species, see Neill) of *Osteolaemus tetraspis*, the West African dwarf crocodile, which may reach a maximum length of as little as 1.2m. (Neill 1970) *P. palpebrosus* is known to reach maximum length of approximately 1.7m. The larger individuals are always males; the average length of female *P. palpebrosus* is only about 1.1m. A physical description of this species must emphasize the unusually armored nature of its integument; *P. palpebrosus* may have the heaviest armor in the order. It is difficult to penetrate, even between the scutes, with pressure from the point of a heavy-gauge syringe. (Junge, during routine blood extractions for exams). The head is very robust and proportionally large when compared to other caiman species.

Habitat Considerations

Medem (1983) interprets this excessive armor as necessary protection against the rocks in the turbulent streams of the sloping, hilly habitat where this species can be found in eastern Colombia. Outside of this particular habitat however there appears to be irregular access to situations that would promote these adaptations for that purpose. Neill (1971) summarizes other observations that report *P.*

palpebrosus in shady situations of floodplain ponds. Many other reports including my own (N.Guyana) are from shady, heavily forested areas in slow flowing streams, or still water within zones that lack the topography to support rapid currents.

The convenient ecological analog to *Paleosuchus* is the aforementioned dwarf crocodile(s), *Osteolaemus tetraspis*, of West and Central Africa. The most common description of its habitat preferences read so much like those of *Paleosuchus* that it is practically a reprint: "The preferred habitat of *Osteolaemus* seems to be swamps, ponds and small sluggish streams in rainforest areas, with some populations occupying more arid savannah terrain." (Steel 1989) There are records too of *P. palpebrosus* edging into the margins of more open situations, although it always seems to have one foot in the forest. Both groups are observed to be quite terrestrial for crocodilians, spending days away from the water, sequestering themselves in various hideaways. (Magnusson 1990) There are "at least" subspecies within this genus, another point of comparison between these two forest crocodilians. Like *Paleosuchus* but to greater degree, *Osteolaemus* is very distant in lineage from the other crocodilians with which it shares a continent. (Densmore 1989)

Palpebrosus and *Trigonatus*

Beyond the varying descriptions of habitat types that seem to support *P. palpebrosus* there is also a dilemma concerning the ecological partitioning that likely exists between *P. palpebrosus* and its genus mate *P. trigonatus*. The geographic range of *P. trigonatus* overlaps at least 85% of the range of *P. palpebrosus*, (Steel 1989) the latter extending its range further south down the center of the continent. Virtually nothing is reported with confidence about what separates the two species within the very large area where they both occur. While there are important differences between these animals, it may be that mistaken identity of animals seen in the field, aided by their nocturnal habits, has lead to some innocent misreporting of their preferred haunts. Neill (1971) goes so far as to state that it may be that *P. trigonatus*, the more streamlined of the two, is more likely to be the one inhabiting rocky, swift-flowing steams. The more slender, hydro-efficient head and body may facilitate the capture of fish that may be the most common food resource in these situations.

The most sustained and accurate view of a population of *P. trigonatus* comes from William Magnusson (1991), at a near-pristine reserve in Amazonas, Brazil. Here the adult caiman occupied streams that fluctuated within the rainy season but rarely overflowed their banks. Adults had relatively small, well-defined home ranges while newly hatched young quickly dispersed. Older but still sub-adult animals frequently moved through the area. Males were strongly territorial and had ranges that did not overlap. Females seemed to have greater tolerances for each other and individual ranges did overlap. Magnusson came to the conclusion that the minimum ages for maturity in this species are eleven years for females and twenty years for males. This is very extended and is considerably longer than for most other crocodilians and at least as long as some of the largest forms. (The common caiman, *Caiman crocodiles*, may mature in as little as three or four years under the right conditions.) Such a delayed onset of maturity suggests that *P. trigonatus* and perhaps *P. palpebrosus* as well can and do live to great ages. Magnusson additionally found that his adult population of *P. trigonatus* had very low mortality rates. Furthermore this caiman had the highest relative biomass of any large vertebrate in

the Amazonian rainforest. There are good predictive models to support this. Ectotherms can be interpreted to be "low energy systems" as Pough (1983) has suggested. They are slower conduits of trophic energy within a biological system, taking in and dispensing less total energy per unit of biomass than comparably sized mammals or birds. This is critical to consider when pondering which individual taxa or similar metabolic constituents have the greatest "real" impact in an ecological community. Magnusson's studies help elucidate just how different *Paleosuchus* is compared to the short list of other crocodilians that have been studied in any detail. It would of course be very instructive to collect field data of this quality on *P. palpebrosus*. Everything points toward its life history being very similar to its congener, but there must be some measurable ecological partitioning between the two species.

Environmental Challenges to Nesting and Incubation

A remarkable fact of crocodilian and turtle biology that has come to light since the late 1970's is that of temperature-dependent sex determination or TSD (Bull 1980), an alternative to the genotypic sex determination that prevails among snakes and lizards. The much smaller number of Crocodilia species (22) has facilitated a more complete analysis of this phenomenon than for the more than 250 Chelonian species for example, where gender/temperature relationships are less clear. The pattern that has emerged for crocodilians is that "hot" or higher- end temperature nests tend to generate a higher percentage --sometimes 100% -- of males, and that "cooler" nests produce a high percentage of females. Within the critical range of temperatures in which eggs will successfully hatch, a median range (approx.31-32 C) may produce roughly equal numbers of males and females. Controlled incubations have helped to delineate the gender outputs of different temperature treatments. (Ferguson and Joanen, 1982,1983, Schulte 1989) Ferguson and Joanen's studies with the American alligator helped to demonstrate what is likely a common fact of crocodilian gender determination: gender is decided early, during the second or third week within the first trimester of incubation. In alligators the mean temperatures for producing equal gender ratios is closer to 33 C. The timing of the temperature exposures of the eggs is key. Egg-laying ectotherms leave their eggs at the mercy of environmental conditions, even if a constructed nest mediates those conditions. Forest crocodilians are faced with the challenge of exposing their eggs to even the low end of the relatively short spectrum of temperatures that will allow eggs to hatch. Magnusson (1990) provided important insight into this problem with his field observations of *P. trigonatus*: an average temperature of at least 27 C is required to hatch crocodilians at all and one begins to see total nest failure below this point.

> Crocodilians exhibit two basic modes of nesting. Hole nesters tend to deposit eggs in sandy beaches that usually benefit from insolation effects (sunlight). Mound nesters assemble available organic materials, such as leaves, grass, sticks, and soil. These aboveground nests may also receive insolation, or further exploit the heat generated by rotting vegetation within nests or from stumps, logs or other adjacent decaying materials. The metabolic heat of embryos may also produce some minor amount of heat, but only after they are sufficiently large and developed to be fairly near hatching, long after the critical point of sex determination has passed. (Magnusson 1990)

These options had until recently not been observed to be available or utilized in the environment of either *Paleosuchus* species. Even if these crocodilians create nesting situations that operate at the low end of the potential for hatching, where they get enough heat has been a mystery. Then Magnusson (1985) made an alternative and possibly novel discovery. He found that most of the nests constructed by *P. trigonatus* were built on top of or adjacent to tropical termite nests. The collective and well-regulated metabolic state of a termite nest produces enough heat, 32.5-34.0 C, (Noirot 1970) to confer an adequate temperature range for young to develop within the eggs. Nine of thirteen nests were located in situations that took advantage of this unusual heat source. It is possible that the other *Paleosuchus*, *P. palpebrosus,* may do this too, and also the African *Osteolaemus*, among which termite nests are often present.

The paucity of wild nests observed thus far for these species makes conclusions speculative at best. Just three *P. palpebrosus* nests had been well documented in nature by 1985, but they were not associated with termite nests. (Magnusson 1985) It remains to be seen whether these other forest crocodilian taxa utilize termite nests or other unknown sources of heat for incubating eggs. It may be that *P. palpebrosus* have the most suppressed temperature requirements for hatching eggs; then the threshold temperatures for producing either gender would be similarly lower. Preliminary captive data helps support this notion.

Captive Observations

So what have we observed in captive *P. palpebrosus* that may relate to what the species does in nature? An obvious disadvantage of captive animal observations is that removal from the context of the natural environment may distort or occlude many behaviors. Ectotherms however, with their more fixed behaviors, lower activity levels and smaller ranges may exhibit species-appropriate behaviors in captive situations if effort is made to provide at least the basic physical and social opportunities.

Behaviors that are complex and repeated are among the most convincing evidence for true insights into what an organism does in nature. The ability to build sophisticated nests for example is largely instinctive or intrinsic to the animal, although experience may improve the quality of the job. Vocalizing, courting, pair bonding, and care of young are other areas in which sound interpretations may be gleaned from captive observations.

Magnusson's wild observations of *P. trigonatus* diet and environment lend support to captive observations of *P. palpebrosus* as something of a generalist both in habitat and prey acceptance. *P. palpebrosus* will certainly take a variety of offerings in captivity. Most collections give them various fish, rodents, and chicks all of which are taken greedily. It is a pattern of this species to voluntarily reduce its food intake during the temperate latitude winters, even if the actual temperatures of water and air in enclosures remain relatively constant. This was observed for years at the Bronx Zoo, where evenly heated water (26-29 C) was constantly flowing into an approximately thousand-gallon pool. In nature this decline in feeding may possibly correlate with movement and activity associated with the dry season but this information is wanting. In zoo situations where *P. palpebrosus* was maintained

and reproduced there was also exposure to variable photoperiods within the US. These photoperiods may be an important variable for seasonal activities of *Paleosuchus* because there is so little change in day-length over its range and that of other tropical crocodilians. Subtle changes in ambient temperature and dry conditions associated with forced-air indoor heating in more northern locales may better explain the changes in behaviors that characterize tropical reptiles in captivity. Personnel manipulating conditions in these facilities impose some of the changes; others are artifacts of building construction and local climatic patterns. All this adds up to regular breeding seasons for many of the tropical occupants in collections, including *P. palpebrosus*, which usually courts in March and April, nests in May or June, and hatches offspring in late July to early September.

Among the half-dozen institutions that have reproduced this animal and reared young the greatest activity has taken place at the Bronx Zoo; there the author was able to observe *P. palpebrosus* and collect much of the data presented here. More recently Saint Louis Zoo has provided a venue for very interesting observations of parental behavior. Lastly there are relevant comparisons to be made with briefer observations made at other American zoos.

A detailed explanation of crocodilian husbandry will not be attempted here; suffice to say that the general husbandry of crocodilians is largely mastered. Individuals have survived for many decades in captivity; diets have been relatively easy to procure for most species. As expected given the tropical to subtropical environments that support crocodilians, temperatures of water and air need to be relatively warm, 24-34 C. Social constraints may exist depending on the density of crocodilians kept their age, maturity and the layout of enclosures. Most of the 22 species have been bred in captivity.

At the Bronx Zoo many other species cohabited with 3.2 adult *P. palpebrosus*. Groups of giant side-necked turtle, *Podocnemis expansa* and St. Hiliar's turtle, *Phrynops hiliari* interacted most directly with the caimans and also mated successfully within this space. A large male rhinoceros iguana, *Cyclura cornuta* roamed the land area. The total area measured 5.25m by 4.0m but contained break-ups and lobe-like cul-de-sacs that probably helped ameliorate social tensions between exhibit-mates. The aquatic space contained approximately 3800 liters exclusive of about 5% of live animal displacement and had a maximum depth of 61cm. Sloping contours on land and underwater facilitated the movement of animals in and out of the water and probably made aquatic mating maneuvers easier to accomplish. The aquatic system was not filtered but kept heated and hygienic by a constant inflow of heated water (mean temperature 28.5 C) that left the system via an overflow. There was forced-air heat (mean approximately 29 C) and some skylight. The other important feature of this captive design was a 30cm wide, meter-long chute that lead to a segregated nesting area measuring approximately 1.8m by .9m. This space can be sub-divided but was usually kept continuous with a 30cm wooden board to contain the mulch substrate available for nesting.

In retrospect it is remarkable that we were able to keep three adult male *P. palpebrosus* together for seven or eight years in the presence of two adult females: the breeding group that produced most of the offspring. This group of individuals, some still immature, grew up together in a well-designed, intentionally interrupted space that can suppress aggressive tendencies. The constant activity of the many turtles in the aquatic area may have had a mediating effect.

Most or all of these animals were wild-collected from Surinam and arrived from 1977-1985. From 1988 to 1992 this assemblage combined to produce 71 eggs in five clutches, 44 of which hatched although in the last clutch only 1 of 14 eggs hatched. This compatibility and this run of reproduction did end finally when the largest male, a 1.5m, 18kg specimen was discovered nearly drowned one morning after an apparent all-out conflict with one or more of its congeners. It perished a few days later apparently having suffered brain damage from prolonged submergence. He may have been the dominant animal and the father of most or all of the offspring as there was quite a hiatus before *P. palpebrosus* were produced again (1999). The fatal conflict was a surprising and spontaneous event given the specific history of the group with no perceived signs of intraspecific aggression leading up to it.

P. palpebrosus is largely nocturnal in its behavior and exceptionally secretive, more so than other crocodilians. However, Andy Snider at Detroit Zoo states that a pair mated during daylight hours (2001) prior to the female constructing a nest that did not hatch young. The author has yet to witness any real courting or copulation among this species. Male vocalizing and briefly observed fizzling water vibrations caused by subsonic infrasound have been seen however, an ability associated with body posturing seen in other Alligatorids. The head and tail arch up to ride high in the water; the lungs are greatly expanded to generate the pressure required to achieve this remarkable sonic effect.

The first nesting occurred at the Bronx Zoo on June 14, 1988. The 1.1m female had looked obviously egg-laden prior to this so the event was expected. She demonstrated good competence in using the sequestered nesting area and steeply mounded up the material provided. The nesting area was heated underneath by means of a Stanfield heat pad (designed for hogs) controlled by a rheostat dial. The normally passive female showed marked aggression once her clutch of 15 eggs was deposited, and had to be kept away with a broom so that the eggs could be collected, weighed and measured, and placed in an incubator. The internal nest temperature was 33.6 C initially but this was reduced to a mean of 32.0 C. The incubator used was an "old reliable" redwood incubator designed for hatching chicks. Water trays were maintained inside the unit to maintain near 100% humidity and a built-in fan circulated air to evenly distribute the temperature. For most crocodilians the expectation is that this temperature should produce offspring of both genders.

Few notes were available at the time to direct us how to proceed with *Paleosuchus.* The incubation temperature was lowered to 30 C on August 4, when the eggs were 51 days old and gender was set, a move thought prudent based on cursory knowledge of the dwarf caiman's cooler forest environment and other successes reproducing crocodilians in the Bronx. The eggs hatched in just 79 days and all five that did hatch turned out to be males (discovered many months later when non-sacrificial sexing was possible). This was a very short incubation period despite the moderate treatment, and, as it turned out, third-trimester temperature reduction, which must have extended incubation time, possibly saved the fast-cooking embryos. Two had slightly asymmetrical snouts: bone deformities sometimes associated with overly warm incubating temperatures.

In 1990 both females nested, five days apart, on 29 April and 4 May. The clutches contained 13 and 15 eggs respectively, a range seen in the first four nesting events. As with *Osteolaemus, P. palpebrosus* lays small clutches of relatively large eggs. Bronx eggs through this period averaged approximately 62mm by 37mm; mean egg mass approximately 50.5g. Both the females are average for the species

at 1.1m and approximately 8kg body mass. Weights may vary somewhat seasonally and with reproductive status; males may be more than twice as heavy. All these animals may still be growing slowly.

The mean clutch mass for four of the five clutches was 718.5g indicating a roughly 9% sacrifice of bodyweight at nesting for *P. palpebrosus*, perhaps a few percentage points higher than for most other crocodilian species. These figures are reasonably consistent with what has been observed in other collections.

The same procedure was followed in handling these eggs except for the temperature regime, which was more conservative. Both clutches totaling 28 eggs were incubated at an average temperature of 30.5 C. A whopping 27 of 28 hatched out after 87 days of incubation. To yield an even gender distribution this temperature was right up the middle for crocodilians. Yet the results were overwhelming: 100% males! 30.5 C is still a "hot nest" for *P. palpebrosus*. This was really unusual: just how low an incubation temperature is required to produce females in this species? It was also apparent that while incubation was significantly longer than earlier clutches, the total time was still quite short, 87 days. If there is consistency among crocodilians in the time eggs take to hatch then reaching 100 days incubation would require another drop in temperature treatment for this species.

The next year, 1991, one of the females nested for the second year in a row and laid fourteen eggs. They were incubated this time at a "cool" 28 C: just one degree above the accepted limit of 27 C as the minimum required to hatch a saurian. The hatch rate was good with 11 of 14 eggs hatching out healthy neonates after 103 to 105 days. The young not only took longer to begin hatching but also took longer to hatch, spreading the event over two days. There were no dead embryos: the remaining three eggs were not fertile.

This temperature treatment provided the breakthrough to obtaining females. The always-delayed feedback (before confident and benign sexing of young was possible) showed 10 of 11 in this brood to be females. (Further confirmation from the eleventh juvenile is needed to be certain that this was not a 100% female hatch.) In 2000 just one *P. palpebrosus* hatched in St. Louis and this is now confirmed to be a female. The mean temperature of her incubation was 28.6 C.

In all of the nesting events the female *P. palpebrosus* were observed either with the newly created nest or immediately responsive to any noise or disturbance around it. Their defensive aggression was plain to see: hissing with open mouth, erecting the body, presenting laterally to the source of annoyance, as well as biting any object that moved within range. Although small, *P. palpebrosus* is all business when provoked. Their teeth are relatively large and they will bite, hold on, and shake a seized object viciously, with real intent to do damage. This treatment from an adult *P. palpebrosus*, especially a male, could absolutely destroy an unguarded human hand, so they are to be taken seriously at close proximity. "Moms" had to be dissuaded from the vicinity of the nest with several stiff pushes from a broom or deck brush. After this separation there were usually several minutes available to collect the eggs before the female returned her attention to the nest area. Alternatively she could be shut out, but that respond with curiosity or aggression to humans mimicking juvenile distress calls. It would be a worthwhile experiment to see whether *P. trigonatus* adults respond to these distress calls, since beyond some possible assistance to hatchlings at the nest, aftercare of baby caimans is not indicated by Magnusson's study (1991).

At the Rio Grande Zoo in Albuquerque, where Curator Dale Belcher maintained the studbook for a number of years, there have been several reproductions of *P. palpebrosus*. As of a visit by the author in 2000, general husbandry is similar to the Bronx Zoo and animals are well established. The enclosure is spacious but somewhat smaller than in New York at about 6m by 3m. The gravel bottomed pool, ranging to at least 80cm deep, occupies half of this area and is surrounded by irregular contours of rocky outcrops. One male and two females make up the breeding group. The attractive exhibit is well planted with palm species. The nesting area, very similar to the Bronx Zoo, is adjacent to the main space. However in the multiple nesting events that took place at Albuquerque the females decided against using this designated area and instead deposited eggs in the large planters or in one case in the water. Materials in the planters were scraped together to make the nest mound. It is not unusual for females uncomfortable with nesting options to "abort" their clutch via the water route; if recovered quickly these eggs can still be viable. Egg collection elicited defensive behavior on the part of the females; eggs were removed to incubators and hatched at temperatures that had yielded males in the Bronx.

Belcher agreed that exposing *P. palpebrosus* eggs to the same temperature regimes that yield more or less equal gender distributions among other crocodilians was probably causing a surfeit of *P. palpebrosus* males to be produced in U.S. zoos. The National Zoo and Knoxville Zoo have also hatched *P. palpebrosus* in recent years, at temperatures above 29 or 30 C.

A drawback to the intense management of these eggs is that it deprives observers of the opportunity to document sophisticated saurian behaviors. Nest guarding, (Cott, 1971) nest opening, (Ogden, 1978) parent-assisted egg hatching by gentle oral manipulation, (Pooley and Gans, 1976) transport of young by mouth to water (Pooley and Gans, 1976) and aftercare have been seen in a number of crocodilians both in and out of captivity. In the case of *P. trigonatus* aftercare is curiously absent as young are seen to disperse quickly after hatching (Magnusson 1991). It may be that initial predation pressures are not as great in forest environments where there is a great deal of natural cover and diminished light; the lack of open vistas may hinder visual scanning by predators. The aftercare habits of its congener, *P. palpebrosus*, remain unknown due to managed hatching.

In many captive cases to date the emphasis on ensuring egg hatching has preempted the follow-through behaviors of prospective parents. Exhibits or other environments provided don't always contain the proper materials or temperature regimes that promote good hatches. However these obstacles have been overcome at a few institutions such as Ft. Worth Zoo (Tryon, 1980) and Zoo Atlanta (Hunt, 1980).

West African dwarf crocodiles (*Osteolaemus tetraspis*) in Ft. Worth, and Morelet's crocodiles (*Crocodylus moreleti*) in Atlanta showed much of what they are capable of as parents, including direct involvement of males that in some instances carried young down to the water in their mouths. Females assumed this role in the great majority of cases, but it does show that under some circumstances fathers can be involved in this kind of activity. It would follow then, that in nature, three months after eggs are deposited, "daddy" is still nearby, prepared to assist with hatchling care.

As the emphasis on simply producing captive-bred young is relaxed, (captive carrying capacity of crocodilians may shape this factor) it may be possible to set up

situations where crocodilians can demonstrate their full range of parental behaviors. Nest-hatching only part of a clutch is one answer: behaviors of parents and young can still be observed.

A good situation exists currently at the Saint Louis Zoo for observing captive behaviors of *P. palpebrosus*. The glassed-in exhibit is part of a large solarium, where the temperature varies somewhat seasonally and during the day, (there is some "greenhouse effect") but is usually in the range of 26 C to 29 C. The exhibit is a roughly rectangular 6.5m by 3.2m. There is a large soil-and-sand land space with tropical trees (Ficus, Philodendron, and Pothos). It is shady and leafy debris lightly covers the ground. The enclosure is hemmed in on two sides by overhanging rock walls that separate it from the adjacent exhibit. The pool, 2.5m by 1.5m, meets the land area at a steep angle, broken up by irregular contours and footholds, so occupants can negotiate more easily. The passively heated water is 1 or 2 degrees cooler than the air; depth reaches 75cm.

The author assembled a group of *P. palpebrosus* in this situation by allowing one or two females to establish for five or six weeks before introducing a male. Saint Louis Zoo currently possesses 3.2 adults but two of the males are always kept isolated. The breeding group was assembled for three winter/spring seasons prior to when courtship is typically seen, in February or March. As at the Bronx Zoo, males have been heard calling occasionally, mostly in March and April.

During the first two years it became subtly apparent, usually in the pool area, which female the male was courting. For periods of up to two months the male would spend long periods of time adjacent to or in actual body contact with the female that eventually nested. In the second year the male was seen to come into body alignment with the female and gently rub his body and head on her dorsal area. Some light stroking by the male forearm along her back was observed. A few times when she moved away across the pool he followed her. No copulation was witnessed.

In St. Louis nesting has taken place on 7 June 2000 and 21 June 2001. A bale of hardwood mulch is provided and utilized for that purpose, along with a selection of leaves and other organic debris scattered across the large land area. When each female nested she systematically reconnoitered the entire land space, piled up just about every loose bit of material, and dragged vines and pothos tendrils in the direction of the nest.

During the second year the female was observed building the nest; after normal business hours, from 6:30 to 8:30 PM. Approximately half the nest was already roughly assembled from human placement of the mulch. The female added to and refined the nest mound by systematically taking positions around the base of the nest, and, while facing away from it, raked mulch, leaves, and some dirt on top of it with backward strokes of her hind feet. With great consistency she would take usually five, sometimes four strokes with one foot, then the other, before moving to another spot. The foot-strokes were effective in clearing the material from a spot and adding it to the nest pile. She seemed to have a high awareness of her body position in relation to the nest as she performed her work without turning around to judge it. She moved like the hands of a clock round and round the periphery of the nest, which was not supported by rockwork within the enclosure: about 240 degrees were open for her to work. Now and then she would venture out a little farther to kick back debris more distant from then nest. At 8:00 PM she backed up onto the mound to deposit her clutch; it was only a rehearsal however. She nested the

following evening and put down an unusually small clutch of 8 eggs. She is not a small specimen but a radiograph had recently confirmed the peculiar fact that only one side of her body contained eggs.

As in the Bronx, it was observed of all the females that as soon as eggs were laid, if the nest were approached from any angle they would position themselves between the nest and the intruder, ready to defend. What was new in St. Louis however was that there was a slow but escalating build-up of aggression in the male over a six-week period prior to the nesting. He became increasingly intolerant of keepers entering the exhibit even for the familiar routines of pool cleaning etc., to the point where he would not merely approach closely in a threatening manner, but would actually continue the advance on a stationary person with apparent intent to attack and bite. He could be fended off by rough shoving and blocking with a sturdy, long handled deck brush, but would recoup in a moment or two and advance again. In the author's experience this is really unusual and determined behavior for any crocodilian, especially when so outsized by an adversary.

This behavior was more marked in the second year when eggs were allowed to remain in the nest. The pattern emerged that his aggression would build but the female would not become aggressive until the eggs were laid, when she would dedicate herself to protecting the nest site specifically. Pool cleaning was performed by reaching over a wall at a distance from the nest, when both animals were out of it and the water had been drained. The female stationed herself between the author and the nest. The male, waiting three or four meters away, would advance after four or five minutes and attempt to "clear the area." He succeeded. The pair was encouraged to preserve the integrity of their space so that other parental behaviors might be observed. Furthermore he was so aggressive that he might have been injured by a serious effort to keep him away.

Discussion/Conclusion

That these behaviors have revealed themselves in the St. Louis situation may have largely to do with the spatial dynamics: the nest area has not been sequestered from the caimans, which could engage the nest space visually and physically at all times. Leaving the nest intact and yielding to the parents' defense also may have encouraged the persistence of these behaviors.

The male's behavior is open to interpretation but is suggestive of Tryon's (1980) hypothesis that crocodilians may bring to bear alternative strategies for some phases of parental behavior. This makes sense for smaller species like *Paleosuchus*: the adult female *P. palpebrosus*, hardly larger than a house cat, may be more compromised in defending against predators than most crocodilian mothers. It is reasonable to speculate that the job of defending a nest would be better accomplished with the assistance of not merely another caiman but one with twice the body mass. The preliminary observations of male defense in St. Louis point toward this scenario. It is also possible that mate guarding or a territorial imperative is working here. In either case the extreme behaviors of the male appear to be stimulated by mating and nesting activity. Tryon (1980) observed peaking aggression in both sexes of *Osteolaemus* during nesting and incubation. Teichner (1977) at Metro Toronto, saw nest guarding and defense by a pair of *Osteolaemus* at that institution.

As with some avian parenting scenarios, working shifts to spell the other parent, in this case over about 100 days rather than a few weeks, is another

possibility. Crocodilians can withstand long periods without food. However a small female that has just dispatched 9-10% of her body mass for an egg clutch, and expended energy building a nest, might benefit from the freedom to feed once or twice over the course of the incubation if spelled from nest duties by a larger partner. If *P. palpebrosus* are like the *P. trigonatus* in Magnusson's population, a postulate may be that *Paleosuchus* of both species rely on an intense period of protection for eggs and young, through hatching and perhaps escortment to water. Parental duties relax as the hatchlings rapidly disperse from the nest site to live an independent existence. This would balance the initially high time and energy budget of the parents expended within a four-month period.

An additional 2001 observation in St. Louis was that during the last trimester of incubation (even though this clutch did not hatch) the nesting female began exhibiting aggression toward the female who had nested in 2000. Because this female did not nest in 2001 she seemed passive and uninvolved, until two months after the eggs of the nesting female had been laid, when small abrasions and nicks began appearing all over her body, mainly on her dorsal area. Similar minor injuries also showed up on the nesting female, probably received in retaliation from the attacked female, who was getting the worst of it. No activity was seen during the day. Only these subtle evidences were available for interpretation. The subordinate female, undoubtedly stressed, went off her feed in summer. This was most atypical. She was removed to another area where she quickly recovered and began feeding again.

P. palpebrosus are so persistently cryptic and nocturnal it is often a puzzle what they're up to. Crocodilians are often opportunistic feeders and this can include cannibalism. It could be that the continued close proximity of the other female was perceived as a threat to hatchlings as hatch time approached. It is widely known that under most circumstances female crocodilians are more tolerant of each other than are males, which are less cohabitable.

The Saint Louis Zoo is looking forward to having a *P. palpebrosus* nest hatch out on exhibit so that we may have a chance to observe and interpret some parental behaviors which are extremely difficult, but not impossible, to glean in nature. The fascinating observation and experimentation achieved by Tryon and colleagues at Ft. Worth Zoo and at other institutions in Toronto and Tokyo with *Osteolaemus tetraspis* may be one of the best predictors for what may eventually be seen with *Paleosuchus palpebrosus*, the closest ecological reflection.

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Osteolaemus tetraspis while he was still at Ft. Worth Zoo contributed mightily to my thinking and curiosity regarding this species.

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Captions for Photos

1. Author with a fully-grown female *P. palpebrosus* or Cuvier's dwarf caiman, "the matchbox croc." (Photo C. Dresner; courtesy of Saint Louis Zoo.)

2. Parent *P. palpebrosus* with an eight-month-old offspring. Adult female left, male right. (Photo C. Dresner; courtesy of Saint Louis Zoo.)

3. *P. palpebrosus* habitat in northern Guyana during the end of the winter dry season. (Photo by author.)

4. An adult pair of *P. palpebrosus* in Bronx Zoo exhibit 1989. Male in foreground. Six reproductive events have occurred here with this species since 1988. (Photo by author; courtesy of Bronx Zoo.)

5. Adult female *P. palpebrosus* (1.1 m, 8.5 kgs) positioning herself in a decidedly defensive posture. Eggs have recently been deposited in a nest of her own construction just behind her and to her left. (Photo by author; courtesy of Saint Louis Zoo.)

6. Uncovered eggs within egg chamber of nest constructed by a female *P. palpebrosus* at Saint Louis Zoo. This clutch numbered 12. Eggs average 62mm length and 50g in weight. (Photo by author; courtesy of Saint Louis Zoo.)

Taylor, P. Photo 1.

Taylor, P. Photo 2.

Taylor, P. Photo 3.

Taylor, P. Photo 4.

Taylor, P. Photo 5.

Taylor, P. Photo 6.

Hellbenders: Past and Present
(Abstract Only)

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Missouri populations of the long-lived hellbender, *Cryptobranchus alleganiensis*, were censuses in 1998-1999. These data were compared to data from previous studies from the 1970's and 1980's. The hellbender populations appear to have declined in all rivers sampled. This decline is characterized by an increase in average body size, due to an apparent lack of recruitment of young into the population. Hellbenders from all rivers, except the Niangua, tended to be in better body condition in the 1998-1999 sample than they were in the past. It is not known whether the population decline for hellbenders has a single cause of whether each population has experienced independent declines.

The Ecology, Conservation, and Management of the Timber Rattlesnake *(Crotalus horridus)*, Corn Snake *(Elaphe guttata)* and Northern Pine Snake *(Pituophis melanoleucus)* in the New Jersey Pine Barrens

(Abstract Only)

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Herpetological Associates, Inc. conducted surveys for corn snakes *(Elaphe guttata)* and pine snakes *(Pituophis melanoleucus)* from 1977 - 1997 for the New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Endangered and Nongame Species Program (NJDEP), the Trust for Public Land, the New Jersey Conservation Foundation, and The Nature Conservancy. Evaluations of potential suitable habitats were made within the historic known range in southern New Jersey. Critical habitat for corn snakes (e.g., such as winter dens and nesting areas) were confirmed at 14 sites in Burlington County, 2 sites in Cumberland County, and 5 sites in Ocean County. Critical habitat for the northern pine snake was also found; 9 sites in Atlantic County, 16 sites in Burlington County, 1 in Camden County, 1 in Cape May County, 3 sites in Cumberland County, 1 in Gloucester County, 1 in Monmouth County, and 10 in Ocean County. Methods to capture and observe these snakes are provided in order to determine presence or absence along with the biology and important life history notes. Radio-telemetry was used to determine habitat selection, activity range size, seasonal movements, nesting sites, and winter hibernation sites. The average home range of 21 northern pine snakes was 50.10 hectares (125.29 acres), whereas the average home range of 5 corn snakes was 18.30 hectares (45.23 acres). Likewise, between 1984 and 1986, radiotelemetry was used to monitor the movements, foraging strategy, and habitat use of the timber rattlesnake (*Crotalus horridus*) in southern New Jersey. Movement patterns of males and non-gravid females consisted of constantly shifting, non-overlapping activity areas. In most cases these snakes moved in a looping pattern during the active season and returned to the same hibernation site from which they departed. Males generally exhibited the largest activity ranges *(N* =7, mean 48.6 hectares, range 3.5 to 123.5 hectares), and the sizes of their ranges were positively correlated with the number of days the snakes were monitored. This was not true for gravid or non-gravid females. Gravid females exhibited more static, overlapping activity areas and shorter migratory distances *(N*= 7, mean 9.9 hectares, range 1.8 to 20.4 hectares) from hibernacula. Whereas non-gravid females moved farther from overwintering sites *(N* = 6, mean 17.3, range 5.4 to 46.4 hectares) than gravid females, but not as far as males. Typical habitat consisted of pitch pine and Virginia pine mixed with black, post, scarlet, scrub, and white oaks. These upland forests often have intermittent stream corridors, *Sphagnum* bogs, or grassy savannahs interspersed within them. Pine Barrens rattlesnakes used underground rodent burrows and natural spaces under the root-systems of cedar, sour gum, and red maple trees along stream edges for winter refuge. The ground surface at hibernacula is often covered with a thick carpet of *Sphagnum* moss, in densely vegetated Atlantic white cedar stands. Early in April 1995, an extensive forest fire

burned an estimated 20,000 acres (8,094 hectares) of Pinelands. Approximately 90% of the forest area used by rattlesnakes during the previous study was burned. In an attempt to learn about changes in habitat selection, activity range size, or behavioral shifts following a major forest fire, follow-up radio telemetry studies to Reinert and Zappalorti's (1988a) earlier studies have been initiated. This included foraging sites, gestation sites, and hibernating sites. Fortunately, at the time of the fire, the rattlesnakes were still underground. When they emerged from hibernation, only two individuals had minor facial burns, which subsequently healed after shedding. This massive fire-induced alteration of the structural environment surrounding the overwintering habitat of rattlesnakes provided an opportunity to examine responses of snakes to infrequent natural disaster. Data collected after the fire provided a direct comparison for pre-burn and post-burn habitat disturbance. Preliminary results of this investigation include the first observation of two neonate *C. horridus* hibernating in an artificial den, similar to the type described in Zappalorti and Reinert (1994). This was the first time Pine Barrens rattlesnakes were observed hibernating in an upland situation. One of the two individuals was radio-tracked for two successive years. In the fall of 1995, it shifted to a more typical situation at the stream-edge of the cedar swamp, and returned to the same location in the winter of 1996. Another first-time observation involves the shift from one overwintering stream to another by a postpartum female in the winter of 1996. After emerging from her overwintering burrow in the spring of 1995, she moved south through the burnt forest about 1.6 km to a trash-pile on the edge of a sand road. She remained there for about one month, then moved 25 meters east to a field-edge mound. After giving birth to 12 young, the female moved 0.5 km, towards a stream where she overwintered in 1995. This was the first time we observed a Pine Barrens rattlesnake shifting stream corridors to hibernate. Such behavior has important implications because it demonstrates non-fidelity to a particular stream corridor and suggests that Pine Barrens timbers may be more pioneering in surrounding available habitat than previously thought. In 1995, the snake's hibernaculum was engulfed by the fire, whereas her location on the new stream had not been burned. Several other radio-monitored rattlesnakes moved to unburned sections of the den-stream, while a few returned to partially burned sections. Shifting overwintering sites may be beneficial to the survival of a population, especially if the habitat becomes radically altered by natural or human causes. Thanks to funding provided by The Nature Conservancy and the Trust for Public Lands, we have completed 5 years of this comparative radio-tracking study in the burned acreage of the Pine Barrens. The information obtained will not only provide answers to basic ecological questions, but it will also generate invaluable insight useful to the NJDEP and other wildlife conservation groups who are interested in the management of these 3 declining species.

THE JOSEPH LASZLO MEMORIAL AWARD WINNER

Exotic animal veterinarian Dr. Scott J. Stahl of Fairfax, VA received the 2001 Joseph Laszlo Memorial Award. The award is given in honor of the late Joseph Laszlo, herpetologist, herpetoculturist, and long-term Superintendent of the Department of Reptiles at the San Antonio Zoo. It is presented each year at the Symposium to the speaker who has demonstrated that his or her work represents new and exciting views and advances in herpetoculture and herpetology.

Dr. Stahl was recognized for his presentation on Reptile Obstetrics, an emerging discipline in herpetological medicine and surgery.

"The herpetological and veterinary community must come together in order to advance our knowledge of herpetological disease," says Scott Stahl, DVM, Chief of Staff at the Eastern Exotic Veterinary Center in Fairfax, VA. "Innovative medical and surgical techniques can increase the reproductive success of reptiles and amphibians".

To learn more about the life of the late Joseph Laszlo, please see the article on the next page of this publication.

Scott J. Stahl, DVM, DABVP-AVIAN

IN MEMORIAM

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JOSEPH LASZLO

"One man's *Crotalus willardi* is another man's *Lampropeltis alterna*.
No man can be truly rich or free until he reproduces both in captivity!"

Joseph Laszlo
1986

It is not every herpetologist who has endured or enjoyed as varied a background as Joseph Laszlo; Superintendent of the Reptile Department at the San Antonio, Texas Zoo. He died on 14 November 1987 as a result of an aneurysm. He was born in Budapest, Hungary on 13 September 1935. His interest in natural history began to develop as a youngster and at age six, he found a water snake while collecting fish for his aquarium. This experience led to a lifetime interest in herpetology.

Times were difficult for the Laszlo family during World War II and he often told stories of great hardships. Food was rarely available and on one occasion, he was forced to eat the carcass of a dead horse. Joe developed a strong distaste for conquerers and invaders of any kind.

Joe attended Petofi Sandoa Public High School and St. Antal College in Budapest between 1945 and 1953 where he completed academic courses in literature, natural and physical sciences, mathematics, languages and art.

When he was twenty, he was drafted into the Hungarian Red Army but was forced to escape later when he turned over the keys to an ammunition depot that he was guarding to the Hungarian rebels when the Russians invaded Budapest. Several escape attempts went awry before he was able to make it to Austria. In his first attempt, he was captured by Russian soldiers at a checkpoint as he journeyed toward the Austrian border. He carried a detailed military map to assist in the escape but its discovery would have led to instant death; he swallowed it as he sat between two machine gun-laden Russian soldiers. The Russians turned Laszlo over to the Hungarian Army after a three day detention. The second escape attempt was no more successful. A sympathetic Hungarian soldier allowed him to hide under a pile of hay but Joe had hay fever. The journey was arduous as he tried to control his sneezing. Unfortunately, as he slipped out of the hay truck to continue his escape, he discovered in horror that the driver had disembarked at the same Russian control post where he had been detained earlier. Finally, after a few more false starts, he arrived at the Austrian border aboard a train where he walked across the Andau Bridge to freedom. He stayed in a Red Cross camp in Vienna until he was able to arrange passage to the United States.

Immediately upon arrival, Joe began a pilgrimage through the US to locate herpetologists by searching for their addresses in the herpetological literature. Since he was not conversant in English, he communicated with gestures, drawings and by using scientific names, and was able to get his point across to his colleagues. He was awarded a scholarship, through the efforts of Wilfred Neill, to the University of Florida in 1957 but unfortunately lost it due to the language barrier.

In 1963, he became a US citizen and worked for the Humane Society of Greater Miami, Florida. His first job at a zoo was in 1963-1964 at the Crandon Park Zoo in Miami, Florida.

I initially met Joe in the Fall of 1965 while employed as a reptile keeper at the Atlanta Zoo. His boundless enthusiasm and absolute dedication to herpetology were awe-inspiring. Joe was a raconteur par excellence and often he would regale any assembled throng of herpetologists with anecdotes of his early days in Europe, his theories on captive reptile management and, finally describe his Weltanschauung in elaborate detail. Many pleasant hours were spent listening to him as he punctuated his stories with wonderful facial expressions and charming imagery.

Joe was hired as a keeper at the Columbus Zoo by the late Louis Pistola but alas, the association was tumultuous. Pistola directed him to clean the king cobra enclosure but no shift box was in evidence. Understandably Joe was reluctant to enter the cobra's domain and he expressed his reservations vociferously. To demonstrate, Lou proceeded to enter the cage, stimulated the snake to rear its magnificent body and then tied a handkerchief around its eyes so that it could not see. In response to this, Joe quickly sought employment elsewhere.

Joe and I arrived in Texas in tandem in 1966, Joe to the Ft. Worth Zoo as assistant supervisor at the Herpetarium and I to the Dallas Zoo. Joe's ideas on proper captive reptile care were beginning to solidify and he investigated thermoregulation, medical treatment, feeding techniques and so on in meticulous detail. In fact, as a measure of commitment, his house had virtually no furniture but rather was filled with an impressive array of terraria, herpetological literature and diagrams of heating elements, enclosures, cooling devices, myriad paraphernalia and lists of medications for reptiles.

In an effort to expand his horizons, Joe secured a position at the Houston Zoo in 1966. He admired John Werler, herpetologist and Director of the Zoo, who had a Mexican natricine snake (*Nerodia rhombifera werleri*) named in his honor. During one of my visits to the Zoo, Joe, in a state of abject despair, lamented on how he had accidentally fed some of John's namesakes to the king cobra. In fact, the snakes which were fed were some donated *Nerodia r. rhombifera* from Texas, and his coworkers, with John's complicity, had foisted an elaborate practical joke upon Joe by insisting that the snakes were *werleri*. Days passed before the practical joke was exposed as Joe ruminated about his future in the zoo profession.

In response to Joe's interest in cooling and hibernating reptiles to elicit reproduction, the staff at the Houston Zoo began experimenting with techniques and soon the service area was filled with reptile enclosures, festooned with dials and gadgets, of every size and description. One evening in Houston, as a group of us were sitting around talking about reptilian husbandry as related to cooling our charges, an atrocious foreign movie about an attack of dinosaurs on a heavily populated Japanese city flashed on the television. We began speculating how these creatures, if they now existed, should be maintained in zoological gardens. Joe, after deliberate thought, rolled his eyes skyward and said "You've got to keep them cool, mon" with absolute certitude. With that statement, he deftly solved the controversy surrounding dinosaur thermoregulation.

Joe's final position was Superintendent of Reptiles at the San Antonio Zoo in 1970 where his creative energy flourished. He embarked on a series of projects related to lighting, heating, cooling, and exhibitry of reptiles and amphibians. A visit to view his charges was always exciting. Joe, with stupefying energy, opened

virtually every enclosure, gave a detailed history of the inhabitant, recaptured those few creatures which had exited their cages as he was speaking, and presented detailed taxonomic information and literature citations for each.

Joe's particular passion was directed toward reproduction in the Old World vipers (*Vipera*); he often said that he wanted to produce vipers in such numbers that..."The snakes would cover the world like Sherwin Williams paint, mon."

It is likely that there have been herpetologists who have had more impressive credentials or higher visibility in the herpetological community. But it is unlikely that any will be as sorely missed as Joe. Ever the devoted father, he was generous, kind, helpful, creative and maintained a remarkable enthusiasm for herpetology, mostly self-taught, for over forty years. We will all miss his unique and colorful view of life. No doubt, Joe has already convinced St. Peter to remodel the Heavenly Gates into an entrance for his new reptile building.

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Joseph Laszlo holds two newly hatched water monitors at the San Antonio Zoo during February 1981. Photograph by John Tashjian.

COVER PHOTO CREDITS

Front Cover:

Bothriechis schlegelii by R. Dennis Johnston, Palo Alto, CA. Grand prize winner for best overall herp photo. Nikon F100, 28-105mm Nikkor lens, Nikon SB-28 flash, Kodachrome 200 film.

Rear Cover:

Upper left: *Heterodon platyrhinos* by Andrew Myers, Gaylord, MI. First prize winner for the "Natural Moment" category.

Upper right: *Hyla rosenbergi* by R. Dennis Johnston, Palo Alto, CA. First prize winner for the "Abstract" category.

Lower left: *Geochelone pardalis* by E. J. Pirog, San Diego, CA.

Lower right: *Crotalus ruber* by Gene Woodlock, Las Vegas, NV.