16th INTERNATIONAL HERPETOLOGICAL SYMPOSIUM ON CAPTIVE PROPAGATION & HUSBANDRY

St. Louis, Missouri, U.S.A.
June 25-28, 1992

Unedited Proceedings

International Herpetological Symposium, Inc.

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16th INTERNATIONAL HERPETOLOGICAL SYMPOSIUM
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Unedited Proceedings

Captive Propagation and Husbandry of the Southeast Asian Spiny Turtle, *Heosemys spinosa*, at Zoo Atlanta

Dennis W. Herman, Department of Herpetology, Zoo Atlanta, 800 Cherokee Avenue SE, Atlanta, GA 30315

Many Asian batagurine turtles are presently threatened by deforestation of their fragile habitats and by their increased value in the commercial pet trade. This is especially true for the Southeast Asian spiny turtle, *Heosemys spinosa*. The spiny turtle inhabits forested areas of Malaysia and Indonesia, where forestry practices have eliminated much of their available habitat. The bizarre spiny appearance of neonates and juveniles of this species has made it a popular turtle in the pet trade, but individuals often languish in captive situations and slowly starve to death.

Zoo Atlanta has maintained spiny turtles since 1974, but successful reproduction did not occur until 1991. Like other batagurine species, spiny turtles usually deposit one or two eggs per clutch, but may lay several times during the year. One turtle was hatched from a clutch of one egg in July 1991, after three years of infertile egg production. The diet was reviewed and manipulated and this may have been the reason for the successful hatching. As far as we have been able to determine, this is probably the first successful breeding of the spiny turtle in North American collections.

Notes on Three Island Populations of *Boa constrictor* in Belize

Bob Sears, Private Breeder, Wingate, Texas

This presentation will consist of observations on *Boa constrictor* populations on three cays off the coast of Belize. A short slide show will be included.

During the course of three trips to Belize, Central America, three small mangrove cays were visited, Crawl Cay, Coco Plum Cay, and Wee Wee Cay. Each was found to have populations of dwarf, tree dwelling *Boa constrictor*, in addition to several species of lizard. The boas present did not exceed four feet in length, nor two pounds in weight. Ten of the Crawl Cay boas were brought back to the United States, six males and four females. Three of the females have bred in captivity, and it appears that the small size is genetic. I will also discuss the outlook for survival of these island boas in such a rapidly developing country.

Rosy Boas (*Lichanura*): Current Taxonomic Controversies

David E. Spiteri,

In 1868 Cope described *Lichanura roseofusca* and *L. myriolepis*, both within the same type locality of "... the northern part of Lower California". This vague record has caused considerable controversy as to the identity of subspecies recognized today. Another contribution to the taxonomic dilemma is the lack of specimens recorded by early herpetologists. They considered themselves fortunate to have had nine specimens at once for comparative study, whereas, today, we have hundreds of specimens in our museums available.

Modern herpetologists use scale characteristics, geographic range, and the color and evenness of the stripes for identification of the subspecies. The large number of specimens available for study, computer programs incorporating univariate and multivariate statistical techniques, and analysis of early literature, have helped clarify the taxonomic relationship of the members of the *Lichanura* group. This presentation will discuss the results of these findings.

Indian Herpetology and the Madras Crocodile Bank

Romulus Whitaker, Director, Madras Crocodile Bank, Madras, India

India has 240 described species of snakes, 157 lizards, 31 turtles and tortoises, three crocodilians, 165 frogs and toads, 15 caeeilians, and a newt. This wealth of "herps" is sufficient to keep the few full time herpetologists hard at work and the search is always on to recruit more. Ironically, new species are constantly being found while habitats are rapidly being destroyed for human development. Most of the larger reptiles such as pythons, crocodilians and the varanids are threatened. However, efforts toward habitat protection and a number of other measures have been taken by Government wildlife agencies as well as by organizations such as the Madras Crocodile Bank. Established in 1976 with 50 crocodilians of three species, the Bank now has 10,000 of ten species plus 25 species of turtles and tortoises and a breeding group of water monitors. The Croc Bank is involved in field surveys in the mainland and in the Andaman and Nicobar Islands, as well as research at the Bank which has been recently designated "Centre for Herpetology" by the Trustees.

The Brown Tree Snake, *Boiga irregularis*, in Guam: Controlling the Spread of the Reptilian Mongoose of the South Pacific

Sean McKeown, Curator of Reptiles, Chaffee Zoological Gardens of Fresno, CA

This presentation will focus on the introduction of the Brown Tree Snake, *Boiga irregularis*, to Guam from the region of New Guinea following WWII and the resulting ecological disaster brought about by this "super-tramp" species to the island's wildlife. During 1991 at the request of the State of Hawaii's Department of Agriculture and the Hawaiian Gas and Electric Company, Brown Tree Snake Control (BTSCG) members Paul Breese, Don Hunsacker and the author traveled to Guam to be briefed in detail by the USFWS biologists on Guam as to their findings, to study the Brown Tree Snake in the wild, and to review existing procedures for moving civilian and military cargo from Guam to Hawaii. The final part of the presentation deals with our recommendations as to what measures should be additionally implemented to prevent the Brown Tree Snake from entering and becoming established on the Hawaiian Islands and the status of these proposals.

Old World Chameleons: Collecting, Captive Breeding and Conservation

Gary Ferguson, Ph.D., Texas Christian University, Department of Biology, Fort Worth, TX

The brilliant colors, potential captive-hardiness, unusual adaptions and lack of definitive studies of the behavior and natural history of old-world chameleons have made their acquisition in great demand by private, zoo-based, and scientific herpetologists. This has resulted in a large-scale commercial importation of these animals in recent years.

However, the current large-volume importation and lack of knowledge or attention to the special needs of these animals has created serious concerns. Two of these concerns are the conservation of potentially vulnerable species in the wild and preventable poor health and mortality of in-transit and recently imported specimens. The pros and cons of either 1) banning collection and importation versus, 2) more restricted and regulated importation combined with ongoing sanctioned studies of selected species in the field and in captivity to address the concerns are presented.

Preliminary Comments on the Management of the Galapagos Tortoise, *Geochelone elephantophus*, at the Oklahoma City Zoo

Carl Sandefer, Department of Herpetology, Oklahoma City Zoological Park

Reproduction of the Galapagos tortoise is almost nonexistant in zoos located in the temperate zone of the United States. For the past two years, the Oklahoma City Zoo has successfully reproduced Galapagos tortoises even though the winters can be long and severe and the tortoises have to remain indoors for up to six months at a time.

In this paper, I will review some of the methods thought to be helpful in achieving successful copulations. I will also discuss egg incubation techniques and juvenile tortoise rearing.

In Search of the Tete'chien: Observations on the Natural History of *Boa constrictor nebulosa* with Notes on Captive Care

Terry L. Vandeventer, Private Breeder, Clinton, MO

The snake species *Boa constrictor* occupies one of the largest ranges of any land serpent. The reptile is deeply ingrained in the mind of the general public who frequent refer to any giant snake as a "boa constrictor". Considerable mention is made of *B. constrictor* in scientific literature but much of this is anecdotal or even fanciful. The species has figured prominently in the pet trade for decades. Still, the natural history of *Boa constrictor* is virtually unknown and its taxonomic status poorly understood. Observations on the natural history and captive husbandry of the insular subspecies *B. c. nubulosa* are presented here.

Natural History and Captive Husbandry/Propagation of the Rare Chinese Frog, *Rana schmackeri*

Phillipe de Vosjoli and Robert Mailloux, Professional Herpetoculturists, Lakeside, CA

Rana schmackeri is the second species in the Hylorana complex bred by the authors. The method used to maintain and breed this species, habitat simulation within a greenhouse, has wide ranging applications in the breeding of anurans. Negative environmental factors which may contribute to current declines of amphibians can be eliminated using this system. Southern tomato frogs, *Dyscophus guineti*, Mexican dumpy tree frogs, *Pachymedusa dacnicolor*, and otheres were bred under similar conditions. The authors will also present their controversial, skeptical and pessimistic views on amphibian declines and the role of herpetoculture in amphibian conservation.

Observations on Incubation, Diet, and Sex Determination in Hatchling Tortoises

Richard Fife, Private Breeder, Phoenix, AZ

Three aspects of tortoise husbandry will be included in this paper. First, embryonic development, as seen by candling procedures will be described. Second, research on growth and shell development using Zu/Preem Primate diet will be discussed. Finally, the development of sexual characteristics will be examined.

The Herpetology of Trinidad and Tobago

Hans E. A. Boos, Curator, Zoological Society of Trinidad and Tobago, Inc., Emperor Valley Zoo, Port of Spain, Trinidad

The herpetofauna of the twin-island Republic of Trinidad and Tobago is generally classified as an impoverished one, differing only slightly from that of South America. Lying four kilometers of the northeast coast of Venezuela, Trinidad and Tobago's topography, consisting of many different biotypes, has a good representative selection of reptiles and amphibians found on the mainland. However, some temporal geologic isolation has given rise to several endemic species in isolated habitats. Some mysteries remain to be solved concerning the herpetofauna of Trinidad and Tobago.

Establishing a North American Turtle Collection at the Tennessee Aquarium

David Collins, Curator of Forests, and Gregory George, Herpetologist, Tennessee Aquarium, Chattanooga

The Tennessee Aquarium opened to the public in May, 1972. The focus of the institution is freshwater ecology, relying heavily on the Tennessee-Mississippi River drainage as its vehicle. Situated in Chattanooga, the Aquarium is centrally located in region of tremendous chelonian diversity and has the potential to make significant contributions to chelonian conservation.

This presentation will describe the process of developing and assembling the Aquarium's North American freshwater turtle collection which currently includes 24 species. Several specific projects under development and potential for future research are described

Vipers of The Caucasus: A Molecular Approach to Systematics and a Zoogeographical Review

Höggren M.[1], Andrén C.[2], Nilson G.[2], Orlov N.L.[3], and Tuniyev, B.S.[4]
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2 Department of Zoology. University of Göteborg, Box 25059, S-400 31 Göteborg, Sweden
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The shield-headed vipers of the Caucasus region and adjacent parts of NE Asia Minor (i.e. "*Vipera kasakovi* complex") comprise a highly variable species-group, distributed in a wide array of habitats from close to sea level up to subalpine environments. Montane populations in the western Main Caucasus show an exceptional degree of external polymorphisms, with body patterns and color morphs reflecting phenotypes of several different species of Eurosiberian vipers. Phylogenetic and phenetic analyses of 27 presumptive loci scored by enzyme electrophoresis, where the 12 populations investigated (including two outgroups) were encoded as terminal taxonomic units, support that the four polymorphic populations sampled in the western Main Caucasus belong to one species (*V. dinniki*). The most parsimonious cladogram further revealed a close monotypic relationship to *kaznakovi*, *ursini* and *renardi*.

The Effects of Stress on Lizards and Its Applications to Captive Management

Dale DeNardo, DVM, Department of Integrative Biology, UC Berkeley

To better understand the effects that stress has on reptile reproduction, both laboratory and field studies have been carried out on the side-blotched lizard, *Uta stansburiana*. The hormone corticosterone was implanted into male lizards and the effects on social interactions were determined. In the laboratory, corticosterone reduces, but does not eliminate aggression in males, and similarly, territory size and survivorship is greatly reduced in the field. These results, while not directly related to captive management, provide insight to the importance of reducing stress in captive reptiles in order to maximize reproduction. Examples of common captive stressors and ways of reducing their effects are covered.

Ophidian Paramyxoviruses - Historical Overview and Current Recommendations on Control

Mark Lynn Lloyd, DVM, Toledo Zoo, Toledo, OH

Ophidian paramyxovirus has had significant economic impact on numerous zoologic and private collections since its identification as a pathogen in 1976. This brief retrospective of documented outbreaks and recent research data may allow the herpetologist to prevent or minimize losses from this etiologic agent. An outline of the clinical presentations and course of the disease, along with diagnostic tools currently available, are included to aid identification of the infection. Recommendations on control and treatments, once identified, are presented,as well as recent research on prevention via vaccination. Finally, a brief discussion of paramyxoviral infections in other species in lieu of further information on the ophidian type(s) to enhance understanding of this group of viruses and potential danger to wild populations.

Sex Determination of Reptiles by Fluid Injection

Ken Foose, P.O. Box 511, Virginia City, Nevada 89440
Mark Ditzworth, DVM, 3653 Kings Row, Reno, NV 89503

The sex of a wide variety of reptiles was ascertained using fluid injected into the base of the animals' tails. This procedure was used on snakes, turtles, tortoises, and a wide variety of lizards. Emphasis was placed on lizards whose sex could not be easily determined by visual means. The usefullness and drawbacks of this procedure are adddressed.

Fiat Lux: Some Characteristics of Lamps Used in Herpetoculture

William H. Gehrmann, Ph.D.. Natural Sciences Department, Tarrant County Junior College, Fort Worth, TX

Lamps may differ in both the quality and intensity of light output. Spectral power distributions (SPD) can be used to describe quality by indicating the relative power or energy associated with various wavelengths ranging from ultraviolet through the visible specturm and into the infrared (heat) region. The quality of light from artificial lamps differs from that of natural light in several ways. However, the extent to which quality influences biological processes, such as growth and reproduction in various species, has not been experimentally established. Preliminary laboratory findings and a large body of anecdotal data indicate that quality in the visible region may have little effect on some processes, even in heliophilic species.

Reptilian Dystocias -- Common Causes and Relative Treatment Success

Mark Lynn Lloyd, DVM, Toledo Zoo, Toledo, OH

Reptilian dystocias in captivity occur in nearly 10% of the reproductive population according to a recent survey of approximately 50 institutions, including 1600 specimens. First, an examination of the causes and their relative importance including environmental factors, nutrition, maternal or fetal morphologic abnormalities, infection and oviductal compression allow insights into the second section, relative treatment success and prevention of dystocias. Finally, a suggested flow chart of the appropriate management of reproductive females summarizes the prevention and treatment of reptilian dystocias as a concise reference for herpetologists involved in captive propagation.

Mitochondrial DNA Analysis of Box Turtle Systematics

Patrick Minx, LGL Ecological Research Associates, Bryan, TX

The North American box turtles are a morphologically diverse genus that exhibit considerable intraspecific variation. Relationships within the genus are complex and the subspecies of *Terrapene carolina* are especially problematic. Two phylogenies constructed from morphological data (Milstead, 1969 and Minx, unpublished data) are contrasted with a phylogeny based on restriction endonuclease analysis of a portion of the 12S and 16S, and portion of the ORF2 and COI regions of the mitochondrion. A well resolved phylogeny was produced from one of the morphological studies, though both studies supported subdividing the four species into two species groups. The phylogeny derived from mtDNA analysis concurs with some relationships indicated in the other two phylognies, but splitting the genus into two species groups was neither supported nor contradicted. The results of the analysis, a polytomy of six major haplotypes, may indicate that maternal lineages within the box turtles are older than anticipated, especially within the *T. carolina* complex. Introgression within *T. carolina*, and between *T. carolina* and *T. coahuila* is also evident in these findings.

Snake Venom Poisoning: First Aid and Medical Management

Findlay E. Russell, M.D., University of Arizona Health Sciences, Tucson, AZ

Snake venom poisoning is an entity widely diversified in its result due to the nature of the venom, the conditions under which a bite occurs, the species of snake involved, the age and size of the snake, the amount of venom delivered, the time of the year, the age and the size of the victim and his psychological condition, the time to the first-aid treatment and subsequent medical care, and other factors. Although there are an estimated 45,000 bites by snakes in the United States each year, only about 8000 of these are inflicted by venomous snakes (Russell, 1973, 1980). Mortality is less than 1%, there being 9-15 snakebite deaths per year. This has been reduced from an estimated 70-100 deaths per year during the earlier parts of this century and can be attributed to the advent of antivenin and its availability, the improvement in first-aid and emergency medical treatment and, certainly, to a better knowledge of reptile fauna and habits.

The presentation will review the current protocols in the U.S. for bites by native and exotic venomous snakes. Particular attention will be directed to the immediate or first attender care of the victim and advice on subsequent medical treatment.

Russell, F.E. Snake Venom Poisoning, Lippincott, Philadelphia, 1980; Scholium International, Port Washington, NY, 1973.

Old World Chameleons: Growth Under Laboratory Conditions

Larry G. Talent, Ph.D., Associate Professor, Oklahoma State University, Stillwater

Hatchling *Chameleo gracilis* and *C. pardalis* were raised to maturity under identical laboratory conditions. Hatchlings were housed in standard plastic mouse cages (28L x 17.5W x 12.5 H cm). Crickets and mealworms were provided ad libitum. Ambient room temperature was a constant 26-27 °C and a 40 watt incandescent light bulb provided a thermal gradient for 14 hours per day. No florescent lighting was provided. Food items were not dusted with a vitamin/mineral mix. Instead, individual vitamins were given orally to each chameleon at regular intervals. Both *C. gracilis* and *C. pardalis* grew well and matured within five months. Both species needed considerably more vitamin D_3 than is usually available in commercial vitamin mixes. Conversely, both species grew best when given less vitamin A than that commonly given on dusted food items. Symptoms associated with hypervitaminosis A included edema of the throat and neck, shedding problems, and metabolic bone disease.

Species Survival Plans: It's the Breeding and a Whole Lot More

Robert J. Wiese, Ph.D., AAZPA Conservation Center, Bethesda, MD

The species Survival Plan (SSP) was established by the American Association of Zoological Parks and Aquariums (AAZPA) to assist conservation efforts for species currently in threat of extinction. The SSP's first priority is maintenance of the species' original genetic diversity through relative equalization of founder contributions. Monitoring founder contribution is also required to reduce selection for captive conditions or other human imposed factors. The second priority is to maintain a healthy population by minimizing inbreeding. Ultimately, the SSP supports the wild population through basic research, development of technologies transferable to wild populations, reintroduction, field research, habitat preservation and education. Captive breeding programs that do not scientifically manage the population for retention of genetic diversity, attempt to minimize selection, and provide for the wild population do not further conservation efforts.

The Green Anaconda, *Eunectes murinus* (Linnaeus, 1758) in Captivity: Maintenance, Reproduction, and Neonatal Growth

Pete Strimple, Reptile Research and Breeding Facility, Cincinnati, OH

A brief review of the natural history of the green anaconda, *Eunectes murinus* (Linnaeus, 1758), is provided, as is information on the acquisition and maintenance of specimens maintained by the author over the last 14 years. *Eunectes murinus* has been successfully reproduced by the author on three separate occasions, and details of these breedings are discussed. Parturition occurred on 24 December, 1985, 18 January 1988, and 26 December, 1990, with respective litter sizes (live neonates only) of 17, 21, and 30. Information is also provided regrading the size, maintenance, and growth of the neonates. Moreover, the current reproductive status of the above mentioned specimens is discussed, as are the future plans for reproduction of this species at the Reptile Research and Breeding Facility.

Lizard Egg Incubation Techniques: How to Increase Hatching Success, and How to Control the Sex, Size, and Color of Your Hatchlings

Brian E. Viets, Department of Biology, Indiana University, Bloomington, IN

Maximizing hatching success is one the goals of any successful captive breeding program, be it research, conservation, or commercial-oriented. Although many species of lizards require specialized incubation techniques, some generalities can be made.

Selecting an incubation temperature is very important. For most species, a constant or fairly constant incubation temperature is preferred. Some lizard species exhibit temperature-dependent sex determination, so the incubation temperature selected can greatly influence the sex ration of the offspring. In addition, incubation temperature influences total incubation time, hatchling survivability and growth, as well as adult sexuality and pigmentation patterns. Some lizard species can tolerate a wide range of incubation temperatures (from 24-35°C in species such as *Eublepharis macularis* and *Sceloporus undulatus*), but incubation at extreme temperatures often increases mortality.

The selection of an appropriate incubation medium can also influence hatching success. I have had the greatest success using vermiculite in my lizard egg studies. The grade and water content of the vermiculite largely depend on the eggs to be incubated. Small eggs do well in fine vermiculite, whereas larger eggs do better in coarse vermiculite. A 1:1 water;vermiculite ratio by weight works for most species, although many iguanid eggs do better slightly drier, whereas eublepharid gecko eggs do well slightly moister. The effects of extreme dryness or wetness during incubation on hatchlings is not yet well understood in lizards, but is likely to be similar to the effects of extreme incubation temperatures.

Plastic boxes (e.g., Rubbermaid® Servin' Saver™) work well as incubation containers. Eggs should be aerated at least once daily (more often for larger eggs such as *Varanus*, especially towards the end of incubation). Containers should be sealed between daily aerations, but the corner of the lid may be left unsealed if further air exchange is required. For most species, eggs should be buried halfway in the vermiculite, the other half being exposed to the air. Egg crowding should be avoided.

Although exogenous factors are perhaps most important for hatching success, endogenous factors should not be overlooked. The nutritional condition of the female at the times of ovulation, fertilization, and oviposition will have a direct effect on egg quality.

Nutritional Considerations in Feeding Reptiles (Calcium and Vitamin D)

Duane E. Ullrey, Ph.D., J. B. Bernard, B.S., Mary E. Allen, Ph.D., Department of Animal Science, Michigan State University, East Lansing, MI & Baer Associates, Inc., Olney, MD

Rickets and osteomalacia, classic signs of calcium and vitamin D deficiency, are commonly seen in certain sun-basking reptiles when they are housed indoors. Insectivorous reptiles, such as the leopard gecko, *Eublepharis macularis*, have been fed crickets unsupplemented with calcium and vitamin D and, as a consequence, developed poorly mineralized bones with persistent osteoid, thin cortices and multiple fractures. When analyzed, the unsupplemented crickets contained 0.16% calcium, 0.85% phosphorous and immeasurable amounts of vitamin D_3 (<400 IU/kg) on a dry matter basis. If the crickets were provided a high calcium (8%) diet without or with 7000 IU of vitamin D_3/kg for two days prior to being fed to the leopard geckos, the supplemented crickets contained 0.95% calcium, 0.85% phosphorus and < 400 or 700 IU of vitamin D_3/kg. This was a consequence, at least in part, of the retention of supplemented dietary calcium in the gut of the cricket and the contribution of gut contents plus the cricket body to the total nutrient supply. The leopard geckos fed supplemented crickets had normally mineralized bone, but the response appeared due largely to the increased supply of calcium. When an herbivorous reptile, the green iguana, *Iguana iguana*, was fed a artificial diet containing 1.4% calcium, 0.7% phosphorous and 2000 IU vitamin D_3/kg in the absence of ultraviolet light, bone demineralization and fractures were evident. In addition, serum concentrations of vitamin D metabolites were lower than in serum from green iguanas permitted solar exposure in Costa Rica (9 vs 146 ng of 25-OH cholecalciferol/ml and 44 vs 257 pg 1,25-diOH cholecalciferol/ml). When green iguanas were fed as above and exposed to 12 hours of artificial light, including significant amounts of ultraviolet B (285 to 315 nm), bone mineralization appeared normal, and serum concentrations of vitamin D metabolites were 220 ng of 25-OH cholecalciferol and 133 pg of 1,25-diOH cholecalciferol/ml. It has not been established why dietary supplies of vitamin D were ineffective for the green iguana, but it appears that certain reptiles may require exposure to the sun or to an artificial light source that simulates the solar spectrum.

Husbandry and Natural History of *Rhacodactylus*

Tim Tytle, M.D., Private Breeder, Oklahoma City

Initial remarks will include an overview of the geographic location, topography and climatic conditions of New Caledonia, the only island on which this genus is definitely endemic. The six species which comprise this genus include *Rhacodactylus leachianus*, the largest living gecko, *R. trachyrhynchus*, an ovoviviparous species, and several species with prehensile tails. Personal insight into the captive management of *R. auriculatus*, *R. chahoua*, and *R. saraslnorum* and the captive reproduction in the first two will be discussed.

Aspects of the Natural History of the Genus *Bothriechis* in Costa Rica

Alejandro Solarzano, Instituto Clodomiro Picardo, Universidad de Costa Rica, & Serpentario Tropical, San Jose

Three arboreal pitvipers occur in Costa Rica: *Bothriechis lateralis*, *B. nigroviridis*, and *B. schlegelii*. *Bothriechis lateralis* and *B. nigroviridis* are distributed along moderate to high elevations of the Cordillera Volcanica Central, Cordilleras de Tilaran and Guanacaste, and Cordillera de Talamanca. *Bothriechis schlegelii* inhabits lowland rainforests of the Atlantic and Pacific versants. The reproductive cycles of these species show a pattern that is clearly seasonal, with births occurring during the Costa Rican rainy season (May - December). Feeding habits are quite similar among the three species inasmuch as theri diets are base on rodents and other small vertebrates. *Bothriechis lateralis* and *B. schlegelii* are primarily nocturnal, while considerable diurnal activity has been observed for *B. nigroviridis*. Breeding and temperature-related aggregations have been observed frequently for *B. lateralis*.

Declining Amphibian Populations: Insights and Possible Causes

Alan Pounds, Ph.D., Monteverdi, Costa Rica

Sudden population declines leading to the disappearance of golden toads (*Bufo periglenes*) and harlequin frogs (*Atelopus varius*) at a montane site in Costa Rica coincided with 1986-87 El Nino and the greatest moisture-temperature anomalies on record in the area. While data concerning the effects of the unusually warm, dry conditions on golden toads are limited to their eggs and larvae, data for harlequin frogs suggest important effects on adults. The severe local impact of this moderate El Nino raises questions about the role of climate cecellations in reported amphibian declines in various parts of the world.

Status of the Indian Python in India and Captive Breeding for Release

Romulus Whitaker, Director, Madras Crocodile Bank, Madras, India

The Indian Python, *Python molurus molurus* and *Python molurus bivattatus*, has been exploited for the skin trade since the early 1960's. Once common throughout India from sea level to over 2500 m in the hills, it has been exterminated from much of its former range due to the skin trade, habitat loss and incidental killing. This paper provides an update of python status in some parts of India and proposes a tested methodology for a captive breeding and release program to restock suitable wild habitats.

The Amphibian Fauna of Australia

Michael J. Tyler, Professor, Department of Zoology, University of Adelaide, Australia

Anurans are the only Amphibia native to the Australian continent. Currently 202 species are recognized but numerous undescribed taxa are known, and the actual total is probably c.a. 225. Four families are represented: the Hylidae and Leptodactyliodae which range across the entire continent, and the Microhylidae and Ranidae which are confined to the north and northeast.

There are close faunal links with New Guinea involving shared genera and/or species, but essentially the Australian frogs are unique. They include two reproductive novelties: hip pocket transport of young by *Assa darlintoni* and gastric brooding by two species of *Rheobatrachus*.

The Gàstric Brooding Frogs

Michael J. Tyler, Professor, Department of Zoology, University of Adelaide, Australia

The description of *Rheobatrachus silus* Liem (1973) from southeast Queensland attracted interest because of its superficial appearance to the southern continents family *Pipidae*. But in 1974 it was reported that this species was unique in brooding its young in its stomach. A research program based in Adelaide examined the physiological processes involved in converting the stomach to a womb and , finally, took photographs of the behavior of oral birth.

In 1979-80 the entire wild population of *R. silus* disappeared. A colony in my laboratory lived on for several more years. Despite the most extensive and intensive search the species has not been seen since.

In 1984 a second and larger species of gastric brooder was discovered in closed rainforest several hundred kilometers to the north. It was described as *R. vitellinus*. Initial studies revealed fundamental differences in the internal gastric environment. This species has also disappeared.

The Herpetofauna of Baja California and the Sea of Cortes

L. Lee Grismer, Ph.D., Department of Biology, San Diego State University, San Diego, CA 92182

The Baja California peninsula is the second longest and geographically most isolated peninsula in the entire world. Its complex geological origin coupled with its diverse climate and well sculpted topography have given rise to and supported a diverse array of reptiles and amphibians representing an equally diverse range of adaptive types. The majority of endemic species in Baja California occur in its southern section and evolved in association with the geological origin of the peninsula. Current geographic variation observed in transpeninsular taxa appears to coincide with the distribution of phytogeographic regions. The reptiles on the islands in the Gulf of California comprise a varied group as well. Generally speaking all are well adapted for living in hot arid environments and are derived from both peninsular and mainland sources. Endemism at the species level appears to be greatest on continental and oceanic islands as opposed to landbridge islands. The Pacific islands off the west coast of Baja California contain a number of peninsular derivatives. There are no endemic species on any Pacific islands although endemism at the subspecific level is high on many islands. Also, there are some very intriguing distributional and morphological anomalies found on Pacific islands.

The Children's Python Complex

Brian Kend, Palos Verdes Estates, CA

This paper will discuss the natural history and reproductive biology of *Liasis childreni*, *L. maculosis*, *L. stimsoni stimsoni*, *L. stimsoni oreientalis*, and *L. perthensis*. Also included will be information about these snakes from both American and Australian perspectives. Data will be presented to support the contention that these animals are separate species, and should not be classified under singly under the umbrella of "*Liasis childreni*".

The Nutrition of Herbivorous and Carnivorous Reptiles

Mary E. Allen, Ph.D., National Zoological Park, Smithsonian Institute, Washington, D.C.

The quantitative nutritional requirements of reptiles are not known. However, the same nutrients (e.g. amino acids, fatty acids, vitamins, minerals) that are required by mammals and birds appear to be necessary for reptiles. Although energy metabolism, reproductive strategy and physiological characteristics may influence the nutritional requirements of reptiles, a primary distinction must be made between carnivorous and herbivorous species. Unlike carnivorous reptiles which have relatively simple digestive tracts, herbivorous species such as tortoises and iguanine lizards, typically have capacious guts that retain digesta and thereby facilitate microbial fermentation of plant fiber. Fermentation produces amino acids and vitamins that may satisfy the requirements for these essential nutrients. The "salad" commonly fed to herbivorous reptiles in zoos is very different in composition from foods normally consumed in the wild. Most "salads" are limiting in fiber, low in protein and are usually inappropriately supplemented. Plants consumed in the wild by the green iguana (*Iguana iguana*), Galapagos land iguana (*Conolophus* ssp.) and the desert tortoise (*Gopherus aggassizi*) are characterized by relatively high protein and fiber concentrations. Young green iguanas fed diets with 25% protein had significantly greater growth rates than did those fed diets with 15% protein. The improvement of "salads" fed to herbivorous zoo reptiles can be achieved by the use of a manufactured herbivore pellet (used in hoofed stock diets) as approximately 50% of the diet (by weight), greens at approximately 40%, and fruits at approximately 10%. Carnivorous reptiles, by contrast, are adapted to highly digestible diets that consist of vertebrate or invertebrate prey. Prey such as mice and rats, if maintained on foods to meet the requirements of rodents, should be adequate when used to feed snakes and other carnivorous reptiles. Fish are highly subject to spoilage and oxidative change when stored and thawed inappropriately. Consequently, when fish are used to feed crocodilians and other carnivorous reptiles, vitamin E should be supplemented at the rate of 100 IU/kg of fish. Because thiamin in some fish may be unavailable, this B vitamin should be added to fish at the rate of 25 mg/kg of fish. Insect prey, such as mealworm larvae and crickets, is typically low in calcium and the use of such prey, if unsupplemented with calcium, as the sole food for insectivorous reptiles will result in skeletal pathologies. Insects should be either "dusted" with a calcium source or fed a diet high in calcium (8%).

The Use of Enrofloxacin in Reticulated Pythons

Roger J. Klingenberg, D.V.M., Greeley, CO
Brian P. Backner, M.D., Sharon, MA

The flouroquinolone antibiotic enrofloxacin was investigated via a three phase study. First, serum half-life was determined. These results were then combined with MIC_{50} data for commonly isolated pathogens to determine a dosage and frequency schedule in phase II. Finally, data was collected throughout the study to look at the question of enrofloxacin-related renal toxicity.

INDIAN HERPETOLOGY AND THE MADRAS CROCODILE BANK

Romulus Whitaker

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Abstract: India has 240 described species of snakes, 157 lizards, 31 turtles and tortoises, 3 crocodilians, 165 frogs and toads, 15 caecilians and a newt. This wealth of "herps" is sufficient to keep the few fulltime herpetologists hard at work and the search is always on to recruit more. Ironically, new species are constantly being found while habitats are being rapidly destroyed for human development. Most of the larger reptiles such as pythons, crocodilians and the varanids are threatened. However, efforts toward habitat protection and a number of other measures have been taken by Government wildlife agencies as well as by organisations such as the Madras Crocodile Bank. Established in 1976 with 50 crocodilians of three species, the Bank now has 10,000 of ten species plus 26 species of turtles and tortoises and a breeding group of water monitors. The Croc Bank is involved in field surveys on the Indian mainland and in the Andaman and Nicobar Islands, as well as research at the Bank which has been recently designated "Centre for Herpetology" by the Trustees.

houses are "up to the mark" however, with generally high mortality and inadequate curatorship.

In the early 1970's the author set up a sea turtle hatchery south of Madras and initiated the first surveys on sea turtle status and distribution. At that time we also started collecting and hatching crocodile eggs. In the late 1970's crocodile egg collection and rearing centres were set up for the rehabilitation of India's three threatened species in the states of Andhra Pradesh, Orissa, Uttar Pradesh, Gujarat and Tamil Nadu by the Central and State governments, with assistance from the Food and Agriculture Organisation of the United Nations. Over 10,000 mugger, gharial and saltwater crocodiles were hatched and reared at these centres and 4,000 released in protected areas. Several sanctuaries were gazetted specifically for crocodilians, in particular the National Chambal Gharial Sanctuary which protects the largest remaining gharial population (about 1000 animals) along 600 kms of the Chambal River and the Bhitar Kanika Sanctuary in Orissa for the saltwater crocodile.

In 1976 the Madras Crocodile Bank was started by the author and his wife Zai on 8 1/2 acres of coastal land 50 kms south of Madras City for the conservation and study of India's three crocodilians.

A Review of Indian Herp Diversity

Crocodilians: India has three crocodilians; the mugger (*Crocodylus palustris*) which is found in diverse aquatic habitats throughout most of India; the gharial (*Gavialis gangeticus*) which is restricted to deep water river systems of the north; the saltwater crocodile (*Crocodylus porosus*) with a present range corresponding to the last significant tracts of mangrove in India (Orissa, West Bengal, Andaman and Nicobar Islands).

Turtles and Tortoises: Four species of sea turtles nest on India beaches: olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), and hawksbill (*Eretmochelys imbricata*). Only the ridley nests on mainland India in small numbers along both coasts. In Orissa, however a tremendous arribada occurs on Gahirmatha Beach each January and March with an estimated peak of over 500,000 nesters. The other species nest in the Lakshadweep and Andaman and Nicobar Islands in significant numbers.

There are five species of land tortoises in India, all of which are under heavy pressure from habitat loss aggravated by usage by tribals as food (which was okay when sufficient habitat and tortoise numbers existed). The star tortoise (*Geochelone elegans*), common in scrub jungle near Madras fifteen years ago is now rare. In

Gujarate where there are few meat eaters it is still widespread and commonly seen. The Travancore tortoise (*Indotestudo forstenii*), with its range restricted to vanishing moist deciduous forests in the southern Western Ghats will be an endangered species within a decade. The elongated tortoise (*Indotestudo elongata*) was never common in India and is likely to be endangered now. The same is true of the Asian brown tortoise (*Manouria emys*) of the northeast.

Among the softshell turtles the most common is the flapshell (*Lissemys punctata*) which needs only small seasonal ponds to survive. All of the other softshells (seven of them) are big turtles (growing to 100 kgs and 100-180 cm in length) which need larger bodies of water and perennial rivers. Besides the problem of habitat loss through damming and channelling natural river courses, the Ganges softshell (*Aspideretes gangeticus*), the chitra (*Chitra indica*), and peacock softshell (*Aspideretes hurum*) are (along with *Lissemys*) the most popular turtles in the meat markets of West Bengal. While the large, organized rail shipment of turtles to Bengal has been curtailed by the implementation of the Wildlife Act there is still a considerable clandestine trade in turtles for meat, almost exclusively to West Bengal. Most tribal people include turtles in their diet but fortunately in no State other than West Bengal are turtles commonly eaten by non-tribal villagers.

Of the hardshell turtles the batagur (*Batagur baska*) is the most endangered of the larger species. The smallest, the forest cane turtle (*Geoemyda silvatica*), a terrestrial species inhabiting rain forests in Kerala and Karnataka, is perhaps India's rarest turtle. Other forest species, the Asian leaf turtle (*Cyclemys dentata*), the keeled box turtle (*Pyxidea mouhoti*) of northeast India appear to be equally rare, though little is really known about them. The most common and widely distributed hardshell is the Indian black turtle (*Melanochelys trijuga*). *Kachuga tecta* and *Kachuga tentoria* are still common in many North Indian rivers but *Kachuga kachuga* appears to have become scarce in the last decade. Hardshell turtles also enter the trade for meat in West Bengal and they are of course affected by the tremendous habitat alterations taking place all over India in the face of development.

Lizards: Of the lizards, the larger species (the four varanids) and the species restricted to endangered habitats (the rain forests in particular) are under threat. Very little can be said about the status of lizards in India, they just haven't been studied except for isolated observations on individual species. The diversity and richness of India's lizard fauna is a reflection of the wide range of habitats in the country, from desert to rain forest and from 6,000 metre mountain ranges to oceanic islands. There are about 54 geckos, 44 skinks and 43 agamids in India. There are also legless lizards (*Barkudia* and *Ophiosaurus*), a chameleon (*Chameleo zeylanicus*) and a relict agamid genus isolated on South Indian hilltops (Salea). Among the geckos are some notables like the Andaman day gecko (*Phelsuma andamanense*), the well studied (abroad) *Eublepharis macularius* and the forest day geckos, *Cnemaspis*. The skinks include species of *Leiolipisma* at high altitudes, the 50 cm long Tytler's skink (*Mabuya tytleri*) in the Andamans and a number of obscure forest forms with apparently many more to be discovered and described. Typical Indian agamids are the *Calotes* group and the rock agamids *Psammophilus* of peninsular India and *Agama* up to 5000 metres in the Himalayas. The toad-headed agamids (*Phrynocephalus*) of the high altitude desert in ladakh are reminiscent of the horned "toads" (*Phrynosoma*) of the U.S. and Mexico. The spiny-tailed lizard (*Uromastix hardwickii*) is still cruelly boiled alive for its fat, believed to be a potent aphrodisiac.

Of the varanids, the Bengal monitor (*Varanus bengalensis*) is the most widespread and still common and easy to see in parts of the country (including Rajasthan, Gujarat and madhya Pradesh) where monitor killing for skin and meat is uncommon. The water (*Varanus salvator*) only survives in the mangrove forests of Bhitarkanika in Orissa, the Sunderbans of West Bengal (scarce now), and the Andaman and Nicobar Islands where it is still fairly common. Much less is known about the yellow monitor (*Varanus flavescens*), a semi-aquatic species and the desert monitor (*Varanus griseus*), both over-exploited for skins till the 1970's and still under some pressure from that industry. Habitat loss affects all varanids and local exploitation for meat and "medicinal" fat keep monitors in most parts of the country understandably wary of humans (whereas in parts of Sri Lanka unmolested water monitors are as tame as village dogs).

Snakes: Predictably, large snakes such as the rock python (*Python molurus*) and king cobra (*ophiophagus hannah*) are threatened species, the former from the skin trade, and both because of habitat loss and incidental killing out of fear. The python is fortunately an adaptable species and still has a wide distribution in a wide array of habitats. King cobras prefer cooler, moist forests and, oddly enough, mangrove swamps.

The common snakes really hammered (and still exploited, though to a much lesser extent) for the skin industry were the ratsnake (*Ptyas mucosus*), common cobra (*Naja naja*) and boa (*Eryx conicus*), Russell's viper (*Vipera russellii*) and checkered keelback watersnake (Xenochropis piscator) in that order of preference. The cobra, ratsnake and checkered keelback seem to actually benefit from the conversion of natural habitats to paddy land with its attendant huge rodent and frog population, bush-covered bunds between fields and long availability of water. The resilience of these species is manifest by their common occurrence in areas near Madras where Irula tribals culled millions per year for several decades. The effects of chemical weedicides, pesticides and fertilizers of the green revolution on these reptiles (and the rest of the biota) has yet to be ascertained.

But other snakes haven't fared so well. The rapid destruction of India's forests (submergence by dams; legal and illegal timber operations for paper, plywood and construction; fuelwood needs of both urban and rural people; clearing for agriculture and plantations of exotic, are some of the reasons) has put thousands of life forms in jeopardy and right now a number of plants and animals are disappearing forever. Snakes are no exception and the hill forest forms (for example shield-tail snakes (*uropeltids*) and other fossorial forms, hill species of major groups like *Oligodon, Lycodon, Elaphe, Callophis,* and many others) are rapidly losing ground as their habitat is opened up, drastically changing temperature and humidity regimes. There are no less than 18 species of pit vipers in India and all are associated with these same hill forests.

The overview is no substitute for substantial survey work, especially for the more vulnerable taxa, and the (probably many) as yet undescribed species in vanishing moist hill forests.

Amphibians: The Himalayan newt (*Tylototriton verrucosus*) is the only member of the family in India and is restricted to an elevational zone between 1200 - 1800 m in the central and eastern Himalayas of Nepal and India. Loss of their pond habitats for agriculture and other human use and collection for the biological supply trade has depressed their population. Since most of the amphibians in India (about 140 species out of the total of 180) are found in the wet forests of the Western Ghats and the northeast region, their survival problems relate to the rapid loss of forest habitat in both these areas. As with the reptiles, most species have never been looked at except as pickled specimens and it is evident that many more species await discovery.

Some of the more representative Indian frogs include the Malabar flying frog (*Polypedates malabaricus*), the marbled balloon frog (*Uperodon systoma*), the painted frog (*Kaloula pulchral*), paddy frog (*Rana limnocharis*) and the verrucose frog (*Rana keralensis*). The widely distributed plains species that were the mainstay of the $12 million a year frogleg export industry are again, examples of remarkable resilience to heavy exploitation. As many as 70 million bullfrogs (*Rana tigerina*), green frogs (*Rana hexadactyla*) and *Rana crassa*, were killed each year as a "luxury protein" export item to America, Japan and Western Europe til 1988. The industry was finally banned (after lobbying by Indian herpetologists and animal welfare activists) as it was entirely out of hand and insect control in India required increasingly huge imports of pesticides (often those banned for use in the countries exporting them). To reiterate, the effects of chemical inputs to Indian agriculture on amphibians need to be examined.

India has fifteen caecilians, about which very little is known except their taxonomy and approximate distribution. Changes in their microhabitats due to the major habitat alterations taking place in this country are major problems for these cryptic amphibians.

Madras Crocodile Bank - Centre for Herpetology

In the early 1970's it looked like India's three crocodilians were on their way out, especially the gharial, down to 200 with only about ten known adult males in the wild. At that time the author and several colleagues undertook WWF sponsored crocodile surveys in India, Nepal and later, Bangladesh, confirming the precarious position of the gharial, mugger and saltwater crocodile.

With Forest Department sanction I collected and hatched mugger eggs from wild habitats in Tamil Nadu from 1970-1974 and set up a breeding group at the Madras Snake Park. In 1976 my wife Zai and I set up the Madras Crocodile Bank on 8 1/2 acres of land on the Coromandel Coast, 50 kms south of Madras. Nearby Mahabalipuram, an ancient shore temple and major tourist attraction, assured an annual inflow of paying visitors to the Crocodile Bank which total close to a million today.

Now a Trust, which includes prominent Indian naturalists and Government representatives, the Croc Bank is deeply involved in conservation, research and public education. The Bank presently has 10,000 crocodilians of ten species, a freshwater turtle breeding programme with 200 animals of 26 species and a breeding group of 65 water monitors.

The Crocodile Bank is managed by Deputy Director, Harry Andrews and his wife Romaine, Office Manager. Croc Bank Scientific Officer, Dr. Indraneil Das is presently on deputation to the Brunei Government. Recently Dr. Ranjit Daniels, formerly of the Indian Institute of Science, joined the staff as Research Scientist, to expand our research outputs and encourage more students in this field. Fifteen maintenance staff care for the reptiles and the grounds, all of them local villagers turned expert reptile handlers.

Over the years the Croc Bank has been fortunate to receive financial help from the World Wide Fund for Nature, The Government of Tamil Nadu, the Wildlife Preservation Trust International, New York Zoological Society, Conservation International and private donors.

At present the Croc Bank earns its basic overheads from ticket sales to visitors (an annual total of about U.S. $40,000) and obtains periodic grants for research and further development.

For the past eight years, the Croc Bank has been collaborating with Dr. Jeffrey W. Lang of the University of North Dakota on crocodile research with support from the Smithsonian Institution, National Science Foundation and National Geographic Society. The research focus has been on crocodilian breeding biology and in particular, temperature related sex determination (TSD). Efficient, low cost incubators have been perfected with accuracy to 0.1°C. Second and third generation mugger crocodiles (with meticulous breeding records from the start) are now being studied and their growth and reproduction monitored in relation to their own incubation temperatures. TSD studies are now being applied to turtles and monitor lizards. The Bank collaborates with the Centre for Cellular and Molecular Biology in Hyderabad, looking at DNA fingerprinting in crocs and with a number of other Indian institutions with herp programs (see Appendix 2).

The Croc Bank and Centre for Herpetology is encouraging research scholars to take up graduate studies in herpetology and hope to soon obtain a University affiliation in order to be able to offer formal guidance for M.Sc and Ph.D. students. The Croc Bank's expanding herpetological library is the most extensive in the country and the air-conditioned office and laboratory are equipped with three computers and basic research equipment.

In addition to the ongoing reptile breeding projects at the Croc Bank we are expanding our herpetological field programs. At present Research Assistant Smita Satheesh is studying the breeding ecology of the mugger in the wild. R. Arumugam on mugger feeding ecology; Staish Bhaskar is carrying out surveys and studies on sea turtles in the Andamans and Nicobars; Jayshree Ratnam is studying the water monitor breeding group, preparatory to doctoral work in the field on the species; Karthikeyan V. is studying breeding ecology of freshwater turtles in the Ganges River. The Croc Bank's journal, *Hamadryad,* is in its seventeenth year of publication and fills an important herpetogeographical gap between Africa and the Far East.

We have special concern for the herpetofauna of the moist tropical forests and our present focus on field work in general herpetology are surveys in these habitats, initially concentrating on the Western Ghats and Andamans and Nicobars.

Acknowledgements

My thanks to my colleagues Harry Andrews, Ranjit Daniels and Ed O'Keefe for help in compiling the information in this paper. Thanks are also due to the Trustees of the Madras Crocodile Bank for their support of my work. I'm grateful to Drs. Richard Ross and Brian Backner and the International herpetological Symposium for inviting me to participate in the 16th annual meet. Thanks to Romaine Andrews for typing and editing this paper.

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Romulus Whitaker

APPENDIX 1

COMMON, ADAPTABLE AND WIDESPREAD HERPETOFAUNA OF INDIA

I. Crocodilians

Crocodylus palustris - (the mugger crocodile, while no longer common, is widespread and adaptable if given the chance).

II. Turtles and Tortoises

Lepidochelys olivacea

Lissemys punctata

Melanochelys trijuga

III. Lizards

Calotes versicolor

Mabuya carinata

Hemidactylus frenatus

Hemidactylus brooki

Varanus bengalensis

IV. Snakes

Typhlina bramina

Eryx conicus

Amphiesma stolata

Xenochropis piscator

Ptyas mucosus

Ahaetulla nasuta

Dendrelaphis tristis

Naja naja

Echis carinatus

V. Amphibians

Rana tigerina

Rana Cyanophlictis

Rana limnocharis

Microhyla ornata

Tomopterna breviceps

Bufo melanostictus

APPENDIX 2

INDIAN INSTITUTIONS WHERE HERPETOLOGICAL WORK IS BEING CARRIED OUT

1. **Zoological Survey of India (ZSI)** (Government) - Mainly systematics and distribution of Indian herpetofauna. ZSI scientists publish both scientific and popular works and have several inhouse publications. The ZSI maintains the largest collection of preserved herpetofaunal specimens in the country at its headquarters in Calcutta.

Zoological Survey of India
27, Jawaharlal Nehru Road
Calcutta 700016

2. **Bombay Natural History Society** (BNHS) (Private) - Maintains a large collection of preserved specimens and carries out taxonomic, distribution and conservation-related studies on Indian herpetofauna. The BNHS has one herpetologist and publishes the scientific journal for the BNHS and a popular magazine, Hornbill.

Bombay Natural History Society
Hornbill House, Shahid Bhagat Singh Road
Bombay 400023

3. **Wildlife Institute of India** (Government) - Mainly a learning facility for State Wildlife Department Officers and for M.Sc and Ph.D wildlife biologists. Herpetology is one component of the curriculum.

Wildlife Institute of India

New Forest P.O., Dehra Dun 248006, Uttar Pradesh

4. **Centre for Cellular and Molecular Biology** (Government) - Premier Indian institution in work on reptilian DNA and chromosomes.

Centre for Cellular and Molecular biology

Hyderabad 500007

5. **Pune Serpentarium** - Small research and public education establishment with an occasionally published newsletter, "Herpeton".

Pune Serpentarium

"Usant", Pune-Satara Road, Pune 411 009

6. **Madras Snake Park** - Small research and public education centre with a newsletter "Cobra".

Madras Snake Park
Guindy Deer Sanctuary, Raj Bhaven P.O.
Guindy, Madras 600022

7. **Utkal University** - The Department of Zoology has a number of ongoing herpetological research projects concentrating on frogs and sea turtles.

Utkal University
P.G. Department of Zoology, Vani Vihar
Bhubaneswar 751 004, Orissa

8. **AVC College** - This college specializes in wildlife studies toward M.Sc degrees and has encouraged several herpetological studies.

AVC College
Mayiladuthurai, Tamil Nadu

9. **Salim Ali School of Ecology and Environmental Sciences (Pondicherry University)** - This institution is for M.Sc scholars seeking a degree in wildlife ecology and is, along with Wildlife Institute of India and AVC College, the best potential source of the next "generation" of Indian herpetologists.

Salim Ali School of Ecology and Environmental Sciences
Pondicherry University, Kalapet, Pondicherry 605 014
Pondicherry 605 014

10. **Irula Snake Catcher's Cooperative Society** - A venom extraction centre, owned and operated by Irula tribals.

Irula Snake Catcher's Cooperative Society
Vadanemmeli Village, Perur Post, Mamallapuram
Tamil Nadu 603 104

11. **Nandankanan Biological Park** - Staff of this large zoo have been doing studies on the herpetofauna in and around the Park since 1972. Observations on the breeding biology of the Indian python, chameleon and crocodilians are some of their significant contributions.

Nandankanan Biological Park

APPENDIX 3

DIRECTORY OF INDIAN HERPETOLOGISTS

	NAME AND ADDRESS	SPECIALTY
1.	L.N. Acharjyo Nandankanan Biological Park P.O. Barang Dist. Cuttack Orissa 754 005	captive husbandry and veterinary medic
2.	Harry V. Andrews Madras Crocodile Bank, Centre for Herpetology Post Bag 4 Mamallapuram Tamil Nadu 603104	crocodilians, monitor lizards
3.	S. Bhaskar Madras Crocodile Bank, Center for Herpetology Post Bag 4 Mamallapuram Tamil Nadu 603104	sea turtles
4.	S. Bhupathy Wildlife Institute of India P.O. New Forest Dehra Dun 248006 Uttar Pradesh	python, freshwater turtles
5.	D. Basu Crocodile Rehabilitation Centre Picnic Spot Lucknow 226 016 Uttar Pradesh	gharial, freshwater turtles

	NAME AND ADDRESS	SPECIALTY
6.	Karmavir Bhatt 511 Shree Apartments Makaipool, Nanpuru Surat 395 001	python
7.	B.C. Choudhury Wildlife Institute of India P.O. New Forest Dehra Dun 248006 Uttar Pradesh	mugger crocodile, general
8.	S.K. Chanda Zoological Survey of India 27, Jawaharial Nehru Road Calcutta 700016	amphibians
9.	Indranei Das Madras Crocodile Bank Centre for Herpetology Post Bag 4 Mamallapuram Tamil Nadu 603104	freshwater turtles, amphibians, general
10.	Shekar Dattatri Plot No. 40 IIIrd East Street Thiruvanmiyur Madras 600041	snakes
11.	S.K. Dutta P.G. Department of Zoology Utkal University Vani Vihar Bhubaneswar 751 004	amphibians

The Captive Maintenance and Propagation of the Rare Chinese Frog *Rana schmackeri*

ABSTRACT. *Rana schmackeri,* a ranid of the Hylarana complex, was obtained by the authors and maintained in a large planted greenhouse enclosing two small manmade ponds. These frogs have thrived and successfully reproduced under these conditions. The tadpoles proved relatively easy to raise if allowed to feed on biological detritus and algae at the bottom of the ponds. At the time of writing, a number of froglets had achieved a snout-to-vent length equal to half of that of the adults. The authors also discuss their views on the potential role of naturalistic design and environmental control of greenhouses as tools for the conservation of amphibian species diversity.

Introduction

Over the past ten years we have been responsible for captive-breeding a significant number of frog species, as well as introducing some new species to herpetoculture, with varying degrees of success. As mentioned in one our earlier papers, we use a number of approaches including the use of rain chambers, gonadotropic and pituitary-stimulating hormones, and naturalistic greenhouses to encourage or induce captive-breeding of amphibians, depending on the species involved.

The interesting aspect of breeding *Rana schmackeri,* the second member of the Hylarana complex that we have successfully reproduced (see De Vosjoli and Mailloux, 1989), is that the methodology used, the design of a landscaped and environmentally controlled greenhouse, may be one of the most useful tools for the effective maintenance and propagation of a wide range of amphibian species. It should be pointed out that with certain species other methods will be more effective from a purely production perspective. For example, there is no doubt that with ceratophrynid frogs, hormonally-induced reproduction will yield the greatest numbers of frogs in the shortest period of time. However, with many anuran species, hormonally-induced reproduction is either not effective or wrought with problems of synchronizing breeding behaviors and cycles, or sustaining proper blood hormone levels for a sufficient period of time for breeding to occur. In our experience, with many members of the genus *Rana,* hormone-induced reproduction is not the method of choice for captive propagation, particularly because the most effective hormones on members of that genus are usually those derived from pituitary extracts of con-specifics. Aside from requiring the sacrifice of a number of specimens which may not be readily available, these pituitary extracts are often only effective during times of the year which would correspond to the normal breeding season. We have found that establishing small populations of frogs, including members of the genus *Rana*, in carefully designed, landscaped, and environmentally controlled greenhouses allows for many species to breed naturally and spontaneously. If the water sections are well-designed, these greenhouses will also allow for a high success rate in terms of rearing tadpoles.

RANA SCHMACKERI

Rana schmackeri, Boettger 1892, a member of the subgenus *Hylarana* (in the *Rana luctuosa* group), is a fairly-widespread species, distributed from Southeastern China, including Hainan Island, north to Gansu and Shaanxi. Its present status is difficult to assess because it is a secretive species, remaining concealed during the day and emerging only at night for feeding. According to collectors, it is only readily obtained during the relatively short breeding season, in September or October, when pairs gather at night for a few days out of the year. According to Oscar Shiu, a Chinese dealer, commercial collectors have reported a gradual decline in observed numbers over the past few years. As with most amphibian species, there is little real monitoring of wild populations. This species is rare in herpetoculture and appears, like many ranid species, to be declining in the wild. Though not quite as attractive as *Rana ishikawae* from Okinawa, this is still an appealing ranid which, like *R. ishikawae* (another member of the *Hylarana* complex but of the *Rana chalconota* group), has well developed toe pads and a degree of climbing ability. Many ranids of the *Hylarana* complex (not all, e.g., the commonly imported *Rana erythraea* still retains significant typical characteristics) have a number of features usually associated with hylids. These include relatively poorly developed thigh muscles, the presence of more- or less-developed toe pads, relatively small heads, and a propensity to climbing among shrubs and thick-stemmed foliage.

Size: The males of *Rana schmackeri* in our possession have a snout-to-vent length of 2 3/4 to 3 1/2 inches. The females have a snout-to-vent length of 3 3/4 to 4 inches.

Sexing: Males are smaller than females. Males have dark markings on their throats, while the throat of females is whitish. The best criterion for sexing animals is breeding behavior. Males will chirp when in breeding and will display two well-developed lateral vocal sacs when calling. Unfortunately, these vocal sacs are difficult to discern when not inflated.

Calling: The call of *R. schmackeri* males is a birdlike whistle similar to, but not quite as loud as, *that of R. ishikawae.*

Origin of animals in our breeding group: We obtained two groups of *R. schmackeri.* A small group, consisting of four animals, was obtained in October, 1990. A second group, consisting of 2 dozen animals, was purchased in September, 1991. Both groups were imported by reptile dealers.

Housing: Both groups were released inside a specially-constructed and naturally-landscaped greenhouse (35 feet x 30 feet) enclosing three small manmade ponds. The sides of the ponds are heavily planted with lilies, papyrus, elephant ears, large philodendrons, other plants and bordered by various sections of wood, including diagonally-placed dead tree branches and freshwater driftwood that provide a variety of shelters. Both adults and froglets are somewhat arboreal and tend to hide during the day in horizontal cracks in logs or low tree limbs.

Temperature: At the level where the frogs are active, the temperatures will vary during the warmer months from a high of 85°F during the day to a low of 70°F at night. During the cool months, the daytime high will reach 75°F and the nighttime low 55°F. A greenhouse heater with thermostat controls the minimum temperature in the greenhouse. Because the greenhouse is located in southern California near the coast, extreme temperatures are generally uncommon. The greenhouse is cooled by opening up panels in the roof and sides, and when necessary by regular spraying of water. The water before introduction into the pond is moderately hard, with a pH of 7.4 - 7.6. In the pond pH levels tend to decrease, particularly in sections where plant matter decomposes. Various plants in the pond, including water cabbage *(Pistia stratiotes)* and water hyacinth *(Eichornia crassipes)*, contribute to maintaining a good level of water quality in the pond, as can be attested by the high survival and growth success of several species of tadpoles in these ponds.

Photoperiod: In the greenhouses, the animals are exposed to the natural variations in photoperiod. We suspect that the decrease in daylight associated with fall may play a significant role in eliciting breeding in *R. schmackeri.*

Changes in barometric pressures and rainfall: In addition to the *R. schmackeri,* several other species of frogs are kept loose in the greenhouse, including White's treefrogs *(Litoria caerulea)* and two species of tomato frogs *(Dyscophus antongili* and *Dyscophus guineti).* Both species of tomato frogs have bred spontaneously in response to changes in barometric pressure and associated rainfall. All frogs in the greenhouses are exposed to the seasonal changes in barometric pressure, as well as the sound of rainfall on the fiberglass panels making up the greenhouse. We also have a sprinkler system above the pond areas to simulate rainfall when it is raining outdoors. However, breeding by *Rana schmackeri* was not associated with rainfall. We did not monitor changes in barometric pressure at that time, so cannot assess any correlations with breeding behavior.

FEEDING

Adult *R. schmackeri* are fed every one to two days on a variety of live prey, including large crickets *(Acheta domestica),* King mealworms *(Zophobas morio),* mouse "pinkies" and "fuzzies." Every other feeding, all insect prey are coated with a mixture consisting of 3 parts of Super Preen®, a bird multivitamin/mineral powder and one part Osteoforme®, a calcium/vitamin D3 supplement. Food is only offered in the evening when the animals have emerged from their shelters.

BREEDING

In the wild, *R. schmackeri* is said to breed in September and October. Interestingly, the group of frogs obtained in November, 1990, which was presumably collected in the wild during breeding in October, started calling on September 13, 1991, and bred on September 16, 1991. The males of the second group, which was purchased on September 20, 1991, started calling soon after release in the greenhouse and members of this group bred in September and October of that year.

Several egg masses were deposited in the ponds in September and October. Each egg mass measured approximately 18 inches in diameter and consisted of approximately 800-1200 eggs. All egg masses were deposited in shaded or secluded sections of both ponds. Initially each egg mass consists of a floating single-layered mass. In time, some of the eggs sink. It is important not to create conditions which cause the eggs to clump. In many anurans, single layering of eggs is important to allow for enough oxygen availability and water flow around individual eggs. The eggs measured 1/8 of an inch in diameter and were grayish white in color, very similar to eggs of Rana ishikawae. At a water temperature which varied between 70°F and 74°F, the eggs required 10-14 days to hatch.

Tadpoles: The tadpoles initially formed tight congregations with specific daily patterns, hiding under rocks or dark, sheltered areas of the ponds during the day and coming out to feed at night. As with *Rana ishikawae*, the tadpoles did not feed directly on fish flake food, but rather on biological detritus at the bottom of the ponds and possibly on algae growing on rocks and other surface areas. The tendency for this species to be nocturnal in its activity patterns is thus apparent even in the tadpoles. After a few weeks, the congregations of tadpoles started to disperse though tadpoles tended to remain in the same general sections of the ponds. The tadpoles grew relatively slowly to a total length of approximately two inches, at which point many started to metamorphose.

A few tadpoles that hatched in late September and early October emerged from the water on December 24, 1991, but most did not metamorphose until February, 1992, and some tadpoles still remain in the ponds at the time of writing (6/92).

Froglets: The 3/4 inch froglets have proved easy to rear initially on one to two week old crickets and small mealworms offered every one to two days. These insects are vitamin/mineral-supplemented at every other feeding. The *R. schmackeri* froglets have proven to be relatively slow-growing. The largest froglet at eight months old has a snout-to-vent length of only two inches. This species may require 18 to 24 months to reach sexual maturity.

WHAT CAN BE LEARNED FROM THE BREEDING OF *RANA SCHMACKERI*?

Through the use of our experimental greenhouse and through our success in maintaining and breeding *Rana schmackeri* and several other species of anurans under these conditions, it has become apparent that this particular approach may prove invaluable as a tool to conserve amphibian diversity. Indeed, in carefully designed experimental greenhouses, many environmental factors can be controlled, and negative environmental factors currently present in the natural habitats of various species can be eliminated. This would include factors related to predation, food availability, niche availability, temperature, relative humidity, amount of UV radiation exposure, water quality, and even air quality. Thus, most environmental factors that might contribute to decline could be modified. From an economic point of view, the location of such greenhouses, to minimize expenses with regards to heating and cooling, would have to be considered. Another critical factor in selecting a location for establishing such experimental greenhouses with respective species is the frequency and annual patterns of rainfall and associated drops in barometric pressure of a given area. For example, we now suspect that a probable cause of egg-binding (in frogs these are eggs that are not passed through the oviducts), in both captive-raised and wild-caught female tomato frogs *(Dyscophus antongili)*, may be related to a general failure by herpetoculturists to regularly expose animals to simulated rainfall and low barometric pressures. As should appear obvious, considerable thought needs to be given to the location of greenhouses for the purpose of captive-breeding.

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OLD WORLD CHAMELEONS: COLLECTING CAPTIVE BREEDING AND CONSERVATION

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Abstract: The brilliant colors, potential captive-hardiness, unusual adaptations and lack of definitive studies of the behavior and natural history of old-world chameleons have made their acquisition in great demand by private, zoo-based, and scientific herpetologists. This has resulted in a large-scale commercial importation of these animals in recent years.

While forest destruction poses the greatest threat to chameleon diversity, the current large-volume importation and lack of knowledge or attention to the special needs of these animals has created serious concerns. The pros and cons of collection, importation, captive breeding, and farming are discussed. The need for field and husbandry research is emphasized.

Introduction

Old world chameleons include up to 130 recognized species (Klaver and Bohme 1986). The taxonomy of this group of distinctive scansorial specialists is under current revision at both the family and generic levels (Frost and Etheridge, 1989, Klaver and Bohme 1986). Until the revisionary research is complete and well-accepted I will use the old classification systems (i.e. Family Chamaeleonidae, Genera *Chamaeleo, Bradypodion, Brookesia, Rhampholeon*).

Chameleons, due to their unusual adaptations and bright, often metachromatic, color patterns attract considerable interest as pets, zoo exhibits and research subjects. This has led to heavy collecting and commercial exportation in recent years. Dodd (1982) reported over 80,000 specimens exported from Kenya in the late 1970's. Recent figures from a survey by the International Union for Conservation of Nature IUCN suggest a similarly high number in the 1980's from other African countries and Madagascar.

Concern for the conservation of chameleons has lagged somewhat behind their exploitation. All chameleons are currently listed on Appendix II of CITES and must have export permits from the country of origin to be imported to the U.S. and other first world countries that subscribe to CITES. However, field studies attempting to assess the status of populations that are being either exploited by the pet trade or inhabiting endangered forest ecosystems are non-existent. Such studies do not seem to be of very high priority by conservation organizations but are desperately needed to formulate regulatory policies.

Based on experience and interest generated over the past 15 years, I offer opinions on three topics regarding old world chameleons. The first topic regards unique aspects about the capture of chameleons and harvesting their populations. The second regards insights into the potential success and significance of captive breeding of chameleons. The third regards important factors relating to their conservation.

Capture

Most chameleons spend most of their life above ground in trees, bushes, grasses, or weeds. Because the do no retreat into holes or other terrestrial refuges and have no venom or powerful weapons, they are completely vulnerable to capture by predators once they are discovered. Accordingly, chameleons have evolved elaborate means of avoiding detection by their chief visually oriented predators, birds, arboreal snakes, and arboreal mammals. Because humans are visually oriented mammals, we are subject to these defenses. Cryptic coloration, shape and behavior make it very difficult for a casual collector to find a chameleon in its arboreal habitat. However, a few species, such as the Malagasy panther chameleon, are easy to find because of their large size, abundance and bright non-cryptic colors. Why their cryptic adaptations are less evolved is not clear.

There are two ways to overcome chameleon crypticity and efficiently find chameleons. Using either or both of these approaches local chameleon populations of all but the few species inhabiting the high portions of trees can be harvested to virtual extinction. The first approach involves employing local citizens of the area. In rural areas of Africa and Madagascar, the people live very close to the land. Throughout their lives they have observed most aspects of their ecosystem very closely. Usually, they have observed most of the individual chameleons inhabiting an area more than once; they know where chameleons are likely to be located and with a carefully developed search image can find them very easily. With a slight monetary incentive and by pooling resources a group of local children and adolescents can become a powerful harvesting machine.

The second approach to find chameleons is to search for them at night with a flashlight. Chameleons sleep in exposed situations. Their color blanches to light gray, green, or yellow. Their laterally compressed bodies reflect light much better than surrounding vegetation. In some areas chameleons are apparently subject to nocturnal predators. Their two defenses against this type of predator make them even more vulnerable to human collectors. First the climb to the exposed tips of branches where they are even more easily seen and upon being awakened by movement of their supporting twigs they drop to the ground where they can often (but not always) be easily retrieved.

In conclusion, many chameleon species are extremely vulnerable to overcollecting. If they are rigorously harvested prior to a breeding season, when there are no underground eggs ready to repopulate, local extinction is possible.

Captive Breeding

Over three dozen species of chameleons have been imported to the U.S. in recent years. Despite the heavy loss (sometimes exceeding 90%) of recent imports, individuals of many of these species have adapted to captivity, fed well and reproduced. While most individuals survive less than two years in captivity and the risk of loss during the adjustment to captivity is high, the real chance of least short-term success seems to have maintained the market. Demand remains high and the potential market for a large attractive species that can be mass-produced through captive breeding remains, in my opinion, untapped. While many argue that a naturally short life span for many chameleons is a detriment, others would argue that high turnover drives the market. This certainly seems to have been the view of the American auto industry over the past couple of decades!

In Europe and the U.S., active attempts to maintain and breed chameleons on a small scale have been successful over the years for several of the most heavily imported species. The most success has been with Jackson's chameleon (*Chamaeleo jacksonii*), other members of the bitaeniatus complex from east Africa (*C. bitaeniatus, C. ellioti*), members of the *C. chamaeleon* group (*C. chamaeleon, C. dilepis, C. calyptratus*) and a few of the Malagasy forms (*C. pardalis, C. lateralis*)(Bustard 1989, Schmidt et al. 1989, DeVosjoli 1990 a and b, Ferguson and Blades 1991). With most of these species, success past the first captive generation has been sporadic at best and strongly associated with maintaining individuals outdoors with naturally occurring insect food and climates that mimic those in their natural habitat. There are currently a few attempts to mass produce *C. pardalis* and *C. calyptratus* for commercial purposes. These are two of the hardier captive species. In my opinion this means that they are two of the most tolerant to deviations from their optimum requirements. Success with these two has been better than sporadic, but not perfect. In my opinion lack of long-term success with any species of chameleon is largely due to improper nutrition and perhaps seasonable temperature cycling. Research should target these two aspects of chameleon husbandry. Findings for one chameleon species should not be uncritically applied to other species. As diverse as habitats are for chameleons there must be equal diversity in optimum nutrition, tolerances for nutrient imbalances and the need for temperature cycling. Identical controlled experimental studies on as many species as possible will in my opinion lead to dramatic increases in the success of captive husbandry of chameleons in the near future.

I am aware of at lease one attempt to "farm" chameleons in their country of origin (Madagascar). Juveniles from this "chameleon farm" have been imported to the U.S. Farming in the country of origin is technologically much easier and more likely to succeed than mass captive breeding in temperate zoned first world countries, but such farming may be logistically more difficult to finance and set up in the third world country of origin. Both activities can potentially satisfy the public demand for these creatures while relieving pressure on wild populations. Whether or not this comes to pass should be revealed in the near future.

Conservation

The fundamental world conservation problem is **too many people on earth**. The human species is basically an aggressively exploitive creature with the power to annihilate its own ecosystem and little ability to efficiently regulate its own power. Tropical ecosystems, especially the forests, are unable to recover from exploitation at least in a short-term time frame (few centuries). Because chameleons are tropical and arboreal, the center of diversity for chameleon communities is in tropical forests. Of the 55 described Malagasy chameleon species only about a dozen are not confined to the eastern tropical rainforest belt. Mature Malagasy rainforest is structurally diverse and a local area can support up to 7 species of chameleons (Parcher 1974). Studies on tropical American anole communities show that equivalent diversity can exist because species partition the habitat spatially (Williams 1983). Thus, species A through F coexist by confining their activity to exclusive portions of the forest (e.g. tree crowns, mid level branches, or low trunks). Consequently, they avoid interspecific competition and predation. While parallel studies on chameleon communities do not exist, removal of the Malagasy rainforest results in a few years in second growth called savoka, which is much less divers structurally. While most of the original chameleon species might maintain a marginal existence in forest remnants or in savoka, when they invade savoka the different species probably interact intensively in the more uniform microhabitats. Competitive exclusion may result and one or two "dominant species" may persist while the others become extinct. Also "weedy species" that were originally adapted to disturbed habitats along the forest edge might flourish in the disturbed habitat and exclude all of the forest species.

In Madagascar at least three "weedy" species seem to be flourishing in disturbed habitat and could conceivably lead to the demise of the forest species in disturbed areas. These are *C. pardalis, C. oustaleti* and *C. lateralis*.

While forest destruction (exploitation) in my opinion is the chief threat to Malagasy chameleon diversity, what is the probable or potential impact of commercial exploitation of Malagasy chameleons? Commercial exploitation of chameleons, given the vulnerability of local chameleon populations and the high demand by the pet trade, is a potentially powerful threat if unregulated. However, the most exploited species in Madagascar so far have been the most common, large, attractive and hardy species. These include *C. pardalis, C. oustaleti, C. lateralis, C. parsoni, C. brevicornis*. At least the first three are disturbed habitat specialists or "weeds". With their high reproductive rates, large populations and extensive geographic ranges they are perhaps the best able to withstand exploitation with little long-term damage to their populations. I have had almost no field experience with *C. parsoni* or *C. brevicornis.* However, both species are large and widespread through the forest zone. *C. brevicornis* is an extremely aggressive chameleon (especially to smaller chameleons). Both have ecological equivalents that seem rarer or more restricted in geographic distribution than *C. brevicornis* or *C. parsoni.* Ecological equivalents of *C. brevicornis* seem to include *C. cucullatus* and *C. malthe.* Those of *C. parsoni* seem to include *C. globifer, C. oshaughnessyi* and *C. balteatus*. Possibly *C. brevicornis* and *C. parsoni* might be the dominant winners in a second-growth competitive scenario such as that outlined above. By targeting the flourishing species in what seems to be an overall degrading ecosystem, current collecting activities could be aiding some of the rarer less competitive species. This, of course if pure speculation and may be totally false. What would seemingly **not** help the conservation of Malagasy chameleon diversity is the unrestricted harvesting of the rare, geographically restricted species such as *C. cucullatus, C. malthe,* and *C. balteatus* as well as many of the forest-floor dwelling *Brookesia* species with restricted distributions.

In my view there is not yet any compelling evidence that the harvesting of wild populations has seriously impacted any species to the point of threatening its extinction. However, the potential damage of unregulated harvesting definitely exists. I feel that there are serious pros and cons to the international trade of chameleons that to some degree might be generally applied to other animal species. Some of the issues are:

1. Trade will create awareness of these fascinating, uniquely adapted creatures and their world. What the world community does with this awareness can be positive or negative. Individuals in first world countries can exploit chameleons to extinction or they can become dedicated to the preservation of their diversity and that of the ecosystems.

2. Trade will make available to the scientific community material to increase our knowledge of arboreal and scansorial evolutionary specialization as well as husbandry requirements. While other vertebrates share some of these adaptations (sloths, primates, parrots, etc.) chameleons may be better model systems to study some of these unique adaptations. Conversely, natural scientists have been known to put scientific objectives ahead of conservation considerations, e.g.l sanctioning destructive sampling or overcollecting fragile populations.

3. Chameleon farming could become a source of income for the Malagasy population and could be one way to divert attention from the rural slash and burn agricultural lifestyle which is so destructive. Chameleons with their high reproductive rate are much more of a renewable resource than tropical rainforest. On the other hand the current trade structure seems to be benefitting the non-Malagasy financially more than the Malagasy. Changing lifestyles and attitudes is something that is very complex and progresses slowly. Changes must be generated from within a culture to be successful.

4. With legally sanctioned international trade, regulations can be imposed to prevent over-exploitation of the populations and to maximize well-being of the exported and imported animals. Bag limits, harvesting seasons and restriction or banning or importation of rare and localized species or populations can be legislated through CITES and through local legislation in the country of origin. Merchants at every level could be licensed and forced to comply with minimum standards of collecting, transient maintenance, housing and shipping conditions. Merchants at the first level (country of

origin) should be required to provide general locality information (approximate collecting region or locality, altitude, date collected) to increase the scientific value of the specimens and better inform the ultimate recipient of appropriate husbandry requirements (temperature, seasonality etc.). Banning legally sanctioned trade will definitely decrease trade volume but black market, criminally initiated trade may increase. Such trade can not be easily controlled to attain conservation objectives.

In conclusion, chameleons are a unique resource of great interest to the herpetological and herpetocultural communities. Their husbandry, commerce, and conservation is still in an early developmental stage. Techniques, policies and programs will rapidly change in the near future and, hopefully, become standardized in such a way to benefit the chameleon, chameleon enthusiast and natural ecosystems that chameleons inhabit. Both field and captive based research is critically needed.

Acknowledgements

Most of the opinions stated in this article were generated from personal experience with chameleons in the field or in captivity and during discussions with numerous individuals involved with chameleons and these issues. To avoid leaving anyone out or accidentally wrongly implicating any individual of a particular view I will just provide a general "thank you" to all of those who have discussed any of these topics with me.

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The Brown Tree Snake, Boiga irregularis, in Guam
Controlling the spread of the "reptilian mongoose"
of the South Pacific
by

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This presentation focuses on the introduction of the Brown Tree Snake, Boiga irregularis, to Guam, an unincorporated territory of the United States, from the region of New Guinea following World War II and the resulting ecological disaster brought about by this "supertramp" species to the island's wildlife. During 1991 at the request of the State of Hawaii's Department of Agriculture and the Hawaiian Gas & Electric Company, Brown Tree Snake Control Group (BTSCG) members Paul Breese, Don Hunsaker and the author traveled to Guam to be briefed in detail by the USFWS biologists on Guam as to their findings, to study the Brown Tree Snake in the wild, and to review existing procedures for moving civilian and military cargo from Guam to Hawaii. The final part of the presentation deals with our recommendations as to what measures should be additionally implemented to prevent the Brown Tree Snake from entering and becoming established on the Hawaiian Islands and the status of these proposals.

Guam is the largest landmass between Hawaii and the Philippines. Located 3,700 miles southwest of Honolulu and 1,500 miles southeast of Tokyo at the southern end of the Marianas chain of islands, Guam is approximately 30 miles in length with a variable width, ranging from 12 miles to 4 miles at its narrowest point and covers an area of 212 square miles. Bays, beaches and rocky cliffs mark its rugged coast. Dense secondary tropical forests cover portions of the interior of the island. From the high peaks and river valleys of the interior to the coastal lowlands and mangrove forests of its shoreline, Guam offers a variety of suitable habitats for reptilian, avian, and invertebrate fauna. The northern Marianas group of islands stretch northward from Guam for about 400 miles and constitute the highest slopes of a massive mountain range rising close to six miles off the ocean floor. The largest neighboring islands in the group are Saipan, Tinian, and Rota. The total human population of Guam is about 127,000 of which about 23,000 are military or military dependents. Within the last 10 years, extensive modern resort hotels have been built in the Tumon Bay area of Agana, about a 10 minute drive from Guam's moderate-sized international airport. In 1989, nearly 700,000 tourists visited the island. Although utilized by U.S. military dependents and other American visitors, the recent building emphasis has been targeted for attracting increasingly large numbers of tourists from Japan.

Both the green sea turtle, Chelonia mydas agassizi, and the hawkbill sea turtle, Eretmochelys imbricata bissa, can be found in the waters around Guam. Neither are impacted by the brown tree snake. Non-marine vertebrate taxa have not been so fortunate. The native Marianas fruit bat, "fanihi", already endangered due to the fact that it has traditionally been eaten by the native Chamorros, has been further negatively impacted by the brown tree snake. Other species pushed to the brink of extinction by this reptile include the micronesian kingfisher, rufous-fronted fantail, and the Guam rail. In fact, all bird life has been seriously depleted to the point that in many areas, the forests are without songs. Of twelve native species of forest birds, three are extinct. Two others are extinct in the wild, but are being bred in captivity. Three others have been extirpated from Guam but occur on other islands in the Marianas. Several reptilian species have also been decimated including the oceanic gecko, Gehyra oceanica. Another species in decline in some areas of the island is the island monitor lizard, Varanus indious.

Control Methods

U.S. Department of Agriculture, Science and Technology will soon begin testing fumigants for control of brown tree snakes in ship and air cargo moving from Guam to islands at risk.

Traps, Baits, and Barriers

The development of attractants suitable for use in traps has been funded through a cooperative agreement between the U.S. Wildlife Service under Fritts' direction and David Chiszar with the University of Colorado. Additional work on baits and trapping protocols involves service researchers in cooperation with the University of Arizona, Tucson. Work is also targeted by Earl Campbell of Ohio State University on electrical barriers and their possible role in maintaining snake-free areas. Additionally, potential disease vectors are being looked into through specialists with the National Institute of Health (NIH) (Fritts et al. 1991). USFWS has worked closely with the military to inspect facilities and monitor the transfer of military personnel and cargo out of Guam.

The responsibility of keeping brown tree snakes out of Hawaii falls under the Plant Quarantine Branch of the State Department of Agriculture. In September 1989, three detector dogs were specially trained at the USDA detector dog training center in Livermore, California. Six more dogs were later trained in Honolulu. It costs the state of Hawaii approximately $30,000 to train each group of dogs and their handlers. The dogs were used to detect a wide variety of prohibited items, in addition to snakes. During training the dogs showed that they could detect live snakes, as well as cloth bags with snake odor on them. Funding for this beagle detector dog program exceeded $158,000 for the first two years (Fritts, et al. 1991).

THE BROWN TREE SNAKE AS A SUPERTRAMP

Supertramp species of animals are organisms which are successful in their own natural ecosystems in which they evolved. However, when transported by modern man to different geographic areas of the world, and especially to fragile island ecosystems, they cause massive damage. Few species of vertebrae animals truly have the capacity to be supertramps. Those that do, are a timebomb waiting to explode. Rats, rabbits, feral goats, bulbuls and pigs are just several examples of supertramp animals that have done irreparable damage to island ecosystems. Other taxa such as the cane toad, Bufo marinus, did not qualify as a true supertramp in Hawaii to which it was imported from

Panama in 1932. This is because Hawaii had no native amphibians nor amphibian predators. However when imported in 1935 to Australia, it soon achieved supertramp status. Many native Australian species that fed on non-toxic indigenous anurans died as a result of ingesting the deadly skin toxins when attempting to consume this introduced bufonid. Given the extensive damage to the vertebrate fauna of Guam during the past 40 years, the brown tree snake has clearly achieved supertramp status.

The well done pamphlet "The Brown Tree Snake - A Harmful Pest Species" prepared by Thomas H. Fritts of the USFWS specifically point out that not all snakes are bad. It notes that the neighboring island of Palau has four species of native snakes, none of which cause any significant problems. Further, Boiga irregularis is the only species of snake ever implicated anywhere in the world with the possible extinctions of other vertebrate species. Given today's tight monetary resources, island management authorities throughout the mid and south Pacific would do well to gear their efforts into stopping the spread of supertramps.

THE BROWN TREE SNAKE IN ITS NATIVE RANGE

The brown tree snake is a rear-fanged, mildly venomous colubrid snake which is native to Papua New Guinea, northern coastal Australia, and a number of small and mid-sized islands in northwestern Melanesia.

DIET

The brown tree snake has been documented by Worrell, 1963, Cogger, 1975 and McCoy, 1980 as feeding on a wide variety of vertebrate prey including birds, their eggs, mice, rats, and lizards.

REPRODUCTION

The reproductive characteristics of this snake are still not well known. The clutch size in this species has been recorded as between 4-12 oblong leathery eggs, (Zwinenberg, 1978). Deposition sites have included hollow logs, in crevices, under debris, or other sites where eggs are protected from dessication and high temperatures. Up to 2 clutches a year have been documented. The number and timing of clutches may depend on prey abundance and seasonal variation in climate. It may be possible for female brown tree snakes to store sperm and produce eggs for several years after a successful mating, as is the case for most other ophidians.

HABITAT UTILIZATION

Despite their name, brown tree snakes are neither restricted to trees, nor to forests. Cogger, 1975 and McCoy, 1980 have observed multiple specimens not only in trees, but in rocky crevices and along limestone cliffs. They also report that these reptiles commonly crawl down to the ground to forage at night. Daytime hiding places include hollow tree trunks, and amidst coconut and pandanas palm nuts, rock ledges, and even the rafters of buildings. These serpents have readily adapted to areas modified by man and there are numerous references to them taking chickens, other domesticated birds and their eggs.

DENSITY OF SNAKES

Because of its secretive nature and nocturnal habits, there has to date been relatively little detailed work done on brown tree snake abundance within its natural range. Parker, 1983 reports that it is one of the most common snakes in large portions of New Guinea. The author and other members of the BTSCG found brown trees snakes virtually impossible to detect on Guam during daylight hours, even in ares with very high densities.

MAXIMUM SIZE

There may well be genetic differences between Australian and Papua New Guinea populations of Boiga irregularis. Several authorities place the maximum length of this serpent in Australia at slightly over 2 meters. This author observed several large individuals in Guam of significantly greater length, and estimates that on Guam this snake grows to an average length of slightly over 2 meters and a maximum length in excess of 3 meters.

DEMEANOR AND VENOM TOXICITY

If threatened, the brown tree snake typically responds aggressively. It has a long strike range as do most thin-bodied, arboreal snakes. While Park, 1983 considers it to be only mildly toxic to humans, bites that have occurred on Guam indicate that a definite medical risk exists for infants, the elderly or anyone with allergic reactions to snake venoms. although it is only the last 2 teeth on each side of the upper jaw which are grooved and which inject venom, there is some evidence to indicate the snake may not have to chew for an appreciable period to effectively inject venom.

INTRODUCTION OF BROWN TREE SNAKES TO GUAM

Fritts and Scott, 1985 report that brown tree snakes probably arrived as stowaways in military cargo from the Papua, New Guinea area immediately after World War II. McCoid, 1991 pers com., thinks the snakes on Guam are most similar in appearance to those of Manus Island off New Guinea, one of the areas that military equipment was stored at the conclusion of the Second World War. The first extralimital report of a brown tree snake was recorded on Wake Island in 1946. The snake was believed to have arrived in military cargo (Bryan, 1959).

HISTORY ON GUAM

The first reports of brown tree snakes on Guam were in the 1950's in the Santa Rita area near the large naval port (Savidge, 1986). While uncommon until the early 1960's, Savidge, 1986 reports that the snake had successfully colonized over half of the entire island by the early 1960's. By 1968, the snake had been recorded in the extreme northern portion of the island and was thought to be present in all major areas of the island (Savidge, 1987).

DISPERSAL TO OTHER ISLANDS FROM GUAM

Donna Clifton, 1992, pers. com., a herpetology graduate student who did research on the Indian Ocean island U.S. leased military base of Diego Garcia as part of a joint venture between the British Museum of Natural

History and the Smithsonian, reports two instances of brown tree snakes arriving from Guam within the last decade. The first arrived in 1980 via a C131 transport plane. The snake, which had hidden in the wheelwell, slithered onto the runway after the plane landed, where it was killed. The second specimen arrived on a B52 in 1989. Another brown tree snake was documented by CINCPAC during a cargo ship offloading at Diego Garcia. Other confirmed brown tree snake captures have occurred at cargo unloading areas on Kwajalein and Saipan (Fritts, et al., 1991).

PREDATION PATTERNS ON GUAM

During the early 1960's, native species of birds were disappearing from those areas of the island where the snakes were most common. By the late 1960's, healthy bird populations remained only in thick forests in the northern end of the island (Jenkins, 1983). By the late 1970's, bird populations had plummeted throughout the island and the several endemic forest species were critically endangered when listed as threatened or endangered by the USFWS in 1984. Predation has also been heavy on the native Marianas fruit bag (Pteropus mariannus). American zoos in cooperation with the USFWS have played critical roles in salvaging and captive-breeding Guam rails (Rallus owstoni) and the Micronesian kingfisher (Halcyon c. cinnamominia).

ELECTRICAL OUTAGES CAUSED BY BROWN TREE SNAKES

Over 600 power outages were caused by Boiga irregularis from 1978-1988. The problem occurs when a snake climbs onto the power lines and simultaneously touches live and grounded conductors. This has resulted in major power outages and damage to equipment and electrical appliances. Attempts to exclude snakes from lines with large disk barriers was only partially successful because of the variety of ways snakes could gain access to the wires. One of the worst outages, in 1987, lasted for 12 hours, damaged generating equipment and cost the Guam Power Authority in excess of a quarter of a million dollars (Teodosio, 1987).

FEEDING PATTERNS OF THE SNAKES ON GUAM

Detailed fieldwork by Mike McCoid in Guam under the direction of Fritts indicates that while large brown tree snakes feed on birds and mammals, the young and subadult individuals feed primarily on lizards. In recent years, there has been a crash in the numbers of large adult snakes due to depletion of the food base. However, McCoid, 1991, pers. com., believes that subadult females are still capable of producing one or two clutches of eggs while feeding essentially on nothing but small saurian prey. While a mid-sized species of forest gecko, Gehyra oceania, has been virtually eliminated by these snakes from Guam, other smaller species of gecko, ground species of skinks, and the introduced anole (Anolis carolinensis) serve as suitable food items for juveniles and young adults.

Whether or not the brown tree snake can be controlled on Guam is, at this point, still problematic. The efforts by McCoid, Fritts, and other USFWS researchers and associates have been well thought out, directed, and a variety of control measures and agents are being researched and tested. This carefully researched program includes further study of the brown tree snake within its native range, population characteristics of these snakes on Guam, and snake control technology. The latter includes the possible use of baits and attractants, fumigants and repellents, traps, toxicants, and biological control.

THE BROWN TREE SNAKE CONTROL GROUP (BTSCG)

BACKGROUND INFORMATION, MEMBERS, AND OBJECTIVES OF THE BROWN TREE SNAKE CONTROL GROUP

The author has had a long-standing concern about supertramp species as a result of doing fieldwork in a number of mid-Pacific, south Pacific, and Indian Ocean island ecosystems beginning in 1967 and extending through his career as a zoo herpetologist at the Honolulu Zoo during the 1970's and early 1980's and at the Chaffee Zoological Gardens of Fresno from 1983 to present.

The Brown Tree Snake Control Group (BTSCG) came into being as a result of the efforts of its chief coordinator Paul Breese. Breese, former director of the Honolulu Zoo from 1947-1965, has always had a keen interest in both reptiles and Hawaiian ecosystems. After several brown tree snakes had turned up on military runways on Oahu, Breese organized a team to investigate and deal with the problem as it related to Hawaii. BTSCG coordinators include Donald Hunsaker, Ph.D., professor of biology, San Diego State University, who has published previously on, and has experience with, herptofauna of the Hawaiian Islands and who is a highly regarded consultant for environmental accessment studies; the author Duane Mejer, who has served as reptile technician at the Honolulu Zoo since 1983, where he has worked very closely with the Hawaii State Department of Agriculture; John Werler, director of the Houston Zoo and tropical reptile specialist; and William W. Thompson, environmental planner, and former chairman of the Department of Land and Natural Resources for the State of Hawaii. Largely due to the tireless efforts of Breese and Thompson, and the support of the State of Hawaii Legislature, and the Hawaii State Department of Agriculture, the BTSCG received a research grant of $37,500 from the Hawaiian Electric Company, Inc. This was for the Hawaii-Guam phase: research on detection of brown tree snakes to reduce the probability of this supertramp species becoming established in Hawaii. In August of 1991, BTSCG members Paul Breese, Don Hunsaker, and the author, accompanied by Al Lam, Oahu County Supervisor, State Department of Agriculture Plant Quarantine Branch, flew to Guam to undertake the goals of the grant. Initially, we met with the Mike McCoid-led USFWS field team, reviewed their facilities, and discussed their current research and findings. We went into the field in all major geographic areas of Guam to observe brown tree snakes and to see first hand their effects on native fauna. We examined electrical power systems and structures on the island. We met with the military, and reviewed operations and protocol for inspections of cargo planes and ships leaving Guam as well as for container freight operations. We were granted access to all areas of the island including Anderson Field, the large base at the north end of the island which played a key role as a B52 launching area during both the Viet Nam War and Operation Desert Storm.

Before leaving Guam we met with the governor, the honorable Joseph F. Ada, and Antonia Quitugua, Director, Guam Department of Agriculture. As a result of this meeting the governor decided to petition the USFWS for beagle sniffer dogs to inspect outgoing cargo to Hawaii.

The military generally followed the accepted procedures for the inspection of military cargo leaving the islands as well as for the container freight belongings of members of the military and their dependents. In fact, the military protocol for brown tree snakes was extensive, routine, and generally well-enforced. The single weak link as observed by BTSCG members applied to the more remote portions of the huge runways on Anderson Field which were bordered by grassy strips and secondary forest. Much of the military cargo on these strips is left for long period of time and ramp sections of the planes are sometimes in a down position. Definite improvement is needed in these areas. Additionally, planes arriving at a number of military air fields in the Hawaiian Islands from Guam, although checked, are not checked by dogs upon their arrival. This is a serious omission since these snakes are essentially invisible to humans while inside cargo, and adaptable to the point where they have survived in wheel wells on long flights.

To date, a total of 6 brown tree snakes have turned up at air fields in Hawaii. Several have arrived frozen or dead. The others were captured, killed, and turned over to the State Department of Agriculture. At this time, no brown tree snakes are believed to exist on Oahu or other Hawaiian islands. There is no evidence of an established population. As a result of our work, State Department of Agriculture inspectors will be specifically trained to examine the belongings of passengers and commercial cargo arriving at Honolulu International Airport from Guam and these inspectors will be provided with additional specially trained beagle sniffer dogs. Ongoing research and lobbying will continue by BTSCG members relative to preventing brown tree snakes from entering Hawaii.

It is the author's opinion that beagle sniffer dogs need to be targeted to meet every commercial flight coming into Honolulu International Airport from Guam. Special attention should be paid to the wheel well and cargo areas.

Additional procedures are needed for military planes leaving Guam and arriving from Guam into the Hawaiian Islands. Clark Airbase in the Philippines was recently shut down and increased military traffic in terms of both materials and people will be moved to Guam. All military aircraft leaving Guam for Hawaii should be parked away from grassy areas with cargo areas closed except when actually in use. A final inspection before takeoff should be made using sniffer dogs.

Likewise, it is critical that the military deploy beagle sniffer dogs on all incoming flights from Guam arriving at Hawaiian military fields.

Primarily as a result of lobbying efforts by the BTSCG, HB 2387 was approved by the Hawaii State Legislature to provide funds in the amount of $150,000 for training of additional dogs, personnel, and brown tree snake prevention. This is a good start.

These efforts are necessary. Good communication and diligence is also essential. Every effort must be made to keep Boiga irregularis from entering Hawaii. Every effort must also be made not to confuse this issue with the totally unrelated issue of other species of non-injurious reptiles entering Hawaii through the legal permit process.

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ESTABLISHING A NORTH AMERICAN TURTLE COLLECTION AT THE TENNESSEE AQUARIUM

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Abstract: The Tennessee Aquarium opened to the public in May 1992. The focus of this institution is freshwater ecology, relying heavily on the Tennessee-Mississippi river drainage as its vehicle. Situated in Chattanooga, Tennessee, the Aquarium is centrally located in a region of tremendous chelonian diversity and has the potential to make significant contributions to chelonian conservation.

This presentation describes the process of developing and assembling the Aquarium's North American freshwater turtle collection which includes 24 species at present. Some management concerns involving maintaining large mixed-species community exhibits are discussed.

Introduction

Southeastern United States is a region rich in chelonian diversity. Only a few North American turtles do not find some part of their range south of the Mason-Dixon and east of the Mississippi. Not coincidentally, this region is also tremendously rich in freshwater aquatic environments. The latter fact, more-so than the former, had a great deal to do with the concept and design of the new Tennessee Aquarium in Chattanooga.

The Tennessee Aquarium focuses on the importance of freshwater ecosystems. As a vehicle for this message, visitors are lead along a course which follows the Tennessee River from its headwaters to the Gulf of Mexico. Along this journey, the visitor will view aquatic environments which, combined, hold almost half of a million gallons of water.

Before returning to our primary subject, it is important to take a closer look at this half of a million gallons of water and how it is handled. High quality water is an essential ingredient to our program.

All of the major exhibits at the Tennessee Aquarium operate on essentially the same system. Water exits the exhibit pool via surface skimmers. Depending on size and configuration, individual exhibits may have from one to seven skimmers. Water is then piped as much as six floors down to the pump room and into banks of large rapid sand filters dedicated to individual systems. It them passes through either UV or ozone sterilization before being returned to the exhibit. Supply water enters the exhibit through a distribution piping system bedded in a coarse gravel substrate. A two to four inch layer of finer gravel dresses the exhibit separated from the coarse gravel below by a layer of fine screen and one-quarter inch plastic mesh.

Provided with an institution 1) dedicated to freshwater ecology, 2) with a strong regional focus, 3) located in the Southeast and 4) equipped with a sophisticated aquatic life-support system,. the stage is set for the development of a significant North American turtle collection.

Collection Concept

Developing an entirely new collection provided the opportunity to establish priorities and guidelines without the encumbrances and constraints encountered when modifying a pre-existing collection. Our approach was to view this process in terms of three nested priorities: Education, Conservation, and Research.

One of the foremost messages that we want the visitor to take home is an appreciation of the tremendous diversity of turtles which occur in this region. Turtles are familiar animals to most of our visitors, but most have an extremely superficial knowledge of the different species of the specific habitats they occupy. Because of this familiarity, turtles offer an excellent means by which to expand the visitors awareness of their local environments. At present the Tennessee Aquarium collection includes 33 taxa, representing 24 species, of North American turtles. (Table 1)

Among this group, several species bear important conservation messages. Exhibiting representatives of these species affords the opportunity to make the connection with the problems facing wild populations. Interestingly, two species representing opposite extremes in size, the bog turtle (*Clemmys muhlenbergii*) and the alligator snapping turtle (*Macroclemys temminckii*), are among this group and are examples of the diversity of threats to wild populations. Another important group that the Aquarium will focus on is the map turtles (*Graptemys*).

Graptemys are a predominantly riverine group with several species exhibiting extremely restricted ranges involving single river systems. This distribution renders these species particular vulnerable to habitat degradation. Many of rivers of the Gulf Coast drainage have been seriously impacted by industrial and agricultural pollution and dredging for navigational purposes.

Graptemys have occasionally been placed into two loosely defined groups, broad-based forms and narrowheaded forms. We have identified four species, two from each group, to serve as models for the group as a whole (Table 2). These are the broad-headed *G. pulchra* and *G. geographica* and the narrow-headed *G. nigrinoda* and *G. pseudogeographica*. For each of these species we have collected a series of approximately ten mature individuals. Each group was taken from a single, apparently robust population. In doing so we insured a high degree of genetic homogeneity and provided for the option of initiating a head-start and release program, assuming success of our captive breeding efforts. This approach also provides a focus for future research into ecological parameters of each species. From an exhibit standpoint, we find that large groups of typically sympatric (and in this case, literally sympatric) species promotes an array of natural behavior. This adds tremendously to the educational experience of the visitor as well as providing the potential for behavioral research on site.

Collection Process

The acquisition of a large aquatic turtle collection prior to the completion of our exhibits required substantial space for quarantine and holding as well as considerable interaction with numerous state permitting offices. Holding and quarantine facilities were established in a green house environment on the sixth floor of our building. A bank of 150 and 300 gallon stock tanks provided housing for compatible groups and large individuals. Plumbed 10 gallon aquaria were used to house smaller individuals and isolate potentially aggressive animals such as *Sternotherus*.

For many of the reasons mentioned earlier, regarding *Graptemys*, we determined to field collect most native species. In all cases, we have been able to identify strong populations for our collections. At present, we are not permitted for the collection of Federally listed species. Those that we are currently working have been acquired from other institutions.

Exhibits

Each exhibit has been designed to represent a community of plants and animals. The degree of complexity of these communities varies and is most highly developed in two of our largest exhibits. Nickajack Lake and the Mississippi Delta.

Nickajack Lake is the largest single body of water in the Aquarium; holding approximately 136,000 gallons. The exhibit is roughly 50 feet in length and reaches a depth of 24 feet. This exhibit represents that portion of the Tennessee River impounded by Nickajack Dam and stretching northward to Chattanooga. Basking turtles along the far bank are within easy spotting scope reach of our third floor herp reserve room.

The Nickajack Lake exhibit is viewed entirely underwater and is under entirely artificial lighting. The habitat is that of steep limestone outcroppings with fallen trees and limbs providing basking opportunities for turtles at the surface and cover for both fish and turtles below. The present turtle community includes *Graptemys geographica, G. pseudogeographica, Pseudemys concinna, Trachemys scripta, Sternotherus odoratus* and *Apalone spinifera*. Over 20 species of fish are represented and two diving ducks (American goldeneye) make occasional forays below the surface.

The Mississippi Delta is our most complex exhibit in terms of community composition. This approximately 3500 square foot exhibit lies under natural light with supplemental lighting provided by incandescent, metal halide and mercury vapor lamps. Natural plantings of a predominantly Cypress forest community form the backdrop of the exhibit with both submerged and floating aquatic plants in the pools. The exhibit provides over 120 feet of underwater viewing into pools which contain a total of approximately 24,000 gallons of water. The animal community includes fish, frogs, turtles, American alligators and birds in an environment which appears visually to be continuous. Acrylic barriers, bedded in artificial cypress roots and fallen logs, partition the environment to reduce potentially disastrous interactions.

Such encounters aside, our mixed species exhibits present a number of challenges. One of the first of these is how to physically get the proper diet to the right animal. Most of our exhibits support large populations of fish. These fast, agile and seemingly ravenous feeding machines are tough competition for all but the most aggressive chelonian. We've employed a number of tactics ranging from the obvious to the ingenious. Coordination of feeding schedules, saturation feeding and spot or hand feeding seem to overcome many difficult situations. In other cases, acclimating turtles to a terrestrial feeding station is effective; in the Nickajack exhibit, some diets are fed on the skimmer grates which turtles can crawl onto but fish avoid. Highly aquatic species, such as the Neo-tropical *Podocnemis*, have been acclimated to enter a floating feeding basket to find a quiet refuge from the finned horde beneath them.

In these large complex exhibits we are beginning to see many of the turtles, as well as other community members, partitioning themselves much as they probably would in a natural environment. By carefully observing the spatial and temporal activity patterns of individual species and by being sensitive to the needs of less competitive individuals we are optimistic that these communities will succeed.

Table 1. North American Turtle Collection of the Tennessee Aquarium

Apalone ferox
A. mutica calvata
A. m. mutica
A. s. spinifera

Chrysemys picta dorsalis
C. p. picta

Clemmys muhlenbergii

Dierochelys reticularia

Gopherus polyphemus

Graptemys caglei
G. flavimaculata
G. geographica
G. kohnii
G. nigrinoda
G. pseudogeographica ouachitensis
G. p. pseudogeographica
G. p. sabinensis
G. pulchra
G. versa

Macroclemys temminckii

Malaclemys terrapin macrospilota

Pseudemys concinna
P. floridana
P. nelsoni

Sternotherus carinatus
S. minor peltifer
S. odoratus

Terrapene carolina carolina
T. c. major
T. c. triunguis

Trachemys scripta elegans
T. s. scripta
T. s. troostii

Table 2. Graptemys Species Identified as Models for Captive Husbandry

MODEL	APPLICATION
Broadhead Group	
Graptemys pulchra Graptemys geographica	Graptemys barbouri
Narrowhead Group	
Graptemys nigrinoda Graptemys pseudogeographica	Graptemys flavimaculata Graptemys oculifera Graptemys caglei

AUSTRALIAN AMPHIBIA

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Abstract: Michael J. Tyler lost the abstract

Introduction

Australian Amphibia include only frogs because the salamanders and newts and the caecelians do not penetrate south of the Oriental Region. Australian frogs feature conspicuously amongst the frog species sought after by herpetoculturalists, and in the following pages I intend to provide an account of the state of knowledge of the frog fauna, with particular regard to those species most commonly maintained in captivity in the USA.

It is my impression that there needs to be a link between the herpetoculturist and the laboratory and field based herpetologist. I have become aware that herpetoculturists are not capitalizing upon original information gathered during the course of their observations. Similarly the laboratory and field herpetologists are largely unaware of the original and often valuable information being obtained and not communicated by herpetoculturists.

Historical Perspective

The first species of frog from Australia to be described was *Litoria caerulea* (White, 1790). For reasons I have never understood, early settlers and scientific visitors neither sought frogs or recognized their merit. By 1870 the total species had risen to 45, and a further 90 years elapsed before that total had been doubled to 91 (Moore 1961).

The fact that the total number of recognized species has risen from 91 to its current total of 202 reflects an explosion of investigation. At the same time interest in keeping frogs increased just as rapidly and, although journals and newsletters evolved to permit communication in that period, *communication* between herpetoculturists and other herpetologists improved minimally. I suggest that their observations apply to North America equally as well as to Australia.

The Australian Frog Fauna

Five families of frogs are represented in Australia: Hylidae, Leptodactylidae Microhylidae, Ranidae and Bufonidae. Of these all except the last one are native to the continent and the first two dominate in terms of numbers of species.

Family Hylidae: There are three Australian genera - *Litoria, Cyclorana* and *Nyctimystes* including a total of 78 species (Tyler 1989, 1992).

By far the most popular species in captivity are the largest of these: The Green Tree Frog (White's Tree Frog) *Litoria caerulea,* the Bell Frog *Litoria aurea*, the Green and Golden Bell Frog *Litoria raniformis*, the White-Lipped Tree Frog *Litoria infrafrenata*, and the Water Holding Frog *Cyclorana novaehollandiae.* Of these species *Litoria caerulea* would be encountered in public and private collections more frequently than any other. It was first exported in the middle of the last century and a captive longevity record of 16 years was reported by Flower (1936).

Family Leptodactylidae: There are currently 20 or 21 genera depending upon the recognition of the froglets as *Ranidella* distinct from *Crinia*.

The genus most commonly encountered in captivity is the foam nest builder *Limnodynastes*. Of the species known, three are particularly popular: *L. peronii, L. salmini* and *L. tasmaniensis*. Each breeds spontaneously and frequently in captivity, even in small aquaria. In an outdoor enclosure in Adelaide, South Australia, Walpole (pers. comm.) reported a female spawning 26 times in one year.

Family Microhylidae: All Australian species, like their New Guinea associates, are direct developers in which the larval stages remain within the egg capsule for their entire span. The Australian species represent the genera *Cophixalus* and *Spenophryne*. All but one of the species are confined to the Cape York Peninsula of northern Queensland. All are secretive and unspectacular in their appearance.

Family Ranidae: There is only a single species of ranid in Australia: *Rana daemeli*, shared with New Guinea. I am unaware of attempts to maintain it in captivity.

Family Bufonidae: The species *Bufo marinus* was introduced into Australia to control two insect pests of sugar cane. It has now reached plague proportions, occupying more than 1 000 000 km^2. Serious attempts to find a control agent have been underway for several years.

Bufo marinus is a prohibited species in most Australian States, and a license is required to maintain it in captivity. This species is the standard laboratory amphibian for dissection.

Data Sources

General information on the natural history of Australian frogs is included in Tyler (1989). Two revised field guides are anticipated to be available later in 1992: Cogger (in press), Barker, Grigg and Tyler (in press).

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GASTRIC BROODING FROG

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Abstract: Michael J. Tyler lost the abstract

Introduction

The recent disappearance of both species of gastric brooding frogs from their limited geographic ranges in Queensland, Australia, has catalysed interest in the topic of declining frogs.

As each year passes the probability increases that the disappearances of the gastric brooding frogs are actually extinctions. Here I provided a broad overview of the information available on these fascinating animals.

Discovery

The new genus and species *Rheobatrachus silus* were described by Liem (1973). The unique habit of gastric brooding whereby the female swallows her eggs, switches off hydrochloric acid production in the stomach converting it to a womb and finally giving birth to baby frogs through the mouth, was first reported by Corben, Ingram and Tyler (1974).

Mahony, Tyler and Davies (1984) described a second species of *Rheobatrachus: R. vitellinus*, and Tyler and McDonald (1984) reported that it too is a gastric brooder.

Habitat and Geographic Distribution

Each of the *Rheobatrachus* species is closely associated with clear mountain creeks and associated rock pools in closed forest. *Rheobatrachus silus* is confined to the Conondale and Blackall Ranges in southeast Queensland, and *R. vitellinus* to the Clarke Range on the mid-central coast of Queensland (Figure 1).

Physiological Techniques

By far the most is known of the physiology of gastric brooding in *R. silus*. The data are summarised in Tyler (1983, 1984). In essence the jelly coating surrounding the ova as they pass down the oviducts contains a fatty acid: Prostaglandin E_2. When introduced into the stomach the Prostaglandin E_2 halts the release and production of hydrochloric acid by the parietal cells (=oxyntic cells). Ultimately the parietal cells regress.

Data on *R. vitellinus* are confined to observations on a single female (Leong, Tyler and Shearman, 1986). Surprisingly it is evident that gastric brooding in that species is accomplished by a different method involving the coating of the young with mucus, so preventing digestion by a process comparable to the cytoprotection of the stomach mucosa.

Captive Care

A colony of *R. silus* was maintained in captivity at the University of Adelaide from 1976 to 1982, surviving there for two years after the last sighting of the species in the field.

Because *R. silus* is almost entirely aquatic the species was maintained in a fibre-glass box with 0.5 m deep water. Particular care was taken to maintain a water quality free of chlorine and other additives. The chamber included a series of steps to create a flowing stream environment. Food provided consisted predominantly of mealworms (larvae of *Tenebrio molitor*).

Population Decline

Ingram (1983) reported that a field study in which he tagged 61 individuals between October and December 1976. During the same period in the following year he recaptured only nine and this period coincided with the decline of the species throughout its range. Only 26 frogs were caught in 1978 but none was in breeding condition. Two juveniles were located in October 1979 and the species has not been seen in the wild since that date.

Because of worldwide interest in the species enormous effort was expended to try to locate it but without any success.

In January 1984 the discovery of a second species of *Rheobatrachus* was reported. Within 17 months it too disappeared (McDonald, 1990) and has now not been seen for seven years.

The cause of the disappearance of these two species remains unknown. None of the suggested factors (ranging from excessive collecting to localised habitat loss and drought) will sustain scrutiny (Tyler and Davies, 1985). Perhaps significantly other water-dependent species disappeared simultaneously.

Management Implications

Many field herpetologists can testify that many frog species commonly are characterised by large swings in population numbers. Accordingly failure to locate any representatives of a species is not necessarily perceived to be a serious event - rather it will be assumed to be a normal feature. As a consequence management plans are of little value, beyond the laudable strategy of attempting to maintain the *status quo* of the habitat.

In the face of evidence that there are serious declines in frog populations in many species in numerous countries (e.g. that reported for *Bufo periglenes* by Alan Pound: this conference), the role of captive breeding as a means of re-establishing populations lost in the wild, is likely to be considered more seriously. There is, however, little point in re-establishing wild population if the causes of decline remain unknown.

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OBSERVATIONS ON INCUBATION, DIET, AND SEX DETERMINATION IN HATCHING TORTOISES

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INTRODUCTION

In order to improve the production of "Captive Bred" reptiles, specifically Tortoises, I have examined three aspects of tortoise husbandry including: Egg incubation, diet of neonates, and sex identification.

EGG INCUBATION

Determining the fertility of tortoise eggs.

It is helpful to candle eggs to determine their fertility so incubation methods may be improved upon and infertile eggs may be discarded.

Initially I used a homemade candler constructed from a metal can with a 3/4 inch hole cut in the top and a 7 watt night light installed in the can. This homemade light generated more heat than I was comfortable with, and it required excessive handling of the eggs, but it did adequately illuminate the tortoise eggs. More recently I purchased an MDS Probe-lite high intensity candling light. The cost seemed high for the plastic construction, but this new light eliminates any handling of the eggs and develops almost no heat. I feel it was well worth the price.

The eggs must be viewed in subdued light. The following chart describes the development of leopard tortoise eggs.

DEVELOPMENT OF TORTOISE EGGS

DAY	OBSERVATION
1–5	No development.
6–10	Dark bubble formed at top of egg.
10–65	Bubble continued to enlarge.
25–40	Bubble lightened in color and filled top half of egg. Veins evident.
40–70	Bubble (presumed to be yoke) moved to the bottom of egg with veins extending to the embryo located near the top of the egg.
70–100	Embryo increased in size. Three layers evident in egg.
100–120	Embryo beginning to fill egg.
120-Hatch	Egg dark, sometimes with a light bubble at the top of egg.

Moisture content of incubation media.

I have used many types of media for incubation including peat moss, a mix of sand and peat moss, vermiculite, and commercial potting soil. All have worked equally well. The moisture content of the media may be very important.

I have experienced a problem with the eggs from a single clutch hatching over a 30-45 day period. I set up several groups of leopard tortoise eggs to determine if the moisture content of the incubation media may play a part in this problem. The clutch of eggs that produced the most desired results was initially set up in a medium of one part water to one part peat moss. On day 182 the eggs were sprayed down with water increasing the moisture content of the medium. The eggs hatched on day 185 through 189. I speculate that an increase in moisture to the medium may simulate a rainy season which stimulates hatching. Much more work needs to be done in this area.

DIET OF NEONATES

I am continually examining the diet for hatchling tortoises in order to achieve a simple diet that will promote steady, well formed growth.

I have promoted the use of Zu/Preem Dry Primate Diet (moistened with water) as a simplified, well rounded food for hatchling tortoises. From past experience I have found that a grocery store diet doesn't always produce good results.

An example of problems associated with a grocery store type diet is the presence of oxalic acid in some commonly fed vegetables.

Oxalic acid is found in rhubarb, spinach, chard, parsley, and beet tops (Gerras, 1977). "This acid combines withh calcium to form a compound known as calcium oxalate, which passes through the intestine without being obsorbed"(Fleck, 1981).

A review of the nutritional value of other common vegetables reveals a poor balance of calcium and phosphorus in some and unsuitable amounts of important vitamins and proteins in others. If vegetables are carefully selected the above mentioned problems can be avoided.

My son undertook a science project at school which suggested an advantage to a diet of Zu/Preem over grocery store vegetables(graph 1). His paper does not examine why the tortoises fed vegetables did not do well. I speculate the vegetables which were offered the tortoises were too coarse for the small tortoises to eat or the taste was not acceptable.

To further investigate the use of Zu/Preem diet as a main food for hatchling tortoises I set up a group of 12 hatchling, African Spurred Tortoises, _Geochelone sulcata_. The tortoises were housed in a 1.0 meter by .66 meter plastic box. The bedding was newspaper and only incandescent lighting was available. The room temperature was between 78 degrees Fahrenheit and 82 degrees Fahrenheit, and a 75 watt light was available for basking (the basking light was not available between November 30th and January 14th). The tortoises were fed as much as they would eat each morning.

I have concluded from this study (graph 2), that a diet of Zu/Preem Primate Diet used without ultraviolet lighting or other supplements can produce acceptable results. A basking light is very important. I speculate that crowding and competition for heat and food may have contributed to the difference in growth.

DEVELOPMENT OF SEXUAL CHARACTERISTICS

The identification of the sex of a hatchling tortoise is all but impossible to do. In some species the incubation temperature can be regulated to produce males or females. One additional help in determining the sex of an individual is by examining the anal scutes.

As the tortoise matures the anal scutes of males begin to thicken and the angle from the central suture increases. In females the anal scutes are directed more toward the rear of the shell. This difference in anal scutes can be seen in neonates of several species of tortoises, and may be useful in determining sex.

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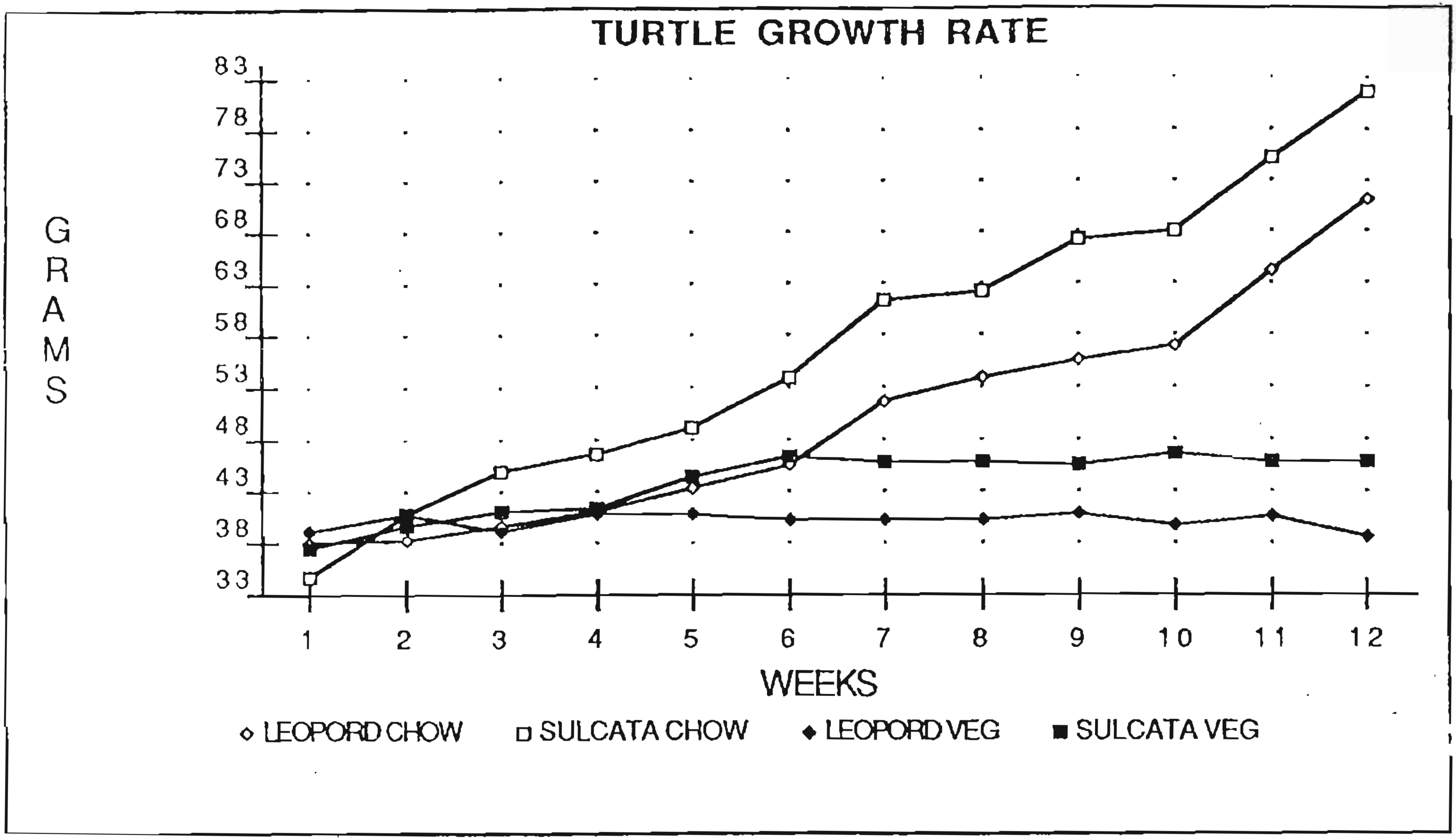
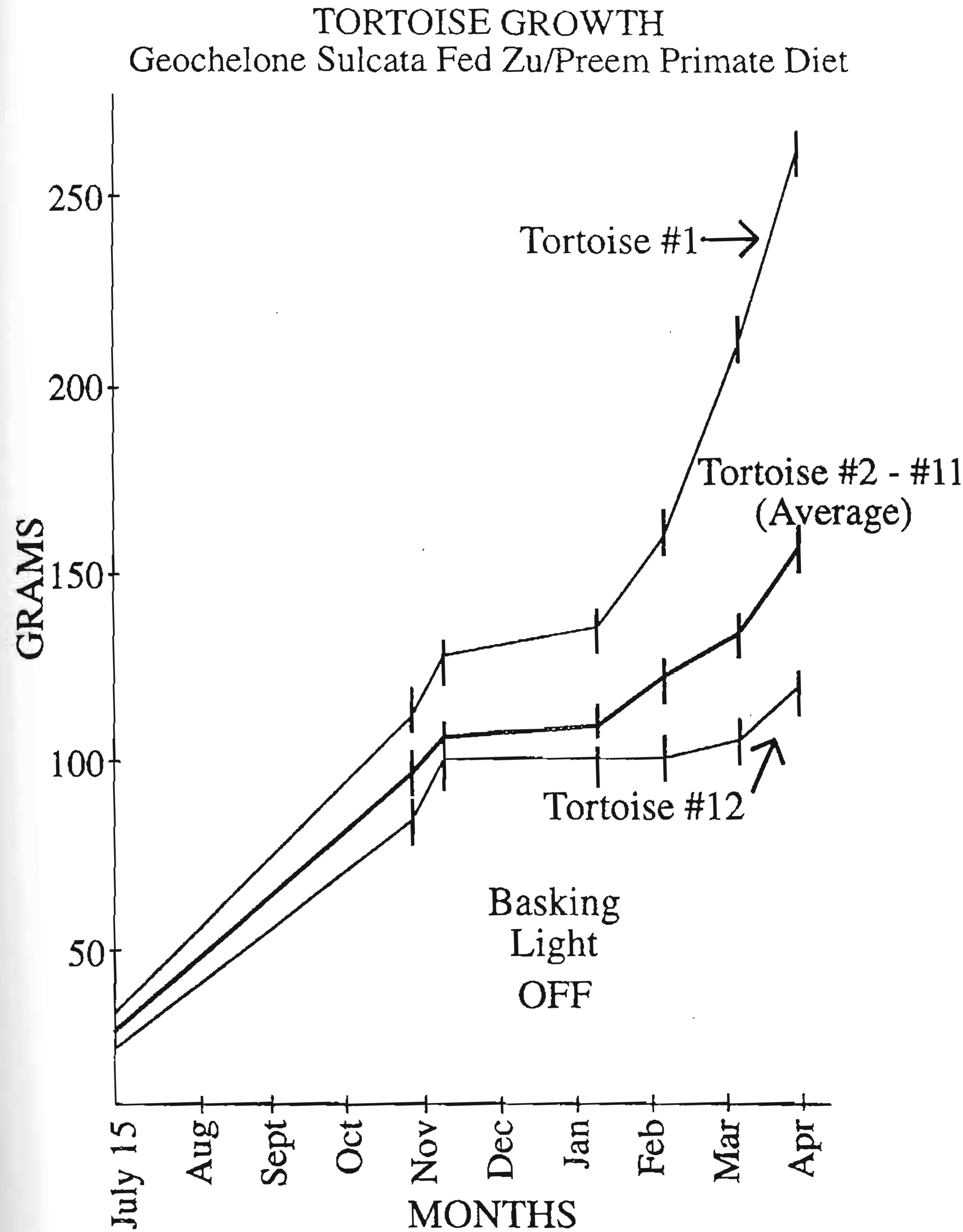

TURTLE GROWTH RATE
GRAMS
83
78
73
68
63
58
53
48
43
38
33
1
2
3
4
5
6
7
8
9
10
11
12
WEEKS
LEOPORD CHOW
SULCATA CHOW
LEOPORD VEG
SULCATA VEG

GRAPH 1


TORTOISE GROWTH
Geochelone Sulcata Fed Zu/Preem Primate Diet
GRAMS
250
200
150
100
50
Tortoise #1
Tortoise #2 - #11
(Average)
Tortoise #12
Basking
Light
OFF
July 15
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
MONTHS

GRAPH 2

SEX DETERMINATION OF REPTILES BY FLUID INJECTION

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Abstract: The sex of a wide variety of reptiles was ascertained by injecting fluid into the base of the animals' tails. This procedure was used on snakes and a wide variety of lizards. Emphasis was placed on lizards whose sex could not be easily determined by visual means. The usefulness and drawbacks of this procedure are addressed.

INTRODUCTION

In 1985 a question was asked of a leading herpetologist, "Is there any way to accurately sex a Gila Monster (Heloderma suspectum)?" The answer came to be "no". In the years preceding and following this discussion, various methods for sexing non-dimorphic lizards, juvenile animals and some boids have been attempted. Sexing of adults has usually been based entirely on (Lawler, et al. 1987) oviposition or extrusion of hemipenes. Probing of lizards has never been conclusive (Wagner, et al. 1976). X-rays and ultrasounds have proven inconclusive, as has surgery (Lawler, et al. 1987). Surgery is also costly and very stressful to the specimen. Determination of sex using general body shape and proportional head size seems to be educated guesswork, and attempting to determine the sex in juvenile lizards and some boids is a virtual crapshoot.

METHODS

In 1989 a reliable method of determining the sex in juvenile lizards was reported (Stewart, 1989). This procedure uses a sterile isotonic solution such as lactated ringers of physiologic saline. The fluid is injected into the tail intramuscularly using a fairly large (18 or 20 gauge) needle, at a point that approximates the caudel extent of the inverted hemipene. The solution surrounds the hemipene and stimulates vascular pressure causing hemipene eversion. In females the cloacal margins become engorged and the openings of the post-cloacal sacs are apparent. In males the hemipene usually everts before the cloaca is markedly engorged. Total eversion of the hemipene is not necessary for sex identification.

Once the sex has been determined the needle is removed. In most cases the hemipene will retract as soon as pressure has been released. The animal is placed in a small container such as an aquarium, shoe box or sweater box. I line the bottom with wax paper and add about 1/8 inch of sterile saline to prevent the hemipene or cloacal margins from sticking to any surfaces and causing potential damage to the organ.

This technique was reported ineffective on larger lizards such as adult monitors (Stewart, 1989). The hemipene retractor muscles in large lizards are strong enough to overpower the injection pressure and prohibit hemipene eversion. Thus the use of this procedure on larger lizards and boids requires anesthesia of the specimen. The anesthesia of choice is isoflorane, a proven product that is also a muscle relaxer. To administer this an anesthesia machine equipped with an isoflorane vaporizer is required. You should anesthetize the specimen with the assistance of a qualified veterinarian.

The time required to anesthestize an animal varies from three to nine minutes depending upon its size and activity level. Calm animals take longer to anesthetize due to slower respiration.

An average size Savannah Monitor (Varanus exanthematicus) took 3.5 minutes. European Legless Lizards (Ophisaurus apodus) took 7 minutes. An adult Gila Monster (Heloderma suspectum) took 9 minutes. A sub-adult Gila Monster (Heloderma suspectum) took 5.5 minutes. Small Blood Pythons (Python curtus) took 6 minutes. A medium Water Monitor (Varanus salvator) took 6 minutes. Yearling Blue-tongue Skinks (Tiliqua scincoides) took 9 minutes.

Once the specimen has been anesthetized the procedure is the same as for non-anesthetized specimens. The amount of fluid required varies with the size of the animal, e.g. 1 ml for juvenile Green Iguanas (Iguana iguana) to 40 ml or more for Savannah Monitors (Varanus exanthematicus).

Once the sex has been determined, the needle is removed. The animal is placed in the container with wax paper and saline. Larger lizards and boids should be placed in larger containers as dictated by their size. Moist toweling can be used in place of wax paper and saline if preferable, especially with larger animals. The hemipene of an anesthetized animal usually takes longer to retract than that of a non-anesthetized animal.

RESULTS

The use of this procedure from our standpoint is foolproof. Sex was verified in every case tested. Sexual identification can be established without everting both hemipenes, and with minimal stress to the subject. The incurred cost of the anesthesia is obvious. I recommend negotiating an arrangement with a veterinarian. When weighing this procedure against intrusive surgery or guesswork, the benefits are evident.

DISCUSSION

In a world of shrinking habitat and more reptiles joining the ranks of the endangered every year, captive breeding becomes more important every day. Yet the captive propagation of non-dimorphic forms of reptiles such as Varanus and Heloderma is still rare. By being able to accurately sex these animals, captive breeding success is enhanced. Acquisition of sexually known specimens takes out the guesswork when adding animals to a breeding group. Just throwing a handful of specimens together in hopes of breeding is haphazard at best. Mounting is both a reproductive and dominance establishing behavior. The assumption that males only mount females is invalid (Stewart, 1989).

This is a safe, 100% accurate method of determining the sex of young and non-dimorphic lizards and difficult to sex boids. It also works on all other species of snakes we have tried. It works on any size lizard or snake. The potential impact on Varanid propagation alone is evident. Despite the potential incurred monetary costs, proper sex determination is a major key to successful captive propagation.

ACKNOWLEDGMENTS

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SPECTRAL CHARACTERISTICS OF LAMPS COMMONLY USED IN HERPETOCULTURE

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Abstract: Lamps may differ in both the quality and intensity of light output. Quality can be described by the color rendering index (CRI), correlated color temperature (CCT), chromaticity coordinates, or spectral power distribution (SPD). Light intensity is usually reported as illuminance or irradiance. The ways in which the quality of light from artificial lamps differs from that of natural light are described. The extent to which quality and intensity influence biological processes, such as growth and reproduction in various species, has not been experimentally established.

Introduction

Lamps are used in herpetoculture in a variety of ways. For example, they may illuminate an enclosure and its occupants, sometimes enhancing colors for the benefit of human viewers. Some types support plant growth while others contribute to the establishment of a thermal gradient. Lamps may facilitate biological processes in reptiles, such as the cutaneous synthesis of vitamin D_3 by sunlamps. To meet one or more of these intents, lamps may be grouped in various combinations.

A property of any lamp is the radiation of electromagnetic waves. The electromagnetic spectrum is divided by wavelength into a variety of bands. For biological purposes, the visible band from 400 nanometers (nm) to 700 nm can be considered central. Below 400 nm is ultraviolet (UV) light, with the 320 nm to 400 nm band designated by various names such as blacklight, longwave, nearwave, or ultraviolet A (UVA). Erythemal, middle-wave, or ultraviolet B (UVB) radiation extends from 285 nm to 320 nm. However, the lower boundary for UVB is sometimes given as 290 nm, and the junction between UVA and UVB may be specified as 315 nm. Between 200 nm and 285 nm is farwave, germicidal, shortwave, or ultraviolet C (UVC). At the other end of the visible spectrum above 700 nm is infrared (heat) radiation. The 700-780 nm band is sometimes referred to as far-red and is important in photosynthesis. The visible spectrum is commonly divided into color bands as shown in Fig. 1A.

Two characteristics of any lamp independent of the user are light quality and power rating, with the power rating related to the intensity of light emitted. Photoperiod and dose, roughly the photoperiod multiplied by the power, are features of light regimens that are determined by the herpetoculturist.

The purpose of this paper is to outline ways of describing the quality and intensity of a light source and to relate these descriptors to selected lamps commonly used in herpetoculture.

Quality of a Light Source

There are several ways to describe the quality of a light source. Technical information sheets for various lamps specify these descriptors as chromaticity coordinates, color rendering index, color temperature, and spectral power distribution.

Information sheets are available from customer service or technical information service departments of manufacturers and lamp distributors.

In one way or another light quality invokes the psychophysiological attribute of light known as color. Three features of light are associated with color vision: (1) hue, (2) saturation, and (3) brightness. Hue refers to the colors of the spectrum differentiated by wavelength. For example, the hue called blue lies between 425-490 nm while red is bounded by 645-700 nm. The second feature of light, saturation, refers to the purity or strength of the hue. A spot of red light projected on a screen will become less saturated, that is pink, if a spot of white light is superimposed. The last feature of light, brightness, is related to the intensity or power of the source. For example, a 60 watt red bulb will appear brighter than a 25 watt red bulb (see Cromer, 1977, for a more detailed analysis of color).

There is evidence that some species of amphibians and reptiles possess color vision (Ali and Klyne, 1985; Bellairs, 1970; Brattstrom, 1978; Hailman and Jaeger, 1974; Jacobs, 1981). However, the relationship between color vision, or lack of it, and light requirements is unknown.

Different hues or colors of light can be combined to form new colors. For example, if spots of red, green, and blue light at the appropriate intensities are combined, they produce a spot of white light. The color composition of a light source, or its quality, can be specified directly or indirectly in several ways.

The color temperature (CT) of a lamp is often used as a descriptor of quality and may be visualized as follows. Metal, such as a stove element, will emit visible light when it is sufficiently heated. This phenomenon is referred to as blackbody radiation, where "black" refers to any material that absorbs most (ideally, all) of the radiation incident upon it. Furthermore, the color will shift in a continuum through the color spectrum from red to yellow to blue-white as the temperature increases. The temperature associated with a given color is called the color temperature and is designated in degrees Kelvin (K) on the absolute temperature scale. The color from any light source can be compared to the colors from a standard blackbody radiator at various temperatures. The color of the source that most closely matches or correlates with that of the standard is called the correlated color temperature (CCT) and is also described in degrees Kelvin.

The sun acts like a blackbody radiator with a CCT of about 5900 K, although this may vary from less than 3000 K near sunrise (reddish) to 20,000 K in a blue-white north sky (Thorington, 1985). In contrast, the CCT of artificial light sources is comparatively constant. The CCT of the fluorescent Vita-Lite lamp is 5500 K (Duro-Test Corp., technical bulletin E1032-8302R2.5) while that of the fluorescent Colortone 50 is 5000 K (Philips Lighting Co. product information sheet). Sometimes the first two numbers of the color temperature appear after the registered name of a lamp as in Colortone 50, Sylvania's Design 50, Duro-Test's Optima 50, and the GE Chroma 50. All of these lamps have a CCT of 5000 K. The CCT of a 100 watt incandescent tungsten filament bulb is about 2900 K (Thorington, 1985).

The color spectrum can be represented by a roughly triangular area with the primary colors of red, green, and blue at the corners and wavelengths designated along two sides of the triangle. This figure mounted in the appropriate position on a Cartesian X and Y coordinate system results in the standard chromaticity diagram which was designed by the International Commission on Illumination (CIE) in 1931 (see Cromer, 1977, for a more detailed discussion of chromaticity and GE Lighting Application Bulletin 905-61701R for a colorized rendition of the diagram). The color quality of a light source associated with a given color temperature can be described by specifying the appropriate X and Y values on the diagram. For example, a Duro-Test Vita-Lite lamp with a CCT of 5500 K can be described by chromaticity coordinates of $x = 0.32$ and $y = 0.35$ (Duro-Test technical bulletin E1032-8302R2.5), while fluorescent lamps with a CCT of 5000 K are at $x = 0.35$ and $y = 0.36$.

Another measure of quality is the color rendering index (CRI). The CRI refers to the ability of a light source to reproduce the appearance of object colors, such as the color of a reptile, relative to a reference light source at the same color temperature. A set of eight test colors have been standardized by the CIE. The reference source is a blackbody radiator for comparisons between 2000 K and 5000 K or natural daylight at the appropriate color temperature above 5000 K. The extent to which a light source shifts the color appearance relative to the standard can be quantified and is expressed on a scale of 1 to 100. No change in appearance indicates a CRI of 100. The CRI of a Vita-Lite is 91 while that of a GE Chroma 50 is 90. The CRI of a 100 watt incandescent lamp with a color temperature of 2900 K is about 98. There is no invariant relationship between the color temperature and the CRI. For example, a warm white fluorescent lamp has a CRI of about 55 while a Deluxe warm white lamp has a CRI of 77, yet both have the same CCT of 3000 K (GE Lighting Application Bulletin 905-6170R).

Perhaps one of the most informative measures of light quality is the spectral power distribution (SPD) which indicates the actual or relative energy or power at various wavelengths (see the section dealing with Intensity for a further description of dimensions). The distribution of power may be represented as a continuous curve (see Fig. 1C) or as a bar graph wherein the height of each bar represents the total power between the two wavelengths specifying the bar or bandwidth. The band-widths in a bar-type SPD may be uniform, for example, in 10 nm increments, or they may be variable and calculated to correspond to the colors and UVR comprising the light spectrum (see Fig. 1B).

Light from a blackbody source, such as an incandescent lamp or the sun, is emitted as a continuum. As previously indicated, as the CT increases the shift is from a reddish color toward a blue-white. This is shown in Fig. 1C for two incandescent lamps. A family of curves at CT between 2500 K and 3400 K can be generated and will be nested between those shown in Fig. 1C. It may also be noted that the relative proportions of light at various wavelengths can be blended to give the sensation of "white" light although the color overtone may vary, for example, warm, cool, bluish, yellowish.

Light from fluorescent lamps, in contrast with incandescent sources, is not continuous and is characterized by spectral emission lines. When electrons emitted from the lamp cathode collide with mercury atoms in the vapor inside the tube, their energy can be transferred to the electrons of the mercury atoms which briefly assume one of several higher energy states. These "permissible" states are not continuous but are quantized or discrete. When electrons return to their ground state, energy is released as radiation, the wavelength of which depends on the energy level of the excited electron. Energy from mercury atoms is emitted at wavelengths of about 254, 297, 313, 365, 405, 436, 546 and 578 nm (see Fig. 2L showing the emission lines from a mercury vapor sunlamp). The light from fluorescent lamps is made continuous by using phosphors on the inner surface of the lamp glass. Radiation, principally at 254 nm, will be absorbed by the phosphors and be re-radiated at wavelengths in the visible range. In SPD curves, the emission peaks associated with the mercury may be omitted or shown in the curve as emission lines or bars (Fig.

1D) (see Sylvania's engineering bulletin 0-341, Fluorescent Lamps, for a more detailed description of the theoretical and practical features of fluorescent lamps).

The primary properties of lamps are reflected in their SPD (see Fig. 1 and 2 for various types). Lamps used in herpetoculture can be classified in accord with a dominant spectral characteristic. The following are the most commonly used types: (1) visible band emitters (2) infrared or heat lamps (3) plant growth lamps (4) blacklights (UVA) (5) sunlamps (UVB). Features may overlap among the groups however. For example, incandescent reflector lamps emit considerable infrared although they are designed primarily for lighting objects. Fluorescent sunlamps are designed to radiate UVB but emit UVA and some visible light as well.

Light quality of some lamps is sometimes described by the term "full" spectrum. Duro-Test Corporation initially defined "full" spectrum to describe its Vita-Lite lamp using natural outdoor light as a reference. The requirements for "full" spectrum were specified as: (1) a CRI above 90, (2) a CCT between 5500 K and 6800 K, and (3) a SPD that simulates that of natural daylight in the visible and UVA and UVB regions. Requirement number 3 with respect to UVR was protected by patents (Duro-Test technical bulletin by P. Hughes, 1982) until 1984. Accordingly, only Vita-Lite lamps could meet all the criteria needed to be called "full" spectrum, even though there were various lamps available which were quite similar. For example, fluorescent lamps with a CCT of 5000 K - 5500 K resemble Vita-Lite in the visible range but don't meet the UVR requirement (compare Fig. 1F and 2G). An important question with respect to lamps is their biological equivalence. For example, will a *blacklight used in combination with a lamp having a CCT of* 5000 K, or even with a cool white fluorescent, (Fig. 1D), have the same biological efficacy as a full spectrum lamp? At this time, the answers to this and similar questions are not available because of an insufficiency of experimental data.

Despite attempts to restrict the use of "full" spectrum, the adjective is widely applied to a variety of lamps that fall short of meeting the original criteria, rendering its use tenuous. The phrase "broad spectrum" is sometimes used synonymously with "full spectrum," which further complicates the picture. However, the complication can be simplified because questions pertaining to the quality of a lamp can largely be answered by examining the SPD and other quality characteristics specified by the manufacturer.

In contrast with "full" spectrum, fluorescent lamps described as "wide" spectrum are usually plant growth lamps. These lamps emphasize wavelengths in the blue and red regions and have a SPD quite different from natural light (compare Fig. 1A and 2H). A wide spectrum lamp such as Sylvania's Gro-Lux/ws is similar to Sylvania's Gro-Lux, but has a greater amount, is "wider" on a SPD, of energy in the far-red region between 700 nm and 800 nm (Sylvania Engineering Bulletin 0-285).

Intensity of a Light Source

Strictly speaking, the term "intensity" as used by illumination engineers refers to radiant intensity or luminous intensity, which describes the radiant or luminous flux per unit solid angle in steradians (see Kaufman and Christensen, 1985, for more details). The term is used here in a broader sense to mean the magnitude of energy emitted from a system, for example, a light source, and it can be described in several ways.

Irradiance describes the radiant flux density at a surface. Radiant flux or power is the rate of energy delivery, in ergs or joules (J), per second, where a joule is 10^7 ergs, and is described by the unit watt (W). Specification of watts per area, for example, watts per square centimeter ($W\ cm^{-2}$), is the irradiance. The irradiance within a narrow band, such as one nanometer, can be measured over an interval of wavelengths by a spectroradiometer giving $W\ cm^{-2}\ nm^{-1}$. This information can be used to generate a SPD. Some radiometers will integrate the irradiance over a wide interval,for example, 400 nm to 700 nm, giving the total irradiance ($W\ cm^{-2}$), in this case for the visible light spectrum.

Illuminance is the luminous flux, in lumens (lm) per area of surface. If the area is expressed in square meters (m^2), one lumen per square meter ($lm\ m^{-2}$) is equal to one lux (lx). One footcandle, another unit of illuminance, equals 10.76 lx.

Visual responses to bright light are mediated by cones of the retina and are referred to as photopic responses; responses to dim light are processed by retinal rods and are called scotopic responses. The eye exhibits a spectral sensitivity, that is, it responds differentially to wavelengths or "colors" of light. Maximum response for photopic vision in humans is associated with green light at about 555 nm and the response becomes progressively less at wavelengths toward the red and blue ends of the spectrum (see Kaufman and Christensen, 1985, for tables detailing human photopic and scotopic sensitivities). Thus, a green light will appear brighter than a red or blue light even though the irradiances are the same. It is for this reason that there is no simple method for converting illuminance to irradiance and vice versa. The early designs of fluorescent lamps emphasized output in the green band because this maximized the brightness, that is, lumens $watt^{-1}$, for a given power input (see Fig. 1D of a cool white fluorescent lamp).

For some studies, particularly in sensory physiology, description of light as packets of energy known as quanta or photons may be a preferable alternative to characterizing light as electromagnetic waves. The energy of photons is dependent on the frequency and can be calculated by multiplying Plank's constant (h) by the frequency (hf). The frequency can be determined by dividing the velocity of light by the wavelength ($c\lambda^{-1}$). In addition to the energy associated with individual photons, the number of photons and their rate of delivery, that is, photon flux, can be calculated for a given wavelength or set of wavelengths. Methods for interconverting photometric, radiometric, and quantum units are discussed by Thimijan and Heins (1983).

The intensity of visible light in enclosures illuminated by artificial lamps will usually be considerably less than that of natural light. The illuminance of natural light at noon in June at 35^{0}N latitude is about 100,000 lx (Thorington, 1985). The illuminance of a 20 watt Vita-Lite at 46 cm is about 344 lx while that of a 20 watt cool white fluorescent at 46 cm is about 525 lx. The illuminance from a 250 watt infrared reflector lamp at 46 cm is 4300 lx and that of a 150 watt reflector flood lamp at the same distance is 2690 lx (Gehrmann, 1987).

Both UVA and UVB are a part of natural light and are emitted in various amounts from many artificial lamps. The intensity is usually described by irradiance as $\mu W\ cm^{-2}$. The irradiance of UVA in June at noon at 35^{0}N latitude on a clear day is about 5800 $\mu W\ cm^{-2}$ while that of UVB is about 150 $\mu W\ cm^{-2}$. The irradiance of UVA in mid December under the above conditions is about 2640 $\mu W\ cm^{-2}$ and that of UVB is about 44 $\mu W\ cm^{-2}$ (Thorington, 1985). Seasonal and latitudinal variation in UVR have been described by Schulze and Gräfe (1969).

For some processes, the dose of UVR received will be important. Dose refers to the irradiance multiplied by the time of exposure. For example, if 20 $\mu W\ cm^{-2}$ is applied for five seconds, the dose delivered will be 100 $\mu W\text{-}sec\ cm^{-2}$. Since the watt represents the rate of delivery of energy, in joules sec^{-1}, the dose can be described as the total energy delivered per area. In the above example, 20 $\mu W\ cm^{-2}$ is equal to 20 $\mu J\ sec^{-1}\ cm^{-2}$ multiplied by five seconds which yields 100 μJ cm^{-2}. It can be calculated that when the irradiance is halved (or doubled) and the exposure time is doubled (or halved) the dose will remain the same. For example, 10 μW cm^{-2} for ten seconds is also equal to 100 μJ cm^{-2}. The idea that a given dose will produce a constant biological response is called the reciprocity law. It has been demonstrated that this law applies to many responses over a wide range of irradiances (Parrish, et al., 1978). Whether the law applies to processes involving long term chronic exposure remains to be verified. For example, will a ten minute exposure to UVB once a week have a similar effect on vitamin D_3 synthesis as a daily low irradiance exposure resulting in the same dose over the course of a week?

Artificial sources of UVR fall into three major categories: those that emit (1) mostly UVA (blacklights), (2) mostly UVB (fluorescent sunlamps), (3) both UVA and UVB in proportions similar to those found in natural light and with high irradiances (self-ballasted mercury reflector lamps). A small amount of UVA may also be emitted from various incandescent lamps (see Fig. 1C).

Blacklight fluorescent lamps are available in various lengths and wattages. A typical blacklight SPD is shown in Fig. 2I. Blacklight blue (BLB) lamps are similar but filter most of the visible radiation (see Fig. 2J). The UVA irradiance at 46 cm from a 20 watt blacklight lamp is about 85 μW cm^{-2} while the UVB irradiance is about 1.4 μW cm^{-2} (Gehrmann, 1987). Many UVB emitters are fluorescent lamps. A typical sunlamp SPD is shown in Fig. 2K. Note that a small amount, about 5%, of possibly biologically detrimental UVC is also emitted. The UVA irradiance from a 20 watt fluorescent sunlamp at 46 cm is about 9 μW cm^{-2} while the UVB is about 37 μW cm^{-2} (Gehrmann, 1987). Reflector, bulb-type sunlamps emit both UVA and UVB. Since there is no "smoothing" phosphor as in fluorescent lamps, most of the radiation is emitted in tight bands or emission lines (Fig. 2L). For a 275 watt sunlamp, the UVA irradiance 46 cm below bulb center is about 355 μW cm^{-2} while that of UVB is 70 μW cm^{-2} (Gehrmann, 1987). Reflector-type sunlamps are no longer produced and marketed as "sunlamps". However, self-ballasted, reflector mercury lamps are currently available in 160 watt and 250 watt sizes with either a standard or mogul base. The irradiances of UVA and UVB emitted are somewhat less than those from "sunlamps" but they can be considered as an acceptable substitute in many cases.

Guidelines for Selecting Lamps

In view of the fact that the importance of light quality and intensity for growth, reproduction, and other biological processes in different species is largely unknown because of a paucity of experimental data (see Gehrmann, in press, for a review), how may lamps for use in herpetoculture be selected? The selection process involves the consideration of a variety of factors. Some of these factors are: (1) size of the enclosure, (2) heat load, (3) species involved, (4) lamp quality and power, (5) lamp cost, and (6) maintenance cost.

Lamps to be used for producing a thermal gradient can be incandescent reflector types which are available in powers from 30 watts to 500 watts. Note that reflector spot lights will concentrate light and heat in a smaller area compared to reflector flood lamps. The light quality of these lamps may be adequate for some species, but note that wavelengths toward the red are emphasized (see Fig. 1C). To add balance toward the blue end of the spectrum, a variety of fluorescent lamps may be used. For some species, a warm white or cool white lamp may be adequate but colors will not be optimally rendered for the viewer (see Fig. 1D and 1E). Light with a color balance closer to natural light is emitted from lamps that have a CRI greater than 90 and a CCT between 5000 K and 7500 K. As the CCT increases from 5000 K toward 7500 K, the light assumes a progressively bluer overtone. The degree of similarity between lamp output and natural light will also be observed by comparing the lamp SPD with that of natural light at the same color temperature; this information is usually available from the manufacturer or distributor.

Most fluorescent lamps will emit some UV light (Gehrmann, 1987). Vita-Lite lamps manufactured by Duro-Test Corp. and Excella lamps distributed by Dura-Tron Lighting Corp. (there may be other lamps in this category) emit UVA and UVB in amounts roughly proportional to that found in natural light at 5500 K. The irradiance of UVA is about three times that of other non-full-spectrum lamps but in all cases is still considerably less than that of natural light because of the lower lamp power. To boost UVA output from a luminaire, some facilities use a blacklight in conjunction with one or more visible light emitters. This arrangement appears to be quite satisfactory for a majority of species maintained and bred in captivity.

Except for fluorescent sunlamps, the UVB irradiances from fluorescent lamps, including blacklights, is low compared to natural light (Gehrmann, 1987). For species that do not thrive and reproduce in captivity even when dietary, thermal, and other assumed requirements are adequately met, exposure to UVB can be tried. This is especially so if symptoms of metabolic bone disease (MBD) are evident (Frye, 1991). UVB exposure must be done with great care because a potentially fatal UVB toxicity syndrome may ensue (Gehrmann, in press). Self-ballasted reflector mercury lamps or fluorescent sunlamps may be used as a source of UVB. Reflector lamps may be permanently installed in large enclosures provided they are not the primary heat source used for thermoregulation. The ideal time and frequency of exposure remains to be determined but some provisional recommendations can be found in Moyle (1990). For example, he exposed an enclosure containing the desert lizard, <u>Uromastyx</u>, to radiation from a fluorescent sunlamp positioned at 50 cm (20 inches) above the substrate for five ten-minute intervals each day for six months with no obvious signs of eye or skin problems. It should be noted that the enclosure contained hiding places, so exposure was "voluntary".

Light levels (illuminance) in large enclosures can be increased by augmenting existing lighting with high output lamps. Tungsten-halogen lamps, a kind of incandescent lamp with a SPD similar to those shown in Fig. 1C, are available in powers up to 1500 watts. Some metal halide lamps, a type of high intensity discharge (HID) lamp, have a high lumen output as well as a CRI greater than 90. High wattage lamps however, add considerably to the heat load of the enclosure.

As part of maintenance, the diminution of output with time should be considered; this reduction is shown in power depreciation curves. These curves are available for the visible band, as well as for UVA and/or UVB for some lamps.

Acknowledgements

This paper is dedicated to the memory of Joseph Laszlo who lighted my interest in this subject and whose spirit continues to illuminate my studies. I express my appreciation to Don Hamilton for his helpful comments and support. I thank Patsy Hemmings for her patience and cheerful perseverance in processing this manuscript.

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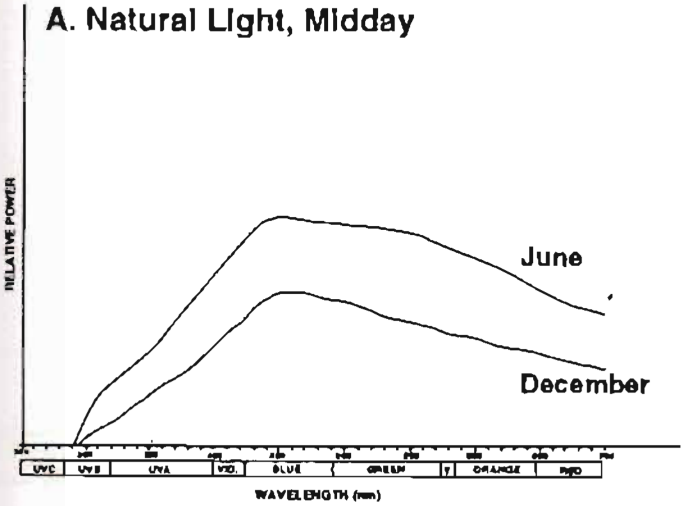
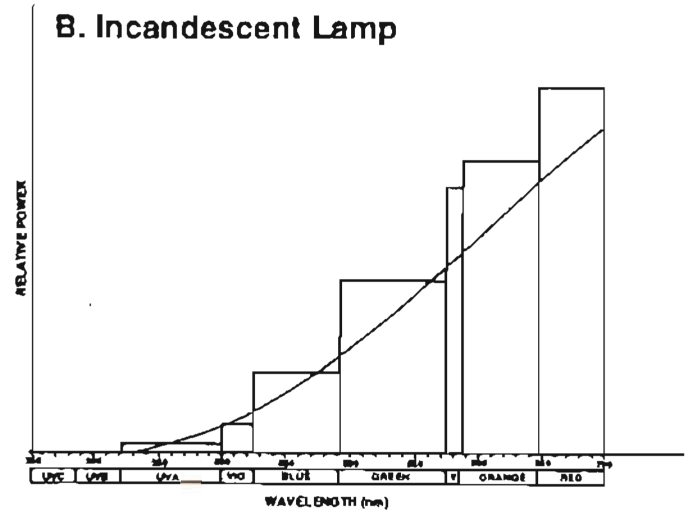
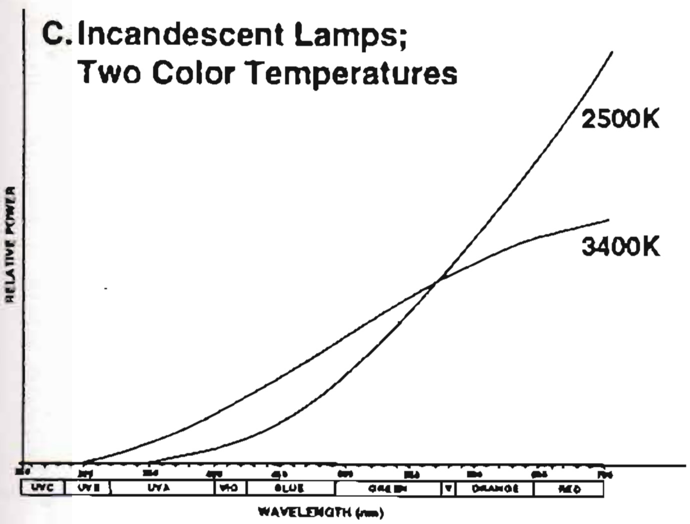
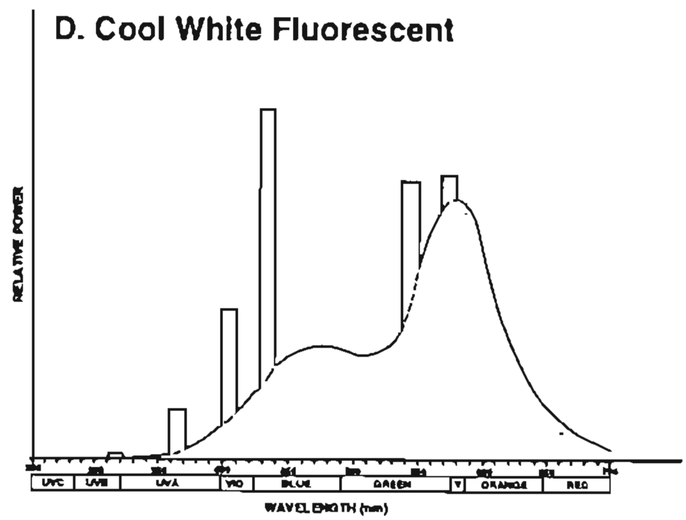
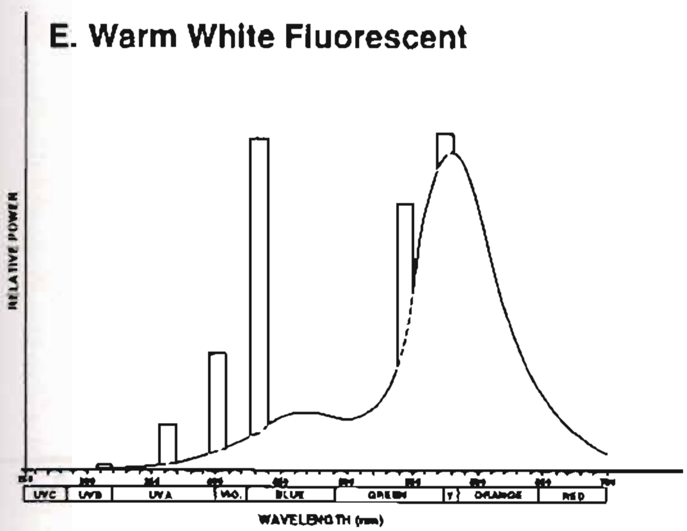
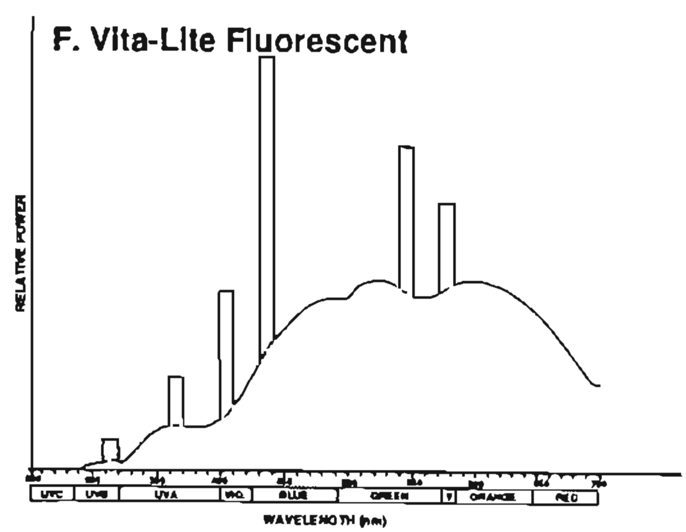

A. Natural Light, Midday
June
December
RELATIVE POWER
WAVELENGTH (nm)


B. Incandescent Lamp
RELATIVE POWER
WAVELENGTH (nm)

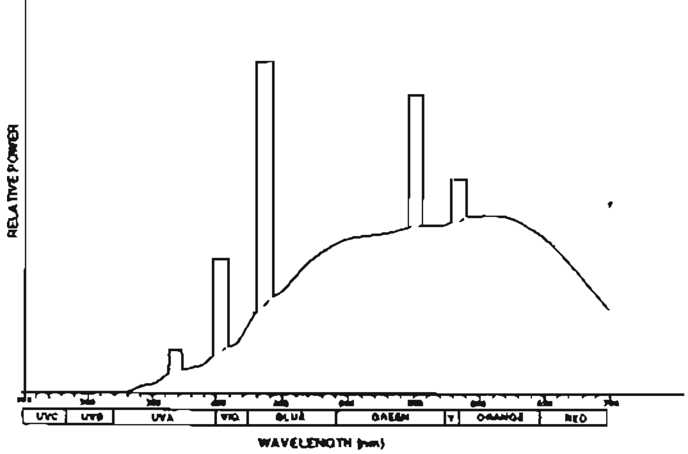

C. Incandescent Lamps; Two Color Temperatures
2500K
3400K
RELATIVE POWER
WAVELENGTH (nm)


D. Cool White Fluorescent
RELATIVE POWER
WAVELENGTH (nm)

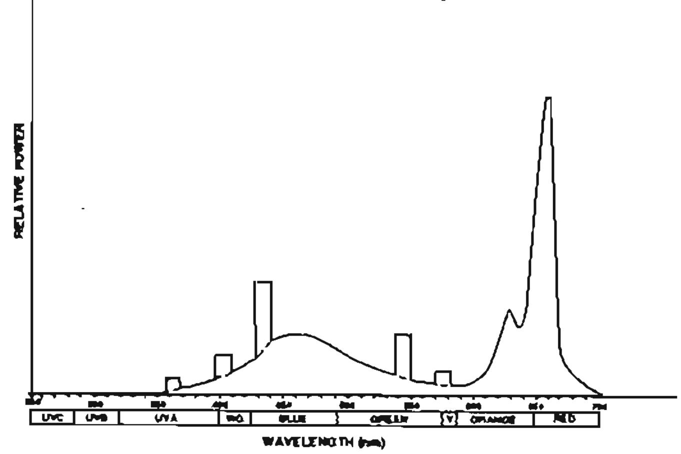

E. Warm White Fluorescent
RELATIVE POWER
WAVELENGTH (nm)


F. Vita-Lite Fluorescent
RELATIVE POWER
WAVELENGTH (nm)

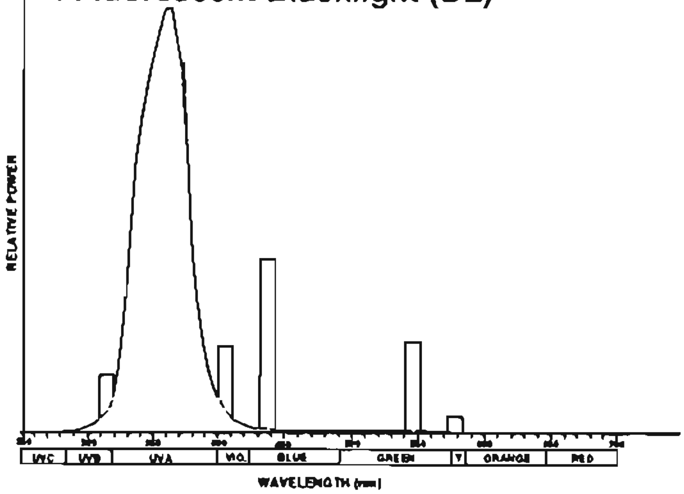
G. Fluorescent; Color Temperature 5000K



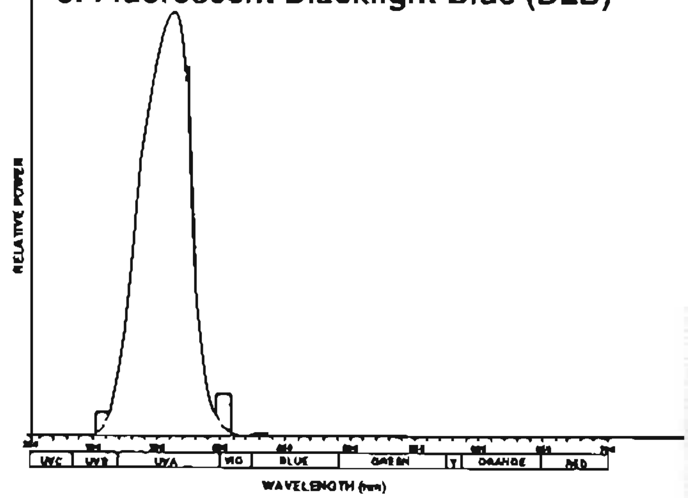
H. Fluorescent Plant Lamp



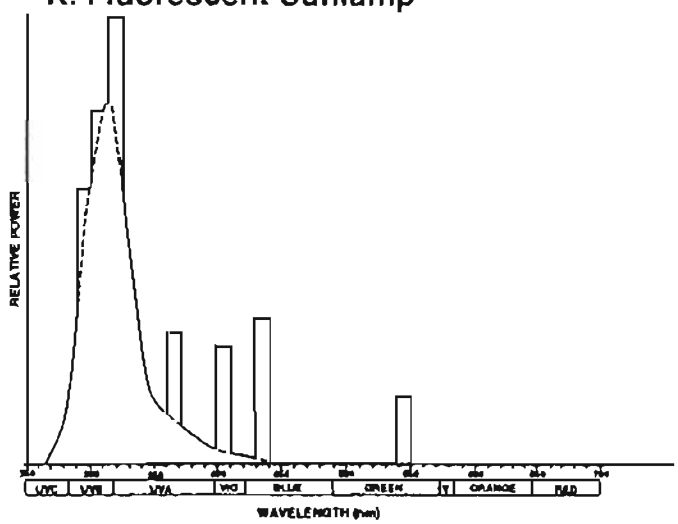
I. Fluorescent Blacklight (BL)



J. Fluorescent Blacklight Blue (BLB)



K. Fluorescent Sunlamp



L. 275 Watt Reflector Sunlamp

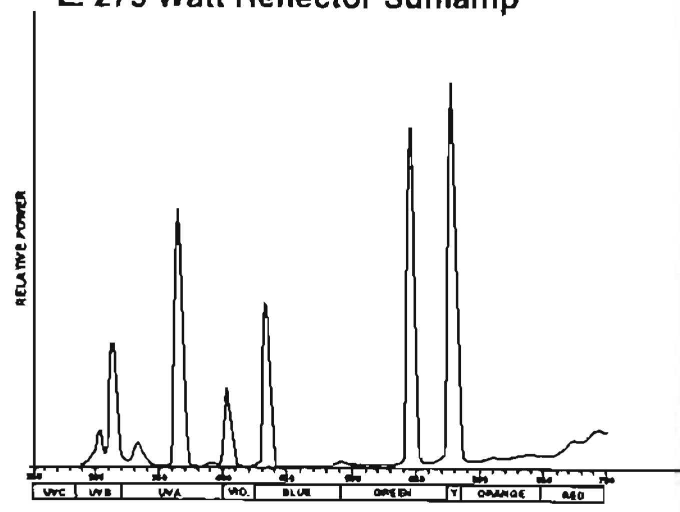


Fig. 1. Spectral power distribution (SPD) curves for various lamps. The curves are based on data from various sources.

Fig. 2. Same legend as Fig. 1.

HUSBANDRY AND NATURAL HISTORY OF RHACODACTYLUS

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Abstract: Six New Caledonian species of the lizard genus Rhacodactylus have been described. All are probably predominantly arboreal and concentrated in the more mountainous and humid central and eastern portions of the main island. Five of the six species have been maintained and propagated in captivity. A review of the literature is combined with personal experience of the author to produce an overview of the natural history as well as a formula for captive maintenance and reproductive success. The captive husbandry and propagation of R. auriculatus and R. chahoua are emphasized.

The New Caledonian lizard genus Rhacodactylus has become one of the most popular as well as one of the most expensive lizard genera to purchase. It is of herpetological interest for several reasons. Rhacodactylus leachianus may be the largest of all living geckos and has webbed feet, possibly as an aid in gliding (Meier, 1979). R. trachyrhynchus is viviparous, a characteristic not found in geckos outside New Zealand (Mitteilungen, 1979; Meier, 1979). In addition, several species exhibit varying degrees of utilization of a prehensile tail (Boulenger, 1883; Mertens, 1964; Meier, 1979; Bauer, 1985).

With the exception of R. ciliatus, all New Caledonian members of the genus have been maintained and reproduced in captivity. Most of the published reports relative to captive husbandry and propagation, however, have been in German. It is the purpose of this paper to provide the English-speaking herpetoculturist with my firsthand experience with three members of this genus, combined with salient excerpts from the English and German literature.

Aaron Bauer (1990) prefers to include three Australian forms under the subgenus Pseudothecadactylus. He differentiates these on the basis of a clawless digit I of the manus. By contrast, all digits are clawed in New Caledonian members of the genus. No further comments will be made relative to the subgenus Pseudothecadactylus.

The small island of New Caledonia is technically a French Overseas Territory located in the South Pacific almost equidistant between Australia and Fiji, and northwest of New Zealand. The central and eastern portions of this cigar-shaped island are more mountainous and humid than is the flatter, drier west coast. Although deforestation is widespread, a considerable area of primary and secondary forest remains. Since most Rhacodactylus live at various heights of medium and large trees, the greatest success in capturing these lizards stems from frequenting logging operations.

Captive reproductive success has been achieved in five of the six New Caledonian species. While my experience is confined to three members of the genus (R. auriculatus, R. chahoua and R. sarasinorum), a pertinent brief overview of the remaining taxa is in order.

The "prize" of any Rhacodactylus collection would be the large (SVL to 245 mm) (Bauer, 1990) R. leachianus. It is distributed primarily in the mountainous central portion of the southern half of New Caledonia and throughout its east coast. It is most commonly encountered at night high on the sides of large trees (Bauer, 1990). Bauer and Vindum (1990) also note that males were occasionally found on the trunk and lower branches of trees, while females usually remained in the canopy. Contrary to popular belief, R. leachianus is common in the wild (Bocage, 1881; Bauer, 1990). This does not tend to support the extremely high prices for these lizards relative to those species such as R. chahoua and R. trachyrhynchus, each only known from five localities (Bauer, 1990). While I have no experience with them, they have been captively reproduced both in the United States and in Europe.

Rhacodactylus trachyrhynchus is a fairly large species attaining a maximum snout-vent length of 170 mm (Bauer, 1990). It is the only viviparous gecko species outside of New Zealand. It has been successfully reproduced in Europe. Two young are born and at birth they are nearly half the adult length (Bartmann and Minuth, 1979; Meier, 1979). To my knowledge, R. trachyrhynchus has not been reproduced in the United States.

Rhacodactylus sarasinorum is a more gracile gecko attaining a snout-vent length of 125 mm (Bauer, 1990). It has been captively maintained and reproduced both in the United States and in Europe. There are two general color phases, a lighter marbled phase and a darker blotched phase. I have found this species to be no less hardy than R. auriculatus or R. chahoua. I have yet to have a female of reproductive size.

Rhacodactylus auriculatus, smallest member of the genus, is endemic to southern New Caledonia where it is frequently collected (Bauer and Vindum, 1990). Unlike the more arboreal species, it is often collected while crossing dirt roads in the evening hours (Bauer and Vindum, 1990). This species is common in captivity where it is easily maintained and breeds readily.

Rhacodactylus ciliatus is not well known, as all of the known specimens were collected in the nineteenth century. No reproductive data are available (Bauer, 1990).

At my facility, the maintenance and propagation of R. auriculatus and R. chahoua and maintenance of R. sarasinorum are nearly identical and will therefore be addressed collectively. Early captive husbandry was described by Robert Mertens (1964) who notes the predilection of R. leachianus for bananas, an observation shared by Aaron Bauer (1985) about R. chahoua. Bauer believes also that, in the wild, R. chahoua is probably omnivorous, taking insects, smaller vertebrates and fruits. The consumption of flowers and a bird has also been reported (Bavay, 1869; Roux, 1913). I have found that Rhacodactylus will adapt to a large variety of insects, small immature rodents, and fruits. I also supplement the diet by dusting the insect prey and Gerbers strained peaches baby food with a powdered vitamin-mineral mixture (one part Super Preen to one part Rep-Cal). I have also found that during periods of reproductive activity, adult females may consume this powdered mixture directly from a small dish placed in their enclosures.

In general, adult Rhacodactylus are easily sexed. The males have prominent hemipenile bulges distal to the vent which are lacking in females. Sexing is difficult in immature individuals. Caution is therefore advised in purchasing "predetermined" groups of immature Rhacodactylus for breeding purposes.

Breeding pairs or trios of one male and two females are housed in nonlighted plywood cages, the insides of which have been painted dark brown. Indirect, broad spectrum lighting in approximately 13-hour daily light cycles is provided. A removable framed glass front is secured by magnetic catches. The cages vary in size, but persistent reproductive success has been achieved in cages as small as that of a 10-gallon tank. For convenience, Astroturf or an equivalent is utilized as substrate, and two or three logs and sheets of stripped bark are provided for hiding sites. For oviparous species, an opaque nest box with 1/2"-deep vermiculite mixed with water until slightly moist is used. In addition, several large pieces of stripped bark are provided in a vertical position for climbing and horizontally on the Astroturf for hiding sites. As discussed earlier, a dish of vitamin-and-mineral supplementation is also placed in each enclosure. The room is subterranean, making it inexpensive to maintain an ambient temperature between 23°C (74°F) and 29°C (84°F).

Female R. auriculatus and R. chahoua lay clutches of one or two oblong leathery eggs. My preliminary data suggest that R. auriculatus breed throughout the year except for December and January, an observation also noted by Bauer and Vindum (1990). Egg deposition in R. chahoua is slightly more restricted to the warmer months (Fig. 1). Both species utilize the nest boxes for egg deposition. Rhacodactylus auriculatus nearly always bury their eggs, while R. chahoua nearly always deposit their eggs on top of the vermiculite (Tytle, 1992). All eggs are removed to an incubator preset to 29°C (84°F) and are placed on a slightly damp vermiculite substrate. At this temperature, R. auriculatus eggs should hatch in 41-59 days. I have found the incubation period in R. chahoua to range from 68-74 days. Henkel (1986) reports an incubation period of 42-48 days for R. auriculatus and 85 days for R. chahoua. During peak breeding times, R. auriculatus can produce clutches every 4½-5 weeks and R. chahoua can produce clutches every 6-7 weeks.

I have noted a relatively high percentage of both R. auriculatus and R. chahoua eggs to be infertile. This is particularly evident if the eggs are laid on the Astroturf rather than in the nest box. While fertile R. chahoua eggs nearly always hatch, about one-third of the viable R. auriculatus eggs fail to hatch. When opened the eggs are often noted to have dead term or near term overtly normal embryos. This was found as frequently in young as well as in older, reproductively active pairs. I have been able to further reduce this mortality by opening the second egg of the clutch if it has failed to hatch within 24 hours of the first unassisted hatchling. The etiology of this remains a mystery, although a poorly developed egg tooth could be responsible.

After hatching, the offspring are immediately removed from the incubator and placed individually into one-gallon jars with a newspaper substrate and small vertical branches or pieces of wood. A hiding site is generally not provided but may prove useful. They are misted daily and provided with appropriately-sized dusted crickets, wax worm larva, and strained peaches in a small dish. The uneaten excess is removed within 24 h. Both species grow rapidly, attaining near adult size in about a year. Viable eggs have been produced from my R. auriculatus in 14 months. My long-term experience in this area is more limited in R. chahoua.

While the procedures described here should be adequate to maintain and reproduce members of this genus, further refinement of captive husbandry and breeding techniques should certainly follow. Through collective interaction, such as provided by IHS and other like-minded organizations, I feel certain that they will be.

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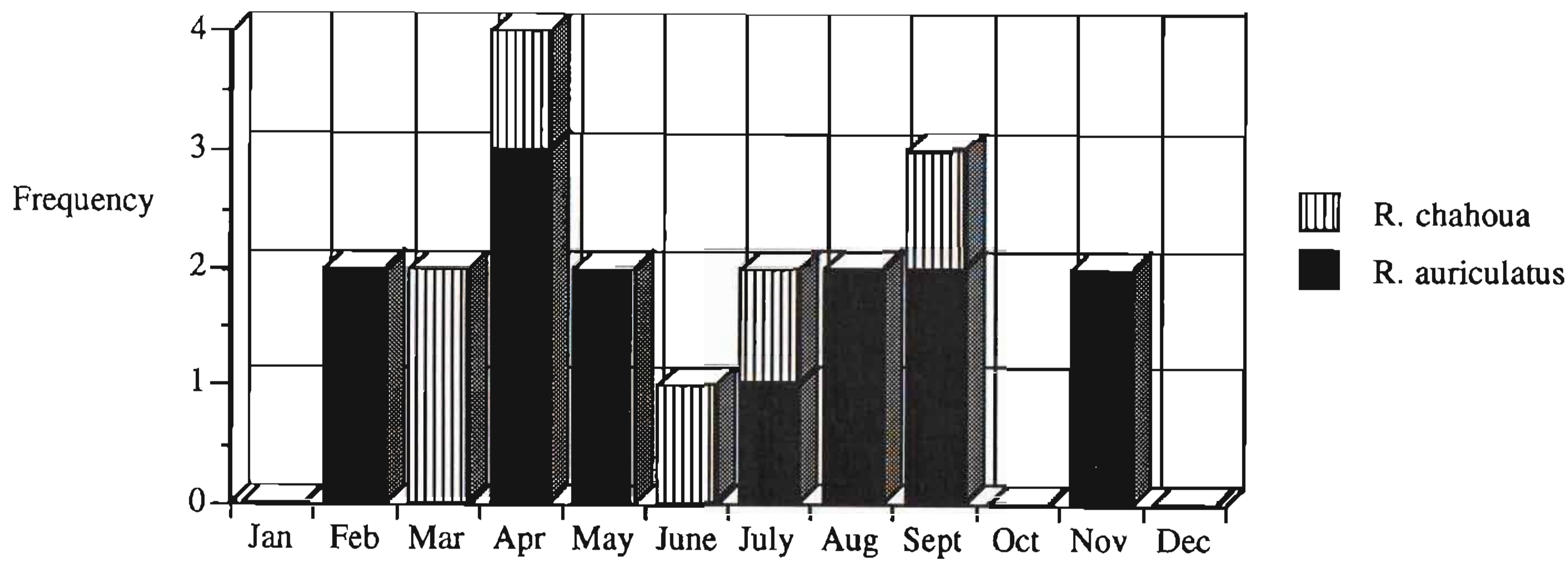
Tytle, T. 1992. The natural history and captive husbandry of the New Caledonian lizard genus Rhacodactylus. The Vivarium 3(6):32-36.

Clutch Deposition



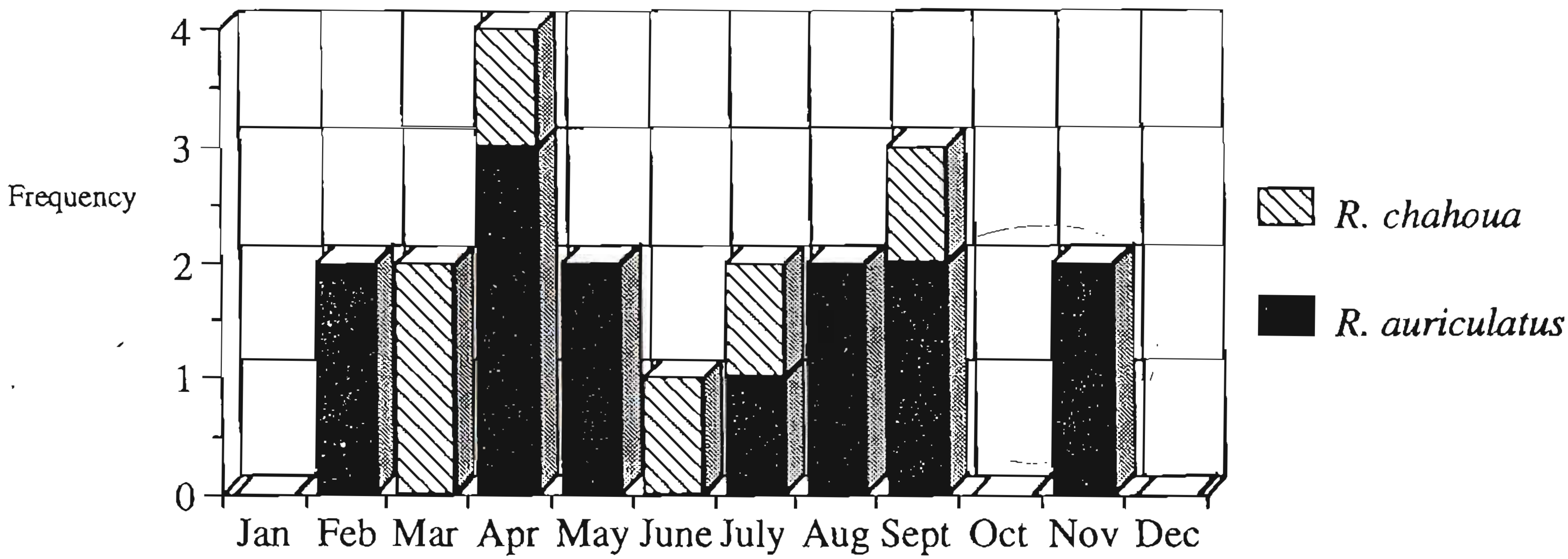


Figure 1. Frequency of clutch deposition for two species of *Rhacodactylus*. The frequency for each month represents the sum of that month's ovipositions over three years.

IN SEARCH OF THE TETE'CHEIN: OBSERVATIONS ON THE NATURAL HISTORY OF *BOA CONSTRICTOR NEBULOSUS*

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Abstract: The snake species *Boa constrictor* occupies one of the largest ranges of any land serpent. The reptile is deeply ingrained in the mind of the general public who frequently refers to any giant snake as a "boa constrictor." Considerable mention is made of *B. constrictor* in scientific literature but much of this is anecdotal or even fanciful. The species has figured significantly in the pet trade for decades. Still, the natural history of *B. constrictor* is virtually unknown and its taxonomic status poorly understood. Observations on the natural history and incidental notes on captive husbandry are presented here.

As might be expected with such a wide ranging species as *Boa constrictor*, many geographical races, or subspecies, have been assigned over the years. Several of these (constrictor, amarali, sabogae, imperator, occidentalis, nebulosus, orophias) are widely accepted, while others (melanogaster, ortonii, sigma, longicauda) are either considered invalid or highly questionable. These races in question may, in fact, be genuine entities deserving of subspecific recognition, but either insufficient evidence or poor taxonomic methods render these names inappropriate at this time.

Boa constrictors from the Lesser Antilles have been known for many years. Ditmars (1931) illustrated a "West Indian boa" and stated that it inhabited both St. Lucia and Dominica, and further elaborated that babies were sometimes inadvertently transported to neighboring islands with produce. Stull (1935) referred to boas from both St. Lucia and Dominica as Constrictor orophias. Upon examining the preserved head of a boa taken on Dominica by Samuel Garman, James Lazell of the Harvard Museum of Comparative Zoology (where Garman was previously employed) felt that he saw differences which warranted some investigation. Being familiar already with orophias from St. Lucia, Lazell decided to spend some time looking at boas on Dominica. In 1964, he described Constrictor constrictor nebulosus from Woodford Hill, the Commonwealth of Dominica. It was through my association with and the subsequent urging of James D. "Skip" Lazell that I decided to revisit Dominica 26 years later.

The island of Dominica is often confused with the Dominican Republic far to the north. Pronounced "dom-in-EE-ka," this tiny island is only 29 miles long and 13 miles wide. It lies in the Lesser Antilles north of Trinidad and the South American mainland.

Jutting out of gin-clear tropical waters, it is the tallest Caribbean island at almost 5000 feet on its highest volcanic peak. It receives over 300 inches of rainfall yearly, producing lush rain forest over most of its area, thus the nickname, "the Emerald Island."

Dominica was discovered by Christopher Columbus on November 3, 1493. He was impressed by its beauty but was unable to land on its rocky coastline. As he passed by on a Sunday evening, he named it Dominica for the day of the week. Although one of the poorest Caribbean nations, Dominica is rich in flora and fauna and leads many of its neighbors in its efforts to preserve its unique natural heritage.

In February of 1990, Robert A. Young, Tyler Miller, and the author spent eight days on Dominica observing and collecting herpetological specimens. Special emphasis was placed on the endemic Dominican clouded boa, now known as Boa constrictor nebulosus. During this time, we observed 15 adult nebulosus in the wild and examined another two very large females in a private zoo on the island. At the end of this time, having painstakingly acquired the proper permits, five adult pairs were exported to the United States. These specimens are housed in two facilities (TLV & RAY) and upon their deaths will be deposited at Harvard University and the University of Texas at Arlington.

Through the assistance of a local snake catcher who served as our guide, we were able to photograph, videotape, and capture the Tete'chein with some ease. The name "Tete'chein" is French for "dog head" and is used on both Dominica and St. Lucia. Nowhere did we hear any other names used, including "boa constrictor."

The Tete'chein has an unusual habit which it reportedly shares with the boas of St. Lucia whereas they tend to aggregate in small groups called a "cavalesche tete'chein" or loosely, a "snake tunnel." These dens were piles of rocks, a root system, or most frequently, a shallow undercut in a stream bank. The site is in full sun but shaded by tall sedges and grass. All were in the immediate vicinity of hot springs and sulfur gas vents along volcanic mountain streams. On a single occasion, we found a large, lone female, completely opaque in preparation to shed, basking in a patch of sunlight in the rain forest. All others were found in groups.

Most days during our visit were mild, ranging from the mid 80s (Fahrenheit) during the day and dropping to the 60s at night. Cool, moist ocean breezes made daytime activities quite pleasant, but cool nights limited our observations to the little geckos, Hemidactylus mabouia, which hung around the hotel hall lights. Most mornings were rainy until about 11:00 a.m., at which time the sun warmed things up and scattered clouds prevailed for the remainder of the day.

After about an hour long drive along narrow mountain roads, we would meet our guide and continue on foot. We hiked up beautiful creeks and rivers, always noting the large Anolis oculatus when we saw them. Of equal interest were the boiling springs and blowing gas vents along the way. Near these blow-holes, the rocks and vegetation were covered with yellow sulfur deposits and we soon learned how to hunt snakes with our noses! Here the boas set up their cavalesche. During our forays, we discovered three such aggregations numbering 2, 5, and 7 adult snakes. No offspring were observed on the trip.

These dens are very reliable and host snakes year round. It is reasonable to think that mating occurs here but the true reason for gathering is not understood. None of ours were in copula when they were discovered (boas often remain in copulation in excess of 48 hours) and the snakes remain here throughout the year. Our guide hunts the tete'chien for "medicinal" oil and is very familiar with its habits. He does not own a cage but simply visits his favorite cavalesche when he needs a snake, plucking out those that he wants and leaving the rest for a later date.

Within the cavalesche, we found the boas in close piles with heads resting on top. The boas were hooked or pulled into the open where we could work with them more easily. The snakes were quite hot to the touch as a result of coiling directly on the volcanically active soil. Each defended itself in typical boa fashion, hissing, striking, and releasing musk. Oddly, these snakes soon calmed down and a few hours later in our hotel room, we were handling them as if they were old pets.

Although Dominica lacks the big lancehead pitvipers (<u>Bothrops</u>) of nearby Martinique and St. Lucia, the people still fear their native tete'chien. It is often killed on sight. The Dominican Government discourages this practice and some individuals recognize the snakes' value as ratters, but old fears run deep. Boas routinely take fowl, which certainly doesn't help its reputation with the impoverished country folk. Like all Boa constrictor, nebulosus is sexually dimorphic in size, and additionally, color, and probably eye diameter. Males average 4 to 5 1/2 feet long, while females went from 6 to 8 1/2 feet. Males were slender and more distinctly patterned. Females were lighter gray, and except for the tail, were nearly patternless anteriorly. Very large, old females were virtually solid shiny black. Since size dictates diet, it is reasonable to believe that it is most often large females which tend to raid the henhouse. In the jungle, boas feed on birds, the native "manacou," or opossum (Didelphis m. insularis), and the introduced Rattus rattus. Juveniles may feed upon lizards, as well as small mammals.

The subspecific epithet nebulosus refers to the poorly defined or "nebulous" dorsal pattern of the race. After the island was colonized by hurricane waifs from the mainland, natural selection produced the more somberly colored snakes we see here now. Since this species is totally isolated from all other races and interbreeding does not occur anywhere, there exists a good case for elevating nebulosus (and orophias) to full species status.

After returning, fulfilling C.I.T.E.S and U.S. Fish & Wildlife obligations, and finally arriving home, we were pleased to see how well our new charges adapted to the captive state. The first morning after our return, 8 of the 10 boas accepted dead rats as food. By the next morning, the remainder had fed. They were housed initially in two groups (2.2 and 3.3) in standard wood and glass snake cages. Newspaper served as substrates and although hide boxes were provided, they were shunned. The snakes preferred to coil in piles much like we had found in nature. Each cage had a floor area of 2 x 6 feet. At one end, the floor was heated from beneath by means of an electric heating pad. Ambient temperature was maintained at 84 degrees fahrenheit and the snakes rarely utilized the hot spot provided.

All of the boas had ticks but none of them exhibited the "cauliflower" scarring on the heads and necks which ticks produce on B. c. constrictor from Guyana and Surinam. It is thought that mainland boas soak in pools to alleviate ticks. The ticks migrate to the snake's head and neck from under the water, forming concentrations (and perhaps infection) which produces the scarification. Dominican clouded boas were not observed in pools, and ticks were located randomly over the dorsum. Removal with forceps was effective. Internal parasites included tapeworms, roundworms, protozoans, and pentastomes. Metronidazole (250 mg/kg), Niclosamide (150 mg/kg), and Ivermectin (200 mcg/kg) was administered with good results. Pentastomes were forcibly expelled from the lungs within 30 minutes of receiving Ivermectin I.M. injection.

During the latter part of March, breeding activity began among the boas. This continued through most of April and four females exhibited distinct mid-body swelling. As is typical for Boa constrictor, this lump lasted for 36 hours, then redistributed along the posterior half of the female. Gestation lasted about four months with three litters (7, 9, and 11) in late July and August of 1990. The neonates were average in size (approximately 17 inches) and were more vividly marked than the parents. A fourth female dropped 13 infertile ova and one premature neonate in early July. The baby did not survive.

The offspring from all three litters were initially difficult to feed. Offspring from other races are quite hearty by comparison but these young, born from different litters in two different facilities, steadfastly refused food. All manner of fare was offered under a variety of conditions and ultimately most began feeding, seeming to prefer newborn rats while confined in a small container. Three refused food, and although great efforts were extended by experienced curators, they succumbed. Of the survivors, growth was rapid and unremarkable once feeding became regular.

Since the breeding of these naturally cycled wild captives took place in 1990, no new reproduction has occurred. Standard techniques used to stimulate breeding in other subspecies (winter cooling, precipitation, photoperiod manipulation, etc.) has been ineffective. One adult female has expired and was placed at U.T.A. All of the remaining 5.4 continue to thrive as of this presentation (6/92).

Acknowledgements

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OPHIDIAN PARAMYXOVIRUS

HISTORICAL OVERVIEW AND CURRENT RECOMMENDATIONS

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Abstract: Ophidian paramyxovirus has had significant economic impact on numerous zoologic and private collections since its identification as a pathogen in 1976. This brief retrospective analysis of documented outbreaks and recent research data may allow herpetologists to prevent or minimize losses from this etiologic agent. An outline of the clinical presentations, course of the disease and diagnostic tools currently available are included to aid identification of the infection. Recommendations on control, treatments and recent research on prevention via vaccination are presented. Finally, a brief discussion of paramyxoviral infections in other species is covered in lieu of further information on the ophidian type(s). Hopefully this will enhance understanding of this group of viruses and potential danger to wild populations.

HISTORY

One of the first well documented epizootics attributed to ophidian paramyxovirus (OPMV) occurred at a serpentarium in Switzerland in 1972, affecting 123 out of 431 Brazilian lanceheads (Bothrops moojeni). In fact, it was referred to as "Fer-de-Lance

Virus" until characterized as a paramyxovirus four years later (Clark, et al., 1976).

In 1980 the first well documented United States outbreak occurred in a breeding colony of rock rattlesnakes (Crotalus lepidus) producing eight deaths out of nine individuals. All affected members of this group exhibited neurologic abnormalities such as seizures, opisthotonos and loss of righting reflex (Jacobson,et al., 1980).

Also in 1980, the Louisiana Purchase Zoo experienced an outbreak in which 35/438 viperids were affected (Jacobson, et al., 1981).

In 1988 The Audubon Zoo lost 20 viperids with respiratory disease and histopathologic paramyxo - like lesions. Virus was also isolated from six of the necropsy specimens. An additional ten clinically unaffected specimens (both viperids and non - viperids) exhibited positive antibody titers to OPMV (Wells and Bowler, 1988).

In 1988 The Reptile World Serpentarium had 108/325 of the collection (multiple genera) affected by a viral epizootic attributed to OPMV (Van Horn, 1989).

Also in 1988, the Toledo Zoo experienced a die-off involving at least 11 animals, elapids and viperids. Interestingly, copperheads (Agkistrodon contortrix) in cages adjacent to mortalities were clinically unaffected. A pair of Russel's vipers (Vipera russelli) also nearby, appeared unaffected initially but became progressively emaciated in spite of a fair appetite, and had repeated bouts of gastrointestinal protozoal overgrowth. When one died approximately one year later, histopathology revealed lung lesions strongly suggestive of OPMV. Serologic testing found the cagemate to be positive for OPMV antibodies. The cagemate was removed from the building and used to infect two other species of viperids. Some animals died and others were kept alive through intensive supportive medical treatment. Seroconversion or death took as much as ten weeks indicating the inadequacy of a 60 day quarantine used by most institutions. Some of the specimens, in sharp contrast to reported outbreaks, lived for over a year while actively shedding the virus (Lloyd and Flannagan, 1991). Specimens which are capable of this type of reservoir status present the greatest obstacle to control of disease and are the greatest threat to a collection.

The Baltimore Zoo, as recently as 1990, lost approximately 75% of their quarantined viperids after acquiring a group of snakes from a Central American venom laboratory. Thanks to an excellent quarantine protocol, the exhibit collection was unaffected (Cranfield, personal communication).

These cases clearly point out the significant economic and epizootic importance of this disease. In most cases the exact source of the infection was undetermined. In some cases the incoming animals were the most severely affected. Therefore they may have acted as the indicator species rather than the source of the infection as they are often incriminated. The source may be within the collection in the form of OPMV resistant, clinically normal or chronic "poor-doer" animals shedding virus.

CONTROL

Quarantine

1. Quarantine susceptible species 90 days minimum (viperids, elapids, hydrophids?, insular species? all ophidians ?)
2. Minimum of two "clean" fecals before leaving quarantine (protozoal overgrowth often associated with chronic cases)
3. Monitor food consumption, weight, fecal output
4. Use virucidal disinfectants - footbaths, cages, cage props, tools (ex: 3% Na hypochlorite)
5. Separate tools for quarantine area
6. Serologic testing pior to release from quarantine (University of Tennissee Vet Diagnostic Lab)
7. Release only healthy, feeding animals from quarantine

General

1. Disinfect all tools and props between cages (hooks, hide boxes, etc.)
2. Destroy difficult to disinfect cage props after use (wood, cardboard, dirt)
3. Necropsy all deaths (histopath - lung, liver, kidney, spleen and save frozen serum pending histopath)
4. Serologic testing of all deaths with suspect histopath

Treatment

Careful thought should be given to the value of any specimen infected with OPMV in relationship to the potential risk to the collection. Animals deemed worth the risk should be sequestered from the collection and the air handling system thereof. Medical treatment consists of supportive care and treatment of secondary bacterial and protozoal pathogens. No specific antiviral treatment is presently available for OPMV.

DISCUSSION

To put the paramyxovirus (PMV) group in perspective, consider examples from mammal, avian and human medicine which have been researched extensively. PMV's are ubiquitous and diverse. Exotic diseases such as rinderpest of African hoofed stock and avian Newcastles disease are the reasons for the establishment of national quarantine stations. Endemic diseases include canine distemper for which we annually vaccinate our family dog, and at least ten avian parainfluenza strains. Like distemper and newcastles disease, OPMV can exhibit either respiratory or neurologic signs, depending on the tissue tropism of each case. Human respiratory syncytial disease, and even childhood measles and mumps, can be attributed to PMV's. Evidence suggests PMV 's may even cross orders. Avian parainfluenza strains 2 & 3 may have mutated from human or murine forms.

At this time, reptilian virology is in its infansy. Further research is needed to identify and characterize pathogenic strains. Modes of transmission and delineation of both affected and reservoir species are required for control. Considerable research has been focused OPMV but many questions remain unanswered. Most information has come from outbreak situations.
Post mortem samples have identified primary species affected and

organ tropism, but provide limited data on reservoir hosts. In order to prevent the disease, these hosts are critical to identify. Commercial availability of serologic testing may be the only reliable means of their identification. Fortunately, it is most likely available soon from the University of Tennissee Vet Diagnostic Lab. Dr Jack Gaskin, University of Florida, may be able to aid diagnosis in the event of outbreak but his resources and time are limited (Gaskin, et al, 1989). OPMV vaccine trials are currently underway but so far results are mixed (Flannagan,et al,1989). The danger of reintroduction of reservoir animals or chronic carriers and the epizootic potential cannot be overemphasized. For naive, susceptible species with limited ranges such as Aruba Island rattlesnakes (Crotalus unicolor) an outbreak, in theory, could eliminate the wild population. The utmost care should therefore be taken to insure only specimens free of disease are reintroduced back into the wild.

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REPTILIAN DYSTOCIAS: THE COMMON CAUSES AND RELATIVE TREATMENT SUCCESS

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Abstract: Reptilian dystocias in captivity occur in nearly 10% of the reproductive population according to a recent survey of approximately fifty institutions, including 1600 specimens. First, an examination of the causes and their relative importance including environmental factors, nutrition, maternal or fetal morphologic abnormalities, infection and oviductal compression allow insights into the relative treatment success and prevention of dystocias. Finally, a suggested flow chart of the appropriate management of reproductive females summarizes the prevention and treatment of reptilian dystocias as a concise reference for herpetologists involved in captive propagation.

Introduction

According to a recent study, reptilian dystocias occurred in nearly 10% of the captive population annually (Lloyd, 1990). Data is unavailable on incidence in the wild, but may be much lower due to natural selection. Left unresolved most would end in death of both the dam and offspring. The report included specimens from zoologic and professional herpetologic collections where a relatively high standard of veterinary and husbandry care were maintained. In spite of this fact the high incidence still occurred, leading to questions concerning the causes and potential prevention methods.Several trends were noted.

1) Less than 1% occurred in ovoviviparous or viviparous species therefore most can be considered "egg binding" in one form or another.

2) Crocodilians were conspicuously absent from the list of most common species experiencing "egg binding."

3) Squamates comprised about 20% of captive reptilian dystocias.

4) Ophidians and chelonians (chiefly terrestrial spp.) were involved in approx. 40%of dystocias each.

CAUSES

Environment

The captive environment was implicated in most (37%) dystocias as the primary cause. As a subcategory, inappropriate oviposition substrate was the most common problem. Reptiles, in sharp contrast to mammals, exert a large degree of "psychological" control over the initiation of labor, even though oviductal smooth muscle is primarily under involuntary hormonal control. Once labor has been initiated, mammal parturition must ensue within hours or a medical emergency is eminent. Reptiles, on the other hand, are affected by subtle environmental cues.The environment strongly influences reptilian hormonal levels and their concert of physiological and psychological effects. This allows them to select not only the best incubation conditions but also minimize potential neonatal predation, sometimes by even dividing clutch sites. Unfortunately, prolonged retention from inadequate environmental cues leads to egg-uterine adhesions, oviductal insensitivity to hormonal stimulation and general debilitation. There is no substitute for recreation of the natural oviposition environment. For example, species such as desert tortoises seldom lay eggs in deep leaf litter in the wild. Nocturnal species such as many geckos would be inhibited from laying if kept on a 24 hour light cycle. Newspaper and "astroturf" are unnatural substrates for any species. Temperature is certainly important to ectotherms and oviductal compression strength doubles within a range of 75 - 118 F (24 - 48 C) for some species of lizards (LaPoint, 1977). It is important to note however, that HIGHER temperatures are NOT necessarily associated with greater contractile strength. In fact, for those species with lower optimal contractile temperatures, their strength DROPPED precipitously at higher temperatures. In lieu of optimal temperature data for each species,the best environment is one with a thermal gradient to allow thermoregulation by the specimen itself. Ideally a gradient is provided in both the light as well as a thermal gradient in seclusion. This provides the specimen the ability to control its body temperature without leaving the area it feels most secure.

Nutrition

About one fourth (24%) of dystocias were believed to be the result of malnutrition. Due to difficulty in balancing the diets of herbivorous and insectivorous specimens, they were the most susceptible. Dietary calcium and calcium:phosphorus ratios were the most likely nutritional deficiencies associated with dystocias. Obesity is a form of malnutrition too. When obesity is coupled with poor muscle tone from a sedentary captive lifestyle, it too can lead to difficulty with labor. Proper hydration is essential for oviductal secretions and ova lubrication as well. If the drinking habits of gravid females are questionable misting or soaking should be employed. Compounding an improper diet, an artificially increased reproductive rate of several clutches per year and inadequate U.V.exposure for vitamin D metabolism were common in captivity. Recent research with green iguanas (Iguana iguana) indicated that even with preformed dietary or injectable vitamin D-3 supplements, serum levels of the vitamin were relatively unaffected UNLESS appropriate radiation was supplied (Bernard,et al.,1991).

Morphologic Abnormalities

Dysplastic oviducts and pelvic abnormalities account for another fourth (23%) of dystocias.Congenital fetal abnormalities, and infertile eggs add another few percent (3%). Often difficult to diagnose, a history of trauma, previous salpingotomy or absence of copulation should raise the index of suspicion for morphologic or congenital problems.

Oviductal Compression

Cited in only a small percent (7%) of the cases as the primary cause, compression is most often due to overfeeding gravid females late in gestation. Although females often become anorexic while gravid, this is not always the case.

Infection

In only a few of the cases (7%), oviductal bacterial invasion prevents proper oviposition. Prevention requires breeding only healthy animals, maintained under sanitary conditions.

TREATMENTS

In zoological collections most dystocias were successfully treated. Success was gauged by survival of the dam, since many were associated with infertile ova, dead fetuses, etc. It cannot be overemphasized that early intervention, moving from least invasive to most, has the fewest risks and the greatest promise of success.

Environmental Manipulations

Responsible for more than one fourth of the positive treatment outcomes, environmental manipulations also offered the greatest potential for prevention. Availability of oviposition substrate and the ability to thermoregulate are critical to labor initiation and completion. Other aspects to consider include but are not limited to; photoperiod, humidity, isolation (from conspecifics and humans), noise level and low frequency vibrations (footsteps, HVAC units, air pumps, adjacent cage cleaning, etc.).

Nutritional Supplementation

Supplementation at the time of dystocia occurrence is only occasionally successful. Prolonged malnutrition cannot readily be corrected by short-term treatments. Injectable calcium is sporadically effective but regular dietary supplementation, both prior to and during pregnancy can potentially prevent the dystocia.

Supplement examples:

Calphosan (Ca lactate 5mg/ml + Ca glycerophosphate)

    0.2 - 0.5 ml/kg every 72 hrs IM or SQ * 4 - 5 treatments

Nekton - Rep (multi vitamin/mineral supplement)

    Daily food dusting

Neo - Calglucon (Ca glubionate 30mg/ml)

1 ml/30 ml drinking H2O ad lib

Hormonal Induction

Oxytocin is the only widely-used labor-inducing hormone. Unfortunately it does not have an equal potency on reptilian oviducts as it does on the mammalian uterus. Several hormones stimulate oviductal smooth muscle contraction, including oxytocin, vasotocin, mesotocin and vasopressin. Synthetic vasotocin, available from Sigma Chemical, has been shown to be ten times more potent on isolated reptilian oviducts than oxytocin (LaPoint, 1977). For either oxytocin or vasotocin, efficacy is much greater when used prior to dystocia. One institution, the Columbus Zoo, using oxytocin to harvest eggs as soon as well calcified, achieved a 70% success rate. Once adhesions, uterine fatigue and inertia have undermined egg passage, few options except surgery are likely to work. If calcification is evident radiographically, or on palpation, little danger exists with early induction, other than a failed attempt to deliver.

DOSES:

Oxytocin	5 - 30	IU/kg	IV,IM
Vasotocin	0.01 - 1.0	mcg/kg	IV(preferred),IP,IM

(pretreatment with injectable Calcium for Oxytocin or Vasotocin is recommended)

RELATIVE

DYSTOCIA INDUCTION SUCCESS RATES

Oxytocin	19%
Vasotocin	73%

Furthermore, 18 % of those successfully induced with Vasotocin were treated unsuccessfully with Oxytocin during the same dystocia.

Percutaneous Ova Aspiration

Commonly employed in avian egg binding to collapse the egg and aid passage, it is less often used in reptiles (Harrison and Harrison, 1986). It is a viable alternative to salpingotomy or as a pretreatment for induction. The leathery shell of many species minimizes the risk of oviductal laceration from shell fragments. Negative aspects include the risk of peritonitis, scarring, damage to other internal organs and the loss of offspring. Usefulness is limited in chelonians, particularly large specimens. Inspissated ova and mummified or macerated fetuses do not lend themselves to aspiration. Even if the attempt fails the diagnostic value may be worth the risk itself.

Surgery

Although the most invasive, over half of the dystocias are managed by salpingotomy / caesarean section, most likely due to procrastination until no other treatments are affective. I firmly believe this preponderance could be greatly reduced by early initiation of less invasive options.

Conclusion / Recommendations

Each case is different but the most critical points are; provide the proper environment with emphasis on the appropriate oviposition substrate and anticipate problems and intervene early.

PREVENTION (the treatment of choice)

U.V. Radiation-----> MATURE <-------Thermal Gradient

Balanced Diet-------> HEALTHY <-------Substrate Availability

Hydration--------> SPECIMEN <-------Seclusion

DYSTOCIA TREATMENT (recommended in this order)

Misting / Soaking----> Injectable Ca Supplementation

----> Oxytocin / Vasotocin Induction

----> Percutaneous Ova Aspiration

----> Repeat Induction Attempt (may increase dose)

----> Salpingotomy/Caesarian

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PRELIMINARY COMMENTS ON THE GALAPAGOS TORTOISE *(Geochelone elephantopus)* PROGRAM AT THE OKLAHOMA CITY ZOOLOGICAL PARK

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INTRODUCTION

Galapagos tortoises (*Geochelone elephantopus*) have been in the Oklahoma City Zoological Park's ("OKC Zoo") collection since the mid 1960s. The tortoises produced a large number of eggs through the years, but none were fertile. In July 1988, I became a keeper at the OKC Zoo herpetarium and inherited the tortoise program of four males and four females. Many problems had to be addressed including social organization, diet and extremes of climate. In March 1990, the first successful hatching of a Galapagos tortoise at the OKC Zoo occurred. In this paper, I will review some of the methods thought to have contributed to the successful reproduction and rearing of the Galapagos tortoise. It is hoped that publication of these methods will contribute to greater success with the reproduction of captive giant tortoises.

HOUSING

Five areas are used to house the tortoises at the OKC Zoo. Two outdoor lots and an indoor "tortoise room" are part of the OKC Zoo's "Galapagos Exhibit." The south lot, a triangular-shaped area approximately 30m x 15m x 17m, is the largest lot and is covered by bermuda grass. Several trees provide shade throughout the day. On one side a stream, made out of gunite, carries water overflow from the indoor tortoise pool. A mud wallow is provided in the opposite corner.

The north lot is about half the size of the south lot, and for most of the spring is covered by a mixture of bermuda and fescue grass. A freshwater pool, approximately 3m x 1.5m, is located in this lot.

The tortoise room, located in the Galapagos building, houses the tortoises in the winter. This room is connected to the south lot and the north lot by separate tunnels. The tunnels can be barricaded to separate the lots. The tunnels are boarded in the winter to prevent the influx of cold air. The room is 15m x 3m and has a nesting area 2.5m x 1.5m filled with a sand/clay mixture to a depth of one meter. A pool located in this room is 22.5m x 1.5m wide and has tepid water running into it. The rest of the floor space is covered by 1-inch thick hard rubber tile. A skylight allows the tortoises to receive a natural photoperiod. The tortoises spend the months of November through April in this room, occasionally being let outside on warm days. The tortoises are brought back inside if the temperature drops below 13°C. They remain outside once nighttime temperatures stay above 13°C and daytime highs reach at least 21°C.

A fourth area, the "herp lot," is smaller than the north lot and is located adjacent to the herpetarium. This lot contains a mud wallow and seasonal vegetation. It is used to separate male tortoises for weight gain. There are no structures for shelter on this lot, so temperatures must be within the given parameters. Males are separated from the females from May until August.

The fifth lot, approximately 30m x 30m, came into use in 1991 and is used to separate females from males to facilitate weight gain. This lot has a shelter but no pool, so rubber tubs are used to hold drinking water. Females are housed there from May until July, at which time they are taken back to the Galapagos exhibit.

ENVIRONMENT

The summers in Oklahoma can be very hot, making it difficult to maintain consistent temperatures in the Galapagos exhibit. During summer months the outside air temperature can exceed 38°C. For this reason, the tortoises are provided with mud wallows. When the outside temperature is 31°C, the tortoises become inactive, resting in the mud wallow or lying under a daily stream of water from a lawn sprinkler.

The winter temperature can remain below freezing for several days at a time. The tortoise room is heated by a thermostatically controlled gas furnace and ideally gives the tortoises an air temperature of 26°C. Radiant heaters, mounted two meters above the ground, provide two 29°C basking areas at opposite ends of the room.

DIET

The daily tortoise diet consists of a mixture of kale, mustard and collard greens, endive lettuce and 16 chopped carrots. Three times a week the tortoises are fed six oranges, cut into quarters. One-half teaspoon of vitamin powder mixture, consisting of equal parts Osteoform and Theralin and three cups of moistened dog food are offered to the tortoises twice a week. In the summer the tortoises also graze on the various grasses and weeds found in the exhibits.

Alfalfa and prairie hay are provided at all times throughout the winter months. A specially designed feeder holds the hay in the top part, while the greens and carrots are contained in the bottom (see Fig. 1). By keeping the hay in the top part, the tortoises can feed at their leisure, the hay stays dry and clean, and hay waste is minimized.

Rodents and Nebraska Brand® Feline Diet were fed to the tortoises from April 1989 to November 1989 as an experiment to see how the tortoises would react to meat and the response was overwhelming. The tortoises became very aggressive towards me and each other, fighting to get at the meat. The mice were buried under a pile of salad and the tortoises would push aside the salad to get at the mice. Once a week each adult is fed four to six dead adult mice and occasionally a small to medium rat. Average adult mice can be swallowed whole by an adult tortoise; however, large mice and rats must be torn into pieces before being eaten, the offensive sight of which prompted discontinuation of rodents in the diet in November 1989.

The feeding of rodents was resumed in February 1991. (Please see the diet section under DISCUSSION.)

REPRODUCTION

"The reproduction of the Galapagos tortoise was recognized as a conservation priority in 1980 when the Galapagos Islands exhibit was opened. The realization of this goal rests on the contributions of many dedicated people" (Grow 1990).

The Tortoises

Male -07: "Max" is now the largest and dominant tortoise and has been most frequently observed copulating.

Male -06: "Abercrombie" is a high-domed shell tortoise and only has occasionally been observed achieving copulation.

Female -01: "Debbie" is the most passive of all the females and has been observed copulating most frequently with male -07.

Female -08: "Spike" has been seen digging the most false nests. She has also been seen trying to copulate with other females in the group, complete with mounting, thrusting, and grunting.

Female -10: "Tortilla" is the dominant female and has been observed copulating with male -07.

Female -12: "Miss Ellie," on loan from the Dallas Zoo, somewhat resembles a saddle-backed tortoise. She lays the largest eggs of any of our tortoises. Only one successful copulation with male -07 has been observed and copulation with male -06 has never been observed.

Separation and Reintroduction of Tortoises

In April 1989, the females were placed on the south lot and the males on the north lot. On 3 August 1989, male combat was noted between -07 and -06. Male -07 rammed -06 head-on several times. The two males briefly raised their heads, then -06 withdrew into his shell. Male -07 then charged -06 laterally a few times before moving to the rear of -06 and apparently attempting copulation. This continued for about an hour until -07 moved off. On 4 August 1989, both males were feeding next to each other with no signs of hostility nor were there any signs of combat for the next few days. On 8 August 1989, male -07 was again mounted on top of male -06, appearing to try to copulate. This behavior prompted the removal of the barriers between the two lots allowing the males and females access to each other.

On 9 August 1989, male -07 was mounted on female -01 and she appeared to be trying to raise up off the ground, perhaps to allow penetration by -07. Copulation was successful, lasting 15 minutes. The air temperature at the site was 27°C at 10:30 am. The previous night's low was 16°C. After copulation, -01 moved into the mud wallow and remained there the rest of the day. Male -06 was still on the north lot at that time. The temperature of the mud wallow was not recorded.

On 10 August 1989, copulation between male -07 and female -12 was observed. Copulations and attempted copulations were seen throughout August and into September. There were no successful copulations observed between male -06 and any of the females at this time.

Egg Laying

The tortoises were brought inside in October 1989 for the winter. On 13 November 1989, 12 eggs were found in a nest directly under the radiant heater. Temperature of the nest was not recorded (temperatures from later nests in 1990 and 1991 were in the range of 26° to 29°C), the nest was approximately 30 cm deep and was damp. The smell of urine was quite noticeable and fecal material was also found in the nest. The eggs were round and white with patches of sand adhered to them. Most of the eggs ranged in size from 55 cm to 60 cm in diameter and 58 cm to 69 cm in length. Weights of the eggs ranged from 119 to 130 grams. The eggs were removed from the nest for artificial incubation.

Egg Incubation

The eggs were placed in 30 cm x 15 cm x 11 cm deep plastic shoeboxes filled with vermiculite to a depth of six cm. The vermiculite was moistened with water at a ratio of 1:1 by weight. Six eggs were placed in each box and buried three-quarters of the diameter of the egg. The eggs were incubated at 29°C. Because yolk sacs on the first few hatchlings were so large at the time of hatching at 29°C, incubation temperature for later clutches was lowered to 27.5°C. This seemed to produce positive results as yolk sacs on later hatchlings were somewhat smaller.

Weights of the eggs have varied dramatically from 49 to 149 grams. There have been no fertile eggs recorded weighing less than 82 grams.

According to Moss (personal communication), eggs can be candled to determine fertility, with a dark spot at the top of the egg indicating fertility. Further into incubation the spot appears to encompass the egg. Until recently, all eggs with the spot were determined to be fertile. However, some of the eggs of the 1991-92 season appeared to have the spot but proved to be infertile. It is not known what caused the spots. At the time of writing, 40 eggs were incubating from four different clutches. At 2 weeks of incubation, 26 of the eggs had the spot. After 120 days of incubation, only 11 eggs appear to be fertile. Incubation periods have ranged from 94 to 134 days. This season more eggs ruptured during incubation (that is eggs that oozed, leaked or caved in) than in either of the previous 2 years. All combined, 1991-92 eggs that ruptured were incubated at 29°C. The 11 apparently fertile eggs are being incubated at 27.5°C.

Hatching and Raising of the Juvenile Tortoises

On 21 February 1990, an egg pipped and then cracked open revealing a small, black, wrinkled tortoise (see Table 1 for weights and incubation periods). Seven hatchlings were produced at the OKC Zoo in the 1990-91 season. Initially, the young tortoises were placed in a large aquarium with a rabbit (alfalfa) pellet substrate, but this could not be cleaned properly. Life Fellowship recommended that we try corrugated cardboard as they have had considerable success raising tortoises on this substrate. After a short time of using cardboard, we decided that the tortoises had insufficient traction and cardboard was discontinued.

We next tried sand which seemed to work well until radiographs showed large amounts of sand in the gastrointestinal tract of the young tortoises. This was a concern, but after several soakings in lukewarm water, the tortoises passed the sand without any apparent side effects. The youngsters are now maintained on the same padded tile provided for the adults.

All the young tortoises are growing at a fantastic rate. They are fed a diet similar to the adults, plus mixed thawed frozen vegetables. Diet composition was not strictly monitored. Initially babies were fed twice a day using a flat pan approximately 15 cm by 30 cm. The pan was covered evenly with the diet. At about 3 months of age, it was noticed that there was a depression in the plates on the top of the tortoises' shells. Suspecting insufficient protein, insects were added to the diet. Waxworms were accepted readily, so 15 to 20 were put in the cage two or three times a week to be consumed by three hatchlings. All worms disappeared quickly. After about a month of feeding worms, the first tortoise to hatch was found gasping and subsequently died. Although there was a substantial number of waxworms in the intestine, the cause of death was not determined; however, this particular tortoise seemed to have consumed most of the waxworms. Waxworm feeding was reduced to three to five worms per tortoise twice a week. The depressions in the shells disappeared after about 6 weeks. Whether feeding worms resolved the problem or the shells just grew and filled in the depressions was not determined.

The juveniles seemed to be growing well until we received two juvenile tortoises from Life Fellowship. The largest of the new arrivals was hatched in October 1989. This animal was only slightly larger than our oldest baby hatched in March 1990 (see Table 2 for size comparison), but Life Fellowship's tortoises had smooth carapaces. Our tortoises showed slight pyramiding of plates on their carapaces. Now suspecting too much protein, waxworms were discontinued immediately but to no avail. The tortoises still have some pyramiding of their shells. In fact, because their growth rate accelerated at the OKC Zoo, the Life Fellowship tortoises have developed some pyramiding as well.

The diet did not seem to have too much protein. Visiting colleagues assured us that the tortoises' shells were growing just fine. The conclusion is that the tortoises grow so fast when fed generously that their shells distorted somewhat with this pyramiding effect. Currently one tortoise is on a strict diet of only 250 to 300 grams of food per day, as opposed to the more generous portions offered to the other tortoises. Diet composition was not strictly monitored and although this tortoise is growing slower than the other tortoises, its shell appears to be growing without pyramiding.

DISCUSSION

Several factors are thought to have contributed to our successful reproduction of Galapagos tortoises.

HOUSING and ENVIRONMENT - In previous years, the female tortoises were separated from the males so they could lay eggs in a nesting area located in the back of the Galapagos building. Access to this area was difficult for the females because the door is several inches smaller than the width of the tortoise. For a tortoise to enter this area, she had to be tipped up on edge to fit through the door. Additionally, the roof leaked sometimes allowing the nest area to be covered with cold rainwater, extinguishing any inclinations of laying eggs. It was difficult to maintain a temperature suitable for tortoises to lay eggs.

These problems were resolved by abandoning the inadequate nesting area and utilizing the primary nesting area in the indoor tortoise room. Females could enter this area at their leisure when they felt compelled to lay eggs. No tipping on edge or stressful handling was involved. This area was well heated and the tortoises soon selected a nest site underneath the radiant heater. All clutches of eggs except one have been laid within a one-meter circle on the ground directly under this heater.

There was also a hierarchy problem in previous years. The then-dominant male -02 exhibited breeding behavior but would sometimes mount the wrong end of the wrong sex. He also harassed other males and prevented them from breeding. In May 1989, -02 and male -05 were isolated from the rest of the group except during winter when they were returned to the exhibit. With the removal of -02 and -05, male -07 soon exhibited dominance.

DIET - When females were placed in the back nesting area for winter, their food intake was very low. The previous keeper stated that at times, when the females were located in the back, they might only eat one or two carrots each for several days. By keeping the females in the inside tortoise room where they could maintain a higher temperature, they consumed food at the same rate as in summer enabling the females to maintain their weight.

Our yellow foot tortoises (*Gechelone denticulata*) did not produce fertile eggs until they started eating the meat portion of the diet intended for the rhinoceros iguanas (*Cyclura cornuta*) that shared the enclosure (Wheeler, personal communication). Rats and mice were fed to the Galapagos tortoises in the past, but not with any regularity. After eliminating rats and mice from the diet in 1989, fertility went down to only two fertile eggs the following year. After rats and mice were added back to the diet, fertility increased with 11 fertile eggs just hatched. A Galapagos tortoise has been observed killing and eating two rats and a pigeon in the wild. This same tortoise was also suspected of killing and eating a macaw and an agouti that shared his enclosure (Loveridge, 1945). Galapagos tortoises have been observed at the Philadelphia Zoo preying on feral pigeons (Barrie, personal communication). Perhaps more meat(protein) is needed in the diet of the Galapagos tortoise than commonly thought.

Because the weeds grow so thick on the herp lot, we place the two males there during the summer to take advantage of the additional food source. By having access to such vegetation, the males are less destructive to the foliage in the north lot when they are returned. The same is true for the females being moved to the animal management lot in the spring to feed on the weeds. The females are brought back to the south lot in early July so they can again become comfortable with the lot before breeding season.

REPRODUCTION - Historically, male tortoises would spend most of the day trying to breed with a female in the mud wallow, driving the female down into the mud. This appeared to create stress for females experiencing depressed appetites after such attention from the males. In the past, the females were separated from the males to lay their eggs, as well as to enhance the males' inclination to breed when reintroduced to the females in the outdoor lots in the spring. The females had to fend off advances by the males at a time when they needed to gain weight. After some discussion, it was decided to keep the animals separated from each other until August and then remove the barriers separating the lots and allow the tortoises to find each other at their leisure.

After copulations between male -07 and the females, the females would retreat to the mud wallow where they would remain for several hours to a day or more. Because temperatures during August and September in Oklahoma can be high, using the mud to thermoregulate may allow the sperm to live longer in the female and have a greater opportunity to fertilize the egg. The staff at the Honolulu Zoo "felt the soft mud might conceivably exert some effect on fertility" (Throp, 1969).

During the past 3 years, none of the females have actually been observed laying eggs, although some have been seen digging false nests. Because so many tortoises have access to the nesting area, it is difficult for the staff to see nests. This year, when preparing the nest area for egg laying, potting soil was added to the river sand to facilitate locating the nests. This was done by digging a hole in the sand to a depth of about 40 cm, mixing potting soil with the sand in the bottom of the hole, then filling in the hole with sand. Only the area in the prime nesting spot directly under the heater was prepared. The area was checked daily for any signs of potting soil on the surface. When potting soil was discovered, we would begin digging carefully in the area until the eggs were located. Some eggs have been damaged in the past when exact nest locations were not known. The procedure worked well. Only once did we find potting soil on the surface of the sand and no eggs below and this year, using the potting soil method, only one egg out of four nests was damaged.

CONCLUSION

Whether or not any of the individual changes made in husbandry, diet, or housing were responsible for the Galapagos tortoise reproduction at the OKC Zoo has yet to be determined. However, it may be appropriate to accept the success of hatchling tortoises for 3 consecutive years as good evidence of the efficacy of our methods in general.
The reduction of stress for the females certainly helped. The mud wallow seems to be a common denominator in most of the copulations. Without rodents in the diet, there were no fertile eggs. The first time rodents were fed, four fertile eggs were laid. After discontinuing rodents and keeping all other parameters the same, fertility dropped to two. After restarting the rodent feedings, we have 11 fertile eggs.

An interesting observation we have made is nest guarding by females. When we dig for eggs, an individual female will investigate our activity. Sometimes the female will actually sit on the nest, preventing us from digging. All of the females have demonstrated this behavior. This year, four clutches were laid and all four females demonstrated this behavior.

One problem we experienced in raising the juveniles was their tendency to crawl up on the food plate to eat, then defecating on the food. This problem was solved (at least temporarily) by using a dish strainer basket with the tabs bent down on the side of the basket. The tortoises are able to feed without being able to walk on their food.

Two eggs from the clutch of 11 that just hatched were special. When these two eggs were laid, they each had a chip in the shell about the size of a quarter but the inner membrane was intact. Using Elmer's white glue and a paper towel, a patch was made to cover the chips. Both of these eggs were incubated in the same way as the rest of the clutch. One egg pipped and revealed the tortoise inside. The other egg was manually opened and also contained a live tortoise. Candling these eggs revealed a large air pocket in each egg that took up half of the space inside the egg. Both tortoises hatched but were deformed and died a few days later.

Whatever the reasons for our success, we hope that other institutions might be able to use these techniques to enhance the reproductive success of Galapagos tortoises as well as other tortoise species. No one should assume that their animals are stagnant and will not reproduce. Consider the details of your management program, and of course, as David Grow says, "Never give up."

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PRODUCTS MENTIONED IN THE TEXT

Nebraska Brand® Feline Diet: Central Nebraska Packing Co. North Plat, Nebraska 69101

Osteoform: A calcium, phosphorus, and vitamin supplement manufactured by Vet-A-Mix, Inc., Shenandoah, IA 51601.

Theralin: A vitamin supplement manufactured by Lambert Kay, Division of Carter Wallace, Cranbury, NJ 08512-0187.

Elmer's School Glue: A white glue made by Borden Inc., Columbus, OH 43215.

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Table 1 - Weights and Incubation Periods for Hatchlings

Hatchling #	Date Egg Laid	Date of Hatch	Days Incubating	Length at Hatch in mm	Weight at Hatch in Grams
-13	13 Nov 89	21 Feb 90	101	NA	75
-14	13 Nov 89	21 Feb 90	101	NA	72
5212-15	10 Nov 89	2 Mar 90	113	NA	70
5274-16	11 Feb 90	7 May 90	94	66.42	68
5423-19	NA	NA	NA	NA	NA
5480-20	4 Nov 90	4 Feb 91	95	58.7	49
5586-21	6 Mar 91	18 Jul 91	134	67.03	56
-22	8 Jan 92	21 May 92	134	70.6	85
-23	8 Jan 92	21 May 92	134	68.2	80
-24	8 Jan 92	21 May 92	134	69.9	81

Table 2
Growth Comparison Between OKC Tortoise and Life Fellowship Tortoise

Tortoise	Owner	Date	Length mm	Weight	Days Old
5212-15	OKC	12 Oct 90	131	486 gr	228
5399-17	LFBS	12 Oct 90	145	476 gr	365
5212-15	OKC	30 Jan 91	155	789 gr	333
5399-17	LFBS	30 Jan 91	170	1118 gr	479
5212-15	OKC	22 Dec 92		7 kg	1,024
5399-17	LFBS	22 Dec 92		13 kg	1,170

The Small Pythons of Australia

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Along with the large, often spectacular pythons found in Australia, there are also the four smaller species of python. These are the Children's python *(Liasis childreni)*, the spotted python *(L. maculosus)*, the Stimson's python *(L. stimsoni)* and the ant–hill python *(L. perthensis)*. In the past, these four species were not distinguished, and were often lumped together as the Children's python. This paper discusses the characteristics of the species and details their distribution as presently defined. Also, an attempt was made to assign specific name and geographic origin to specimens in U.S. herpetological collections.

The spotted python, *L. maculosus,* is found in coastal Queensland from the Torres Strait south nearly to the New South Wales border and is found on numerous islands off the Queensland coast (Smith, 1985). It has a dark gray and brown background with large irregular spots of dark gray or brown. The spotted python is distinguished from the Children's python and Stimson's python because of its dorsal pattern of chocolate–brown, ragged–edged blotches which tend to join anteriorly and posteriorly, often to form a broken zig–zag stripe on the dorsum (Smith,1985). The spotted python is the largest member of the Children's python group. Hoser (1989) reports that the spotted python can reach a length of two meters. The largest specimens of spotted pythons come from Northern Queensland (Hoser, pers. com.).

The spotted python is the most common of the four species being kept in U.S. collections, although the snakes are often referred to as Children's pythons. Many published reports on the breeding of Children's pythons may actually refer to specimens now designated as spotted pythons. A probable reason for the predominance of spotted pythons in U.S. collections is because they are found in Australia's most heavily populated areas and consequently are encountered more frequently than the other species. Also, the Taronga Zoo has exchanged specimens of spotted pythons with American zoos (Fischer, pers. com.).

The Children's python, *L. childreni*, is found in the Northern Territory, west of the Cape

York Peninsula. It is highly variable in color, but is distinguished from the spotted python and Stimson's python by having little or no dorsal pattern as an adult. Color pattern, if present, consists of small, irregular, smooth–edged, purplish–brown blotches moderately or barely contrasting with the ground color of the snake (Smith, 1985).

Currently, there are specimens of Children's pythons in the United States, although many specimens being bred as "Children's pythons" are actually spotted pythons or hybrids resulting from a spotted python – Children's python mating. Generally, Children's pythons are much smaller than spotted pythons as adults.

The Stimson's Python, *L. stimsoni*, is the third member of the Children's python complex. The Stimson's python is divided into two subspecies; the western Stimson's python, *L. stimsoni stimsoni*, and the eastern Stimson's python, *L. stimsoni orientalis*. The western Stimson's python is confined to coastal Western Australia while the eastern form occurs throughout the Northern Territory, New South Wales, Southern Australia, Western Queensland, and the Eastern parts of Western Australia. In Western Australia, there is a natural integration area between both subspecies (Smith, 1985). In addition, both subspecies naturally hybridize with Children's pythons where their ranges overlap.

The eastern Stimson's python, *L. stimsoni orientalis*, has bold, reddish–brown, smooth–edged transverse bars (Smith, 1985). The western Stimson's python, *L. stimsoni stimsoni*, has irregular patterns, dominated by round blotches (Smith, 1985). Toward the eastern margins of the territory, the patterns begin to resemble that of *L. stimsoni orientalis*, becoming transversely elongated and darker in overall coloration (Smith, 1985). *L. stimsoni stimsoni* also differs from *L. stimsoni orientalis* by having fewer ventral scales (243–284 vs. 260–302) (Smith, 1985). *L. stimsoni orientalis* can reach 1.5 meters (Gow, pers. com.).

The ant–hill python, *L. perthensis*, is the smallest python in the world. It occurs in the Pilbarra region of Western Australia. The species has a known length of 25 inches. It has a red color that varies in intensity. Specimens may be patterned similarly to Children's pythons. Hoser (1989) reports that his captive bred ant-hill pythons had visible patterns (similar to *L. childreni)* that faded with age to resemble their wild caught parents from Shay Gap, Western Australia. Ant–hill pythons are often patterned with light markings on the mid–body scale rows, although this characteristic can vary in intensity with geographic location. Ant–hill pythons are visibly different from the spotted and Stimson's Pythons by their lack of dorsal patterning as adults. They are distinguished from the Children's python by their smaller size and fewer midbody and ventral scales (31–35 and 212–250 vs. 36–46 and 251–300 as per Smith, 1985).

The Ant–hill python lays a small number of eggs. The clutch size varies from 2 to 5 eggs (Hoser, pers. com.). In the first captive breeding of the ant–hill python, 2 eggs were laid (Hoser, 1989).

The Children's Python Complex

Originally, all the forms of the spotted and Stimson's python were classified under *L. childreni*. The different "color phases" were thought to be only geographic variations of the widespread Children's python. The ant-hill python was considered a subspecies of the nominate form, being referred to as *L. childreni perthensis*.

Smith's 1985 revision of the Children's python complex and proposed recognition of the discussed four species is widely accepted. Recent authors such as Hoser (1989, 1991, 1992), Shine (1991), Kortlang (1989), and Barnett (1987) have used Smith's proposed revision of the Children's Python in recent publications.

As might be expected, other herpetologists disagree with Smith's proposed revision of *L. childreni*. Some feel that future work may demonstrate *L. stimsoni* and *L. maculosus* to not be valid species (Banks, pers. comm.).

One specific criticism of Smith's revision is that he had difficulty in assigning specimens from Queensland to a given species (Hoser 1991; Fyfe pers. com.). The specimens in question tended to come from areas where three species (*maculosus, stimsoni orientalis,* and *childreni*) occur, indicating the possibility that all three species hybridize in the wild. This appears to be true, as both Hoser (1991) and Fyfe (pers. comm.) have seen wild Queensland specimens that are similar in characteristics to both *L. stimsoni orientalis* and *L. maculosus*. Fyfe (pers. com.) has also recently inspected wild specimens that had characteristics of both *L. childreni* and *L. stimsoni orientalis*. In contrast, ant–hill pythons do not hybridize with Children's pythons even though are often found sheltering in termite mounds together in Western Australia (Hoser, 1981).

A second criticism of Smith's revision comes from the fact that, without locality data, it is impossible to distinguish with certainty between *L. childreni* and *L. maculosus*. This is because of extreme overlapping in the range of the scale counts provided in the revision.

An example of this occurred when I met with Harvey Fischer, Curator of Reptiles at the Los Angeles Zoo, to try to decide if a certain specimen in his collection was an example of *L. childreni* or *L. maculosus*. We counted both labial and midbody scales. Our results showed that the snake in question was a spotted python by its labial's but a Children's python in its midbody scales. The snake in question had the typical pattern of *L. maculosus*.

The ambiguities demonstrated by this snake may illustrate geographic variation within the complex not accommodated by Smith's revision. Perhaps they demonstrate possible hybridization that has taken place inadvertently in captive populations. Such are the problems of propagators who wish to identify their specimens.

Conclusion

Australian herpetologists, when presented with photos of U.S. specimens of the Children's python complex, were unable to reach concencus regarding the identity of 11 out of 15 specimens. The probable fact is that most U.S. specimens are the result of breeding animals of unknown geographic origin. These animals should, in the future, be managed as domestic lineages, not representative of any geographic origin.

Not until future legal shipments of specimens of known similar geographic origin be imported into the U.S., will it be possible for U.S. collections to maintain specimens of certain origin and species. I think that the best reason to preserve Laurie Smith's classifaction of this group is to establish standard identification criteria which would allow responsible breeders to maintain relatively pure genetic lines.

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Thursday June 25, 1992

8:00 am - 7:00 pm	**Registration Open**
8:00 am - 8:30 am	**Opening Remarks:** -Ed Tunstall, St. Louis IHS Coordinator -Harry Steinmann, Host Committee Chair -Brian P. Backner, M.D., President, IHS, Inc.
Moderator: Richard A. Ross, M.D., M.P.H.	
8:30 am - 9:00 am	**Global Change and the Past, Present and Future of Herpetofauna** -Jim McMahon, Ph.D., Dean, College of Science, Utah State University, Logan
9:30 am - 9:55 am	**Rosy Boas (*Lichanura*): Current Taxonomic Controversies** -David E. Spiteri, Alta Loma, California
9:55 am - 10:20 am	**Lizard Egg Incubation Techniques: How to Increase Hatching Success, and How to Control the Sex, Size and Color of Your Hatchlings** -Brian E. Viets, Department of Biology, Indiana University, Bloomington, Indiana
10:20 am - 10:30 am	**Break**
10:30 am - 10:55 am	**Species Survival Plans: It's the Breeding and a Whole Lot More** -Robert J. Wiese, Ph.D., AAZPA Conservation Center, Bethesda, Maryland
10:55 am - 11:20 am	**Husbandry and Natural History of *Rhacodactylus*** -Tim Tytle, M.D., Private Breeder, Oklahoma City, Oklahoma
11:20 am - 11:45 am	**Natural History and Captive Husbandry/Propagation of the Rare Chinese Frog, *Rana schmackeri*** -Phillipe de Vosjoli, Advanced Vivarium Systems, Lakeside, California -Robert Mailloux, Advanced Vivarium Systems, Lakeside, California
11:45 am - 1:30 pm	**Lunch**
Moderator: Michael J. Uricheck, Ph.D.	
1:30 pm - 1:55 pm	**The Amphibian Fauna of Australia** -Michael J. Tyler, Ph.D., Dept. of Zoology, University of Adelaide, Australia
1:55 pm - 2:20 pm	**Preliminary Comments on the Management of the Galapagos Tortoise, *Geochelone elaphantophus*, at the Oklahoma City Zoo** -Carl Sandefer, Department of Herpetology, Oklahoma City Zoological Park
2:20 pm - 2:45 pm	**Captive Propagation of the Southeast Asia Spiny Turtle, *Heosemys spinosa*, at Zoo Atlanta** -Dennis W. Herman, Department of Herpetology, Zoo Atlanta, Atlanta, Georgia
2:45 pm - 3:10 pm	**Reptilian Dystocias -- Common Causes and Relative Treatment Success** -Mark Lynn Lloyd, D.V.M., Roger Williams Park Zoo, Providence, Rhode Island
3:10 pm - 3:35 pm	**Sex Determination of Reptiles by Fluid Injection** -Ken Foose, Virginia City, Nevada -Mark Ditzworth, D.V.M., Reno, Nevada
3:35 pm - 4:00 pm	**Break**

Thursday June 25, 1992

4:00 pm - 5:00 pm	**WORKSHOPS: TO RUN CONCURRENTLY:**
	Varanids
	-Michael J. Uricheck, Ph.D., Western Connecticut State University, Danbury, Connecticut
	-David Grow, Curator of Herpetology, Oklahoma City Zoo
	Turtles and Tortoises
	-Brett Stearns, Institute for Herpetological Research, Stanford, California
7:00 pm - 10:00 pm	**Icebreaker**
	-Cash Bar
9:00 pm - 10:00 pm	**Slideshow Contest**
	-Presented by John Tashjian. Get the highest number of right answers and win free registration to the next two IHS meetings!

Friday June 26, 1992

8:00 am - 7:00 pm	Registration Open
Moderator: Ed Tunstall	
8:30 am - 8:55 am	**Indian Herpetology and the Madras Crocodile Bank**
	-Romulus Whitaker, Director, Madras Crocodile Bank, Madras, India
8:55 am - 9:20 am	**Notes on Three Island Populations of *Boa constrictor* in Belize**
	-Bob Sears, Wingate, Texas
9:20 am - 9:45 am	**The Brown Tree Snake, *Boiga irregularis*, in Guam: Controlling the Spread of the Reptilian Mongoose of the South Pacific**
	-Sean McKeown, Curator of Reptiles, Chaffee Zoological Gardens, Fresno, CA
9:45 am - 10:10 am	**Observations on Incubation, Diet, and Sex Determination in Hatchling Tortoises**
	-Richard Fife, Phoenix, Arizona
10:10 am - 10:30 am	**Break**
10:30 am - 10:55 am	**The Nutrition of Herbivorous and Carnivorous Reptiles**
	-Mary E. Allen, Ph.D., National Zoological Park, Washington, DC
10:55 am - 11:20 am	**Establishing a North American Turtle Collection at the Tennessee Aquarium**
	-David Collins, Curator of Forests, Tennessee Aquarium, Chattanooga
	-Gregory George, Herpetologist, Tennessee Aquarium, Chattanooga
11:20 am - 11:45 am	**Old World Chameleons: Collecting, Captive Breeding, and Conservation**
	-Gary Ferguson, Ph.D., Texas Christian University, Fort Worth, Texas
11:45 am - 1:30 pm	**Lunch**

Friday June 26, 1992

Moderator: David Hulmes

1:30 pm - 1:55 pm	**Declining Amphibian Populations: Insights and Possible Causes** -Alan Pounds, Ph.D., Monteverdi, Costa Rica
1:55 pm - 2:20 pm	**The Gastric Brooding Frog** -Michael J. Tyler, Ph.D., Dept. of Zoology, Univ. of Adelaide, Australia
2:20 pm - 2:45 pm	**In Search of Tete'chien: Observation on the Natural History of *Boa constrictor nebulosa* with Notes on Captive Care** -Terry L. Vandeventer, Clinton, Missouri
2:45 pm - 3:10 pm	**The Effects of Stress on Lizards and Its Application to Captive Management** -Dale DeNardo, D.V.M., Department of Integrative Biology, UC Berkeley, CA
3:10 pm - 3:35 pm	**The Green Anaconda, *Eunectes murinus* (Linnaeus, 1758) in Captivity: Maintenance, Reproduction and Neonatal Growth** -Pete Strimple, Reptile Research and Breeding Facility, Cincinnati, Ohio
3:35 pm - 4:00 pm	**Break**
4:00 pm - 5:00 pm	**WORKSHOPS: TO RUN CONCURRENTLY** **Rattlesnake Roundups: Getting Involved** -Bob Sears, Wingate, Texas **Dendrobatid Frogs** -Dale Bertram, M.D., ISSD, Madison, Wisconsin
7:00 pm - 8:30 pm	**Banquet** -Cash Bar
8:30 pm - ???	**The Herpetofauna of the Amazon Rain Forest** William Lamar, University of Texas, Tyler, Texas
??? -- ???	**Auction**

Saturday June 27, 1992

9:00 am - 3:00 pm **Registration Open**

Moderator: Harry Steinmann

9:00 am - 9:25 am	**Nutritional Considerations in Feedings Reptiles (Calcium and Vitamin D)** -Duane E. Ullrey, Ph.D. and J.B. Bernard, B.S. Department of Animal Science, Michigan State University, East Lansing -Mary E. Allen, Ph.D., MI & Baer Associates, Inc., Olney, Maryland
9:25 am - 9:50 am	**Fiat Lax: Some Characteristics of Lamps Used in Herpetoculture** -William H. Gehrmann, Ph.D., Natural Sciences Department, Tarrant County Junior College, Fort Worth, Texas
9:50 am - 10:15 am	**The Use of Enrofloxacin in Reticulated Pythons** -Brian P. Backner, M.D., President, IHS, Inc., Sharon, Massachusetts -Roger J. Klingenberg, D.V.M., Greeley, Colorado

Saturday June 27, 1992

10:15 am - 10:30 am	**Break**
10:30 am - 10:55 am	**Aspects of the Natural History of the Genus *Bothriechis* in Costa Rica** -Alejandro Solorzano, Instituto Clodomiro Picado, Universidad de Costa Rica, & Serpentario Tropical, San Jose, Costa Rica
10:55 am - 11:20 am	**The Children's Python Complex** -Brian Kend, Palos Verdes Estates, California
11:20 am - 11:45 am	**The Herpetology of Trinidad and Tobago** -Hans E. A. Boos, Director, Zoological Society of Trinidad and Tobago, Inc., Emperor Valley Zoo, Port of Spain, Trinidad
11:45 am - 1:00 pm	**Lunch**
1:00 pm - 2:00 pm	**WORKSHOPS: TO RUN CONCURRENTLY** **Fecal Analysis** -Richard S. Funk, M.A., D.V.M., Brandon, Florida **Legislative Preparedness** -Phillipe de Vosjoli, President, American Federation of Herpetoculturists, Lakeside, California -Jeffrey Nunan, Legislative Action Coordinator, American Federation of Herpetoculturists, Lakeside, California
2:00 pm - 2:15 pm	**Break**
2:15 pm - 3:15 pm	**Workshop: Reptilian Nutrition** -Duane E. Ullrey, Ph.D., Michigan State University, East Lansing, Michigan -Mary E. Allen, Ph.D., National Zoological Park, Washington, DC
5:00 pm	**Buses Leave for St. Louis Zoological Gardens**
7:00 pm	**Barbecue at The Living World**
8:30 pm	**Buses Return to Hotel**
9:00 pm - ???	**Hospitality Room Open**

Sunday June 28, 1992

9:00 am - 9:45 am	**State of the IHS Report** -Brian P. Backner, M.D., President, IHS, Inc.
Moderator: Brian P. Backner, M.D.	
9:45 am - 10:35 am	**The Herpetofauna of Baja California and the Sea of Cortes** -L. Lee Grismer, Ph.D., Department of Biology, San Diego State University
10:35 am - 11:00 am	**Ophidian Paramyxoviruses - Historical Overview and Current Recommendations On Control** -Mark Lynn Lloyd, D.V.M., Roger Williams Park Zoo, Providence, Rhode Island
11:00 am - 11:15 am	**Break**

Sunday June 28, 1992

11:15 am - 12:00 pm	**Snake Venom Poisoning: First Aid and Medical Management** -Findlay Russell, M.D., Ph.D., University of Arizona, Health Sciences, Tucson
12:00 pm - 1:30 pm	**Lunch**
Moderator: David Hulmes	
1:30 pm - 1:55 pm	**Mitochondrial DNA Analysis of Box Turtle Systematics** -Patrick Minx, LGL Ecological Research Associates, Bryan, Texas
1:55 pm - 2:20 pm	**Old World Chameleons: Growth Under Laboratory Conditions** -Larry G. Talent, Ph.D., Associate Professor, Oklahoma State Univ., Stillwater
2:20 pm - 2:45 pm	**Vipers of the Caucasus: A Molecular Approach to Systematics and a Zoogeographical Reveiw** -Matts Hõggren, Uppsala University, Uppsala, Sweden -C. Andrén, University of Gõteborg, Gõteborg, Sweden -G. Nilson, University of Gõteborg, Gõteborg, Sweden -N.L. Orlov, Zoological Institute, Russian Academy of Sciences, St. Petersburg -B.S. Tuniyev, Caucasian State Biosphere Reserve, Sochi, Russia
2:45 pm - 3:10 pm	**Status of the Indian Python in India and Captive Breeding for Release** -Romulus Whitaker, Director, Madras Crocodile Bank, Madras, India
3:10 pm	**Presentation of the Josef Laszlo Award** -Louis Porras, ZooHerp, Inc -Richard A. Ross, M.D., M.P.H. -Brian P. Backner, M.D.
3:15 pm	**Closing Remarks** -Ed Tunstall, St. Louis IHS Coordinator -Brian P. Backner, M.D., President, IHS, Inc.