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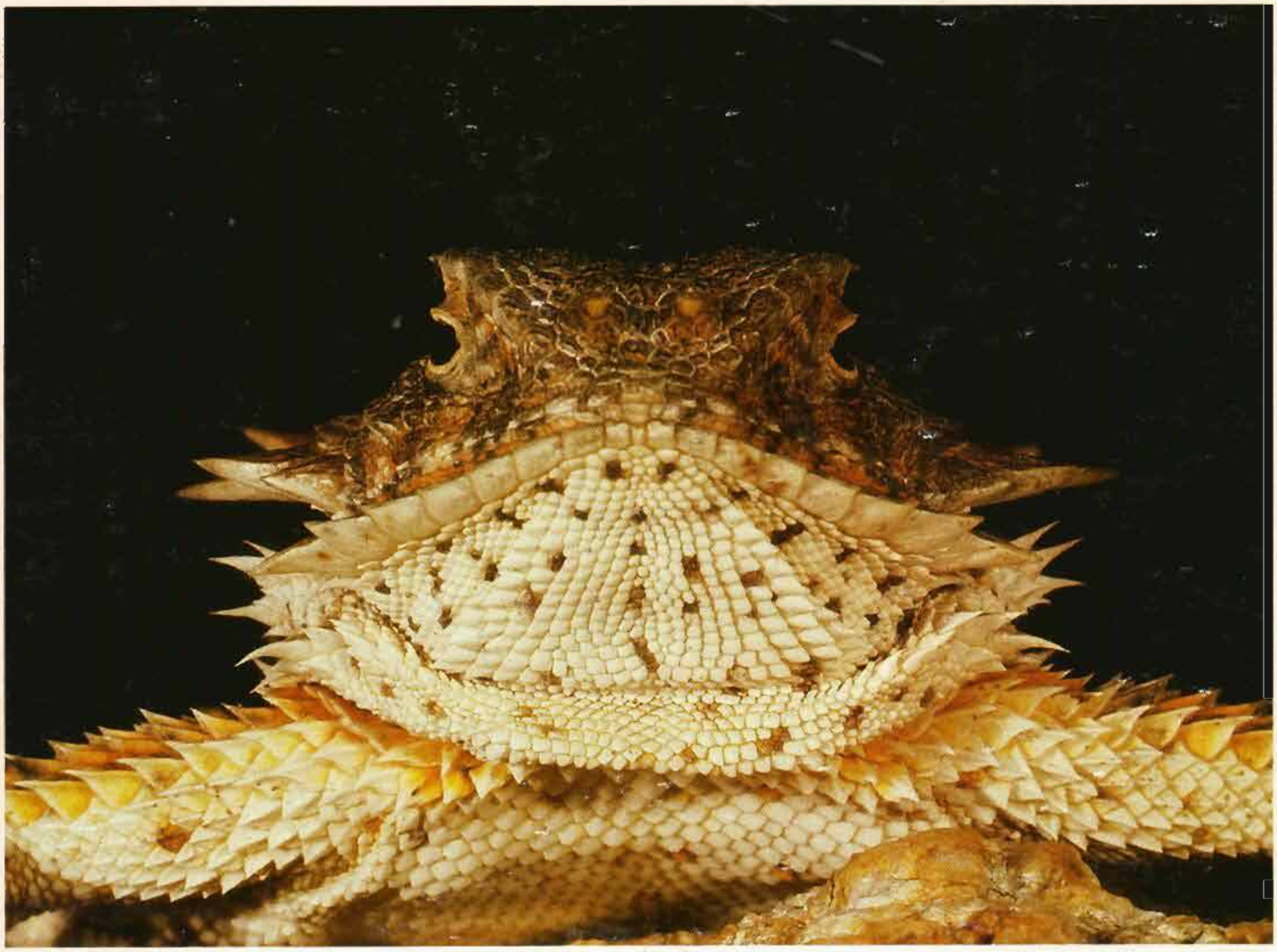

PHOENIX, ARIZONA
June 20-24, 1989

EDITED BY
MICHAEL J. URICHECK, Ph.D.

PROCEEDINGS OF THE

13TH INTERNATIONAL HERPETOLOGICAL SYMPOSIUM on Captive Propagation And Husbandry

PHOENIX, ARIZONA

JUNE 20-24, 1989

Edited by
Michael J. Uricheck, Ph.D.
WESTERN CONNECTICUT STATE UNIVERSITY

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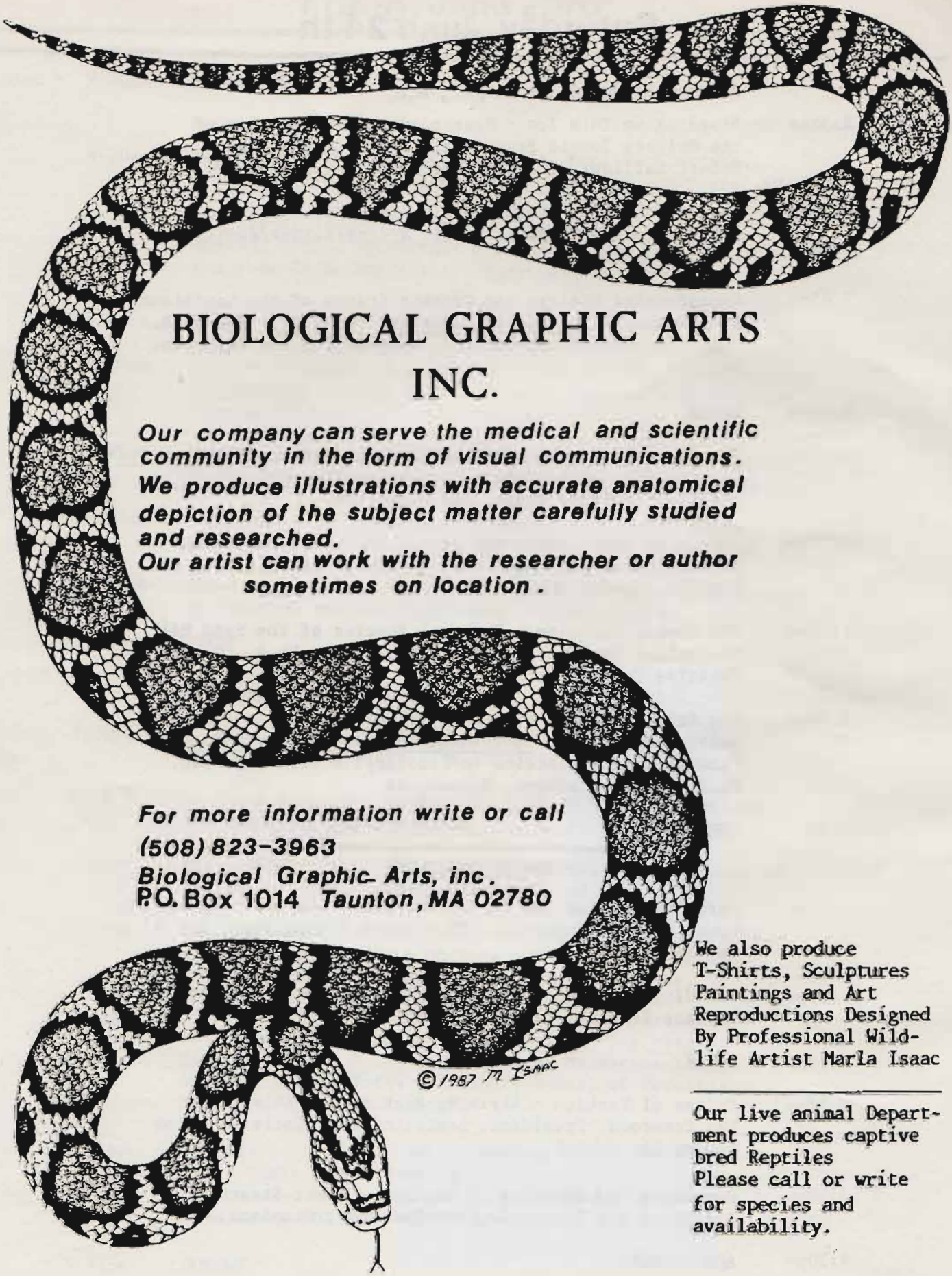

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CONTENTS

INTRODUCTORY COMMENTS

Though it seems almost cliché, the decade of the 1990's will hold the greatest challenge ever to confront herpetology. As tropical deforestation and species exploitation continue, captive propagation may hold the only chance of survival for many species. The International Herpetological Symposium was originally conceived as a form for "amateur" and "professional" herpetologists to share information and experiences on captive propagation and husbandry. As such, the flow of information the IHS represents looms ever more important for species survival as we enter this crucial decade.

By 1988, however, the ability of the symposium to draw participants from the widely varied backgrounds needed to sustain it had been called into serious question. In response to these questions and to become more adaptable to the needs of the future, the "International Herpetological Symposium on Captive Propagation and Husbandry" became the International Herpetological Symposium, Inc. Federal non-profit status and the establishment of long range planning and financial goals are changes soon to follow that will further enhance flexibility and viability.

The less obvious concern to the IHS has been the controversy recently raised by "professional" herpetologists regarding "anecdotal" data reported by "amateurs." Anecdotal data, that which is observed in uncontrolled or unexperimental situations, has long been discounted by pure scientists in fields such as physics and chemistry.

Now, concerns regarding the validity and value of these observations have been raised by publications such as Herpetological Review. Some of the papers contained in the following pages might therefore be denounced as being unscientific or uncontrolled. However, these papers represent but a fraction of the value of an IHS meeting. Even as the need for formal research and large-scale, multi-national projects, such as the Species Survival Plan Book, increases, so too does the need for networking and the free exchange of ideas. Following Phoenix, the IHS is alive and well! We hope to see ALL interested and concerned herpetologists in Dallas and beyond.

Brian P. Backner, M.D.
Symposium Coordinator

ACKNOWLEDGMENT

It was a pleasure working with all the people who helped make this publication a reality. Compliments must go to Mrs. Sandra Thompson, whose word processing expertise and enthusiasm for the project helped produce such a high quality product.

Michael J. Uricheck, Ph.D
Proceedings Editor

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PHOENIX, ARIZONA
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BACTERIOLOGY IN WILD AND WAREHOUSED RED-EARED SLIDER TURTLES: *Trachemys scripta elegans*

Barbara B. Bonner, M.S. (*), Denise Eng, Oded Feingold

ABSTRACT

The bacteriology of three sites was examined in wild and warehoused red-eared slider turtles *Trachemys scripta elegans*, in order to determine whether these sites are sterile in the turtle and to evaluate differences in prokaryotic colonization between the two groups. The blood, the peritoneal cavity and the urinary bladder were sampled aseptically; the samples drawn were cultured aerobically and all bacteria recovered were identified. Anaerobic inoculation into rich media was made and the presence of anaerobic growth was noted. The data collected from the wild turtles is consistent with the hypothesis that these sites are generally sterile in healthy animals. The data gathered from both groups revealed striking differences between the wild and the warehoused turtles. The warehoused turtles demonstrated significantly higher numbers of all types of bacterial flora in each site sampled. Supplementary data drawn on all animals suggests strongly that the warehoused turtles were severely comprised by polymicrobial colonization.

Biological supply companies in this country receive and warehouse wild-caught reptiles and amphibians for resale to educational institutions. Aquatic turtles, particularly the red-eared *Trachemys scripta elegans* are a major component of this industry.

The primary turtle market for biological supply companies is threefold. The turtles are sold alive as dissection and research specimens. They are injected with colored latex while still living to form preserved specimens. The remainder die in house and are sold as articulated or disarticulated skeletons. Turtle shells and skulls are also sold individually and as part of vertebrate comparison sets.

The greatest profit comes from the sale of skeletons, the least profit comes from selling living animals, so the motivation to provide care for the living is questionable. Laws ensuring minimal standards of care for warehoused poikilotherms are unenforceable or nonexistent.

Physical examination and observation of warehoused *T. s. elegans* at one biological supply company revealed the following conditions:

1. Wasting, emaciated animals
2. Hemorrhagic regions on the carapace and plastron
3. Sloughing of the keratin on the carapace and plastron
4. Full and partial peripheral paralysis
5. Slowed cardiac and respiratory rate
6. Overall lethargy and apathy
7. Swollen, inflamed eyes, often with purulent drainage
8. Respiratory problems: wheezing, open-mouth breathing, epistaxis
9. Open lesions on limbs and head; generally poor skin tone
10. Diarrhea: blood, mucus, and living and dead worms in stool

11. Mylasis
12. Algal overgrowth on skin and shell lesions
13. Fungal colonization
14. Marked anorexia in spite of full food selection and attempts at forced feeding.

Initial attempts to rehabilitate a group of eighteen warehoused adult *T. s. elegans* by improving environmental conditions, revising and supplementing their diet, and subsequently by administration of intraperitoneal gentocin administered with Ringer's Lactate were largely unsuccessful. Mortality with in the study group was 5-8 animals/week. Overall mortality exceeded 95%.

In order to discover why this figure was so high, we hope to conduct a long-term, thorough analysis and documentation of the health of warehoused *T. s. elegans* in relation to their wild counterparts. This analysis will include examination of nutritional status, bone density, nonbacterial parasites, aerobic and anaerobic bacteriology, and ultimately, development of extensive treatment protocols for intensive care and rehabilitation of seriously ill chelonians.

An obvious application of such research concerns the protection status of *T. s. elegans*. The second attempt to have the red-eared slider listed on Appendix II of CITES (Convention on International Trade In Endangered Species) was recently submitted. That proposal included the following facts:

1. 100,000 adult female turtles are removed from the wild yearly to replace breeding stock on turtle farms.

2. During a six month season, tens of thousands of adult wild red-eared turtles are captured each week in Louisiana, Mississippi, Arkansas, and Texas; most of these turtles are shipped to markets in the Far East for use as food.

3. According to industry representatives, wider areas are currently being exploited to satisfy demands for adult red-eared turtles as replacement stock or food items.

4. Declines in populations of red-eared turtles have been noted by turtle farmers; surveys of turtle habitat in Louisiana have substantiated these declines. (Donna Hart, personal communications).

If the adult breeding stock in Louisiana are being depleted to the point of serious concern, and the data supplied by biological supply houses regarding the numbers of animals they furnish from Louisiana to meet orders does not fully account for the estimated animals taken from the wild (as is the case), it may be important to establish facts about the mortality and morbidity of warehoused animals compared to their wild counterparts. This data can then be used to provide a groundwork upon which intelligent conservation and management decisions can be made.

The first component of the planned long-term study is this research, a comparison of the bacteriology of three sites in the warehoused animals and in a wild control group. The sites chosen for analysis are the blood, the urinary bladder, and the peritoneal cavity; these sites were chosen because, if inferences from mammals and birds are correct, these sites in reptiles should be sterile except in case of infection.

The literature on the bacteriology of turtles encompasses a wide range of studies and perspectives. Analyses of the resident flora of specific body sites have focused primarily on enteric bacteria isolated from the intestine or cloaca, and include the work of McCoy and Seldeler (1972), Jackson et al. (1969), and others. Collectively, this work identifies *Arizona, Citrobacter, Edwardsiella* and *Salmonella* as resident indigenous non-pathogenic flora of the healthy turtle.

The *Salmonella* research of the late 1960's and early 1970's established that Salmonella is shed by farmed and captive animals. This work also demonstrated that wild turtles do not necessarily carry enteric *Salmonella* (Baker et al. 1972); Feeley and Traeger (1968); Kaufman et al. (1966, 1969, 1972); Lamm et al. (1972), Otis and Behler (1973) and Hoff and White (1977)). While *Salmonella, Arizona* and some species of *Edwardsiella* are known to be pathogenic to humans and other animals, in the uncompromised chelonian host, these bacteria do not seem to be pathogenic. *Citrobacter freundii,* however, has been identified as the causative agent of septicemic cutaneous ulcerative disease, or SCUD (Kaplan 1957).

Opportunistic and overt pathogens have been described in studies of specific disease processes, in epidemiologic analyses of outbreaks in wild populations, and in necropsy studies. Collectively these sources have enumerated bacteria isolated from abscesses, infectious stomatitis, gastroenteritis, respiratory diseases and shell disease. Extensive studies fulfilling Koch's Postulates are not always done, thus, in some cases, demonstrated colonization by a specific organism is dependent upon circumstantial data showing signs of malaise in the animal colonized by the bacteria that either lead to its death, or that are then relieved upon treatment and elimination of the organism form the affected site to implicate that organism as pathogenic.

Direct and indirect data implicate the bacteria of the genera *Aeromonas, Mycobacteria, Pasturella, Pseudomonas,* and *Serratiatia* as pathogenic opportunistically pathogenic for turtles (Hoff, Frye, & Jacobsen, 1985). Less commonly isolated genera include *Actinobacillus, Bacteroides, Beneckea, Clostridium, Enterobacter, Escherichia coli, Gemella, Klebsiella, Peptostreptococcus, Proteus, Staphylococcus,* and *Streptococcus.*

To our knowledge, a survey in turtle of sites that are accepted as sterile in mammals and birds has never been attempted. The primary goal of this research is to examine the bacteriology of three different body sites in two populations of red-eared sliders. Outgrowths of that objective include establishing methodology which will permit accurate sampling, culture, and bacteriological identification of cultured organisms in the selected sites, as well as standard antibiotic sensitivities of cultured organisms.

MATERIALS AND METHODS

Turtles

We obtained thirteen warehoused adult *T. s. elegans* from Connecticut Valley Biological Supply Company (Southampton, Massachusetts). Eight wild adult *T. s. elegans* were supplied for the study by Dr. Richard Seigel of Southeastern Louisiana University (Hammond, Louisiana). The turtles received were representative of the populations to be compared.

Upon arrival, each group was acclimated to conditions in the University turtle room for ten days. On the tenth day the animals in each group were examined by the project veterinarian and initial cultures were drawn.

All turtles were housed individually in 54.6 cm x 43.8 cm 13.3 cm autoclavable plastic tubs. The tubs contained 5-10 cm. of water, which was changed at least once a day. The temperature of the water (and to some extent the room) was controlled by individual heating pads placed so as to warm one half of the turtle tub. After initial adjustments in set-up and design, temperatures were generally maintained in the range 21°C-30°C.

Two months into the study, all animals were provided with a combination of full spectrum and black light (John Behler, personal communication). The lights were adjusted to a height approximately 30-45 cm above each turtle. The lighting system was placed on a timer providing 14 hours of light in each 24 hour period, approximately what the turtles were receiving from room light prior to the establishment of the lighting system. As needed, the turtle tubs were reinforced with plexiglass walls to stymie wanderers.

The food selection available included ReptoMin Floating Food Sticks, trout chow, cat food supplemented with bone meal, crickets, and greens rich in calcium. Each animal was allowed to eat to satiation. Initially, this required daily feedings; as the animals adjusted to the diet and availability of food, the frequency of feeding was cut back to 2-3 times a week.

The overall health and appearance of each turtle was recorded weekly; more often if the animal had problems requiring special attention. Items monitored included general vigor, food intake and excretory activity. The turtles were weighed at 6-8 week intervals. Extensive photographic documentation of each animal upon admission and intervals thereafter provided a visual record of disease progress or reversal.

Any animals demonstrating bacterial growth from cultured samples **and** signs of illness as determined by our behavioral index were treated with antibiotics to which the cultured organisms were sensitive. Medication dosages were calculated using the Minimum Energy Cost Method developed by Charles Sedgwich, DVM. Animals too weak to eat or take medication were tube-fed high calorie diets and the appropriate medications until they accepted forced feedings or began to eat on their own. Animals suspected of being dehydrated were given supplementary fluids by enema, in amounts based on calculated daily fluid requirements. Turtles demonstrating extraordinary health problems beyond those described were evaluated and treated in conjunction with the Wildlife Clinic of Tufts University School of Veterinary Medicine. Such problems included blood, peritoneal and respiratory fungal and yeast colonization, superficial skin lesions, deep tissue abscesses, eye infections, pneumonia and other respiratory fungal and yeast colonization, superficial skin lesions, deep tissue abscesses, eye infection, pneumonia and other respiratory difficulties, broken bones and shell disease.

All turtles had blood smears made upon admission and at intervals throughout the study. Microscopic evidence compatible with blood parasites was noted. All visible parasites sloughed cloacally and any potentially interesting tissue sloughed or debrided was preserved in 10% formalin and labelled for future analysis.

Sampling techniques

The blood samples were drawn aseptically from peripheral vessels using a sterile small bore needle. Urine samples were drawn after palpation suggesting a urine-filled bladder by aseptic cystocentesis. Peritoneal fluid was sampled by inserting aseptically a sterile catheter (IV Tygon #20 x ¼"). After insuring correct placement of the catheter, approximately 10 ml. of sterile physiological saline was injected into the peritoneal cavity. Holding the catheter securely in place, the turtle was tipped back and forth several times, and as much of the injected fluid as possible was withdrawn into a sterile syringe for culture. All sample sites were disinfected alternatively with betadine solution and rubbing alcohol 5-7 times prior to drawing the sample. Each sample site was also redisinfected after sampling.

Bacteriology (aerobic)

Each sample was plated onto sheep blood agar plates and either Hektoen or MacConkey plates in duplicate. One plate of each duplicate set was incubated at 35°C, and the other at room temperature (approximately 25°C). Plates were examined after 24 and 48 hours. As bacterial growth appeared, isolated colonies were streaked out onto blood agar to obtain pure cultures. Gram staining and other preliminary tests were done as dictated by standard protocols. Each aerobic isolate was then explored to specification.

Identification of *Enterobacteriaceae* to the subspecies level was achieved employing the API 20E System (Sherwood Medical). Identification of non-fermenting bacteria similarly employed the API 20E as well as the Rapid NFT System (also Sherwood Medical). Gram-negative rods not identified by rapid test methodology were speciated by standard biochemical analysis.

Isolated Gram-positive cocci were grouped as *Micrococci, Staphylococci* or *Streptococci* based on standard catalase, oxidase and lysostaphin results. They were then subspeciated using StaphTRAC and RAPIDStrip Identification Systems (Sherwood Medical). Gram-positive rods and Gram-negative cocci were isolated and identified to the species level, following protocols established in the ASM Manual of Clinical Microbiology.

Replicate slants of each isolate were made and stored under refrigeration; replicate vials were flash-frozen and stored at -80°C.

Bacteriology (anaerobic)

Each sample was immediately inoculated into Anaerobic Blood Culture media (Fisher Scientific) and either Thioglycollate media or Anaerobic Chopped Meat media (Scott Laboratories). Turbidity was used as the indicator of growth. Cultures showing turbidity were maintained for future preservation and identification.

RESULTS

We were unable to obtain urine samples from the wild turtles on the designated sampling date; for the purposes of comparison, only blood and peritoneal samples will be analyzed. Both sets of animals were to undergo a two week acclimation period prior to the first set of cultures. Three of the warehoused animals died in the first 9 days. The project veterinarians felt the health of the remaining warehoused animals was extremely fragile. For this reason, all animals were sampled on the 10th day. Treatment was begun immediately for those animals needing medication.

The total number of bacterial isolates from the wild turtles was 14 organisms isolated from 5 sites in 4 turtles. The warehoused animals yielded 49 isolates from 14 sites in 10 turtles.

Three wild turtles showed anaerobic growth in the peritoneal sample site; anaerobic growth was noted in eight out of ten of the warehoused peritoneal samples. No wild turtles had positive anaerobic blood cultures; two out of two of the warehoused turtles tested positive.

Analysis of the identified Gram-negative organisms in the wild turtles reveals 4 genera: *Actinomyces, Aeromonas, Moraxella,* and *Vibrio*. This compares with 11 genera from the warehoused animals: *Acinetobacter, Achromobacer, Alcaligenes, Aeromonas, Escherichia coli, Klebsiella, Moraxella, Pasturella, Pseudomonas, Serratia, Shigella,* and numerous bacteria yet to be identified.

Examination of the Gram-positive bacteria shows *Staphyloccoccus* as an isolate in both groups. *Bacillus, Corynebacterium,* and numerous unknowns were far more numerous in the warehoused turtles than in the wild ones.

None of the 16 sites sampled in the wild turtles yielded fungi or yeast. Some type of fungal growth was recovered in 13 out of 19 of the warehouse cultures. One wild turtle showed mild shell disease, but all ten of the warehoused animals had evidence of moderate to severe shell disease. There were other parameters which were relevant for the warehoused animals and nonexistent in the wild turtles. Eight out of ten of the warehoused turtles had eye infections, eight of ten showed skin lesions. five out of ten had deep tissue abscesses. Two animals had known broken bones. Six had respiratory problems made evident by open-mouth breathing and hoarse rasping breaths. All of the warehoused animals were anorexic upon arrival, and all of them had diarrhea for an extended period of time once they resumed eating. Mortality in the wild group in the first two weeks and four months later was zero; in the warehouse animals, mortality reached 23% in the first ten days, and had climbed to 38% after four months in spite of attempts at treatment.

CONCLUSIONS

The warehoused animals were far more heavily colonized by bacteria than the wild turtles for the two sites compared. The mortality rate among the warehoused turtles and the degree of morbidity observed suggests that these animals were severely compromised by polymicrobial colonization. This conclusion is supported by subsequent treatment records, which show restored appetite, increased vigor, healed lesions, and a decrease in other overt symptomology with appropriate antibiotic therapy.

BACTERIAL ISOLATES: WAREHOUSED TURTLES

Growth: A = anaerobic, F = Fungal, + = yes, ? = questionable, 0 = none
Tests: G+/- = Gram, Ox+/- = oxidase, C+/- = catalase,

Turtle Number	**Bacteria** - Peritoneal Fluid	**Bacteria** - Blood
1	Aeromonas hydrophila +A	*Staphylococcus sp.* Unknown G+, Ox-, C+ rods
5	*Moraxella sp.* *Serratia sp.* Unknown G+,Ox-,C+ cocci +A,+F	Unknown G+, Ox, C+ rods
6	Aeromonas hydrophila CDC DF-2 (presumptive) *Corynebacterium sp.* Unknown G+ rods Unknown G+,Ox-,C+ coccobacilli Unknown Gv, Ox-, C+ sickles Unknown G-, Ox+, C+ rods +A,+F	Unknown G+, Ox-,C+ rods +F
7	+F	
8	*Micrococcus sp.* x2 (presumptive) *Staphylococcus sp.* Unknown G+, Ox-, C+ rods +A, +f	
9.	ABD/BLOOD COMBINED SAMPLE Escherichia coli LDC-ODC Pasturella multocida Shigella dysenteria a-hemolytic Streptococcus Unknown G+, Ox-, C+ cocci +F	
10	Aeromonas hydrophila +F	klebsiella pneumoniae Pseudomonas fluorescens Pseudomonas stutzeri

Turtle Number	Bacteria - Peritoneal Fluid	Bacteria - Blood
11	*Bacillus sp.* #1 *Bacillus sp.* #2 Corynebacterium #1 Corynebacterium #2 Moraxella phenylpyruvica +F	+F
12	Serratia liquefaciens Serratia marcescens Unknown G+, Ox-, C+ rods Unknown G-, Ox-, C- rods +A, +F	+A
13	Achromobacter G Grp. VD Acinetobacter calcoaceticus lwoffi Alcaligenes faecalis Pasturella lopatheta Pseudomonas fluorescens Pseudomonas stutzeri Pseudomonas vesicularis Unknown G-, Ox-, C+ rods +A, +F	Aeromonas hydrophila *Bacillus sp.* (presumptive) Pasturella lopatheta Pseudomonas stutzeri +A, +F

BACTERIAL ISOLATES: WILD TURTLES

Growth: A= anaerobic, F = Fungal, + = yes, ? = questionable, 0 = none
Tests: G +/- = Gram, Ox +/- = oxidase, C +/- = catalase

Turtle Number	**Bacteria** - Peritoneal Fluid	**Bacteria** - Blood
22	None	*Actinomyces sp.* (presumptive) *Micrococcus sp.* *Moraxella sp.* *Staphylococcus sp.* Unknown G+, Ox-, C+ rod ?A
24	*Staphylococcus sp.* *Streptomyces sp.*	+A
25	*Moraxella sp.* Unknown G+, Ox+, C+ rod Unknown Gv, Ox+, C+ rod Unknown G+, OX-, C+ rod	Aeromonas hydrophila Vibrio parahaemolyticus +A
30	Staphylococcus epidermidis	

Total Isolates: 14/16 sites sampled
Total + Fungal: 0/16 sites sampled
Total + Anaerobic: 3/16 sites sampled

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Megophrys carrinensis
Photo by Ed Oshaben

TREATMENT OF DEHYDRATION AND STARVATION IN REPTILES

Thomas H. Boyer, D.V.M

INTRODUCTION

Starvation is commonly encountered in recently imported or diseased reptiles which refuse to eat. Unfortunately reptile veterinary literature related to this subject is not lengthy (Cooper and Jackson, 1981, Frye, 1973, 1974, 1979, 1981, 1986, Jackson and Cooper 1984, Jackson and Lawrence, 1985, Jarchow, 1988, Klingenberg, 1988, Lawrence and Jackson, 1983). This paper discusses pathophysiology of starvation, estimation of caloric needs of reptiles and rational approach to treatment of starvation. Dehydration often accompanies starvation therefore this also will be covered.

To appreciate how to treat starvation we must first understand what changes occur during starvation. Though scant literature is available on reptilian starvation, mammalian starvation is fairly well understood. Mammalian physiology is similar enough to reptiles that extrapolation of mammalian changes seem suitable for appreciation of reptilian starvation.

PATHOPHYSIOLOGY OF STARVATION

Food deprivation produces a drop in blood glucose, amino acids and fatty acids which are used as body fuels. As glucose levels decrease the liver increases glycogenolysis (breakdown of glycogen reserves into glucose) and gluconeogenesis (formation of glucose from noncarbohydrate sources such as protein, acetate and glycerol) in an effort to maintain normal blood glucose levels. In mammals glycogen reserves in liver and muscle are exhausted within eight to twelve hours, most likely this takes much longer in reptiles (Jackson, 1981, suggests three months). The body needs to maintain blood glucose levels for nervous and kidney tissue as well as red blood cells, which rely solely on glucose for energy production. After glycogen stores are exhausted glucose is produced from protein mobilized from the liver, gut, and muscle. As blood glucose becomes scarce, all other tissues begin to use alternate forms of fuel such as fatty acids and ketones. Within several days enzymatic changes in peripheral tissues allow increased usage of ketone bodies for energy and decrease the demand for glucose thus sparing protein being consumed during gluconeogenesis. Concurrently, energy demands decrease as the metabolism and activity level of the animal slows down. Never the less, protein continues to be slowly leached form liver, gut and muscle.

The liver is one of the first organs to be affected and decreases production of plasma proteins (such as albumin) as it's size and function shrink. Albumin is the most important of plasma proteins and as concentrations of it fall plasma volume and oncotic pressure (the osmotic force exerted by plasma proteins) decreases. This makes the animal much more susceptible to shock from blood or plasma loses. The low oncotic pressure also makes it more difficult to absorb nutrients from the gastrointestinal (GI) tract.

The GI tract with its rapid turnover and high protein demand looses mass and is less able to digest and absorb food. Ileus (intestinal stasis) and poor digestion of food result from a decrease in digestive enzyme production and absorptive surface area and atrophy of gastrointestinal smooth muscle. The kidney is less able to respond to fluctuations in acid base balance. Antibody and complement

production decreases weakening humoral immunity. Lymphocytes decrease in number and leukocytes (white blood cells) become less motile and bactericidal. The barrier function of skin and mucosa is not well maintained thus host immunity becomes severely comprised and is wide open for opportunistic infection. Wound and fracture healing takes much longer than normal and the animal is much more likely to suffer infection. Pulmonary (lung) function is also compromised. Cardiac muscle atrophies and the heart is less able to circulate blood and cannot respond to increased stresses. Ultimately congestive heart failure can develop. Skeletal muscles are depleted later in starvation. Therefore, if muscle wasting is obvious, significant wasting of other organs has already progressed. Terminally diarrhea develops as the small intestine is whittled away and pneumonia is common. At this point the animal often has no reserve what so ever to any stress place upon it. Simple manipulation for examination can cause death. Eventually, the prolonged "auto cannibalism" causes failure of multiple organs and sepsis sets in and the animal dies (Lewis, et al. 1987, Crowe, 1988, Wheeler 1989).

When starvation is accompanied by illness and/or injury, the patients' metabolism increases (rather than decreasing as in starvation) proportional to the extent of the injury. Thus, sick animals that are starving waste away much more rapidly than animals that are simply starving. Obviously it makes no sense to treat a bacterial infection solely with antibiotics in a malnourished reptile and hope that it will feet in the future because without nutritional support the reptile has little chance of overcoming it's present predicament. Good medical care is inextricable intertwined with good nutritional support.

SIGNS OF STARVATION AND DEHYDRATION

Diagnosis of starvation is fairly easy by simple observation. However a thorough history and physical exam of the reptile is imperative to discover any other problems secondary to starvation or perhaps causing starvation. It is important to keep good records on your animals. For excellent descriptions of history and of physical examinations of reptiles see Jacobson or Jarchow, 1988 or Russo, 1987. Signs of starvation and dehydration are very similar in reptiles because dehydration usually accompanies starvation (Frye, 1979, 1984). A starving reptile is starkly thin with sunken eyes and shrunken skin stretched over bony prominences. In snakes, the skin feels loose and may have fluid pockets under it and the spinal column is obvious dorsally. In lizards, the pelvis is prominent and the base of the tail is sunken. The animal feels light for it's weight and comparison to previously known weight is useful to assess the magnitude of weight loss. Signs of dehydration (Frye, 1984, Jarchow, 1988) include loss of skin and subcutaneous turgor, wrinkling of the integument, and multiple small indentations may be present in the spectacle of those species lacking movable eyelids. As in starvation, the eyes may be sunken (enopthalmic) bilaterally in lizards, chelonians, and crocodilians.

Dehydration in reptiles can be isotonic as a result of blood loss, extensive tissue damage, vomiting, diarrhea or anorexia; hypotonic as a result of prolonged anorexia or hypertonic as a result of cutaneous water loss or failure to drink (Jarchow 1988). Reptiles have a higher relative body water content (65-73%) than do mammals (60%). In those species that excrete uric acid (terrestrial chelonians and squamates) large amounts of water are required to keep uric acid in solution. With dehydration uric acid can precipitate on viscera causing gout and precipitate in the urinary tract causing urinary stasis and renal damage if not corrected (Cooper, 1986).

TREATMENT OF STARVATION AND DEHYDRATION

Now that we have identified the starved/dehydrated reptile, we must proceed with treatment. Certainly, for mildly debilitated reptiles that will eat on their own every effort should be made to see that they do so. For an excellent discussion of correction of anorexia in reptiles see Klingenburg, 1988. Many mildly dehydrated reptiles will rehydrate themselves if allowed to soak in warm water (26°C or 80°F) or if the cage is misted. Rain cans work very well for many species (see Boyer, 1986, for further discussion of watering techniques for reptiles). Mildly emaciated reptiles often respond to improved environment (correct temperature, humidity, photoperiod, diet, etc.) and begin eating on their own. It is crucial that they be minimally disturbed; appreciation of the natural history of the species is indispensable!

NUTRIENT PRECEDENCE

For severely emaciated, listless, inactive reptiles that have not responded to improved husbandry or reptiles that present semi-comatose the above approach won't work and we must intervene. During starvation some nutrients are more important than others to replace (Lewis, 1987). By far the most important nutrient to initially replace is water. Obviously a lack of water kills most animals before a lack of food. Next in importance are the energy supplying nutrients such as carbohydrates, proteins and fat. Of these, fats provide roughly twice the energy of proteins or carbohydrates. The next nutrient in importance after water and energy nutrients is protein. Protein is important for organs to remain functional and can also act as a supply of energy in gluconeogenesis. The last and least important nutrients to replace are vitamins and minerals (unless an obvious deficiency is present such as vitamin A or calcium deficiency). Clinical signs related to deficiencies of vitamins or minerals occur much later than do signs of water, energy or protein deficiency. An exception can be made for B vitamins which are believed to increase appetite in many species, including reptiles (Jackson, 1981, Klingenburg, 1988). It is much more logical to worry about water and energy supplying nutrients first then supplement vitamins or minerals later when the animal is stable and better able to utilize them.

FLUID ADMINISTRATION

In mammals fluids are usually given intravenously but this is impractical in all but the very large reptiles. The second quickest route of fluid uptake in mammals is intraperitoneally (although intramedullary routes are now coming back into vogue and offer much promise for use in reptiles). Reptiles have no diaphragm (except for a transverse diaphragm in crocodilians) therefore they have no peritoneal (abdominal) cavity, rather they have coelomic cavities (pleural peritoneal cavities combined). Therefore intraperitoneal injections are actually intracoelomic when referring to reptiles. The problem with intracoelomic injections in reptiles is that they lack a diaphragm thus nothing separates the lungs from the abdominal contents therefore lung capacity and tidal volume can be compromised when large volumes of fluids are instilled intracoelomicaly. (Jarchow, 1988, Ross, 1984). I limit intracoelomic injections in reptiles when possible over a route I consider far superior, the GI tract. If the gut is working it should always be used! Lawrence and Jackson (1983) and Klingenburg (1988) also advocate using enteral routes over parenteral routes (all other routes besides the oral route). With starvation the small intestine is certainly atrophied but still is somewhat functional and since plasma oncotic forces are low but identical for gastrointestinal and coelomic uptake, I feel more comfortable giving fluids enterally (i.e., via stomach tube). Unfortunately, enteral fluids are much more stressful to give then parenteral fluids. In many chelonians enteral fluids can be impossible without chemical restraint and in these cases coelomic or even epicoelomic fluids are preferable (see Jarchow, 1988 for a description of this technique).

Another option of subcutaneous (SQ) fluid administration but for large volumes it is much easier for me to give fluids via stomach tube or coelomically. I find even severely dehydrated reptiles will absorb SQ fluids. While rehydrating the patient one must watch closely for signs of overhydration (edema, abdominal distention and pneumonia). Total protein, packed cell volume and weight should be monitored if possible (Jarchow, Millichamp, 1988). Ideally, one should also monitor serum electrolytes, but it is difficult to obtain enough serum for this and is expensive. However with new micro-chemistry analyzers becoming available, volume becomes practical but cost continues to be restrictive.

FLUID TYPES

Water requirements of reptiles are virtually unknown (Millichamp, 1988). Cooper, 1976, recommended isotonic fluids such as lactated ringers solution (LRS) to be given orally by stomach tube or intracoelomicaly at a rate of 4 percent of body weight for rehydrating tortoises. Jarchow (1988) regards this as close to the maximum volume that can be safely given to reptiles and recommends limiting parenteral fluids to 2 to 3 percent of body weight for chelonians. He also recommends mildly hypotonic fluids such as two parts 2.5 percent dextrose in 0.45 percent sodium chloride mixed with one part Ringer's or an equivalent electrolyte solution for correcting dehydration. Klingenburg, 1988, suggest 2.5 percent dextrose in LRS can be given intracoelomically to chelonians. Frye (1984) recommends 20 to 25 milliliter (ml) of LRS per kilogram (kg) of body weight injected intracoelomically daily or on alternate days to treat dehydration.

ALLOMETRIC SCALING

Another approach to calculating energy and fluid requirements of reptiles is allometric scaling (Sedgewick, 1988). Traditionally energy and fluid requirements of reptiles have been calculated based on weight or mass, as we have seen. Unfortunately, metabolism of all species varies with size; therefore the energy and fluid requirements of a small animal are greater on a milligram per kilogram basis than a large animal with a slower metabolism. This is of particular importance when working with reptiles because of the large variation in size. For example a small lizard may weight 10 grams whereas a large python may weigh 20 kilograms, a difference of 2,000 fold! In contrast a large dog only weighs 200 times more than a newborn puppy. If one plots mass of an animal versus it's metabolic rate a straight line relationship develops with the slope of the line equal to 0.75. The relationship holds true for all species from eubacteria to whales, and was first realized in the 1930's (Sedgewick, 1988). By utilizing this relationship we can calculate the energy and water requirements much more accurately for reptiles. Thus, the basal energy requirements (BER) in kilocalories (Kcal) over 24 hours in expressed as follows:

$$BER = K(W^{0.75})$$

where K is a taxonomically dependent constant based on average core body temperature which for reptiles at 37°C is equal to 10, and W is equal to weight in kilograms of the reptile.

If your calculator cannot raise numbers to powers another way to do it is by cubing the number and taking its square root twice (if you don't have a calculator, good luck). BER is the amount of energy used by an animal in post absorptive state at rest in a neutral ambient temperature. An important feature of this formula is that the water requirement in milliliters for healthy animals approximately equals their energy requirement in Kcal (Lewis et al, 1987). The above formula applies to healthy animals, therefore we must correct it for various disease states because, as we have seen, disease increases energy demands. Fudge factors are needed (Fig. 1).

Figure 1

Problem	Fudge Factor
Sleep, cage rest, malnutrition, pneumonia, peritonitis, minor infection, trauma or surgery	1.25 - 1.50
Major surgery, sepsis or trauma	1.50 - 1.75
Massive sepsis or a young growing animal.	1.75 - 2.0
Severe injury or malnutrition	2.0 - 3.0

This chart was modified from Crowe, 1989, Sedgewick 1988 and Wheeler, 1989. If two or more conditions are present use the single highest factor as the fudge factor (never use more than one fudge factor).

To update our formula we now have for maintenance energy requirements:

$MER = K(W^{0.75})FF$

where FF is the given fudge factor.

Thus, with allometric scaling we can calculate fluid and energy requirements for reptiles over an enormous range of sizes and conditions much more realistically than ml. per kg. or as a percentage of body weight.

In addition to maintenance fluid requirements, a dehydrated reptile also has a water deficit which can be calculated by estimating what percent the reptile is dehydrated, though this has not been worked out for reptiles. A level of approximately 10% is a good reference point although dehydration can reach 15% in mammals just before death. Thus, to correct for the deficit we multiply the reptiles weight in grams by 0.10 (10%) to get the deficit in mls. We want to add this amount to daily maintenance requirements and correct the total deficit within two or three days.

OROGASTRIC FEEDING

Once the patient is rehydrated we must turn our attention to the next important nutrients to replace, the energy nutrients (carbohydrates, proteins and fat). Many reptiles, once rehydrated, will eat if food is placed in their mouth or pharynx and this is certainly easier than tube-feeding. However, if the reptile refuses to eat or is too weak to swallow on it's own, orogastric tube feeding is indicated. This is relatively easy procedure in reptiles because their glottis is located rostrally, just caudal to the base of the tongue. Thus it is easy to visualize, and the danger of passing a feeding tube into the respiratory tract can be avoided. In some chelonians and crocodilians the glottis is located more caudally, making this more difficult (Bennet, 1989). The stomach tube should be soft but not so flexible that it can't be

passed down the esophagus. The tip should be lubricated with K.Y. jelly or vegetable oil and not have any jagged edges on it. One person should hold the animal with a mouth gauge in place and another person pass the tube along the roof and towards the back of the mouth (Morris, 1984). Be certain that you can see the glottis and aren't passing the tube through the glottis into the trachea and lungs. Passing food into the respiratory tract is a sure way to kill most animals (Lewis, 1987). If the tube doesn't pass easily down the esophagus, back up and try again. Remember the mucosa of starved reptiles is thinner and weaker than normal so don't apply undue pressure!

Tube feeding healthy chelonians can be a challenge but most debilitated chelonians are weak enough that it is not. For tortoises, Jackson and Lawrence (1985) recommend measuring the tube from the caudal end of the abdominal shield and marking it just anterior to the gular notch. The tortoise's neck is extended with it sitting on its caudal shields and the mandible is gently pried open from the commissure. The lubricated tube is then carefully slid down the straightened esophagus into the stomach with the marker just entering the mouth. The liquid diet is then slowly (over several minutes) injected into the stomach; too rapid a rate of infusion will cause regurgitation. Watch the pharynx for the tube feeding formula coming back up and stop if it does. Keep the animal vertical for several minutes then slowly return it to it's cage.

Squamates are much easier to tube feed but snakes regurgitate very easily so infusion should be slow with minimal struggle and gentle immediate return to the cage. It helps to keep the squamate head higher than the stomach as well. In snakes, the stomach generally starts just anterior to the midportion of the body; in lizards, I generally pass the tube to the level of the posterior portion of the cranial third of the distance between the front and rear legs. As with chelonians, it is important it infuse the material slowly and watch for regurgitation.

TUBE FEEDING DIETS

Finally, we must consider what diet to feed. A diet widely used for malnourished dogs and cats and one that I have used successfully with lizards in a gruel made-up of water and canned cat food (Crowe, 1989, Lewis et al, 1987). Although I don't recommend cat foods for reptiles because of their high protein content, in this case I think it's warranted because of the protein deficit of the starving reptile. It is important to rehydrate the reptile before starting on this diet or we will aggravate the problem of uric acid deposition. This diet is high in fat and protein, is balanced for calcium and phosphorus. and contains enough vitamins that additional supplementation is not recommended. The diet is made by blending for one minute one half can Hill's Prescription Diet Feline p/d in three fourths cup water (170 ml) and a tablespoon vegetable oil. The gruel is then strained through a kitchen strainer two times and can be tube fed through a size 8 french tube or larger. For small reptiles, I find a tom cat catheter (size 3.5 french) with tip snipped off even works well. If you don't strain the gruel it will clog in you feeding tube. This yields about 405 ml of diet that is 83% water, 7.4% protein, 5 5% fat, 2 8% carbohydrates, and has 1.2 kcal per ml. If mixed and stored in clean containers the gruel keeps well in the refrigerator for several days or may be frozen for longer storage without affecting nutritional quality (Hill's Pet Products, personal communication).

Ideally, the daily kcal requirements should be met with multiple small orogastric feedings. Since gastric emptying is relatively slow in reptiles compared to mammals and reptiles in captivity usually consume single large meals and starved reptiles are not very stress tolerant, I only feed twice a day. It is also important to infuse the gruel slowly (over several minutes) or the reptile will reflexly regurgitate.

A variety of other diets have been used for anorexic reptiles. Lawrence and Jackson (1983, [illegible] Holt (1979) recommended Complan (Farley Health Products), Buildup (Carnation Foods) or [illegible] (Veterinary Drug) for tortoises. Holt (1979) recommended Complan mixed with warm water at [illegible] of 5 ml per kg body weight once a week. He felt feeding more often than this could lead to [illegible] overgrowth in the reptiles gut. A monomeric diet, Vivonex (Norwich-Eaton Pharmaceuticals) [illegible] suggested by Jarchow (1988). Frye recommended nutrient dense products such as Pet Kalorie [illegible] or Nutrical (EVSCO) mixed with pureed infant diets, eggs and water for carnivores and [illegible] cereals with ground rabbit pellets or Game Bird Flight Conditioner (Purina) and vitamins [illegible] for herbivores and omnivores (see Frye, 1984 for further discussion). Lewis et al. 1987 point [illegible] Nutrical is not nutritionally complete or balanced even with the addition of meat baby foods or [illegible] and should not be used for any extended period, but as a convalescent diet it seems suitable. [illegible] will on whole rodent diets either slit open or macerated with a pinky pump (B.J. Specialties, [illegible]). Start with very small meals and gradually increase them.

After dehydration has been corrected over the first two or three days of treatment, one may [illegible] tube feeding or force feeding. If one elects to try allometric scaling, for the first week only [illegible] one third of the undiluted diet required mixed with twice that volume of water (1/3 MER + 2/3 [illegible]). On the second week of feeding increase the undiluted diet to two thirds of the MER mixed with [illegible] that volume of water (2/3 MER + 1/3 water). After the second week full strength diet should be [illegible] and total MER met. This allows the GI tract to slowly adapt to a rich diet and avoids placing a [illegible] solution into an animal that is not ready for it yet. I haven't ever tube fed or read about tube [illegible] crocodilians so I'll avoid comment on this group.

CONCLUSION

We have seen how starvation devastates animals and that by the time emaciation is obvious [illegible] the animals is in even more trouble internally. This problem is worse if the reptile is sick or [illegible]. If the reptile fails to respond to approaches advocated by Frye (1984) and Klingenburg (1988), [illegible] is severely emaciated, we must intervene. The first step is to correct dehydration by assuming 10% [illegible] body deficit and allometrically scaling daily water requirements. Hypotonic fluids are preferred [illegible] and may be given intracoelomically, SQ, or via stomach tube. Later, isotonic fluids such as LRS [illegible] be given by stomach tube. Once rehydrated, we may begin feeding and a variety of diets have [illegible] advocated. Within several weeks the reptile should be back to its normal diet, but full recovery [illegible] a minimum of six weeks and often longer.

Remember, change is the only constant in our universe and the recommendations made herein [illegible] likely to change as we become more sophisticated, but the basics will not.

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FACTORS AND PATHOLOGY RELATED TO REPRODUCTIVE FAILURE DURING GESTATION AND DELIVERY IN MILK AND KINGSNAKES

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Those who have dealt with the captive breading of reptiles realize that breeding failure is as much a part of the reproductive process as is success. The etiology of such failures are numerous and diverse but could include such general groupings as male and female infertility, poor husbandry, partner incompatibility, gestation complications, dystocia, and incubation problems. There are many variables in reptile breeding and it isn't as simple as throwing a male and female together and counting the babies as they hatch. Perhaps it is this variability that makes this such an exciting hobby. While all aspects of breeding need to be taken into account when analyzing a failure, the purpose of this paper is to discuss some of the problems encountered during the gestation and delivery of milksnakes and kingsnakes.

Before proceeding to the discussion of gestational and delivery pathology, let's review some basic information on the gestation period and determination of pregnancy in this group of snakes.

REVIEW OF THE GESTATION PERIOD

The average gestation period in this group of snakes consists of three parts. The first phase consists of a 30-45 day period after breeding, but before shedding. The second phase consists of a 5-10 day pre-egg laying shed and the third phase a 1-15 day period during which the eggs are laid. After shedding most snakes will lays their eggs within 6-13 days, with most (but not all) eggs laid outside of this range being infertile. Incubation time of these eggs varies but is typically 55-70 days at a temperature of 78-82 degrees.

Determining if the Snake is Gravid

One of the most difficult features of a breeding program is the actual determination of pregnancy. After breeding, the typical milk/kingsnake will develope a soft, distended abdomen within 2-3 weeks. This swelling can be very subtle or extremely obvious. Significant weight gains may be registered during this time frame. It is not unusual for the female to become finicky or simply refuse food.

It is important to note at this point that many snakes in this group (especially grey-banded kingsnakes) also act and look as previously described due to follicle formation and impending ovulation, and are not gravid. Many reptile breeders use the term "blown up" to refer to a female with maturing follicles and impending ovulation.

So what do you do with a snake that you cannot tell is gravid or "blown up?" The best way to handle this is to wait until the pre-egg laying shed and on day 3 or 4 post shed, place the suspect female with a male. If the female readily accepts the male, then she is not gravid and breeding should continue. If the female refuses the male then she is likely gravid and should be provided with an laying container.

FACTORS AFFECTING THE FATE OF THE EGG DURING GESTATION

Maternal Condition

Reproduction by any group of animals is a luxury, in the sense that reproduction cannot occur unless the health status is such that the extra resources above and beyond normal maintenance are available. Underweight and anorexic females often will not cycle and ovulate normally. This is an obvious self defense mechanism to prevent reproduction from occurring at a time when the body is not able to handle it. Likewise, other serious systemic illnesses can interfere with reproductive cycles.

Nutrition Status

As with maternal health, nutritional status is extremely important. Well fed reptiles have been shown to produce more offspring, which are also larger and more likely to survive.

Environmental Factors

It is not the intention of this paper to discuss general husbandry, but it is very important to reproductive success. Poorly maintained reptiles are extremely stressed which can lead to a variety of problems including a failure to thrive, failure to exhibit breeding behavior, failure to carry offspring to full term, etc. Examples of other environmental factors affecting reproduction are inadequate or excessive temperatures, exposure to chemicals or drugs, inadequate or excessive lighting, exposure to bacterial contamination, etc.

Genetic

Generations of constant inbreeding are likely to lead to a higher incidence of reproductive failure. An example would be a higher incidence of congenital defects contributing to early embryonic death syndrome. While inbreeding may succeed in producing animals with certain desirable traits, there is equal likelihood of producing non-viable genetic traits that will increase the mortality of offspring during and after gestation.

Therefore, consider that the better the maternal health and the care she receives then the better the chances of producing more numerous and viable offspring. It is ill advised to breed reptiles that are severely underweight, anorexic, heavily parasitized, stressed, or harboring any form of bacterial infection. If there is any doubt, better to skip breeding this season and build for the future. It is extremely short sighted to think of short term breeding only.

PATHOLOGIC EVENTS WHICH CAN OCCUR DURING GESTATION

Early Embryonic Death Syndrome

Many healthy reptiles will become gravid, only to have the developing embryo(s) die. If this occurs quite early in the course of gestation, then the early developing egg and its contents can be reabsorbed by the body. Eggs are also sometimes expelled prematurely by the body, in a situation equivalent to miscarriages in mammals. The causes of this syndrome are not well documented but probably are a result of the maternal, nutritional, environmental, and genetic factors discussed previously.

A point to remember is that you should not confuse a "blown up" female that fails to conceive with normally gravid females that reabsorbs or expels her eggs.

Systemic Disease

Many diseases that are present either before or during a pregnancy have the potential to disrupt the pregnancy. A common example would be visceral gout, which is the deposition of uric acid crystals in abnormal tissues due to increased levels of uric acid in the blood stream. This deposit of uric acid causes severe inflammation, fibrosis, and organ damage and the uterus can be involved as well as any other tissue. Uric acid increases result from feeding excess protein or diminished kidney function as seen in dehydration or with overdosage of aminoglycoside antibiotics. The point to be made further you should not breed a compromised or sick animal.

Uterine Pathology

The most common example of uterine pathology is the forced manipulation of retained eggs with resulting rupture/tear of the uterine tissue. This will result in not only potential severe hemorrhage but also the potential of an egg induced peritonitis (see later description). The uterine tissue is quite fragile and manipulation of eggs must be carefully done. If eggs have been retained for an excessive period of time, they tend to absorb fluids, swell, and adhere to the uterine lining. If an egg is reluctant to move, don't force it.

Uterine torsion (twisting upon itself) is rarely seen, but is a severe condition that is almost always fatal. As the cause is not known, there are no specific preventative steps.

Uterine tumors rarely occur, but can act as a potential impedance to the movement of eggs.

Uterine prolapses are again quite common in the forced manipulation of eggs. If uterine tissue is viewed as an egg is being manipulated, then pressure should be released before a tear or actual prolapse occurs. If prolapse tissues are discovered after a spontaneous prolapse, then the tissues

should be immediately gently cleaned with a betadine solution. After cleaning, the tissues can be gently replaced with a lubricated Q-tip. If further prolapse occurs, the surgical removal of the tissue is likely to be required. All prolapsed animals should be handled minimally and given antibiotics. I generally recommend that any reptile that has experienced a major prolapse not be bred again as the likelihood of repeat prolapses, adhesions, etc. are too high.

Retained, Non-infected Eggs

Occasionally a female will be found to have a lump in her abdomen which isn't causing any known health problems. Through palpation, x-rays, and eventual exploratory surgery I have found many "mummified" or mineralized eggs in the uterus. These eggs are to be differentiated from eggs that were attempted to pass but couldn't (egg-binding), as these apparently simply are left after an apparently normal pregnancy and delivery.

Some of these eggs are probably later termed embryonic death eggs that were too well formed for the body to simply reabsorb, so shrinkage due to fluid evacuation and storage occurs.

The question is then, "If left alone, would these eggs eventually pass or interfere with reproduction?" It would seem unlikely (though not impossible) that these eggs would ever pass due to adhesions and oviduct constrictions that develop. There seems to be a higher incidence of such eggs in older, almost senile breeders, so perhaps this happens more commonly in snakes near the end of their reproductive lifespan. These eggs are also potential time bombs by acting as an irritant to the uterus or as a growth media for bacteria, which could result in egg induced peritonitis.

It is also impossible to answer the forementioned question, because all these eggs have been surgically removed when possible to decrease any risk of fertility and peritonitis complications.

Retained, Infected Eggs

It is much easier to predict the course of events in this case. An infected egg that can't pass will serve as a source of bacterial growth and eventually the infection will spread beyond the egg. Bacterial infections in the uterus generally present an extremely grave prognosis as a) therapy with antibiotics isn't sufficient to control the infection without the concurrent surgical removal of the retained egg, and b) a diagnosis isn't usually made until the condition is quite advanced.

Egg Induced or Egg Yolk Peritonitis

An egg induced peritonitis results from the release of the egg from the uterus resulting in a severe inflammatory response in the abdomen. An egg yolk peritonitis occurs when the contents of the egg are released, which causes a far more sever reaction than an egg alone. Obviously, the reaction is much worse and more profound if the egg or its contents are contaminated with bacteria.

The release of the egg plus or minus its contents can occur due to 1) a ruptured or torn uterus, 2) prolonged retention of eggs causing inflammation and erosion of uterine tissue, or 3) the fertilization of eggs outside the uterus (ectopic pregnancy).

One of the major problems with a peritonitis case is to diagnose it before death occurs. These reptiles are usually found acutely ill or dead, but in the early stages will be inactive, anorexic, depressed, and often tractious when handled. The prognosis is extremely grave.

Treatment consists of providing a warm, minimized stress environment in addition to aggressive antibiotic, anti-inflammatory, and fluid regimens. If stabilized, the reptile can then be taken to surgery to establish drainage and removal of infected materials. Needless to say, these reptiles are usually lost as reproductive stock.

PATHOLOGICAL EVENTS WHICH OCCUR AT PARTURITION

In the previous section we discussed the pathological events which can occur during gestation. Much of the same pathology occurs during parturition such as prolapses, uterine ruptures, etc. The most significant event is that of dystocia or as it is commonly referred to, egg-binding.

Egg-binding refers to the specific situation in which a gravid female has carried her eggs to term and then cannot pass all or some of them an appropriate substrate at the appropriate time. This condition is most commonly seen in turtles where it is caused by such factors as abnormally large eggs, misshapen eggs, eggs passing simultaneously, dead fetuses, and bacterial salpingitis.

FACTORS THOUGHT TO CONTRIBUTE TO EGG-BINDING IN MILK & KINGSNAKES

1) Species variation - There is really no evidence to support that a particular species is more susceptible than another. Some breeder have reported that *Triangulum abnorma* tends to lay exceptionally large eggs and therefore is more prone to become egg bound.

2) Age - In the wild, most milk and kingsnakes are probably three to four years old before reaching sexual maturity. In captive programs breeding is often attempted in reptiles as early as one year of age.

3) Growth Rate - Hatchlings are often "pumped" to put on weight rapidly to reach sizes associated with successful breeding. As with the age factor, are we breeding immature animals? Could accelerated growth rates retard normal musculo-skeleton development?

4) Obesity/poor muscle tone - Supporters of this theory will point out that wild caught specimens tend to lay eggs better than captive raised "lumps." Is the confinement so strict that muscle tone is extremely impaired?

5) Inbreeding - Are we selecting animals for size, passive behavior, good eating habits, etc. at the expense of good reproductive traits?

6) Improper environment - Husbandry is extremely important to successful breeding. If inadequate temperatures, improper laying media, lack of privacy, poor feeding, etc. are involved then dystocia can easily occur.

7. Diet - No specific studies have been run, but it would follow that reptiles fed a marginal diet will have marginal reproductive traits. In feeding mice that have been dietarily deprived, the snake will suffer also.

8) Abnormal photoperiod

9) Endocrine abnormalities

10) Bacterial infections - Infections not only weaken the reptile, but infections specifically of the reproductive tract tend to cause eggs to swell and to decrease the viscosity of the oviduct lining.

When to consider a reptile as being egg bound is difficult. Due to variable ovulation times sperm retention over extended periods, etc. it is almost impossible to tell when fertilization occurs and thus the time frame egg laying should occur within. The guidelines most practical in my experience go back to the pre-egg laying shed. Once this shed occurs, most milk and kingsnakes will lay their eggs within 6-13 days. However, regardless of the exact time when the snake starts to lay, it is unusual for eggs from the same clutch to be laid over a long period of time unless they are infertile or become egg bound.

A general guideline would be if eggs are retained more than 48 hours after the others have been passed, or sooner if the gravid female has been observed to be agitated, straining, etc.

TREATMENT OF EGG-BINDING

The treatment of egg binding is subject to controversy, and there is no right or wrong method for each snake. The following scheme has been useful to me:

A) Initially, letting the snake soak in tepid water for 15-20 minutes and then placing in a warm, private cage with a larger laying container. The purpose of the soak is to promote peristalsis, a common involuntary response of reptiles to such soaking. Hopefully, this increased muscle activity will also stimulate the musculature of the oviduct. If no response is seen within a few hours, proceed to Step B.

B) If the retained egg(s) are low and near the vent, gentle manipulation distally toward the vent may be attempted. If any resistance is encountered, stop! A small vaginal speculum (order one from your reptile vet) can be used to gently open the cloacal opening so as the egg approaches, it is less likely to encounter such sever resistance at the cloaca which could lead to an oviduct rupture or prolapse. If visualized, the egg can be grasped with allis tissue forceps and pulled gently through. If the eggs are retained up high or fail to manipulate from a lower position, proceed to Step C.

C) Administer calcium borogluconate at 10 ml of 1% solution per Kg followed by oxytocin (1-10 units) 30-60 minutes later. The theory behind this is that adequate calcium needs to be present to ensure adequate musculature contractile response of the oviduct, so it is administered first.

The use of mammalian oxytocin is controversial for several reasons. Firstly, it isn't known which neurohypophyseal agent is secreted in reptiles and it may differ significantly from mammalian oxytocin. Secondly, oxytocin could cause significant contraction of oviduct musculature which could potentiate egg retention and the risk of oviduct rupture.

If no response within 60 minutes, repeat the initial dose of oxytocin. If there is still no response within 2-4 hours, proceed to Step D.

D) If the egg(s) are retained high and/or are reluctant to move, it is best to aspirate the contents of retained egg(s). Using a sterile 12cc syringe with a 22 gauge needle, move the egg up tight against the body wall. Do an alcohol or betadine wipe of the area over the egg, then plunge the needle into the egg and aspirate as much as possible. This procedure will cause the egg to collapse and present less resistance to passage. At this point, some gentle manipulation can be tried, but if resistance, stop.

Place the snake in its warm, private cage and allow several hours. Induction with oxytocin can be repeated also. If this fails, go to Step E.

E) Surgery - Manipulation is extremely risky, due to the fact that the oviduct is thin and fragile. It is my opinion that too many snakes are over manipulated leading to sever uterine pathology and sometimes death. If an egg cannot be easily manipulated out, then surgery is a much better option.

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The Gila Monster (*Heloderma suspectum*)

DIAGNOSTIC TECHNIQUES IN REPTILE MEDICINE

Howard D. Martin, DVM

The first step in approaching any sick animal is to obtain in accurate and complete history. For reptiles, this should include the following information.

1. The chief complaint (i.e. what the major problem is).
2. Signalment, which includes species, age and sex.
3. Origin - where the animal came from and how long it has been in its current environment.
4. Questions regarding the animal's environment such as:
   a. Cage design, including construction materials, substrate, perches or branches, and disinfectants used
   b. Temperature ranges, humidity and photoperiod
   c. Location of the cage within the building
   d. The type of heat source utilized
   e. For aquatic species, questions pertaining to water quality control, filter systems, source of water, how often the water is changed, whether or not the animal is fed in a maintenance tank or in a separate tank and what if any chemicals are added to the water.
5. Diet - what is offered, how often is food offered, how much is consumed, what is the source of food, and how is the food stored?
6. Water - how often is the water source cleaned or changed and how is the water offered. If there is a water bowl present, how large is it? Does the animal spend time soaking in the water bowl?
7. Feces - how often does the animal defecate (in relation to feeding), the color and consistency of feces, and whether or not a fecal specimen has been examined for parasites.
8. Cage mates - are other animals in contact with it? If so, what species? How are the animals separated in the collection and does the collection maintain an adequate quarantine policy? Physical lay-out of the facility with regard to possible contamination from other cages is also important.
9. The animal's current attitude and behavior
10. The shedding cycle for lizards and snakes - how often they have been observed shedding and when the last shed or ecdysis occurred.
11. Any previous medical history - has the animal been ill before. If so, a description of problems and treatments including the attending veterinarian's name are all important. Also of critical importance is whether or not other animals in the collection have been ill or have died and if so, have their problems been diagnosed?
12. While taking the history, the veterinarian should also be able to make observations of the behavior of the animal, paying particular attention to its overall attitude and how it interacts with its environment.

In evaluating this information, the veterinarian may need help from the herpetoculturist. Most veterinarians will not know or have immediate access to species-specific information such as dietary requirements and food preferences, environmental requirements, breeding information, etc., so important the husbandry and care of many reptile species. It is worth emphasizing here that the reptile keeper and veterinarian MUST work together as a TEAM to solve medical problems and that the veterinarian must often rely upon the reptile keeper for vital information. Conversely, the reptile keeper should be certain to make sure that the veterinarian is familiar with normal reptile anatomy and physiology.

From this history, the veterinarian should be able to generate a problem list and begin to relate these problems to specific organ systems and to generate lists of differential diagnosis. These lists will be modified as we proceed with the examination. From these initial lists, the veterinarian should be able to better prepare for the physical examination.

PHYSICAL EXAMINATION

Physical examination is the most important part of the diagnostic workup. Unfortunately, we are severely limited in many reptile species in the amount of information we can gather as compared to larger mammalian species. The goals of the physical exam are to gather as much information as possible with the least amount of stress to the patient (and the doctor). For many species, this may require anesthesia or sedation. Generally anesthesia and sedation cause less stress to an animal than physical restraint in the case where an animal does not want to be restrained. Anesthesia also affords the veterinarian good muscle relaxation and therefore the ability to easily extend the head and limbs of chelonians and to deeply palpate abdominal structures of lizards and snakes. We will not discuss specific of restraint and anesthesia but it must be kept in mind that the restraint must be safe for both animal and handler and allow for as complete a physical examination as possible. The physical examination consists of the following:

1. Observations of the animal interacting in its environment, preferably within the collection.

2. Starting at the head, the eyes, ears, nose and throat are examined with special attention paid to the tissues of the mouth.

3. The heart and lungs are examined. In most species, a stethoscope is useless in ausculting the heart. However, in many species, the heart may be palpated or a femoral pulse may be detected in some chelonians and lizards. Examination of lungs involves observing the animal at rest for signs of dyspnea or difficulty breathing, using a stethoscope to try to identify any abnormal sounds upon respiration, as well as a direct visual exam of the glottis for signs of exudate which may be coming from the lungs or trachea.

4. The abdominal region should be palpated. Additionally, the entire animal should be palpated and this is particularly important in snakes. Therefore, the veterinarian should become familiar with palpating normal structures and be aware of their location.

5. The genitourinary systems may be examined by palpating in the caudal abdominal region and visual inspection of the cloaca.

6. The musculoskeletal system is examined by observing the animal moving in a natural motion as well as palpating muscles and skeletal structures.

7. Neurological exam is performed by observing the animal interact with its environment and respond to various stimuli.

8. The skin is a very important organ system to examine in reptiles. Often signs of systemic diseases may be manifested in skin lesions. It is important to thoroughly examine the entire animal.

The veterinarian will generate the best information when a physical exam is repeated in a systematic order. Often veterinarians will adapt a physical exam procedure that they are used to using on mammalian species. Obviously, some modification of this exam technique must be made, depending on the species. Based upon the preliminary problem list and list of differential diagnosis, the veterinarian should also be prepared to perform the first round of diagnostic tests at the same time while the animal is being restrained. This is very important in order to decrease the stress of repeated handling. Following the physical exam, the veterinarian redefines his list of differential diagnoses and aims the diagnostic workup according to the organ system(s) involved. The following presentation of diagnostic techniques should be thought of in an organ system approach.

Localization of clinical findings to organ systems or anatomical locations is based upon an integration of information from the case history, clinical signs, physical exam and diagnostic test results. Certain clinical signs may localize problems to a specific organ system or anatomical location. An example of this is a snake with a clinical sign of regurgitation. This is a sign that the gastrointestinal system, more specifically the upper GI tract is affected. This may mean a primary disease of the upper GI tract such as GI obstruction, a foreign object in the stomach, an infection involving the stomach and small intestines, GI parasites, neoplasia of the upper GI tract, etc. However, the sign may also indicate a secondary effect from other problems, not directly but indirectly (secondarily) affecting the upper GI tract such as hepatitis, kidney disease, inappropriate environmental temperature (affecting digestion), stress or handling following a meal, or a general septic condition. This then is our list of differential diagnoses for regurgitation in the snake.

Now, the veterinarian must first assess the upper GI tract with diagnostic test aimed specifically at the region (after evaluating potential environmental problems). The veterinarian may then proceed to evaluate other systems which may also cause these signs. Another consideration in planning the diagnostic approach is consideration of the stress of the test upon the patient, the ease of performing it, the cost, the likelihood of generating useful and important information, and the need to rule out problems requiring emergency treatment. For the regurgitating snake, all of the following diagnostic tests listed could be useful, however it is important to stage these tests to maximize our yield of information. In other words, ruling out potential emergency situations and giving the most important information in the shortest amount of time with the least amount of stress on the patient at the lowest cost.

DIAGNOSTIC TECHNIQUES

The following diagnostic techniques are often useful in working up reptile patients. They are presented in rough order for simplest, least stressful to the more complicated techniques.

1. Fecal examination. Fecal samples obtained fresh from the cage should be examined for parasites by direct microscopic exam, flotation and sedimentation techniques.

2. Colonic wash. If a fresh sample is not available, a colonic wash may be used. A clean plastic tube is inserted through the cloaca into the large intestine. A syringe with sterile saline is connected and a simple flush technique is performed (this may also serve as an enema). Examinations for parasites described above should be performed on this colonic flush as well as cytology.

3. Impression smears. Open ulcerated masses and wounds, as well as tissues obtained by biopsy techniques, may be examined microscopically using impression slides. For surface ulcers or masses, a scalpel blade is used to scrape the surface to remove debris. Paper towels are then used to blot excess blood and finally microscope slides are pressed to the lesion. These slides are then air-dried, stained and examined under the microscope. This technique is very simple and valuable for any surface lesions but may also be used for biopsy samples and postmortem samples. For these tissues, a scalpel blade is used to cut the tissues, the surface is blotted and then pressed to slides, often several areas on each slide. Cell morphology and infectious agents can be identified with this technique.

4. Stomach Wash. When upper GI problems are encountered, a stomach was may be performed. A soft tube or ball-tipped metal gavage tube is lubricated and passed into the stomach. A syringe with sterile saline is attached and a simple flush technique is performed. Material can be examined for parasites (such as ascarids or cryptosporidia), cytological exam can be performed, slides should be stained and examined for presence of bacterial, fungi and a sample may be submitted for bacterial and fungal culture and sensitivity. The pH of the fluid may also be tested and may be of diagnostic value.

5. Bacterial or fungal culture and sensitivity. In diagnosing infectious diseases, a culture to grow a microorganism is necessary. It is of critical importance to attempt to identify the organisms causing the infections in order that therapy may be more specifically directed. This is also important to maintain surveillance within a collection. Along with a culture, an antibiotic susceptibility should be run at the same time. This will give us an indication of which antibiotics are most efficacious.

- Radiography. The use of x-rays is a noninvasive technique that yields tremendous amounts of information quickly. However, to obtain the best results, excellent restraint or sedation/anesthesia must be employed. This is necessary because positioning of the patient is also very crucial. Several views (at least two) are necessary to construct a true 3-dimensional image. For chelonians, a third frontal view is helpful for evaluation of lung fields. Computerized axial tomography (Cat scan), xeroradiography, and fluoroscopy may supply additional information for selected cases. Fluoroscopy is particularly useful to assess GI motility.

- Ultrasonography. Ultrasonography uses ultrasonic sound to construct a visual image in cross-section. As sound waves emitted by the transducer pass through tissues, they are reflected to various degrees. Sound penetrates water very well and therefore is most useful in evaluation of soft tissue structures. The reflected sound waves are picked up by the transducer and translated into a visual image, creating the sonogram. Newer models also incorporate Doppler techniques to identify pulsatile blood flow and measure it. Ultrasound techniques are very useful in evaluation of the reproductive tract, heart structure and function, as well as the internal structures of organs such as the liver, kidneys, spleen, testes and to a lesser extent, the GI tract. Air presents a barrier to ultrasound and therefore, air-filled structures are not easily evaluated. Scales and scutes may trap air beneath the overlap of the skin and good contact with the transducers using a special gel is essential. This is usually not a major problem with snakes but can be significant in heavily plated lizards. Bone also present on obstacle to ultrasound and therefore chelonians can also be ultrasounded around the areas of the legs.

- Urinalysis. A routine urinalysis may be easily performed on some species, particularly the chelonians. In the turtles, a cystocentesis (puncture of the urinary bladder with needle and syringe) may be performed, inserting a needle cranial to the rear legs and into the urinary bladder. Samples are examined for presence of bacteria, cell morphology, pH, specific gravity, presence of casts from the kidneys, glucose content, ketone content and total bilirubin. This is particularly useful in helping assess hydration status and kidney function.

- Blood work. A complete blood count is useful in documenting anemias, inflammation, infection, and some neoplastic processes. Packed cell volume (red cell mass) and total solids (indicative of blood protein level), red cell morphology, white cell numbers, morphology, and blood parasites are determined. Much work still needs to be done regarding normal values and how these values vary in different disease states from species to species.

- Blood chemistries. Blood chemistries including electrolytes (sodium, potassium, calcium, chloride, phosphorus), tissue enzymes which may be released from damaged organs (AST, ALT, CPK, alkaline phosphatase, lactic dehydrogenase, sorbitol dehydrogenase), chemical waste products normally released into the blood and eliminated by the kidney or liver (creatine, uric acid, BUN, creatinine and bilirubin). Again, normal values from statistically significant numbers of animals of a wide range of species are needed. Furthermore, much research is needed to determine how these parameters change with various types of disease in each species. Lack of this type of data is a very strong argument for establishment of individual baseline values to be followed over a period of time.

11. Venipuncture sites. Sites to collect blood samples vary from species to species and their efficacy and effect on patient stress, depending upon the technique employed. For many venipuncture techniques, anesthesia or sedation are recommended.

a. The tail vein or coccygeal vein is located along the ventral spine in the tail. A syringe and needle may be advanced on midline caudal to the cloaca beyond the extent of the anal sacs or hemipene down to the spine and then backed off gently. Some species have large ventral spinous processes that may block the needle. This technique, however, is particularly useful in large iguanids, snakes, and larger chelonians.

b. For smaller volumes of blood, toenails or toes may be clipped and blood collected with microhematocrit tubes. However, this is a more painful procedure and may result in lameness or possibly infection.

c. Many veterinarians routinely use cardiac puncture techniques to collect blood, particularly in smaller species. This site does of course carry a very significant risk but this may be minimized by excellent technique and experience.

d. Jugular veins are particularly prominent and easy to use for blood collection in chelonians once the animal is sedated enough to completely immobilize the head. The vessels are located in the 10 o'clock and 2 o'clock positions.

e. Blood may also be collected from the occipital sinus of reptiles and the larger the animal, the easier and safer the technique. For this procedure, excellent restraint or good sedation and anesthesia are required. If the animal moves, the veterinarian may penetrate too deeply and puncture or lacerate the brain stem below.

f. Palatine veins are well developed and easily accessible in larger snakes, however good restraint is required.

g. In lizards, the abdominal vein running along the ventral midline of the abdominal region may be used for blood collection or catheter placement. Animals should be anesthetized or heavily sedated for adequate immobilization when using this area.

12. Aspiration using a syringe and hypodermic needle is an easy, valuable and quick technique to sample solid masses or fluid-filled structures. Usually a 22 gauge needle and 3-6 cc syringe is used. Following antiseptic preparation, the needle is advanced into the mass and the plunger of the syringe is withdrawn creating a vacuum and then quickly released. For more solid structures, this is usually repeated 2-5 times. One should be careful to avoid creating too much vacuum and aspirating blood into the syringe. Pressure is released and the needle and syringe are withdrawn. The material collected in the needle is then expelled onto a microscope slide for staining and microscopic evaluation. This technique should be used early in the diagnostic workup of any mass or cyst. Anesthesia and sedation are usually not necessary.

Tracheal and lung wash. For animals showing respiratory signs, nasal swabs, flushes and lung washes may be performed. For the animal with upper respiratory signs (sneezing, runny nose, swabs of the nares and choana (nasopharynx) may be taken. These swabs are rolled onto microscope slides which are dried and stained and examined for cytology, bacteria and fungi. The swabs may also be submitted for bacterial, fungal and viral cultures. For the animal with lower respiratory signs (coughing, wheezing, gurgling), a lung wash should be performed. It is best to do this following radiographs, rather than before. Occasionally, fluid left behind from a tracheal wash may change the radiographic picture. This procedure should be done as aseptically as possible using a mild disinfectant on the glottis. Wearing sterile gloves, the veterinarian passes a sterile plastic tube of small diameter through the glottis and into the trachea. The tube is connected to a syringe of sterile saline. A flush is performed by injection from .2 to 1.0 cc followed by aspiration. This may be repeated several times. Material collected in the tube and syringe are then placed onto microscope slides and examined. A direct wet mount as well as dried stained samples are used. This type of exam may yield parasites, parasite ova, bacteria, fungi, and cells for morphological study. A portion of the sample should also be submitted for bacterial and fungal culture and sensitivity.

Biopsy. Biopsy techniques vary depending upon the location and tissue to be sampled. For external solid masses, this is relatively quick and easy and may require only local anesthesia or physical restraint. For sampling various internal tissues, extensive anesthesia and very special equipment may be necessary. Biopsies may be taken with scalpel blades, punch biopsy instruments (most useful for skin and shells), needle biopsy instruments (used to puncture tissues and retrieve a core, usually through a very small skin incision) and specialized biopsy forceps which may also be used in combination with fiberoptic equipment. Ideally, tissue samples should be taken at the margins of lesions in order to include both normal and abnormal tissue. Obviously the problem with percutaneous (or through the skin) needle biopsy techniques is not being able to visualize the tissues being sampled. This may be overcome to some degree using ultrasound fluoroscopy or laparoscopy to visualize the tissue and guide the biopsy instruments. Samples obtained can be examined using impression techniques or submitted for histopathology, electron microscopy, virus culture, bacterial and fungal culture and sensitivities.

Endoscopy. Fiberoptic tubes may be used to examine the GI, respiratory, reproductive and urinary tracts. These instruments may be rigid metal tubes or flexible cables. The more expensive, newer models will include channels to pass biopsy forceps, fluid and air washes and brushes to collect samples with. Use of endoscopes is an easy, noninvasive technique to provide direct visualization of internal surfaces. For example, a snake that is regurgitating can be anesthetized, a gastroscope or endoscope passed from the mouth into the esophagus and to the stomach. The operator can see surfaces of these tissues and select biopsy samples, retrieve foreign objects, and photograph lesions. General anesthesia or at least heavy sedation are required as well as specialized, relatively expensive equipment.

16. Laparoscopy. This is a techniques using rigid fiberoptic instruments which are placed into the coelomic cavity through a small skin incision. Most laparoscopes work in an air interface and therefore the coelomic cavity (or abdominal cavity in mammals) is inflated with a gas (usually CO_2) using a separate infusion needle. The laparoscope is pushed through the muscle of the body wall into the air filled coelomic cavity and the contents are examined. Again, biopsies may be taken and the new equipment can also be used to perform surgical procedures with specialized surgical equipment and lasers. This technique is invaluable in examining internal structures and to sex monomorphic monochromic species. Due to the length and shape of snakes, however, it is of limited value in these species.

17. Exploratory laparotomy (celiotomy). Exploratory surgery may often provide the quickest way to diagnose and correct internal problems. Often used as a last resort due to potential surgical risks, this procedure allows the surgeon direct visualization of internal structures. When GI obstructions, masses in the coelomic cavity, egg retention or similar problems are suspected, an exploratory may be the next step following an initial workup (such as radiographs). If the veterinarian generates on his problem list several conditions requiring surgery, an exploratory laparotomy should be considered earlier in the course of the workup. Obviously, surgical risks including hemorrhage, hypothermia, poor healing as well as the risk of anesthesia must be thoroughly evaluated and minimized. Good anesthesia and surgical technique, however, make this a very acceptable diagnostic as well as therapeutic approach.

18. Postmortem examination. It should be taken for granted that all animals that die in a collection should be submitted for a complete postmortem exam. Sometimes in a large outbreak, euthanasia and postmortem of an affected individual may yield more accurate important information quicker than routine diagnostic approaches. This procedure should be considered in light of the severity of an outbreak, the value of a collection versus the value of an individual, and the time and cost of other diagnostic tests.

These are most of the common diagnostic tests available to veterinarians. For reptiles exhibiting signs of general malaise not referable to any particular organ system or with multisystemic signs, the typical workup may be as follows:

First Phase

1. Fecal examination or colonic wash
2. Stomach wash (food or fluids may be passed by stomach tube following sample collection at the same time through the same tube for patients requiring it)
3. Urinalysis if practical
4. Impression smears of any obvious lesions including oral lesions.

Second Phase - Sedation may be recommended at this stage for the following tests (dependent upon patient condition, attitude and danger).

1. Radiographs and/or ultrasound
2. Blood sampling for CBC and blood chemistries.

This would complete and initial workup. Additional diagnostic tests would depend upon initial results. It is extremely important to emphasize the need for a team approach between veterinarian and reptile keeper. Diagnostic techniques an approaches will in the hands of different veterinarians. The diagnostic approach must be tailored to suit the patient and the clinical situation. What works well for one veterinarian may not be the best approach for another. It is also important to remember the need for early recognition of clinical signs and the earlier the diagnosis is made, the faster appropriate therapy can be supplied.

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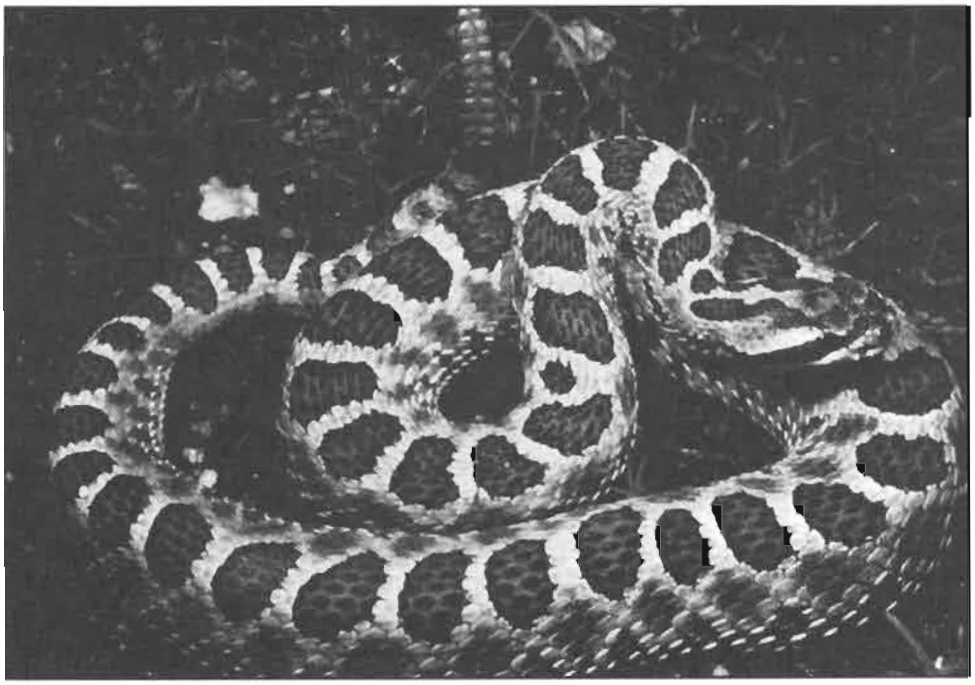

Desert Massasauga (*Sistruris catenatus edwerdsi*)
Photo by C. R. Schwalbe and C. H. Lowe

UPDATE ON PHARMACEUTICALS USEFUL IN REPTILE AND AMPHIBIAN MEDICINE

Scott J. Michaels, DVM, RPH

INTRODUCTION

A bewildering array of pharmaceuticals are available to the herpetoculturist for treatment of disease. New products, in fact whole new classes of drugs, have become available in recent years. Almost all of these new products have been developed for human use and herpetoculturists are frequently unaware of them.

Herpetopharmacology, the study of drugs in herp medicine, is a relatively new science. Until recently, use of even well-known antibiotics in herp medicine was largely empirical, with dosage recommendation based on mammalian data. Only in the last 10 years have controlled pharmacokinetic studies been performed in herps to establish accurate dosage regimens. With the various groups of herps being physiologically diverse and the fact that herps are poikilotherms, it seems clear that drug uptake, distribution, and elimination would be different than in mammals. Several studies in snakes and chelonians have shown this to be true.

This paper reviews anti-infective agents available for use in herp medicine. Specific emphasis is placed on antibiotics, the class of pharmaceuticals most often used in herpetoculture.

AMINOGLYCOSIDES (AG's)

Aminoglycosides have become established in the 1980's as the main class of antibiotics useful in reptile medicine. Examples in this class are gentamicin, amikacin, netilmicin, tobramycin, kanamycin, neomycin, and streptomycin. The latter 3 drugs are of minimal importance in herp medicine because of relatively greater toxicity or antibacterial spectrum[18,30,57]. Current information suggests netilmicin may be somewhat less toxic than other AG's, and amikacin and tobramycin may be more active against Pseudomonas than gentamicin[18,30,57,69].

PUBLISHED ACCOUNTS OF CONTROLLED STUDIES ON AG's

Gentamicin-related nephrotoxicity observed in snakes in the mid 1970's was the impetus to begin controlled pharmacokinetic (pK) studies in the late 1970's. In the last 10 years, several controlled pK studies with gentamicin and amikacin have been performed in snakes[11,31,47], chelonians[10,66], alligators[7], and Necturus salamanders[72].

The first study in reptiles was performed in Pacific gopher snakes *Pituophis m. catenifer* using gentimicin[11]. This study showed that a dose regimen of 2.5mg/kg/72h I.M. (intramuscular injection) produced the most satisfactory peak and trough serum levels when compared with several other tested dose regimens. The serum half-life was determined to be 82 ± 32h at the treatment temperature of 24°C. Earlier preliminary work in a smaller sample size showed a half-life of 104-106h at 24°C and 29-50h at 31°C[78]. At about the same time, another investigator also showed the half-life of gentamicin in water snakes *Nerodia sp.* was temperature-dependant[31]. At 30°C ($T_{1/2}$ = 24h), elimination of gentamicin was 2-3 times faster than at 15°C ($T_{1/2}$ = 48 - 72h). On histopathology exam, the drug was found to produce **more toxic effects on the kidney at 30°C** than at 15°C, despite lower plasma levels. This was probably due to faster accumulation of unchanged drug in the kidney. Similar effects of temperature were also demonstrated with amikacin in Pacific gopher snakes in 1985[47]. In this study, while the half-life at 25°C (71.9 ± 10h) and 37°C (75.4 ± 30.6) was similar, lower plasma levels were seen at 37°C. These investigators, using accepted pharmacokinetic calculations, determined that the volume of distribution was greater at 37°C than 25°C. However, body clearance was also twice as fast at 37°C. Thus, while the **apparent** volume of distribution was greater, it is likely that there was at least some accumulation of drug in the renal excretory system, which may pre-dispose to nephrotoxicity, as shown by Hodge[31]. These authors recommended an amikacin "loading" dose of 5 mg/kg followed by 2.5 mg/kg/72h, a sound practice in pharmacotherapy when one wished to achieve rapid therapeutic serum levels.

In 1977, painted turtles *Chrysemys picta* and red-ear sliders *Trachemys scripta elegans* were used in the first pK study in chelonians[10]. At 26 ± 1°C, a dose regimen of 10mg/kg/48h I.M. based on total body weight including shell produced the most ideal peak and trough serum levels when compared with 10mg/kg/96h and 15mg/kg/48h. However, even with 10/mg/kg/48h, trough serum levels rose with each subsequent dose, so that after 3-5 doses, serum levels were within the toxic range, depending on how one extrapolates toxic serum levels in reptiles with those in mammals. In 1985, a study in red-ear turtles, using the same 10mg/kg/48h I.M. dose regimen, obtained significantly higher serum levels, well within the toxic range, even after the **first** dose[68]. The temperature at which the two studies were performed were similar (26 ± 1°C vs. 24 ± 1°C in the latter), so temperature was unlikely the cause. Site of injection was given as a possible explanation, as it is known that many reptiles posses a renal portal system whereby drugs injected in the caudal half of the body may be cleared more rapidly than if injected in the cranial half[36]. In the 1985 study I.M. injections were given in the front leg but the site of injection was not indicated in the 1977 study. The latter study showed 6mg/kg/48-120h I.M. (based on TBW) was sufficient to maintain therapeutic serum levels in red-ear sliders. A single injection maintained serum levels of ≥ 3.9 µg/ml for up to 72h, which is compatible with accepted 4-8 µg/ml desired level in mammals. One other anecdotal report[75], based on observations in a large private collection, recommended both gentamicin and amikacin at 11/mg/kg/24h subcutaneously for 3 days, skip 1 day, then 11mg/kg/24h for 3 more days for a total of 6 injections, for aquatic and semiterrestrial chelonians. In tortoises, a regimen of 11mg/kg/48h sub-q for a total of 6 injections was recommended. Temperature recommendations were 30°C to a maximum of 45°C, depending on the thermal maximum of the specie. Note that both the dosage regimen and temperature recommendations are higher than the previous studies. Although this report was not based on controlled studies, the authors have had apparent good success.

It was also recommended that in small specimens, higher dosages than 11mg/kg be used[75]. Similar recommendations were made earlier by others[68]. Reasoning for this includes beliefs such as there being minimum amount at which an antibiotic is effective or that very small dosages can't be measured. In fact, very young animals often require lower dosages due to incompletely developed renal and hepatic organ function[30,57]. In adult reptiles of small species and juveniles of larger ones, this author is unaware of any scientific evidence (pharmacokinetic or bioavailability) that even suggests that small reptiles need higher dosages (in mg/kg or frequency of administration) than larger reptiles. While it is true in the general scheme of things that small endotherms have more rapid metabolic rates than larger forms, this is much less true in poikilotherms. Furthermore, there is no evidence that AG's, penicillins, or cephalosporins undergo enzymatic decomposition in reptiles, but rather are excreted unchanged into the urine, a process that is temperature dependant, not size dependant. As will be discussed in the section on carbenicillin, secretion of unchanged drug into the urine of reptiles with bladders may have important implications on dose regimen design. In personal communication with one author (S. Veverka), higher dosages have possibly been the cause of shell defects in young growing chelonians. There is likely to be contention on this point of using higher dosages in small reptiles until controlled studies clarify the situation. The argument that small dosages can't be measured is completely unfounded. Proper dilution and use of insulin syringes allows accurate measurement of minute dosages.

In crocodilians, Jocobson recommended 2mg/kg/72h for 5 treatments based on experience and extrapolation from other reptile dosage recommendations[34]. In 1988, controlled pK studies using both gentamicin and amikacin were performed in juvenile alligators *Alligator mississippiensis*[37]. Gentamicin at 2.5mg/kg and amikacin at 2.25mg/kg I.M. in the forelimb produced desirable serum levels, although studies were limited to only a single injection of gentamicin or 2 injections of amikacin (96h apart). Specimens were maintained in enclosures with a constant water temperature of 22 ± 1°C and air temperature of 26 ± 1°C. The author noted that because toxicity data for alligators was unavailable, specific regimens (ie, number of inj, freq) could not be made based on controlled studies. Therefore, the earlier recommendation of injections every 72h for up to 5 injections appears sound. Another anecdotal report describes gentamicin and amikacin use in 3 cases of gram-negative septicemia[54].

A single report on the use of gentamicin in the aquatic salamander *Necturus necturus*, based on uncontrolled pK study, recommends 2.5mg/kg/72h I.M. when specimens are maintained at their normal [illegible].

Neo > Kana = Ami = Gent = Netil > Tobra > Strepto

and relative ototoxicity is ranked[35]:

Neo > Strepto = Kana > Ami = Gent = Tobra > Netil

Vestibular ("balance") toxicity is more predominant with gentamicin and streptomycin, auditory toxicity is more common with kanamycin, amikacin, netilmicin, and neomycin. These ranking may differ in reptiles (no data yet), but netilmicin may warrant investigation in herp medicine based on relative mammalian toxicity.

For gentamicin, therapeutic serum levels are between 4-8 μg/ml. Peak concentrations should not exceed 12-15 μg/ml; sustained trough levels above 2 μg/ml may correlate with nephrotoxicity[30,36,57,77]. Values for amikacin are approximately twice those for genamicin[57].

In addition to the well known toxicities of AG's, herpetoculturists need to be aware of several other potential problems regarding use of these drugs.

USE IN PREGNANCY

In mammals, AG's cross the placenta and cases of irreversible bilateral congenital deafness have been reported in children whose mother received AG's during pregnancy[30]. In humans, use during pregnancy is only indicated if benefits clearly outweigh the unknown hazards. Ross has used gentamicin and amikacin in gravid snakes (species not indicated) without the occurrence of birth defects or loss of viable eggs[58]. In a controlled study however, data suggested gravid water snakes *Nerodia sp.* were more sensitive to gentamicin toxicity than non-gravid specimens[31]. In gravid reptiles, without benefit of culture/sensitivity results, it may be better to use somewhat lower doses of AG's coupled with an extended-spectrum penicillin or third-generation cephalosporin, as the latter agents are substantially safer during pregnancy[30,57]. The safest route would be to use the latter two groups of agents alone, but this may lead to increased resistance if the bacterial organism(s) is/are resistant and treatment was empirical.

Further, AG's are capable of neuromuscular blockade through a curare-like effect that may aggravate muscle weakness[30]. This problem is most evident during or after anesthesia or use of muscle-relaxing drugs and also in hypocalcemic animals. Because muscle weakness has been implicated as a cause of dytocia in snakes, this is another reason to be cautious with the use of AG's in gravid reptiles, especially near "term."

URIC ACID BLOOD LEVELS

In the 1978 gentamicin study in *Nerodia*, an increase in uric acid blood levels was observed at increased temperatures, with metabolic production of urate waste products exceeding renal elimination. Further, a linear dosage response relationship was observed between gentamicin and uric acid, with an increase in blood urates occurring at increased gentamicin dosage levels[31].

The effect of feeding on uric acid blood levels has been studied[48,70]. Rises in serum urates were higher in specimens fed larger meals, which is to be expected. Peak urate levels of nearly 20mg/dl (normal = 2-5mg/dl in fasting snakes) were observed one to 2 days post feeding.

Some authors advise feeding during AG therapy[86] while others advise against it[36]. AG nephrotoxicity is manifested as visceral gout due to elevated blood urates[53]. It is presently not known at what minimum serum level visceral gout begins to occur in any reptile specie. Because of the known feeding effect on serum urates by gentamicin, feeding, and temperature, at least in some species of reptiles, it seems prudent to be cautious about feeding carnivorous herps during AG therapy. While many herps are anorexic during gram-negative infections and feeding becomes a "mute" point, the decision to assist or tube-feed should be made only after considering the risk of visceral gout that may result from feeding. In many cases, the experienced herpetoculturist will "catch" their specimen in the early course of the disease process while the animal is still in reasonably good body condition and weight. In these cases it may be wise to withhold feedings until antibiotic treatment is completed. On the other hand, veterinarians in practice often see specimens weeks into the infectious process when the specimen is in poor physical condition, and the decision to co-administer nutritional and AG therapy should be made with these points in mind. Most of these specimens are candidates for fluid therapy[36], which will be discussed in a separate paper at this symposium.

EFFECT OF CALCIUM

Calcium availability has been shown to affect gentamicin nephrotoxicity in the rat[64]. High serum levels of gentamicin were shown to be less toxic in presence of increased renal tubular intraluminal calcium achieved through an increase in dietary calcium. Calcium may also prevent or reverse AG-induced neuromuscular blockade[57]. Because calcium deficiency is commonly seen in practice, more work needs to be done regarding calcium therapy during AG treatment. Fluid therapy with appropriate mono-(Na,K,Cl) and divalent (Mg,Ca) ions is an important part of treatment of the dehydrated animal. It has been noted the importance of considering water calcium levels when examining data from different studies on AG kinetics in aquatic species[72].

EFFECT OF pH AND OSMOLALITY

It has been shown that alkaline pH and low osmolality produced enhanced antibacterial effect of gentamicin on *Pseudomonas spp.* in human urine (reviewed in (72)). It has been suggested that in aquatic species, alteration of facility water through mild alkalinization and dilution might decrease the levels of drug required for effective treatment[72]. On the other hand, increased salinity (osmolality) is used by others during antibiotic treatment[51]. Clearly, more work needs to be done regarding use of AG's in aquatic herp species.

EFFECT OF TEMPERATURE

In addition to the effects of temperature already discussed, some authors have shown that minimum inhibitory concentrations (MIC's) of amikacin for certain gram-negative bacteria isolated from snakes were lower at 37°C compared to 25°C[47]. However, Jacobson has data showing MIC values for isolates of *Aeromonas hydrophila* isolated from an infected alligator were the same at 22°, 30° and 37°C[37]. It is also known that the immune system of reptiles is temperature-dependent, with better antibody production at higher body temperatures (reviewed in (21)). However, as noted earlier, at least one controlled study showed increased AG toxicity at higher temperatures[31]. The current consensus is that herps on antimicrobial therapy be maintained at the high end of the preferred optimum temperature zone, but again more investigation is needed.

COMBINATION USE OF AG's WITH OTHER ANTIBIOTICS

In the treatment of gram-negative septicemia in humans, AG's are often combined with beta-lactam antibiotics especially prior to return of bacterial culture/sensitivity results. This subject will be discussed after the section on cephalosporin antibiotics.

Commercial Products

Gentamicin sulfate (Garamycin®, Schering)
2mg/ml; 10mg/ml; 40mg/ml
Amikacin sulfate (Amikin®, Bristol; Amiglyde®, Beechum)
50mg/ml; 250mg/ml
Netilmicin sulfate (Netromycin®, Schering)
100mg/ml; 25mg/ml
Tobramycin sulfate (Nebcin®, Dista)
10mg/ml; 40mg/ml

Paromomycin sulfate (Humatin®, Park-Davis)
250mg/cap

This agent, also an aminoglycoside, is known by many in the herpetological community for its usefulness in ameblasis. A dose of 33-100mg/kg once daily for up to 4 weeks has been recommended[38].

Topical AG's:
Dermatologics
Gentamicin (Garamycin®, various generics)
ointment or cream
0.1% (=1.7mg/gm)

Ophthalmics

Gentamicin (Garamycin®)

ointment, 0.3% (=3mg/gm)

Tobramycin (Tobrex®, Alcon)

ointment, 0.3%

Ophthalmic ointments lend themselves to topical application in cases of mouth rot, useful as adjunct to parenteral therapy. Tobrex reportedly causes fewer local adverse reactions (3.7%) than Garamycin (10.6%)[59].

EXTENDED-SPECTRUM PENICILLINS (ESP's)

The penicillins were the first class of antibiotics to be discovered[30]. In the 1970's, newer penicillins, termed "extended spectrum" due to their capacity to inhibit a wide variety of aerobic gram-negative bacilli, were developed. Examples in this sub-class of penicillins are carbenicillin, ticarcillin, azlocillin, mezlocillin, and piperacillin.

In a review of ESP's, the following was noted[55]:

"Ticarcillin is 2-4 times more active than carbenicillin against Pseudomonas aeruginosa. Piperacillin is more potent than ticarcillin against Pseudomonas aeruginosa and Klebsiella, but has activity similar to that of ticarcillin against most other gram-negative pathogens. Azlocillin is as active as piperacillin against Pseudomonas aeruginosa but is less active against most other gram-negative organisms. Mezlocillin is similar to ticarcillin in antimicrobial spectrum, but it has more activity against Klebsiella."

Compared with AG's, ESP's are associated with a more rapid development of resistance among gram-negative bacteria. Because of this, in serious gram-negative infections in humans, ESP's are usually combined with AG's[18,57,69]. This topic will be covered in a subsequent section in this paper.

PUBLISHED ACCOUNTS OF ESP's IN REPTILES

Carbenicillin was first suggested for used in *Aeromonas* and *Pseudomonas* infections in snakes in 1975, based on the results of in-vitro sensitivity studies[19]. Subsequent investigators showed variable in-vitro activity versus a variety of bacteria isolated from sick reptiles[43]. In-vitro MIC's varied from <16 µg/ml (very sensitive) for *Salmonella*, *Arizona*, and *Proteus* and 32 µg/ml for *Pseudomonas aeruginosa* to >256 µg/ml (resistant) for *Pseudomonas cepacia*, *Aeromonas hydrophila*, *Citrobacter*, and *Klebsiella*.

The first anecdotal report on the use of ESP's in reptiles that this author is aware of was in 1977, when Ross recommended carbenicillin 100-125mg/kg daily in snakes, with a maximum single dose of 250mg[67]. In a later publication, a dose of 100mg/kg was recommended for this and related ESP's[68].

In 1984, sensitivity data and a pK study in snakes using carbenicillin was reported[43]. In-vitro tests showed carbenicillin to be effective against 43 to 56 isolates of *Pseudomonas aeruginosa* and *Pseudomonas ssp.* isolated from sick reptiles over a period of years. In a series of nine snakes (5 *Elaphe sp.*, 2 *Lampropeltis getulus*, 1 *Bioga dendrophila*, and 1 *Python reticulatus*) suffering from either mouth rot or abscesses, carbenicillin was administered as a single I.M. injection at 400mg/kg. Site of injection was not indicated. Specimens were maintained at 30°C throughout the study. Peak plasma levels as high as 269 µg/ml were achieved in 1 hour and therapeutic plasma levels were maintained for 12-18 hours. Reportedly a good clinical response was seen in all 9 snakes after a single injection. The only adverse effect noted was transient pain on injection, using a 200 mg/ml solution. These authors recommended 400mg/kg/24h I.M. daily in snakes maintained at 30°C. It was noted that a dose of 100-125 mg/kg/24h is likely to lead to underdosing and a tendency for selection of resistant strains of bacteria.

Jacobson reported a poor response to antibiotic treatment in a rhino viper *Bitis nasicornis* suffering from a mixed gram-negative osteomyelitis using several agents[35]. Gentamicin (2.5mg/kg/72h x 5) alone, followed by carbenicillin alone at 400mg/kg/73h for 4 treatments and then a combination of gentamicin and carbenicillin, followed by ceftazidime (a 3rd generation cephalosporin) did not resolve the lesions. The viper finally responded to an autogenous polyvalent bacterin made from the mixed infection of *Pseudomonas aeruginosa*, *Proteus Morganella*, and *Escherichia coli* isolated from the osteomyelitis. While some have criticized used of bacterins[68], Jacobson has had additional successes using them[36]. The use of bacterins is beyond the scope of this paper.

Carbenicillin was further studied in the tortoises *Testudo graeca* and *T. hermanni*[45]. In 11 tortoises suffering from "rhinitis" (presumably respiratory disease), a single I.M. injection of 400 mg/kg was given in the hind leg and specimens were maintained at 30°C. In 5 *T. graeca*, peak serum levels (mean = 246, r = 103 - 474 µg/ml) were reached in 1 hour and therapeutic levels maintained for approximately 12 hours. In 6 *T. hermanni*, peak serum levels (mean = 120, r = 112 - 127 µg/ml) were not reached until 8 hours post injection and therapeutic levels maintained throughout the duration of the pK study period which ran 72 hours. Although only 1 *graeca* and 2 *hermanni* were used for blood sampling after 37 hours post injection, both species showed a second peak at 37h and 72h, respectively. While the small sample size leaves open to debate the significance of the variances in timing of the initial peak, the second peak observed in both species was explained by the tortoises' bladder acting as a reservoir of antibiotic available for reabsorption. This was supported by the fact that serum levels were lower in 3 tortoises that urinated during the 72h study period. The authors noted that this mechanism could make difficult the determination of dosage regimens in tortoises for antibiotics which are excreted into the urine as unchanged drug (which includes AG's, most penicillins, and cephalosporins). In this limited study based on a single injection in each tortoise, carbenicillin appeared safe and effective, with transient pain on injection the only adverse effect noted. There was no elaboration on the clinical responses in the tortoises.

This author is unaware of any other anecdotal or controlled study examining the other ESP's. A [illegible] on piperacillin is being presented during this symposium. Given that carbenicillin is the least [illegible] of the ESP's[55], further work with the other ESP's is warranted.

[illegible] OF ESP's

Many herpetoculturists believe penicillins to be non-toxic. While it is true that these agents possess very favorable therapeutic to toxic ratios, there are several potential toxicities. Nephrotoxicity has rarely been associated with penicillins, although rarely[2,30,55,57,69]. Among the ESP's, carbenicillin and ticarcillin occasionally produce dose-dependent abnormalities in platelet aggregation which results in prolonged "bleeding time"[55]. In man, this occurs most often at dosages >300 mg/kg/day. Also reported at very high dosages is central nervous system toxicity (manifested as seizures)[55]. Allergic reactions, on the other hand, can occur at normal doses and may be life-threatening[30,55]. Jacobson reported that Rosskopf (in a personal communication) observed a significant skin rash in the Desert tortoise *Gopherus agassizi* following carbenicillin administration[36]. Electrolyte abnormalities may result from the sodium component of penicillin salts, particularly with carbenicillin (which contains 2 sodium atoms per molecule of carbenicillin).

[illegible] Products

[illegible]cillin disodium (Geopen®, Roerig; Pyopen®, Beecham)
1 gm vial
[illegible]cillin disodium (Ticar®, Beacham)
1 gm vial
[illegible]cillin sodium (Pipracil®, Lederle)
1 gm and 2 gm vials
[illegible]cillin (Azlin®, Miles)
2 gm vial

These agents are available as powders for reconstitution. Normal saline or sterile water for injection can be used, then individual aliquats can be drawn up in insulin syringes, frozen, and thawed for future use.

THIRD-GENERATION CEPHALOSPORINS (CS's)

Cephalosporins are beta-lactam antibiotics similar to penicillins. On the basis of the spectrum of activity against gram-negative bacilli, CS's are categorized into "generations."

First generation agents are the most active CS's against gram-positive cocci, whereas they have minimal activity against gram-negative aerobes. Toxicity was also a problem with some early CS's, such as cephaloridine, which was "recalled" from the market due to nephrotoxicity[28,30,57].

Second generation agents show greater individual variation in their effectiveness against gram-negative aerobes. Cefuroxime has the broadest gram-negative spectrum of the class with activity against *Citrobacter, Enterobacter, Proteus, Providencia, Salmonella sp.,* and *Klebsiella*. None of the second generation agents are effective against *Pseudomonas*[3,18,55,57,60].

Third generation agents can be divided into 2 groups based on reliable activity against *Pseudomonas aeruginosa*. Ceftazidime and cefoperazone are the two important anti-pseudominal third-generation CS's. Ceftazidime is currently the most reliable agent against *Pseudomonas aeruginosa*[30]. It is approximately 32 times more active in-vitro against *Pseudomonas aerouginosa* than carbenicillin[16]. It is similar in efficacy against Enerobacteriaceae in comparison with other third-generation CS's. Cefoperazon is less active than other third-generation agents against gram-negative aerobes other than *Pseudomonas* species. Third-generation CS's are often more resistant to beta-lactamases produced by gram-negative bacteria than are the ESP's[30]. In mammals, in contrast with other third-generation agents that are eliminated via the kidney, ceforperazone is excreted through hepatic pathways. Minimal dosage adjustment in renal failure is needed, so this may be an advantage in herp medicine. Ceftazidime has been shown to have minimal mammalian nephrotoxicity[14]. Incidence and types of adverse reactions are similar to ESP's, so these agents appear to be safe in reptiles.

LITERATURE CITATIONS

Lawrence used cefuroxime at 100 mg/kg/24h for 10 days against multiple resistant strains of *Proteus* in snakes and achieved a good clinical response when used alone or in combination with gentamicin[40].

In an in-vitro study, ceftazidime was shown to have excellent activity against a number of *Pseudomonas, Aeromonas,* and *Enterobacteriaceae* isolates from sick reptiles[42]. Only a few isolates were resistant. Most isolates had MIC's of less than 1 μg/ml. The drug had substantially greater activity compared to carbenicillin for almost all strains tested.

Based on sensitivity results, ceftazidime was used to treat 8 snakes clinically ill with a variety of pathologic conditions[42]. Included in the study were 2 *boa constrictors*, 2 *Python reticulatus*, 2 *Python m. bivittatus*, 1 *Bloga dendrophila, and 1 Elaphe obsoleta*. Snakes were maintained at 30°C and administered a single injection of 20mg/kg I.M. Peak plasma levels were reached 1 to 8 hours post injection. Therapeutic plasma levels were maintained for at least 96 hours. One boa showed no decline in blood levels during the first 24 hours, and a reticulated python showed a significant rise from 75 to 96 hours. This rise may possible be explained by a depot effect in the injected muscle with variations in activity releasing more or less antibiotic into the bloodstream. A rapid and obvious clinical response was reportedly seen in all specimens after a single injection. The solution (dry powder reconstituted to 100 mg/ml) appeared to cause minimal discomfort on injection and no adverse reactions were noted.

Two anecdotal reports in the literature concern the use of third-generation CS's. In the rhino previously mentioned with mixed gram-negative osteomyelitis, gentamicin, carbenicillin, and (20 mg/kg/72h x 14) were all ineffective in curing the infection[35]. In two ball pythons *P.* with pneumonia, cefoperazone at 125 mg/kg daily for 5 days was also ineffective, although and sensitivity were not performed[68]. In summary, third-generation CS's warrant further in herp medicine.

Products

(Fortaz®, Tazidime®, Tazicef®)

1 gm; 2 gm vials

280mg/ml reconstituted in sterile water water for injection is stable 3 months when . Once thawed, the solution is only stable 4 days if refrigerated. Thawed solutions should not be

(Cefobid®, Roerig)

1 gm vial

300 mg/ml in normal saline is stable 3 months when frozen[74]. Thawed solutions are for 5 days if refrigerated.

NEW BETA-LACTAM ANTIBIOTICS

Herpetoculturists may wish to know about two new beta-lactam antibiotics that may play a role herpetoculture.

-CILASTATIN (Primaxin®, MSD)

Imipenem is the first of a new subclass of beta-lactam antibiotics known as carbapenems. It is with cilastatin, a compound that inhibits metabolism of imipenem.

Imipenem has been shown to have the broadest antimicrobial spectrum of any antibiotic, many bacteria resistant to other beta-lactam antibiotics and AG's[55].

(Azactam®, Squibb)

The first of a new sub-class of beta-lactam agents known as monobactams.

Spectrum of activity is limited to aerobic gram-negative bacteria. It is comparable to third-generation cephalosporins and ESP's activity against Enterobacteriaceae; susceptibility of pseudomonas [illegible][56].

CHLORAMPHENICOL (CAL)

Chloramphenicol is an antibiotic frequently recommended in herp medicine[29,36,67]. It is bacteriostatic but can be bacteriocidal at high concentrations[36,77]. In mammals peak serum concentrations of 10-20 µg/ml and trough values of 5-10 µg/ml are considered normal[57]. It is considered the drug of choice for acute Salmonella infections in mammals[57,72], and it has been considered the same for SCUD in turtles (reviewed in (31)). *Pseudomonas* species are commonly resistant[36,77].

LITERATURE CITATIONS

Early work with CAL was performed in gopher snakes *P.m. caterifer* maintained at 24°C[78]. Administered subcutaneously at 40 mg/kg, peak plasma levels of 26 µg/ml were reached in 3.2 hours with a half-line of 5.2 hours. Oral administration of CAL suspension at 12 mg/kg produced a peak of only 10 µg/ml 12 hours after administration. These investigators recommended treatment for 5-14 days using the injectable form, depending on the clinical situation and response to treatment. Others recommended 50-75 mg/kg/day in snakes[67].

More recently, 87 snakes of 16 species were used in a pK study using CAL sodium succinate[15]. Specimens were maintained at 26 ± 2.3°C. Single injections of 25 mg/kg and 50 mg/kg were studied. Biological half-life varied from 3.3h in Florida indigo snakes *Drymarchon c. couperi* to 22.1h in Midland water snakes *Nerodia sipedon*. At 50 mg/kg, plasma levels > 5 µg/ml were maintained for nearly 72h in *Nerodia*, 24h in the Burmese python, and less than 12h in gray rat snakes *Elaphe o. spiloides*, Eastern king snake *Lampropeltis getulus*, and Florida Indigo snake. In 9 specimens of 2 species of *Nerodia* administered 50 mg/kg/72h subcutaneously for 18 days, plasma levels of 2 to 5 µg/ml were maintained throughout the study. The authors recommended dosing intervals between 12 and 72 hours depending on the species (see Table 1). In the extended *Nerodia* study, one Midland water snake developed significant anemia with green discolored plasma days 9 and 18 of the study. The hamatocrit on day 18 was nine (normal = 31 ± 7).

Table 1. The half-life ($T_{1/2}$) and dosage intervals calculated to maintain a minimum concentration of 2 or 5 μg/ml after a single subcutaneous dose of 50 mg of chloramphenicol/kg (from (15)).

Snake	$t_{1/2}$ (hours)	Dosage interval in hours for a minimum plasma concentration of: 2μg/ml	5μg/ml
Indigo snake	3.3	14.1	9.8
Gray rat snake	4.7 ± 2.6	13.9 ± 4.4	7.7 ± 2.4
Boa Constrictor	6.8 ± 1.3	36.6 ± 4.8	27.6 ± 3.0
Copperhead	7.4 ± 2.3	46.3 ± 12.8	36.5 ± 9.8
Cotton mouth	7.9	49.6	39.1
Burmese python	10.6 ± 1.1	43.6 ± 7.1	29.6 ± 5.6
Hog-nose snake	11.0	45.3	30.7
Indian rock python	14.0	68.0	49.0
Eastern diamond-back rattlesnake	15.5 ± 0	71.5 ± 12.6	51.0 ± 12.6
Timber rattlesnake	16.5 ± 10.1	75.1 ± 43.6	53.4 ± 30.3
Red-bellied watersnake	20.2 ± 5.6	88.1 ± 24.2	61.3 ± 17.0
Midland watersnake	22.1 ± 8.4	98.5 ± 35.7	69.2 ± 24.7

Data are expressed as mean ± SD when more than one snake was involved in the calculation.

The authors also performed a bioavailability study (the only one of its kind that this author is aware of in the herp literature) comparing two different CAL products. In 8 gray rat snakes, 4 specimens were administered either Tevcocin® or Mychel-vet® at 50 mg/kg subcutaneously. Mean plasma levels were slightly higher for Tevcocin®, demonstrating slightly better bioavailability for this product. Also consistent in all 8 snakes after initial rise in serum levels was dip at 4-6 hours followed by a second peak at 48 hours post injection. Edema at the site of injection was greater for Mychel-vet® and may have temporarily interfered with absorption.

TOXICITY

CAL is known to cause significant hematologic abnormalities (ie. fatal blood "dyscrasias") in mammals and is rarely used because of this[30,57,77]. In fact, several cases of aplastic anemia have occurred in humans after use of CAL ophthalmic ointment[30]. A dose-dependent reversible bone marrow depression is associated with sustained plasma levels at peaks >25 μg/ml and troughs >10 μg/ml[57].

Some authors claim CAL is non-toxic in both normal and gravid snakes[38]. However, the recent study described above suggest that CAL is quite capable of producing blood toxicity in snakes. Snakes that eliminate that drug more slowly may be at higher risk.

Toxic reactions including fatalities have occurred in premature and newborn human infants at doses as low as 25 mg/kg/day[30,57], although pre-existing liver dysfunction may have been a risk factor. In snakes, neonates and embryos still in-utero may be more sensitive to CAL toxicity. Again, penicillins and cephalosporins are substantially safer in this situation[18,30,57].

Commercial Products

Chloramphenicol Sodium Succinate (Chloromycetin®, Park-Davis)
This drug, the only injectable for of CAL, is intended for intravenous administration; it is ineffective when given I.M. in mammals[57]. In reptiles, it is administered sub-cutaneously[15,36,78]. Commercial products are available as a powder for reconstitution (human) and as ready-made solutions (veterinary).

Chloramphenicol Sodium Succinate
Tevcocin® (Int'l Multifoods)
100 mg/ml
Mychel-Vet® (Rochelle Labs)
100 mg/ml

Disadvantage of ready-made solutions is that they contain propylene glycol, which may cause focal lesions at the site of injections and lead to erratic absorption.

COMBINATION USE OF ANTIBIOTICS

In human medicine, combination antibiotic therapy is often indicated in serious gram-negative infections, particularly in immunocomprimised patients. Combination therapy in these patients is frequently begun prior to obtaining culture/sensitivity results to insure antibiotic coverage of the infecting organism(s). Additional indications for combination therapy include[3,18,55-57,68]:

1. *Pseudomonas* infections
2. Mixed infections, eg, gram-positive & gram-negative
3. Known synergism or additive effects between two antibiotics.

In combination therapy, EPS's and cephalosporins are often combined with AG's. These combinations have been shown to provide in-vitro synergy against *Pseudomonas* and Enterobacteriaceae and improved clinical outcomes in a variety of infections (reviewed in (55-56)). Ceftazidime has been shown to be more effective in combination with amikacin in the treatment of gram-negative septicemia than when used alone[56]. Historically, increased nephrotoxicity was noted when AG's were combined with some older first generation cephalosporins, such as cephalothin[49]. This has not occurred with newer agents.

Physico-chemical inactivation has been documented when AG's and ESP's are combined [illegible]. At physiological pH, the polybasic cationic AG coupled with anionic penicillin leads to complex formation[49]. Because the penicillin is used in a much greater dose, the clinical result is a decreased effectiveness of the AG. This is well documented with carbenicillin and ticarcillin, but has been observed with other penicillins. Tobramycin and gentamicin are more susceptible to inactivation than netilmicin or amikacin. The rate of inactivation depends on concentration and contact time. For example, a 40-60% loss of gentamicin/tobramycin and 10-20% loss of amikacin occurs in 24h at 37°C at penicillin concentrations of 500 μg/ml[60]. This relatively greater stability of amikacin was demonstrated in-vivo in nephrectomized dogs[61].

Inactivation is clinically important:

1. When penicillins and AG's are mixed in the same vial or syringe.
2. During AG assay procedures.
3. In patients with reduced renal function.

Significant inactivation of gentamicin and tobramycin had been demonstrated in renal failure patients receiving carbenicillin, ticarcillin, and piperacillin, as evidenced by a shortened half-life and subtherapeutic plasma levels of the AG[49]. No significant inactivation has occurred in patients with normal renal function. No AG-cephalosporin interaction has been reported.

There is little in the herp literature documenting combined use of AG and beta-lactam antibiotics. As noted earlier, one investigator used cefuroxime at 100 mg/kg daily for 10 days in combination with gentamicin against multiple resistant strains of *Proteus* in snakes and achieved a good clinical result[40].

Jacobson has subsequently made the following recommendations when gentamicin and carbenicillin are combined for use in snakes[36]. Commencing at 48h after the first dose of gentamicin (10mg/kg/72h), carbenicillin (400 mg/kg) is administered every 72h, both drugs being administered at 37°C. In the case of the rhino viper previously mentioned, when the combination was used, carbenicillin was administered beginning 24h after the first dose of gentamicin. At this point in the blood level gentamicin plasma levels would be higher and it is possible that physico-chemical inactivation may have contributed to the poor response.

Ross has recommended ESP's at a standard does of 100 mg/kg daily when combined with AG's[55]. In this case, while the mg/kg dose is lower, the frequency of administration is greater.

More work needs to be directed toward investigating AG-betalactam combinations in herp medicine to determine the proper dosage and frequency. Piperacillin, currently the most reliable ESP against Pseudomonas[55], and amikacin would be a good combination for pharmacokinetic study in snakes.

One last point not to be overlooked is that two AG's should never be combined together because of additive toxicity[57,68]. Half-strengths of each of two AG'S leads to subtherapeutic serum levels of both, as competition with each other occurs for active sites in the target bacteria.

FLUOROQUINOLONES (FQ)

This group of synthetic antibacterials is under intensive investigation[69,79]. Two human and one veterinary product have appeared on the market recently and include:

1. Ciprofloxacin (Cipro®, Miles) human
2. Norfloxacin (Noroxin®, MSD) human
3. Enrofloxacin (Baytril®, Haver) veterinary

An additional FQ, ibafloxacin, is being co-investigated by Beecham/3M Riker and is expected to be released in the early 1990's.

Old non-fluorinated quinolones available in the U.S. include cinoxacin and naladixic acid, but have limited use due to spectrum and toxicity[57,89]. Fluorination of the quinolone molecule was found to markedly expand the spectrum and limit formation of bacterial resistance to these drugs[79]. The mechanism of action is through inhibition of DNA syntheses, which is unique among antibiotics.

FQ's are among the broadest spectrum of all antibacterials[18,57,69,79]. All Enterobacteriaceae are susceptible, although occasional isolates are resistant. *Pseudomonas aeruginosa* and *Aeromonas* species are very sensitive, with in-vitro MIC's significantly < 1 µg/ml for many strains tested. Many *Pseudomanas aeruginosa* strains resistant to gentamicin, azlocillin, and ceftazidime have been shown to be sensitive to ciprofloxacin (reviewed in (79)). Conversely, resistance may occur rapidly in some strains of *Pseudomonas*. Intracellular pathogens such as *Salmonella* and *Mycobacterium* species have been shown to be sensitive to Cipro®.

Ciprofloxacin is additive and in some cases synergistic with other antibiotics. Synergism with azlocillin has been demonstrated against *Pseudomonas aeruginosa*.

Toxicity of FQ's limit their use in pregnant and growing animals. Arthropathy (cartilage damage) has been shown to occur in young animals at very high dosage levels. In addition, renal damage has been reported in rodents fed high doses, which occurred due to poor solubility in alkaline rodent urine.

Despite the potential toxicities, the FQ's are expected to play an increasing important role in both human and veterinary medicine. Currently available products are marketed as tablets only; an injectable form of ciprofloxacin is under development.

Human dosage regimens average 5-10 mg/kg/12h. There are no reports in the herp literature regarding FQ's.

POTENTIATED SULFAS

TRIMETHOPRIM-SULFADIAZINE

Human injectable products include Bactrim® (Roche) and Septra® (Burroughs-Wellcome) and are supplied as trimethoprim 80 mg/ml and sulfadiazine 200 mg/ml. An injectable form of the veterinary preparation Tribrissen® (B-W) is now available as a 30 ml multidose vial. It is formulated in the same concentration as the human preps.

In addition to having a good spectrum of activity against both gram-positive and gram-negative aerobic bacteria, sulfas also shown activity against some coccidian protozoan pathogens. Cryptosporidium, a highly significant coccidian pathogen in herps, has **not** been shown to be sensitive to sulfas.

One investigator used the combination at 1 cc/kg daily in a python (specie not indicated) with pneumonia and achieved good results without toxicity[88]. Another authority recommends a dosage of 15-30mg/kg/24h for 10 days based on the sulfadiazine component, which is equivalent to about 0.08-0.125 cc/kg/24h[89]. While the combination is relatively safe in mammals at the latter dose, the safety of higher doses in reptiles requires further confirmation.

Animals need to be well hydrated during sulfonamide therapy. Sulfas are less soluble in acidic urine where they can precipitate out and cause renal toxicity due to crystalluria. This may possibly occur in reptiles at higher dose levels, particularly desert species which tend to concentrate their urine. Other possible toxicities include blood abnormalities and allergic reactions.

"TRADITIONAL" ANTIBIOTICS

The older, "established" antibiotics, such as ampicillin (an early penicillin) and tetracycline (the first tetracycline) still show efficacy against some gram-negative bacterial pathogens in herps and are not obsolete by any means. For example, ampicillin is often effective in-vitro against salmonella but may be ineffective in clearing clinical cases of the organisms. Tetracyclines frequently show good activity against some herp pathogens but should be avoided in gravid specimens, young growing animals, and those animals exposed to large amounts of ultra-violet light (photo-toxicity).

TOPICAL ANTIBIOTICS

OVER-THE-COUNTER (OTC)

Polysporin® ointment and newly reformulated Neosporin® ointment both contain 10,000 μ/gm of polymyxin B sulfate. Neosporin also contains neomycin 3.5 mg/gm and bacitracin, while Polysporin is formulated with just bacitracin. Either product is excellent for topical treatment of bacterial infections in herps. Betadine® ointment is also good.

PRESCRIPTION

Mafenide acetate (Sulfamylan®) was shown a decade ago to be highly effective in the treatment of mouth rot and dermal infections in lizards and snakes[27], but its role in human medicine has been replace with silver sulfadiazine (Silvadene® cream, Marion). This product is very effective against gram-negative bacteria, including *Pseudomonas*. Other topical prescription antibiotics include gentamicin and chloramphenicol.

Prescription ophthalmic ointments appear to be less irritating when applied orally in cases of mouth rot, but are relatively more expensive than dermatologics. These have been mentions previously.

ANTI-MYCOBACTERIAL AGENT (Isoniazid & Rifampin)

Mycobacterium species are not infrequently associated with clinical disease in herps[32]. Two species, *M. thamnopheous* and *M. chelonei* were named after the herps they were initially discovered in. Recent reports in the literature include 3 cases of mouth rot in boa constrictors due to *mycobacterium* species[39,58,65]. Secondary bacterial invaders frequently mask the diagnosis, as *mycobacterium* are difficult to culture. Published reports usually describe the histopathology quite well but virtually all cases fail to even mention possible pharmacotherapy against the organism.

The mainstay of anti-tubercular therapy in man involves the use of isoniazid and rifampin. Both drugs are hepatotoxic (liver) and generally need to be administered over a prolonged period of time, so it may be extremely difficult to establish safe dosage regimens in herps. As mentioned earlier, ciprofloxacin (a fluoroquinolone) may have efficacy mycobacterium species and is currently under clinical investigation.

ANTI-PROTOZOAL AGENTS

No significant new anti-protozoal agents have appeared on the market in recent years.

Metronidazole (Flagyl®) and dimetridazole (Emtryl®) represent the two most important agents in herp anti-protozoal therapy. The former drug given in a single oral dose of 40-150 mg/kg and repeated in 7-10 days is usually sufficient to clear amebiasis and flagellated protozoan infections. Doses as high as 275 mg/kg have been recommended in the herp literature but this author has never exceeded 150 mg/kg. Deaths in Indigo snakes *Drymarchon sp.* and tri-color *Lampropeltis* have been reported at doses above 100 mg/kg; 40-50 mg/kg is usually safe and effective in these species[36].

Metronidazole has very low solubility in water (10 mg/ml); an intravenous product is available but is too dilute (5 mg/ml) for use in herp medicine. Therefore, oral tablets need to be used in preparation of dosages. Generic products are available and are cheaper than Flagyl®. The accurately weighed amount of drug should be suspended in a small volume of saline and injected into the stomach using a canine or feline urinary catheter. The tube is then flushed slowly while in place to insure delivery of drug particles that may remain in the tube after initial infusion.

Cryptosporidiosis still represents a therapeutic dilemma in both herp and human medicine. There is no effective cure for the disease. Sriramycin (Rovamycine®, Rhone-Poulenc) is an "orphan" drug that has been shown to control diarrhea but not oocyst shedding in human AIDS patients with cryptosporidiosis[22,26]. It is available through the National Center for Orphan Drugs and Rare Diseases (phone number 800-336-4797 or 202-565-4176). *Cryptosporidium* oocysts are also quite resistant to disinfectants; undiluted Clorox® should be used and left to soak the aquarium or plastic shoe box for 8-10 minutes. All cage materials should be discarded preferably by incineration.

ANTI-VIRALS

There are no published reports on pharmacotherapy of viral disease in herps.

ACYCLOVIR (Zovirax®, Burroughs-Wellcome) 2% ointment

May have efficacy in the treatment of Grey-patch disease (due to Herpes) in sea turtles.

AMANTADINE (Symmetrel®, Dupont) 100mg Capsule

Use to treat influenza "A" and Parkinson's disease in humans. May have efficacy in the symptomatic treatment of Paramyxovirus infection in snakes.

ANTI-FUNGALS

OVER-THE-COUNTER (OTC)

Tolnaftate 1% (Tinactin®) and miconazole 2% (Micatin®) are the most effective OTC anti-fungal agents available. Jacobson reported successful treatment of mycotic skin disease in snakes with tolnaftate following twice daily soaks in dilute organic iodine solution (ie, Betadine®)[36]. Malachite green at 15 mg/liter 3 times daily for 1 week was effective in treating mucormycosis in hatchling Florida soft-shell turtles (Trionyx ferox)[36]. Turtles were soaked for 15 minutes each treatment and thoroughly rinsed. The only adverse effect was mild conjunctivitis.

PRESCRIPTION

A number of prescription topical anti-fungals are available. These include:

1. Amphoteracin B (Fungizone®, Squibb) 3%
2. Ketoconazole (Nizoral®, Jennsen) 2%
3. Nystatin (Mycostatin®, Squibb) 10,000 μ/gm
4. Imidazoles: Miconazole (Monistat-derm®) 2%
   Clotrimazole (Lotrimin®) 1%
   Econazole (Spectazole®) 1%

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VITAMIN D AND UV RADIATION: GUIDELINES FOR THE HERPETOCULTURIST

Matthew Moyle, PhD

INTRODUCTION

Over the past decade the art/science of keeping and breeding reptiles and amphibians - herpetoculture - has moved rapidly forward. The herpetoculturist in recent years has been able to not only maintain but also reproduce species that were once thought to be impossible to keep in captivity. Many of these successes are the result of improved captive conditions due to increased awareness of the natural ecology of specific species, including climate, habitat and behavior. In contrast, dietary considerations, especially with respect to vitamin requirements, have lagged. In particular, there is confusion in the amateur literature surrounding vitamin D and ultraviolet (UV) radiation. What is vitamin D? What are its functions? Is it necessary to supplement a herptile diet with vitamin D? Which artificial light sources support the synthesis of vitamin D? In this paper I will address these and other related issues. Although the nature of this material is quite technical, I will attempt to discuss vitamin D and UV radiation as it relates to the care of captive herptiles as non-technically as possible, while still allowing the interested reader to understand how my conclusions were reached. For those herpetoculturists who are strict technophobes, the "bottom line" is presented as a point-form summary at the end of this paper.

VITAMIN D: WHAT IS IT AND WHAT ARE ITS FUNCTIONS?

Vitamin D (also known as cholecalciferol) is a fat soluble compound that is involved primarily in the regulation of calcium metabolism (for a review see DeLuca, 1982). Specifically, vitamin D maintains an acceptable concentration of calcium in the blood. Calcium is essential for a host of metabolic processes including muscle function and mineralization of bone. Vitamin D, in its activated form (see below), acts to increase blood calcium levels by signaling 1) intestinal cells to promote transport of calcium from the gut into the bloodstream, 2) kidney tubule cells to effect retention of calcium from the ultrafiltrate of blood (the precursor of urine) and 3) bone cells to modulate the transfer of mineralized bone calcium back into the bloodstream. Vitamin D is not the sole regulator of calcium metabolism; two hormones, calcitonin and parathyroid hormone, also play a role in the regulation of calcium balance[1]. Of the three calcium regulators, vitamin D is the most important factor for the concern of the herpetoculturist because its levels, unlike calcitonin and parathyroid hormone, can be significantly influenced by captive conditions (ie diet and UV radiation; see below).

CONSEQUENCES OF ABNORMAL VITAMIN D LEVELS

Since vitamin D is a positive regulator of calcium metabolism, an organism that has a deficiency of vitamin D will have abnormally low levels of calcium. A deficiency of vitamin D (hypovitaminosis D) results in bone deformities in growing specimens (rickets) and hypocalcemic tetany in adult animals. Vitamin D can reverse the condition of rickets in growing animals, and it is thus said to have anti-rachitic activity. Too much vitamin D (hypervitaminosis D), on the other hand, causes acute hypercalcemia in the case of massive overdose or an irreversible withdrawal of calcium from the bones and a calcification

[1] For a complete review of the function of calcitonin and parathyroid hormone in reptiles and amphibians as well as the other vertebrates see Feinblatt, 1982.

of soft tissue (eg brain, liver, kidney, etc.) when moderately excessive quantities are given over extended periods. Both these conditions are potentially lethal.

HOW DOES A HERPTILE REGULATE ITS VITAMIN D LEVELS?

Given the deleterious consequences of abnormal levels of vitamin D, it is not surprising that vertebrates have evolved mechanisms the rigorously control the level and activity of vitamin D within their bodies[2]. Before it can be fully biologically active, vitamin D must be chemically converted or "activated" in a two-step process that involves both the liver and the kidney. This allows an organism to safely store moderate quantities of non-activated vitamin D for use at a later time, and it provides a buffer against toxic effects in the event that more vitamin D is ingested or synthesized than is required at a given time. It is important to note that even the unactivated vitamin D possesses some biological activity and therefore this safety mechanism cannot protect an animal from extraordinarily high doses of vitamin D, such as those encountered when even small quantities of concentrated vitamin D are administered orally or by injection. The herpetoculturist should therefore not use concentrated forms of vitamin D as either a dietary supplement or injected therapeutic.

The final conversion of vitamin D to the activated form, 1, 25-dihydroxyvitamin D, is under tight control in order to maintain only minute quantities of this potent vitamin D metabolite in the circulation. Therefore, the direct administration to herptiles of 1,25-dihydroxyvitamin D, which is sometimes used in the management of human kidney disease, should be avoided under all circumstances.

HOW DOES A HERPTILE OBTAIN VITAMIN D?

Herptiles, like other vertebrates, obtain vitamin D from two sources: 1) diet, and 2) synthesis in their skin. Natural dietary sources of vitamin D include whole animals; the vitamin is particularly abundant in the liver. Plants in general do not contain vitamin D but there are some species (including *Solarium spp., Cestrum diurnum, Trisetum flavescens*) that contain compounds that have vitamin D-like activity (reviewed in Boland, 1986). The endogenous syntheses of vitamin D in the skin, on the other hand, requires UV radiation of specific wavelengths (see below). For a particular species, the relative importance of diet and endogenous synthesis as sources of vitamin D thus depends on the feeding and basking habits of that species. For example, a diurnally active desert-dwelling lizard that is primarily herbivorous would likely fulfil its vitamin D requirements by UV radiation-mediated endogenous synthesis. In contrast, a secretive snake that rarely exposes itself to sunlight would probably get its vitamin D entirely from its food. Many herptile species probably obtain their vitamin D from a combination of diet and endogenous synthesis.

VITAMIN D SUPPLEMENTATION

Captive conditions are often problematic in that they may deprive herptiles of a diet that contains a suitable content of vitamin D and in many cases captive conditions lack UV radiation of the specific wavelengths that are necessary to support the endogenous synthesis of vitamin D. As a result, the maintenance of herptiles in captivity often requires specific measures in order to prevent hypovitaminosis D including the supplementation of diet with vitamin D and the use of UV radiation (this is discussed in the next section).

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[2] A detailed account of this topic is beyond the scope of this paper. For a complete review see Bell, 1985.

An important consideration in any vitamin D supplementation program is the extreme toxicity of excessive levels of vitamin D and its metabolites. It cannot be overemphasized that vitamin D in a concentrated form is a very dangerous compound. Chemists and biologists regard vitamin D as a "high-toxic" chemical. Indeed, vitamin D (in large quantities) constitutes the sole active ingredient in several rodenticides! Although acceptable dosage schedules for vitamin D supplementation have not been experimentally determined for any species of herptile, a dosage for herptiles of 100 IU vitamin D per kg body weight per week has been recommended recently (Merck Veterinary Manual, 1986). This dosage for herptiles has likely been determined by extrapolating data obtained from studies with mammalian and avian species. Based on data for mammalian species a one-time dose of 4,000 times the minimum (400,000 IU/kg) would probably be fatal (Huntington and Page, 1983; Gunther et al, 1988). Given the tendency of vitamin D to accumulate in the body, supplementation at rates 100-fold higher than the above recommended dosage, or perhaps even less (ie at about 10,000 IU per kg per week), may be toxic to herptiles especially when administered over extended periods. To prevent vitamin D poisoning by oversupplementation with commercially available multivitamin preparations, vitamin D is present in these preparations in relatively moderate amounts, typically in the range of 100 IU per gram or per milliliter. Table 1 gives a representative list of the vitamin D content of several multivitamin preparations.

Table 1. Some commercially available multivitamin preparations and their vitamin D content

Preparation	Vitamin D Content
Avitron®	156 IU/ml
Linatone®	24 IU/ml
Theralin®	133 IU/ml
Ca-D-Trons®	74 IU/g
DetaForm®	36 IU/g
Super-Preen®	115 IU/g
Vionate®	22 IU/g
Vitamin D	40,000,000 IU/g

When used cautiously, multivitamin preparations such as those listed in Table 1 offer the herpetoculturist a safe and convenient method of vitamin D supplementation. In contrast, pure vitamin D which is by comparison about 400,000 times more potent than these multivitamin preparations is far too concentrated for safe administration to herptiles - one milligram of vitamin D may well prove lethal to a small to medium sized (100 g to 1 kg) specimen.

Whether or not to supplement herptile diets with vitamin D is a tricky question. The herpetoculturist may want to consider UV radiation therapy as an alternative to vitamin D supplementation (see next section). If dietary supplementation is chosen, the recommended dose of 100 IU vitamin D/kg body weight/week can probably be safely administered to all species of herptiles even if steady-state vitamin D levels are already normal (and therefore is not required). For all snakes which usually feed on whole animals, hypovitaminosis D is rare and supplementation is probably not necessary.

Other types of herptiles have more variable diets and with some species, especially for rapidly growing juvenile specimens, vitamin D supplementation may be absolutely essential. In addition, reproductively active female herptiles may have elevated requirements for vitamin D (see below). In special cases, juvenile specimens of some species may require supplementation rates that are higher than the standard dosage recommended here. An increased supplementation of vitamin D may be indicated by early signs of rickets, such as subtle spinal deformities, in specimens that are receiving adequate dietary calcium. If symptoms of hypovitaminosis D are observed, vitamin D supplementation should be increased to 300 IU per kg per week, or higher if necessary, until improvement is seen (during the very early stages these deformities are often partially for fully reversible). In situations were the apparent skeletal deformation is rapid (ie changes occur over a periods of a few days), it may be necessary to give a one-time dose of 1000 IU/kg body weight, followed by a reversion to a lesser weekly supplementation rate. Under no circumstances should the dosage exceed the toxic levels discussed above.

The vitamin D requirements of gravid herptiles is a subject of particular interest to the herpetoculturist who is involved in captive propagation programs. Reptiles, like birds, direct significant quantities of calcium into the yolk (and shells, if any) of their eggs (Jenkins and Simkiss, 1968). Moreover, it is known that birds concentrate large quantities of vitamin D in the yolk of their eggs (Fraser and Emtage. 1976). Assuming that the same is true for herptiles, it is probable that the vitamin D requirement of breeding females is markedly higher than that of reproductively inactive specimens. Indeed, the extended basking behavior exhibited by many species of reptiles when gravid might well function to increase the vitamin D levels in these animals by stimulating the synthesis of vitamin D in the skin.

In discussing vitamin D and the control of its levels in captive herptiles I have dealt with only one aspect of the maintenance of calcium levels. It is important that the herpetoculturist realize that in order to maintain a normal calcium balance herptiles also need to maintain an appropriate dietary intake of calcium (ie a dietary calcium to phosphorus ratio of about 1:1[3]). Because vitamin D is the limiting factor in the regulation of the amount of calcium that is absorbed into the body of an animal from its food, toxicity for excessive dietary calcium is not usually a concern.

A potential source of confusion for the herpetoculturist who wishes to supplement herptile diets with vitamin D is the difference in biological activity between the two commonly available forms of the vitamin: vitamin D_2 and vitamin D_3. Vitamin D_3 is the form of vitamin D that is synthesized within the bodies or vertebrate species. On the other hand, vitamin D_2 is chemically distinct from the former and is derived only from plant steroids. Importantly, there are no known organisms that can chemically interconvert the D_2 and D_3 forms of vitamin D. While these two forms of vitamin D share similar biological activities in some mammals, including humans, vitamin D_2 is not able to effect calcium metabolism in many species of mammals, birds and also probably all reptiles and amphibians (Hay and Watson, 1977). Care should thus be taken to ensure that vitamin D_3 and not vitamin D_2 is used for the supplementation of herptile diets. For the purpose of this paper, vitamin D will be taken as synonymous with D_3 form.

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[3] Dosage given in the Merck Veterinary Manual, 6th Edition, 1986.

ULTRAVIOLET RADIATION AND VITAMIN D SYNTHESIS IN THE SKIN

A major natural source of vitamin D for many vertebrates is endogenous synthesis in the skin under the influence of specific wavelengths of UV radiation. Vitamin D synthesis occurs in the outermost layer of the skin, or epidermis. UV radiation penetrates the epidermis and causes the photochemical conversion of a compound called 7-dehydrocholesterol (which is derived from cholesterol) to previtamin D. Previtamin D, which has a structure that is very similar to vitamin D, spontaneously converts to vitamin D in a heat-dependent reaction that takes place in the epidermis (MacLaughlin et al, 1982). In this way an organism may continue to form vitamin D in the skin for several days after an exposure to UV radiation. This slow conversion of previtamin D to vitamin D may help to buffer against the effects of sudden release of vitamin D generated by exposure to UV radiation. The heat-dependent aspect of the synthesis of vitamin D may be particularly relevant to the care of captive herptiles, which are of course ectothermic. Studies have shown that the conversion of previtamin D to vitamin D is almost twice as efficient at 37° than at 25°C and, the rate of conversion of 0°C is zero (Holick et al, 1980). Therefore the herpetoculturist who is using UV radiation to promote endogenous vitamin D synthesis in captive reptiles should take into consideration the body temperature of the irradiated specimens.

UV radiation is just one of the several different types of radiation that comprise the electromagnetic spectrum. Radiation is often described by its wavelength, which is measured in nanometer units (1 nanometer [nm] = 10^{-9} meter). UV radiation includes wavelengths in the range of 200-400 nm, that is shorter than the wavelengths of visible, infrared and microwave radiation, but longer than X-rays. The UV region of the electromagnetic spectrum is divided into three subregions: UV-C (200-290 nm), UV-B (290-320 nm) and UV-A (320-400 nm). It has been common misconception to associate all UV radiation with the ability to promote endogenous vitamin D synthesis. In fact, only UV radiation in the 295-315 nm region of UV-B can efficiently promote the synthesis of vitamin D in the skin; radiation of 315 nm or more than 320 nm has a relative efficiency for vitamin D synthesis of about zero (MacLaughlin et al, 1982). This rather narrow "action spectrum" of radiation that can support vitamin D synthesis has profound implications on the choice of an artificial source of UV radiation that may be used for the induction of endogenous synthesis of vitamin D by captive herptiles (see below).

One may quantitate the potential of sunlight at a specific geographic location to support the synthesis of vitamin D. Such a "vitamin D potential" can be approximated by integrating the area within the intersection between the vitamin D action spectrum (MacLaughlin et al, 1982) and measured values of UV intensities for specific geographical locations (such as those reported in Dutt, 1978). A vitamin D potential value calculated for the native geographic region of a species may be used as a guideline to approximate the theoretical requirement of captive specimens for exposure to artificial UV radiation in order that they may synthesize adequate vitamin D.

Although all UV radiation in large doses is unhealthy to living organisms, the shorter wavelength UV-C radiation is especially harmful even at low energy levels and can cause eye damage (cataracts) and mutate genetic material (IRPA/INIRC Guidelines, 1985; Sliney, 1983; Dutt, 1978). The ozone layer of the earth's atmosphere effectively block all of the UV-C and some of the UV-B radiation that reaches the surface of the earth from the sun. UV radiation is attenuated by the ozone in a latitude-dependent manner. For example, while radiation as short as 290 nm reaches the surface of the earth at the equator

the minimum wavelength of UV radiation at 40°N and 70°N are 295 nm and 300 nm, respectively (Dutt, 1978). This latitude dependence of UV radiation is caused by the angle of the sun; radiation from the sun has to transcend less ozone at the equator than it does at higher (or lower) latitudes. As might be expected, other factors that involve a variation in the angle of the sun, such as season and time of day, have an effect on the intensity of UV radiation at the earth's surface. UV radiation is thus strongest at noontime and in the summer months. Because of the attenuating effect that the ozone has on the shorter wavelengths of the region of UV radiation that supports vitamin D synthesis (260-315 nm), almost 100% of the natural radiation (ie sunlight) that is theoretically responsible for vitamin D synthesis is actually in the region between 300 and 315 nm. The potentially harmful shorter wavelength radiation in the region 260-300 nm, while able to support the efficient photosynthesis of vitamin D, is blocked by the ozone layer and thus is not a factor in vitamin D synthesis under natural conditions.

ARTIFICIAL SOURCES OF UV RADIATION THAT CAN SUPPORT VITAMIN D SYNTHESIS

The synthesis of vitamin D by herptiles in response to exposure to artificially generated UV radiation is a subject that has received significant attention in the amateur herpetological literature. Unfortunately, there has been considerable confusion as to which artificial sources of UV radiation are able to support vitamin D synthesis in the skin. This confusion can be clarified by considering two facts. First, from the discussion above, we know that only UV radiation in the range 260-315 can support vitamin D synthesis. Second, very few artificial sources that are available to the public emit enough radiation in the 260-315 nm range to support significant vitamin D synthesis. This is true for the following reason. Consider low pressure mercury vapor bulbs (ie fluorescent tubes) as potential sources of UV radiation. There are many varieties of mercury vapor bulbs including cool white, warm white, plant bulb, wide-spectrum, sun-tanning, black light and germicidal. All these lamps work by a common principle; an electric charge is passed through the mercury gas that is contained in the glass tube, mercury electrons are excited and as these electrons become unexcited they give off energy in a package known as a photon. Photons emitted from low pressure mercury tubes are mostly short-wave UV (ie UV-C), but this type of radiation is dangerous to human skin and eyes and furthermore is not the visible range so it is useless as a lighting source. To decrease dangerous short-wave UV radiation and increase the visible light output, lighting manufacturers coat the inside of these glass tubes with a material that captures the UV photons and then releases them as visible light. This material is known as phosphor, and lighting manufacturers are able to attain different "flavors" of light (eg cool white, warm white, etc) by using different phosphors. Importantly, the low levels of the shorter wavelength radiation that escape conversion by the phosphor cannot penetrate the glass that is commonly used in the manufacture of fluorescent tubes. This is the case for all the "white" lamps including wide spectrum (eg Vita-Lite®, Sun-Glo®) and all black lights[4]. Some wide spectrum lamps and black lights do have increased "UV" output compared to normal fluorescent lamps, but this is entirely in the long-wave UV-A region and thus the radiation that these lamps generate has no influence on vitamin D synthesis. On the other hand, germicidal bulbs have a high output of UV-B and UV-C radiation, but the high intensity UV-C that they

[4] Gehrmann, 1987 provides an excellent comparative review of the UV output of a wide variety of fluorescent lamps.

makes them unsuitable for therapeutic use with any living organisms. Indeed, germicidal bulbs used in laboratories to kill bacteria and to generate mutations in cells. In the past, several major manufacturers produced fluorescent lamps for sun-tanning that emitted significant UV-B radiation in the 280 nm region. Because of the danger of this UV-B radiation to human eyes and skin, however, sun-tanning lamps that are currently produced (eg Phillips TL and TLK UVA lamps) emit almost no UV-B radiation. The only bulb available at present in the United States that releases sufficient radiation to support vitamin D synthesis from a distance of several centimeters or more is the UVB Sun Lamp or Fluorescent Sun Lamp (FS-type). The Sun Lamp emits a broad band of relatively high intensity radiation between 280 and 360 nm with a peak output at 302 nm. This lamp is specifically manufactured for the phototherapeutic treatment of psoriasis in humans and is accordingly not widely available. The Sun Lamp can, however, be obtained in standard 2, 4 and 8 foot sizes from a number of medical supply companies in the US[5]. When used at a distance of 50 cm, 30-45 minutes exposure to the Sun Lamp has approximately the same vitamin D potential as one day of equatorial sun or two summer days at 40° latitude. Put in other words, 30-45 minutes exposure to the Sun Lamp should theoretically support the synthesis of the same amount of vitamin D that the animal could produce if it spend one day in the equatorial sun or two days in the summer sun at 40° latitude[6]. In contrast, a specimen must spend on the order of 100 hours under a black light or a wide spectrum lamp (at 50 cm) to receive a vitamin D potential equivalent to one day of equatorial sun[7].

IMPORTANT CONSIDERATION OF UV-B THERAPY

Since the UV-B Sun Lamp has not been widely used with captive herptiles, conditions of exposure for specific species have to be determined ny experimentation. One potential cause for concern is that the Sun Lamp emits shorter wavelengths of UV radiation (down to about 280 nm) than are found in natural radiation anywhere in the habitable regions of the earth's surface. Indeed, with the Sun Lamp radiation in the region 300-315 nm in theory accounts for only about 50% of the total vitamin D synthesis that this lamp can potentially support (compared to 100% for natural solar radiation; see previous section). The balance of the Sun Lamp-induced vitamin D synthesis is theoretically effected by shorter wavelength UV radiation in the region 280-300 nm. Whether or not this could lead to an increased risk of ocular damage in captive herptiles remains to be determined. However, I have kept a colony of 25 *Uromastyx acanthinurus* (juvenile and adult) under conditions of 50 minutes exposure per day to a Sun Lamp (at 50 cm) for the past 6 months and have encountered no obvious signs of eye or skin problems. To ensure that the UV exposure is evenly distributed and that the specimens are not continuously exposed to the UV-B radiation for extended periods, I have programmed the Sun Lamp to operate for 10 minutes each hour over the middle part of the day. The relatively harsh nature of this UV "therapy" suggests that its use may be limited to reptile species that bask heavily and that occur in

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[5] For example, National Biological Corp., 1532 Enterprise Pkwy., Twinsburg, OH 44087 (800) 338-5045 or (216) [illegible]

[6] Calculated from unpublished data supplied by National Biological Corp., Twinsburg, OH.

[7] Calculated from data supplied by National Biological Corp., Twinsburg, OH and published measurement from Lehmann, 1967.

tropical or subtropical desert regions. Species that are confined to forests, even in the tropics, may in nature receive much less UV radiation due to the filtering effects of foliage. Subtropical or temperate species may also be unable to tolerate the shorter wavelengths emitted by the UVB Sun Lamp. It is possible, however, to block these shorter, potentially harmful wavelengths (ie wavelength less than 290 nm) by mounting cellulose triacetate film (Kodacel®) between the lamp and the specimens (Worrest and Kimeldorf, 1976). A second way to decrease harmful short-wave radiation from the Sun Lamp is to mount the lamp further from the animals and increase the exposure time. Although the overall intensity of UV radiation is roughly linearly proportional to the distance from the lamp (up to a distance of several meters and dependent on the size of the bulb used), shorter wavelength UV radiation is attenuated by distance to a greater degree than the longer wavelength radiation. Thus irradiation of specimens for 4.5 hours more at 3 meters from the Sun Lamp, for example, may be safer than 45 minutes at a distance of 50 centimeters.

Amphibians as a group may not be suitable as candidates for UV-B therapy because of their relatively delicate skins. Indeed, studies have shown that exposure to moderate amounts of UV-B radiation (approximately equal to the daily summertime vitamin D potential at 40° latitude) results in developmental abnormalities and mortality in tadpoles of *Bufo boreas boreas* (Worrest and Kimeldorf, 1976).

Above all, it is imperative that the herpetoculturist be aware of an operating UV-B radiation source and avoid skin and eye exposure to this radiation at all times. Plastic masks made from material that does not transmit UV radiation are available to protect the face and eyes and heavy clothing should protect skin when work in the presence of UV-B radiation is necessary. Humans simply cannot tolerate the conditions of intense UV radiation under which many species of reptiles have evolved to live.

When considering UV-B therapy for a particular species of captive herptile, a number of factors should be taken into consideration. Basking behavior is probably the most important factor; a species that does not bask or one that basks only in the early morning or late afternoon is likely to receive very little natural UV-B radiation and such a species may therefore not be a suitable candidate for UV-B therapy. Feeding preferences are also important; a herbivorous species is more likely than a carnivore to satisfy a significant amount of its vitamin D requirement by UV-B induced endogenous synthesis. Cloud and foliage cover in a specimen's natural habitat would effectively decrease its exposure to UV-B radiation. Factors that might increase UV-B exposure are increased elevation and abundance of UV-B reflecting materials such as some types of rock and sand or water. As discussed above , latitude is also a determining factor of UV-B exposure, but this factor may be of somewhat lesser importance since latitude alone affects the vitamin D potential only two or possible three fold for any part of the habitable world.

It seems appropriate in this section on UV radiation to comment on apparent UV requirements of captive herptiles that probably have nothing to do with vitamin D synthesis. Many herpetoculturist have reported that wide-spectrum and black light fluorescent lamps (ie primarily UV-A emitters) appear to have beneficial effects on captive herptiles, and these effects have often been ascribed, incorrectly, to the induction of endogenous vitamin D synthesis. While it is possible that specimens that spend extended periods of time in direct contact with theses UV-A sources may derive enough UV-B radiation in the 260-

synthesize adequate quantities of vitamin D, in the majority of cases the lamps are centimeters or even meters out of the specimen's reach and they should therefore not affect vitamin D synthesis. Instead, the recent discovery that the species of desert iguana *Dipsosaurus dorsalis* may be able to utilize **UV-A** radiation to "visualize" pheromonal markers and food items may go a long way to explaining the benefit that UV-A sources appear to some species of captive herptiles (Alberts, 1989).

herpetoculturist must weight the potential benefit of going to the trouble of providing herptiles with UV-B radiation or instead simply supplementing diet with vitamin D. Probably the argument for UV-B therapy is that some species (but probably a minority) this is the most natural they can be kept - instead of guessing at optimal vitamin D supplementations rates for a that may not naturally receive any vitamin D in their diet, UV-B therapy offers such specimens a to regulate their own vitamin D levels by endogenous synthesis as they would in nature.

herpetoculturists, are on the verge of new and exciting triumphs in the husbandry and captive herptiles. Clearly, a better understanding of the specific requirements of different species for vitamin D and UV radiation will play a key role in these successes of the future. only by communicating our observations of long term captive populations and by conducting controlled experiments can we hope to gain a better insight as to how vitamin D and UV relates to herpetoculture. It is hoped that this paper stimulate a greater awareness and research into this important aspect of the husbandry and propagation of herptiles.

SUMMARY

Vitamin D is a fat-soluble compound that is involved in the regulation of calcium levels. A herptile can obtain vitamin D from its diet or it can synthesize the compound in its skin in response to UV radiation in the region 260-315 nm.

The maintenance of normal vitamin D levels is essential for the survival of captive herptiles. To maintain acceptable levels of vitamin D in captive herptiles, diets can be supplemented at 100 IU/kg body weight/week. Great care should be exercised when supplementing diet with vitamin D as excessive quantities can be lethal.

As an alternative to dietary supplementation, fluorescent Sun Lamps (FS-type) that emit high intensity UV radiation in the region 280-360 may be used with some species of reptiles to stimulate synthesis of vitamin D in the skin. Although the germicidal lamp also emits radiation the vitamin D photosynthetic region, its high intensity UV-C emission makes it unsuitable for therapeutic use with herptiles.

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THE LAST RESORT -- TECHNIQUES USED TO TUBE OR FORCE FEED CHELONIANS

Ellen Nicol

Very often non-feeding is a manifestation of other medical problems that must be investigated and treated before force feeding can be effective. Often a reptile that refuses to feed is a newly-acquired specimen, although sometimes long-term captives will go off feed. Occasionally it is hatchlings that present a problem. Even if you are unable to observe the animal individually to see if it is feeding with the others, its health can be determined by inspection. Signs of inanition are bony and flaccid limbs, hollowness around the eyes, a definite lightness of weight as compared with others of its species and the general lethargy, and indifferent response to **environmental stimuli**. Do not always assume, because a specimen has been obtained as a long-term captive from another hobbyist, that it will not have problems. Turtles and tortoises can live an incredibly long time under poor conditions. I have received debilitated reptiles that were "maintaining" in their former quarters, but soon died after receiving regular diet here. I suspect the cause of death was an overload on the system, coupled with the stress of changing and unfamiliar accommodations.

SUGGESTIONS FOR INDUCING NORMAL FEEDING

If you have such an affected turtle or lizard, there are procedures to try before resorting to tube or force feeding. These may inspire the animal to feed on its own, which is most desirable. Tube feeding, even when done effectively and with minimal effort, is still stressful for you and the creature; best avoided if possible. Please try these suggestions first.

1. Offer live food such as pinky mice or larger mice for larger specimens, wriggling worms, crickets, live fishes or snails, if you can get them.

2. Try foods with the attraction of color or odor, such as red lean beef or smelly fish. Beef has less odor, but red attracts, whereas pale grey fish offers odor attraction. Offer banana, tomato or green raw vegetables.

3. Isolate the animal from others in the tank so it can feed without the other healthy ones eating it first. Feed the ill one separately in a small container. Put the animal and food in a quiet place where it will not be disturbed or distracted, and can inspect its food offering leisurely.

4. If the non-feeder has been kept alone, try putting it in with others in case feeding activity will inspire your non-feeder to get in on the action. This is a long shot; not often successful.

5. Leave food in the housing overnight, as some reptiles may be nocturnal feeders. Some reptiles are "snackers."

6. Raise the temperature in the air or water to speed metabolism of the animal, so that it requires more nourishment.

7. Soak your non-feeders before offering food. This usually encourages defecation, which serves several purposes: (A) you can obtain a stool sample for professional analysis, (B) the animal may be dehydrated or constipated, (C) soaking usually gets an animal's limbs moving, increasing circulation and general activity which may include increased appetite.

8. Know your animal's eating habits in its native country. My first experience 20 years ago with an Australian snakeneck turtle *Chelodina longicollis* was with a newly-acquired adult that refused to feed for three weeks. I found that this species like to stay hidden under a shade board and does not like feeling exposed and vulnerable. Upon introduction of a piece of floating wood, the turtle immediately went under it with just the nose and eyes at water level surfacing from time to time. No turtle is happy in a bare tank with no place to hide. I then offered fish, which it immediately attacked, the long neck lunging out while the body remained secure under the board.

9. Sometimes it is necessary to stun or kill a small live fish or mouse in order for an indifferent feeder to catch it. If the turtle is ill and debilitated, catching an elusive active prey animal may be too much effort.

10. Be sure your non-feeder is not being intimidated by tank mates. There appears to be psychological interaction among different species as well as among individuals of the same species. It is my opinion from long experience that certain specimens will not be as strong as others, even from the same clutch. These may feel less secure within the group, and sense that they may eventually be preyed upon, so have to be on the alert all the time. Such factors may have a detrimental physical effect. In the wild, inferior animals may not live to adulthood, as survival of the fittest dictates. Some species are innately more aggressive than others, so timid species should not be housed with them. Large differences in sizes of specimens within the group may also affect feeding behavior. You would be well advised to know your animals as individuals, whether by observation or by reading about traits of certain species. In my view, hatchlings or juveniles should not be housed with adults in the usually very limited facilities that most hobbyist maintain. Facial bits or wounds can occur when large individuals grab for the food that a smaller one has, and most of the time the small one is forced to relinquish the food item. There may be none left when it gets ready to try again after having been intimidated by others more aggressive.

OTHER FACTORS AFFECTING VOLUNTARY FEEDING

Take time to look over your non-feeder. Has it been bitten by others? Does it have parasites (this will required stool tests)? Has it been held in the extremely stressful conditions between capture and your home for a long time? Do you know how long the former keeper had the animal and how it was housed? Was it kept on cypress mulch or other wood chips which may have been ingested along

with its possibly meager food supply? It is realistic to remember that if an import has been held at various locations without food or water, and exposed to diseases to which it had no immunity, internal damage may have occurred. Despite the best of remedial care, you may not be able to overcome massive internal problems.

If you have been keeping a turtle or tortoise very dry, try soaking it and also providing more humid conditions. This applies most often to semi-terrestrials, but also to tortoises depending on their species. Aquatic turtles, of course, will be housed in water, it is to be assumed. Even a non-feeding tortoise may be brought round by soaking it before offering food. Read up on conditions in the land your pet came from. You may not be able to duplicate them exactly or provide specialized foods they find in the wild, but you can try to come as close as possible.

Don't take as gospel what the hobbyist or dealer you are getting the reptile from tells you about its feeding history. They have something to sell. The stock answer you get is, "oh, it's been eating like crazy, eats everything in sight." This may or may not be so. Often there is a problem getting long-term captives to try other foods once they have been accustomed to food the keeper provided where they came from, inadequate as the diet may have been. I heard of a case of a box turtle *Terrapene sp.* that had been fed only chocolate chip cookies and tomatoes for many years. It was very thin ad debilitated and might have been a candidate for force feeding. However, I feel a better diet at this point, or too much food could quickly kill the turtle. Excess anthropomorphism with no common sense on the part of the original keeper is the culprit here.

Parasites can be living on your new acquisitions, whether imported or from other hobbyists, who should have had their animals checked. I acquired four *Testudo graeca* tortoises from a hobbyist culling out his collection. They were long-term imported captives. The tortoises felt light to me, and were very enthusiastic about offered food. They were generally inactive, sleeping much of the time; not a good sign. I let them float in deep water in my sink, where they bobbed like corks. The mild stress and action of the leg muscles induced defecation which consisted mainly of live, wriggling 50 to 70 mm white worms. The four tortoises were tubed with oral fenbendazole (Panacure®) and continued to expel live worms with each sink-swimming session. Treatment was repeated, and eventually they stopped expelling worms. Who knows what damage was done to their internal organs by this parasite infestation? In fact, the largest male never was very active and was found dead one day. I contacted the former owner who told me, while exhibiting great surprise, that he had wormed them with Tramisol®. If he had taken the time to soak and watch the tortoises, he would have found that the medication wasn't working, and he needed to find another one, meaning probable a visit to a veterinarian for stool samples, medication and instructions.

WHEN ALL ELSE FAILS, CONSIDER TUBE OR FORCE FEEDING

I mentioned earlier that aquatic turtles rarely need to be hand fed. The pleurodires (the snake or sidenneck turtles) are, in some cases, easier to force feed than are the cryptodires, which can completely retract the head. With snakenecks, they merely fold the neck and head back into the axillary cavities which can be gently retrieved to get at the mouth. While a healthy Argentine snakeneck turtle *Hydromedusa tectifera* is normally an inordinately lean turtle, I had an ill specimen that needed immediate attention due to inanition. All that was required was to manipulate a small whole fish into the

mouth, the esophagus and ultimately the stomach. I held the turtle with the plastron facing me, its hind legs in the kitchen sink, and extricated the head from the neck cavity. I held the head in my left hand, my thumb gently pressing on the chin which caused the jaws to separate slightly. With my right hand, I maneuvered a small instrument into the gap and got my left forefinger in a position to prop open the mouth enough to introduce the fish. The mouth was allowed to close and my left hand kept the neck extended, while my right hand massaged the fish down into the stomach. The turtle was then put in water.

The whole procedure took but a few seconds because it was relatively simple. It is critical to get the food down past the point where the turtle can regurgitate. With these turtles, even when the food is all the way down, they will sometimes bring it up intact. If I feel the experience has not been excessively traumatic for the turtle, I will try again but will cut off some of the fish to make a smaller portion, which is harder to regurgitate. Rather interestingly, when I have had to use frozen fish for feeding snakeneck turtles, I would conceal a Vitamin B tablet inside to replace the thiamine lost during freezing. The turtle would keep down the fish, but, moments later, with vigorous muscular activity, up would come the rejected tablet separated from the fish! If this happens, you can then use vitamin B injections or, as I have done, cut the table into quarters making smaller pieces which usually stay down.

On occasion, one or two of my Australian snakeneck hatchlings *Chelodina sp.* will not feed, or will spit out food it has taken. Such a tiny baby not feeding will show emaciation and, from long experience, I know it will die. I hold the baby turtle as I did the Argentine snakeneck turtle mentioned earlier, but it is much more difficult with a turtle about 1½ inches (27 mm or so) long, with an open mouth area no larger than 5 mm! Often a turtle will hold its tongue against the roof of the mouth, so the tongue has to be depressed to reach the throat. With larger turtles it is not a problem. I cut a tiny piece of lean raw beef which has been rolled in Nekton-Rep® power, which is the vitamin/mineral supplement that I happen to have. Other brands that are available may be used. I place the fortified meat close at hand ready to be picked up with a fine tweezers.

Getting even a tiny opening between the jaws to force them open is a very delicate procedure. I use the tip of a dulled, thin-bladed paring knife, all the while pressing the throat of the turtle. When the mouth is wide enough to get the tip of my finger in, I introduce the meat with the tip of the tweezers and try to get it slightly down into the throat. When the mouth closes, I work the piece of meat down the esophagus into the stomach from the outside. It is absolutely essential with these tiny animals to never use a piece of meat to large for the stomach If too large a piece is forced down, it may rupture the stomach which will result in death of the turtle. Other kinds of foods that fall apart of the tweezers or in the mouth present you with an exercise in futility. Beef holds together best, although it is not an ideal food otherwise.

Great care must be taken with these tiny babies that you do not break the jaw in trying to get the mouth open. The turtle will fiercely resist having its mouth forced open, naturally, and if you use too sharp an instrument, it can also damage the soft mouth parts. However, if you can't get nourishment into a turtle at this stage, it will almost surely die anyway. I have a mouth-opening device, able to be purchased from the New York Turtle and Tortoise Society at a reasonable price, that will work with larger turtles, but the knife blade I use is only half the thickness of this official mouth opener.

Getting medication into these tiny snakeneck turtles is also a problem, although different from [illegible]. The mouth-opening procedure is the same, but the neck must be stretched out so that a tube will reach into the stomach. The very fine gauge almost-hairlike tube I use is rigid and must not be [illegible] into the stomach as it could easily puncture the esophagus or other organs, which the soft meat would not do. If the tube is not all the way into the stomach when the plunger is pushed, the fluid medicine could go back up the esophagus and then into the lungs, with possible serious consequences. It could also be expelled from the mouth. Then you will not know how much of the medicine, which dosage has been very carefully calculated, actually got into the turtle. You have to get this right the first time. I had to get such small dosages as .03 to .06 cc (according to gram weight of individual turtles) for my Chelodina *longicollis* and *C. novaeguineae* in the summer of 1988 when they showed up with parasites, and the medication was a crushed (Flagyl®) tablet in suspension. It was complicated by the fact that the liquid had to be frequently shaken vigorously before drawing it up into the syringe so the dosage would be uniform for all. This disease proved to be rapidly fatal, and I was fortunate to have the diagnosis, medication and instructions from Dr. Elliott Jacobson from the University of Florida Veterinary Medicine Teaching Hospital. Between us we were able to save a few of the hatchlings, but fare too many died before diagnosis and treatment. The knowledge gained has proven very beneficial with subsequent hatchlings, which consists mainly of altering conditions so they don't get the amoebiasis in the first place.

SEMI-TERRESTRIALS

Semi-terrestrials include the box types *Terrapene sp.*, the *Rhinoclemmys* species, and a few others. Box turtles have been one of the most successful candidates for tube feeding, and usually respond well. A particularly shy specimen can cause very annoying problems by closing its shell and becoming virtually impenetrable. It can quickly snap shut the front and rear lobes of the plastron, and there is no way you can force them open without injuring the turtle. If your fingers are in the way at closing, you will be astonished at how much it will hurt before you are able to free them. The bite of this turtle can be equally painful -- they just hang on with that pointed beak! However, a debilitated box turtle that would require force feeding will not have the strength of a healthy one.

Assuming the box turtle has closed up, it usually works if you hold the turtle in your right hand, facing you, and gently press on the rear lobe or scratch that area of the plastron. The front "lobe" will usually drop and the head protrude somewhat. You have to work quickly to grasp the head before it is retracted. Your food and equipment should be completely ready before working on the turtle, which is true in all cases of force or tube feeding. If you press firmly on the throat, sliding your finger downward, the mouth should open enough for you to get in a wedge. Then you are ready to introduce the feeding tube which must be inserted to the correct depth before pushing the plunger.

I had an ill box turtle a few years ago that had to be tube fed for a long time. It seemed as though my efforts were for naught, and I was tired of the daily routine. Then one day I was sitting in a chair barefoot, and my toe became positioned over the container holding the turtle which was being exposed to sun shining on the floor of the porch. I felt a nip on my toe and looked to see the box turtle attempting to eat on its own. From that time on, it fed voluntarily, and totally recovered. Tube feeding was a long time, but was ultimately successful.

Other semi-terrestrials may not have the plastron-closing feature, but they can be just as hard to force feed. The *Rhinoclemmys sp.* are able to completely retract the head until it is totally invisible behind folds of neck skin. Even when the turtle decides to put its head out again, it does so very tentatively, and quickly retract it at the slightest movement. Great patience is required with these species and force feeding may not be able to accomplish at all.

LAND TORTOISES

These creatures have their own set of problems when it comes to force feeding. For one thing they can be very heavy, strong, large rambunctious animals. Again, however, one needing force feeding may be more subdued. Another element is the ability they have to very effectively enclose the head tightly behind the heavy, incredibly strong front legs. A spooked tortoise can sit motionless for long periods and any approach by you at the slightest relaxing of its closure will cause it to quickly snap shut again. Approaching the tortoise from the rear, always slowly and quietly, should disturb it the least.

Mastering tube medicating techniques came in handy in another case in 1988 with a tortoise. It concerned a 30 cm juvenile Aldabra tortoise *Geochelone* or *Aldabrachelys gigantea* obtained at the size of about 18 cm. Fecal analysis revealed the presence of parasites, and it was necessary to administer fenbendazole (Panacure®) by stomach tube. This tortoise was determined to prevent access to the mouth by closing the extremely strong front legs to totally conceal the head. By standing the tortoise in the sink, it opened the front legs, I was able to grasp the very strong head, and eventually get the mouth open enough to introduce the tube. The animal's jaws were so strong that it stopped the flow of the fluid by biting down on the soft plastic Tom Cat catheter I used. Eventually it calmed down and I was able to eject the medication into the stomach quite effortlessly. The alternative to this is anesthetizing the animal (for me a 70 mile round trip to the veterinary hospital in Gainesville, at high cost and loss of my time, to say nothing of distress to the animal.

I work at the kitchen stainless steel sink. An almost foolproof method is to put water in the sink and stand the tortoise on the back of its shell (and legs), holding the upper body firmly. Uncomfortable in this odd position, it will usually lower the hind legs and then extend the head and front legs, struggling to get free. The tortoise should be vertical, with the plastron facing you. Prepare for much splashing and thrashing, but the tortoise in its panic may not be able to keep track of all appendages at once, and then you can get a grasp on the head. Hang on tightly if possible. Again, try pressing down on the throat allowing an opening of the jaws.

You will need to pry open the mouth enough to insert part of the feeding tube. If you get the tip of the tube between the mandibles, continue to hold the head, but be quiet and motionless. Usually the tortoise will relax and you can gently work the tube to its proper depth in the stomach. Beforehand, to ascertain the location of the stomach, you can lay the tube along the plastron to see roughly where the stomach is (you will need diagrams to turtle anatomy). Then measure the distance from the mouth to the stomach on the tube, so that when it is inserted, your measurement should tell you that the end has reached the stomach. That way, the contents of the syringe will not be expelled short of reaching the goal when you push the plunger.

If you have the tube inserted and push the plunger, only to find seems jammed, you may have [illegible] the opening against the stomach wall. In that case, withdraw the tube about 10 mm and try [illegible]. If there is still blockage, try twisting the tube slightly and withdrawing another 10 mm. If the food [illegible] can't be pushed through the syringe, the trouble is possibly within the delivery system. You will [illegible] probably have to remove the tube and find out what is happening. Your mixture may have been too stiff [illegible] initially. A more liquid mixture should be tried. It might be advisable to put the mixture once through [illegible] the system before introducing the tube into the tortoise. If it flows freely, you can be sure it will do so [illegible] after you have spooned it into the syringe again.

It should not be a battle of wits with the tortoise. If you are not able to get the contents of the [illegible] syringe to exit or if food is ejected before much has been administered, do not force any more. If you [illegible] want to try one more time, and you and the animal are not too exhausted, rest awhile and start over. If [illegible] results are no better, I would not continue. Something may be wrong internally; there may be blockage [illegible] and you can do irreparable harm by persisting. It may be that you, as a non-professional, cannot do [illegible] anything for this turtle, but you should not be the cause of more pain and suffering due to your [illegible] determination to succeed with the project. In some instances, you will feel triumphant in getting [illegible] substantial amounts of feed into the tortoise, only to find later that it has regurgitated all or most of it. [illegible] You may want to try again, if it has not been too difficult, but using smaller amounts of food more [illegible] frequently. Generally, however, regurgitating of introduced food in an ominous sign.

MATERIALS

I have found a mixture of very moist Zu-Preem® monkey chow, ripe banana and lean, finely-[illegible] ground beef, with added vitamins -- either liquid or powdered -- to be the most effective tube-feeding [illegible] mix. The chow works into a fine mash and is very nutritious. Banana is for sugars, taste, odor and [illegible] "slipperiness" (enhancing travel through the system); meat is for protein. All seem readily digestible. I [illegible] would these together will with a fork on a board, and then flatten the mixture further with a knife blade. [illegible] In my experience, no matter how finely this is mashed, it will not go through a very fine feeding tube.

Unfortunately, I cannot describe the feeding equipment I use very efficiently because (1) it has [illegible] been accumulated over a long period of time and from many sources no longer recalled, (2) there is no [illegible] standard size or device; each is tailored to the individual animal and (3) I can't tell you where to get [illegible] it other than through a veterinarian, a pharmacy (laws vary from state to state on availability of syringes [illegible] due to drug abuse) or chemical/pharmaceutical supply houses. My most useful for large animals is an [illegible] Monoject Monodose™ 10 ml syringe for oral medication only. It has a wide tip to accommodate a 5 mm [illegible] (ID) plastic tube 15 cm in length, with a hole in the rounded end and another 15 mm from the end [illegible] (toward the syringe). I also have another Monoject™ feeding tube holding 35 cc, which accommodates [illegible] a 10 mm (ID) tube cut off to a length of 65 mm. I also have one that fits on a 1 cc syringe with an open [illegible] end. To this I affix a 9 cm long tube of 8 mm I.D. The end of the tube fits over the syringe to a distance [illegible] of 5 mm. I have various other tubes, many made from cut off Tom Cat catheters. There are other in-[illegible] between sizes too difficult to describe here.

Once equipment has been determined, I run water through the syringe and tube. I fill the syringe with the food mixture to the top. Then I affix the tube to the end, and insert the plunger. Slowly I push the food through the system until it reaches the tip of the tube. There should be no air in the system that will be put into the animal's stomach. If I anticipate a minimum of trouble with the animal, I leave the tube attached for introduction. If I can see a real hassle, I disconnect the tube from the syringe and try to get just the tube in place, after which I attach the syringe, and being to push the plunger. Once you have the food all over the walls, yourself and the outside of the turtle, you prefer to do it this way, if possible. All equipment is thoroughly washed each time after use, and the plunger is not left in the syringe, as the rubber tip of the plunger tends to deteriorate.

A point to remember is that the integrity of stomach or esophageal tissues of an animal that has not been feeding for some time may be subnormal, causing it to be more subject to puncture or other damage if handled roughly. The weaker and thinner the turtle, the more likely long-term damage to internal organs has occurred.

If you prefer other foods to what I suggest, keep in mind that any food with fiber, gristle, or other undissolvable lumps will present you with a case of utter frustration as the material hangs up in the system. Foods such as melons, tomatoes, dead mashed pinky mice, vegetables with hulls, such as peas, corn, etc. won't work. Put through a blender it might work, but usually you have such a small amount of food to get into the turtle that much would be wasted. In any case, you can try other foods, but I simply have found my recipe to be the most practical.

Some chelonians, when the head is held and the thumb applied to the throat, will accommodate you by opening the mouth wide. If you have a tablet to get down, or large pieces of meat, this is great -- especially if you can get a helper to slip in the food or tablet while you hold the animal. You can do it yourself, but you will need to keep your finger in the mouth when it is open. You may be bitten. If you get the food or tablet in the mouth, you will need to poke it gently down with a blunt instrument or the animal may spit it out when released. I usually put the turtle in water afterwards to be sure it drinks and washes the item down into the stomach. Mushy food or food that tends to disintegrate doesn't work well. It needs to stay intact like a piece of muscle meat such as beef. I have fed pinky mice this way, which is very unpleasant. However, the welfare of turtle is what I am concentrating on and any personal squeamishness has to be overcome.

CONCLUSION

Anyone who maintains a collection of chelonians (or any reptile, for that matter) must be prepared to deal with a non-feeder. This paper offer some suggestions about how I manage such animals, but I emphasize that force feeding is a last resort. Only in desperate cases, where you don't have access to veterinary services, should force or tube feeding be attempted. Only you can decide if you want to implement what I have described herein, with the full realization that you may kill your animal or cause it to suffer pain. It should not be the standard, routine do-it-yourself project. If at all possible, a veterinarian should be consulted. A veterinarian may detect some dangers that I have not encountered, but which are tangible risks. A veterinarian may also have some suggestions, other than mine, for inducing a non-feeder to eat voluntarily, which is the most desirable solution.

For me, these procedures have been largely successful, and I have saved many an otherwise [illegible] animal by these means. Since some facets of the procedures have not been covered or [illegible] thoroughly due to time constraints, I would be willing to discuss the subject over the telephone with anyone seeking further information or details.

The author expresses appreciation to Dr. Martin J. Rosenberg for his critique of this paper.

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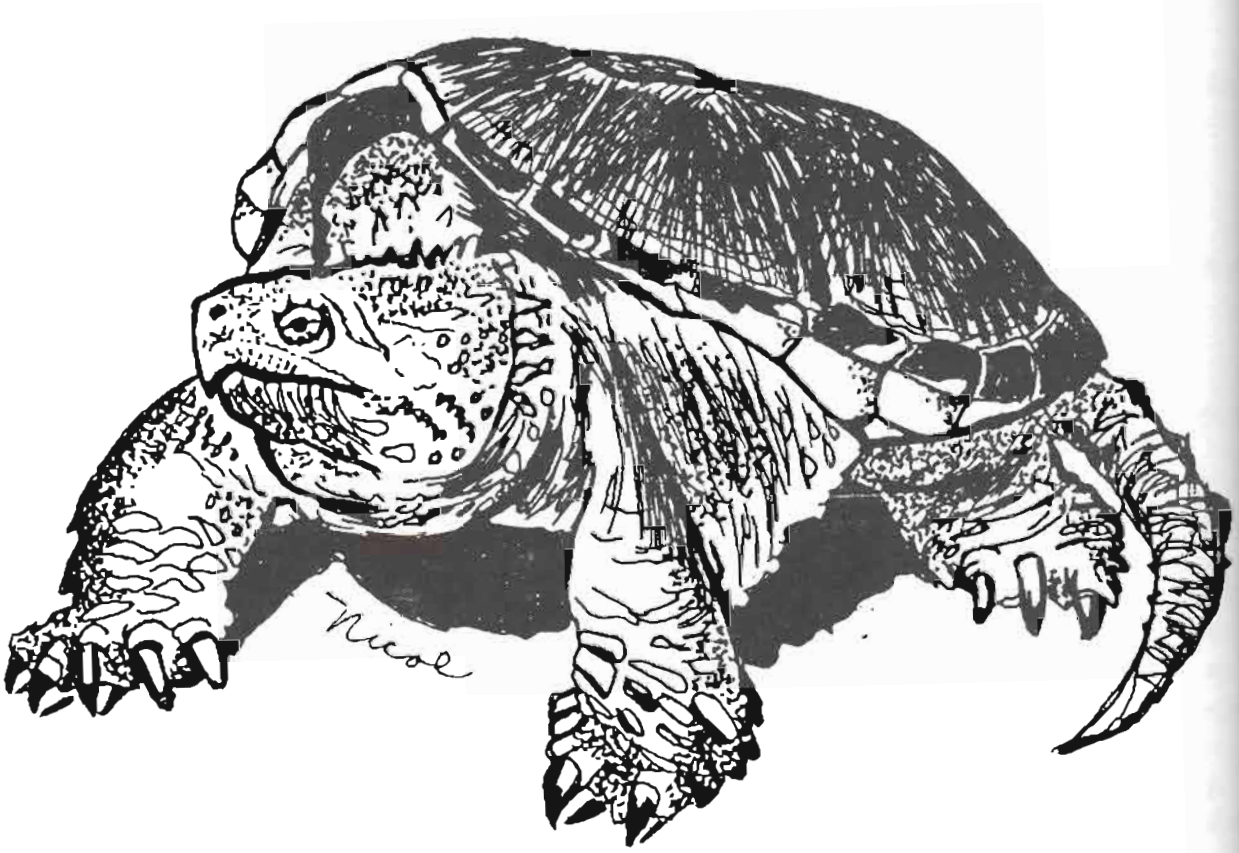

REGURGITATION SYNDROME IN BOID SNAKES

Richard Ross, M.D.

In the early 1980's, a resurgence of importation of emerald tree boas (ETB) and other neotropical snakes such as Brazilian rainbow boas (RBR) and red-tailed boas occurred. Shortly after this, increasing reports of new disease syndrome began circulating. Commonly referred to as "regurgitation syndrome," this disease was characterized by regurgitation of recently eaten food. The disease was most commonly reported in ETB's, but was also seen BRB's as well as other boids that were maintained in collections that housed ETB's and BRB's. The syndrome was further characterized by eagerness to feed among affected specimens, as well as rapid spread within a collection. Attempts at diagnosing and treating the condition were frustratingly futile. Affected specimens generally died of starvation, eating and regurgitating repeatedly until death. Herpetologists generally reported that the disease had been introduced into their collection via ETB's purchased from one of several Miami importers.

In 1987, the Institute obtained a number of ETB's from two Miami importers. All were reported to have begun feeding and to be free of regurgitation syndrome. Also received at the same time were several BRB's and four Argentine boas. All were caged separately and in isolation. Most of the specimens began feeding within one to two weeks of arrival.

About one month after these snakes had begun feeding, one ETB regurgitated a recently eaten meal rat. Within several days, two other specimens also regurgitated. In spite of meticulous handwashing and cage sterilizing, the syndrome appeared to spread to other specimens during the following two weeks, including captive born specimens of other boids.

Based on previous reports that this syndrome was likely to be an esoteric disease entity, several specimens were cultured and immediately treated with furoxone, a drug with both antibiotic and antiviral properties in human medicine. Cultures of the regurgitated rodents all grew Arizona, and some of the affected specimens appeared to be cured as a subsequent meal was not regurgitated.

Subsequently, this syndrome appeared in previously unaffected specimens. Some of the affected specimens that had been apparently effectively treated began regurgitating again. Reculture of these specimens showed no Arizona or Salmonella. Other specimens never regurgitated again. These also were generally not ETB's.

After receiving the culture reports implicating Arizona as the likely pathogen, affected specimens were treated with a single dose amoxicillin, 50mg/K, an antibiotic shown to be effective against the strains isolated. Among affected ETB's, some never regurgitated again. Others continued to regurgitate.

In those specimens that continued to regurgitate, smaller and smaller meals were tried on the assumption that inflammation of the gastrointestinal tract caused regurgitation of average-sized meals. Some of the affected specimens were able to eat and retain small meals, such as fuzzy or pinky rats.

These specimens were fed such meals weekly. Repeat cultures continued to be negative. Over a prolonged period of time, some of the specimens were able to slowly progress to larger meals. At present, nearly 18 months after the onset of the disease, these specimens, all average-sized adult ETB's, are now able to retain adult mice fed every 6 to 7 days.

A number of affected ETB's continued to regurgitate regardless of the size of the meal. These specimens were subsequently treated with a single dose of metronidazole (Flagyl®), 50mg/K, on the hypotheses that a second organism might be present to account for the continued regurgitation. Several of these specimens immediately ceased regurgitating and have since been entirely free of symptoms.

A small number of specimens, perhaps 2 or 3, continued to occasionally regurgitate small meals. These specimens have been treated with three daily doses of metronidazole plus amoxicillin. This treatment has been effective for two of the three specimens.

In occasional cases, ETB's relapsed, and began regurgitating again. In some to these specimens, a procedure that proved successful has been to soak a live or killed rodent thoroughly in water immediately prior to feeding.

During the time period that these treatments were being administered, a total of 18 months, new outbreaks of the syndrome would from time to time occur, both in previously affected and unaffected specimens. Whenever a new outbreak occurred in a non-ETB, the disease was effectively treated with a single dose of amoxicillin. When the new outbreak occurred in an ETB, amoxicillin was not effective, and both amoxicillin and Flagyl® were used. In some cases, a single treatment of both drugs was effective. In other cases, multiple dose treatment was necessary.

In spite of the on-going nature of the problem, which by this time has affected over 30 snakes, every affected specimen has been completely cured except for several ETB's. Only one death from the disease occurred, during the initial phase of the outbreak. Four specimens of the Argentine rainbow boa, *E. c alvarezi*, died. They were all captive-born neonates, and each died immediately after treatment with furoxone. In order to clarify the role of the drug in the deaths of the snakes, the fourth specimen was not treated for three months, during which time it repeatedly ate and regurgitated. At this point it was treated with furoxone, and died the same day.

A further interesting observation was that, among newly acquired specimens that refused to feed, a single does of amoxicillin or a single dose of metronidazole was sometime effective in initiating feeding. This occurred in four specimens.

To summarize the disease process,

- it tends to occur after a short period of captivity in previously healthy specimens;
- the wholesalers all vehemently denied that any of the specimens regurgitated prior to being sold to us;

- it is easily spread to captive-born specimens or other non-affected specimens;
- in some cases it is easily eradicated by a single dose of a non-amebicidal antibiotic;
- in other cases, it is cured by a single dose of an amebicide;
- in yet other cases, three daily doses of an amebicide plus antibiotic have been effective.
- in some affected ETB's, improved hydration and soaking food items was successful.

During this time, we were able to repeatedly isolate Arizona from newly affected specimens. After treatment, no specimen continued to show Arizona in the stool or regurgitation food.

The syndrome of eating followed by regurgitation is quite typical of Arizona-Salmonella syndrome. However, this disease should be easy to treat and should not be highly contagious when proper hygiene is practiced. These bacteria are easily killed by exposure to air and by germicides. We initially had used a combination of clorox plus a phenolic germicide to sterilize cages, support branches and water dishes, and washed hands and snakes in phenolic germicide. Later, when the disease became controlled, we discontinued using clorox. We continued to have sporadic outbreaks in spite of this approach.

What conclusion might be drawn from these observations? The fact that an antibiotic was effective in some cases, while an antibiotic plus an amebicide or an amebicide alone was required in other cases suggests to us that this disease syndrome may be caused by a combination of etiologic agents acting separately or in combination. Initially, we suspected that newborn chicks that were used to feed the snakes might be the source of the Arizona. Although poultry products are a notorious source of Salmonella, Arizona is not commonly found in poultry. Also, we cultured several day-old chicks and obtained no Salmonella or Arizona.

After reviewing our husbandry practices and the epidemiologic pattern of the syndrome, we eventually concluded that this disease syndrome is, in fact, a syndrome in the true sense rather than a single entity. Regurgitation of recently ingested meals appears at this time to be a symptom, or reaction, that occurs, in one of a number of circumstances.

a) Salmonella/Arizona infections
b) Cryptosporidiosis as identified by R. Funk 1988
c) amebiasis
d) overfeeding of feeding too frequently
e) underhydration

a) Salmonella/Arizona infections have long been known to cause regurgitation. These organisms are highly contagious, but easily treated. This accounts for two aspects of the syndrome (1) the spread within a collection and (2) the fact that some affected specimens are immediately cured with a single dose of appropriate antibiotic.

b) Cryptosporidiosis is an infestation that can be difficult to diagnose, but is treatable with TMS, but not with other drugs used to treat Salmonella/Arizona or ameblasis. This accounts for the finding that some specimens were not cured by treatment with drugs used to treat these other entities. It is also difficult to eradicate by standard sanitary precautions, thus accounting for dissemination within a collection.

c) Entameba invadens is the amebic parasite found in reptiles. Outbreaks of ameblasis by this organism are not uncommon in reptile collections. Entameba is easily spread and difficult to eradicate. It reproduces by spores, which have an adhesive or sticky quality which allows them to adhere to any surface and thus be transmitted to other surfaces easily. Asymptomatic snakes with amebiasis can easily re-infect themselves when defecating in a cage, accounting for the observation that some normal specimens later developed regurgitation syndrome in spite excellent hygiene. It is readily treated by a single dose of the appropriate drug, either furoxone or metronidizole. This accounts for the observation that in many cases the symptoms persisted in spite of negative cultures, but some specimens were immediately cured when given a single dose of metronidizole.

d) Emerald tree boas are especially sensitive to overfeeding. Emerald tree boas can ingest a large meal, but rather sedentary and seem to digest slowly. It is tempting to feed snakes weekly, as is appropriate with many boids. However, if fed a large meal and then fed another large meal with 7 to 10 days, emerald tree boas frequently regurgitate. Herpetologist experienced with these snakes generally feed them a moderate sized meal every two weeks.

e) Emerald tree boas, and to a lesser extent, Brazilian rainbow boas, are very sensitive to dehydration. Many herpetologists have reported regurgitation in emerald tree boas when these snakes have been fed when inadequately hydrated. This is true to a lesser extent with BRB's. When this etiology is responsible, the regurgitated meal looks almost desiccated, and has little odor. In cases of Salmonella/Arizona infections, a regurgitation food item is wet, covered with mucous and highly malodorous.

To summarize, we now feel that regurgitation syndrome is an entity that, in medical terminology, has multiple etiologies, or many causes. It is simply the way certain snakes react when husbandry conditions are not optimal, or they are infected with one of several infectious agents.

One phenomenon associated with the syndrome in general is that once affected, some specimens may only tolerate small feedings for an extended time period. This may be due to inflammation of the gut caused by the initial infection.

We have examined stool specimens in a number of affected snakes, and so for been unable to identify Entameba. Because all affected specimens have been treated repeatedly with medications, it may be difficult to identify ameba in these snakes. The one fresh import that we have in the collection at this time had a negative stool examination, and has not developed regurgitation syndrome.

In order to prevent the syndrome from developing, we recommend the following protocol:

a) Treating all new specimens of the characteristic species, i.e., ETB's, BRB's, etc., with a large dose of amoxicillin, tetracycline, or chloramphenicol with a single PO dose of 50mg/k.

b) also treating all new specimens with a single dose of tri-methroprim-sulfa (Tri-brissen, Biotrim, Septra) at a dose of 5cc/k PO.

c) treating all new specimens with a single dose of metronidazole at 50mg/K PO. Alternatively, a single dose of furoxone, same dosage, can be given. Furoxone is available as a liquid preparation and is easier to administer.

d) Husbandry practices for ETB's and BRB's should be oriented towards providing very high relative humidity. ETB's should be soaked once weekly except in localities where the relative humidity is naturally high. BRB's should have a small amount of water in the bottom of their cages from time to time.

Abbreviations:

BRB... Brazilian rainbow boas
ETB... Emerald tree boas
PO... per os, or orally
TMS... trimethoprim-sulfa

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PHARMACOKINETICS OF GENTAMICIN AND PIPERACILLIN IN BLOOD PYTHONS: NEW DOSING REGIMEN

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Gentamicin is one of the most commonly used antibiotic in the treatment of gram negative infections in reptiles, yet there is little data to support the current dosing regiments. Gentamicin, an aminoglycoside, has been proven in mammals and suspected in snakes to be nephrotoxic. Thus, we conducted a prospective pharmeacokinetic study in Blood Pythons to develop a dosing schema for gentamicin that would not effect renal function as monitored by serum uric acid. In addition we also looked at a dosing schema for piperacillin, a betatactam, that has an extended spectrum covering aerobic gram negative organisms with minimal toxicity. Our objectives were to devise dosing schemas that would result in a range of serum concentrations that would exceed the minimum inhibitory concentration (MIC) of a majority of bacteria known to be pathogenic for Boids, as well as not effecting the renal functions.

The snakes used in the study were Blood Pythons *Python curtus* all wild caught, mature in age and ranged from 7 to 10 pounds. Snakes were quarantined for 1 month. Warmed with Levamisole and baseline blood done.

Blood samples were collected via cardiac puncture. Snakes were radiographed and scale clipped for approximate puncture site. Snakes were held and stretched out fully on a table and watched for heart beat. A 23 gauge heparinized needle was inserted just through the body wall staying to the right of midline. Approximately 0.5 to 1.0 cc was extracted. Samples were collected at times 0 (baseline), 6, 12, 24, 48, 72, 96, 120, 144 hours after injections. Plasma was separated by centrifugation and stored at -20°C pending assay. Gentamicin levels were analyzed by procedures described for the Abbott TDX-1.

Piperacillin levels were analyzed by high performance liquid chromatography by Lederle Laboratories. Uric acid levels were analyzed by procedures described for the Reflotron.

The following doses were given for gentamicin:

2.5 mg/kg loading, 1.5 mg/kg at 72 hours
2.5 mg/kg loading, 1.5 mg/kg at 96 hours
3.0 mg/kg loading, 1.5 mg/kg at 72 hours
3.0 mg/kg loading, 1.5 mg/kg at 96 hours

Peak serum concentrations for gentamicin ranged from 8.99 to 4.6 mcg/ml (See Table 1) and half lives ranged from 2 - 3 days. Corresponding uric acid levels for snakes given gentamicin stayed with acceptable ranges (See Table 2).

Piperacillin was given at doses of 200 mg/kg followed by 100 mg/kg at 24 and 48 hours. All pharmokinetic parameters were based on third dose due to the closeness of doses one and two.

Peak serum concentration for piperacillin ranged from 146 to 274 mcg/ml (See Table 3), and half-lives were 12 hours. Uric acid levels for a snake given 100 mg/kg at 48 hours remained well within normal ranges (See Table 4).

PHARMOKINETIC SUMMARY OF GENTAMICIN

Peak concentration of gentamicin occurred at 6-10 hours after injection. Doses of 3.0 mg/kg provided peak serum concentrations of 8 mcg/ml whereas a dose of 2.5 mg/kg provided peak serum concentrations of 5-6 mcg/ml. There was also intra-species differences for half-lives, the range being 2 to 3 days. There was no significant evidence of nephrotoxicity relative to uric acid levels. Our recommended dosing of gentamicin is 2.5 mg/kg loading followed by 1.5 mg/kg at 96 hour intervals. For severe infections where higher concentrations are desired a dose of 3.0 mg/kg loading followed by 1.5 mg/kg at 96 hour intervals should be used.

PHARMOKINETIC SUMMARY OF PIPERACILLIN

Peak concentrations of piperacillin occurred at 12 hours after injections. Half-life was consistent and predictable within the species. No evidence of nephrotoxicity was documented. Our recommended dosing of piperacillin is 80-100 mg/kg every 48 hours.

RESULTS

TABLE 1

Peak serum concentration of gentamicin in Blood Pythons following successive doses

	Dose mg/Kg	Peak mcg/ml
SNAKE #2	3.14	8.99
	1.5	7.52
SNAKE #7	3.0	8.19
	1.5	7.65
SNAKE #4	2.5	5.34
	1.5	4.6
SNAKE #8	2.5	6.18
	1.5	7.46

RESULTS

TABLE 2

Corresponding uric acid levels to gentamicin dosing

	DOSE mg/Kg	RANGE of Uric Acid levels
SNAKE #2	3.14 1.5	3.62 - 5.42 mg/dl
SNAKE #7	3.0 1.5	6.35 - 12.4 mg/dl
SNAKE #8	2.5 1.5	6.03 - 9.92 mg/dl
SNAKE #4	2.5 1.5	2.99 - 7.35 mg/dl

RESULTS

TABLE 3

Peak serum concentration of piperacillin dosing in Blood Pythons; parameters based on third dose

	Dose mg/Kg	Peak mcg/ml
SNAKE #1	100	156.7
SNAKE #2	100	142.6
SNAKE #3	100	274
SNAKE #4	100	194.5
SNAKE #5	100	146.5

RESULTS

TABLE 4

Corresponding uric acid levels in one Blood Python with a Piperacillin dosing of 100mg/Kg at 48 hour intervals:

Time of Sample	Uric acid Levels
Baseline*	3.5 mg/dl
6 hours	4.26 mg/dl
24 hours	6.84 mg/dl
48 hours*	5.20 mg/dl
54 hours	5.56 mg/dl

* Indicates injection of Piperacillin

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THE FIRST NORTH AMERICAN CAPTIVE BREEDING OF THE MANDARIN RATSNAKE *Elaphe mandarina*

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ABSTRACT

Until recently, this very beautiful and enchanting ratsnake from the mountain regions of southern China has eluded captive husbandry and propagation success stories since the time of its exciting discovery by Cantor in 1842. The first known captive breeding in North America was successfully accomplished with the hatching of six eggs. The captive breeding and husbandry techniques used are described including the rearing of the offspring.

The imported wild Mandarin Ratsnake *Elaphe mandarina* has been an extremely difficult ratsnake to maintain in captivity. The high mortality rate of this snake in captivity is usually caused by a combination of factors all of which seem to enhance each other. The most common factors are stress, internal parasites (lung worms and nematodes), bacterial infections, a lack of appetite and improper environmental conditions. In spite of this a few hardy specimens do survive, slowly acclimating to their new environment.

I purchased two pairs of long term wild captive Mandarin Ratsnakes in May of 1987 from a reputable Michigan snake breeder, Tom Lamont. He had purchased these snakes from another reputable breeder, Ernie Wagner, who obtained the snakes in 1983. In those four years neither had any success producing young.

The snakes were placed in separate cages for the first month. One of the females arrived with a respiratory infection and eventually died. In June, I then placed the snakes in a hundred gallon glass terrarium using a natural habitat setting composed of damp bark mulch, spaghnum moss, living indoor plants, and large thin slabs of slate rock. The terrarium was periodically sprayed with water. For lighting, I used a four foot shop light with two wide spectrum Gro Lux fluorescent tubes placed twelve inches above the terrarium. The daytime room temperature averaged about 26.6°C (80°F). The temperature taken in the primary hiding area in the terrarium was 22°C (72°F). Since my reptile facility is located in the basement of my home, there is only a small 4°C-5°C temperature variation between the day and night temperature.

The snakes ate most frequently at night. An occasional feeding was observed during the day if the observer was not detected. Large pinkie and small fuzzy mice were usually accepted but the snakes generally shied away from larger mice. The food items were usually scattered throughout the terrarium with most of the food items gone by morning. The snakes are light feeders with each rarely eating more than three or four fuzzy mice.

Usually one snake was observed out and about in the morning. It would lie motionless when observers were detected and then disappear with the blink of an eye. Most activity occurred during the night. Tail vibration was often observed when the snake was confronted or excited. One of the more aggressive males would occasionally strike when bothered. All three snakes shared the primary hide area.

With the approach of winter, I began preparing the room for hibernation by gradually cooling down the room and reducing feeding. By mid November hibernation was officially on its way. The room temperature dropped to about 15.5°C (60°F). The temperature inside the room was cooled by using the cold outside air. Cooling was achieved with a fan system which was controlled by a thermostat. Colder outside air is drawn into the room as the warmer air is blown out of the room. During the coldest part of winter, the temperature in the room dropped to about 12°C (55°F) for about six to ten weeks. The Mandarin Ratsnakes share the same room with all my other colubrids. All the snakes hibernate in their own or shared housing.

I began warming the room in the third week of February 1988. The Mandarins were not disturbed during the entire winter. When I first brought the snakes out of hibernation I notice they looked healthy. At the beginning of March I began introducing food and they started eating. By late March the female was looking somewhat heavier than normal. At the time, I thought she was probably about due for a large bowel movement, not occurring to me that she may have been ovulating. I also noticed that one of the males was no longer allowed to share the primary hide area. He occupied another hide area on the opposite side of the terrarium. The dominant male was observed jerking as he entered a tunnel in the large flower pot. I could not tell which of the other snakes, the male of female, was occupying the pot at the time. For the greater part of that spring, both the dominant male and female stayed together in the primary hide area.

By April, the posterior of the female continued swelling indicating she was, indeed, gravid. Late May she went into her preshed condition and shedded several days later, May 27. I then placed her in a plastic sweater box with damp vermiculite and a hide box. On June 7 (11 days after shedding) six fertile eggs were laid. The female stayed curled around her eggs. I removed the eggs and placed them in a plastic shoe box filled with damp vermiculite and place this box inside of a large sweater box which was placed on a shelf. The average daytime temperature in the shoe box containing the eggs was 27°C (81°F) and the average nighttime temperature dropped to 24°C (76°F). I felt this might be a more appropriate temperature range than my incubator (28.3° or 83°F) since these snakes inhabit a cooler climate. They have been recorded in elevations ranging from 700 m to 2300 m (2,200' to 7,500') in the high lying mountain woods of Southern China (Fleck 1985).

I expected the eggs to have a longer incubation period because of the lower temperature. When checking the eggs on July 26, I noticed one egg was slit. It had only been 49 days since the eggs were laid. I thought perhaps the egg slit from hydration but later noticed a nose protruding through the slit. They began hatching! They all hatched within the next 36 hours. The babies weighed 10-12 grams, with an average length of 30 cm (TL) (12"). The babies went through their first shed on August 4-5. One baby ate a pinkie mouse before its first shed. The sex ratio came out even, 3 males and 3 females. The babies looked identical to the adults in color and pattern.

Another wild Mandarin Ratsnake imported that same summer laid two fertile eggs on July 14 which hatched 54 days later on September 7. These eggs were incubated at a slightly higher temperature, daytime 27.7°C (82°C) and nighttime 25.5°C(78°F). Both of the hatchlings were sexed as females.

The hatchlings were kept in individual plastic sweater boxes with a high level of damp bark mulch (later switched to aspen bedding), a large piece of bark for hiding and a water bowl. All of the hatchlings began feeding on a regular basis after their first shed accepting new-born pinkie mice. Rarely was more than one pinkie taken. They were fed approximately every four to six days. Occasionally the food was not accepted because either the food item was too large or the snake was preparing to shed. After six months, the largest hatchlings have reached a length of 49.5 cm (TL) (19½"). They also show the same characteristics as the adults of being shy and spending most of their time hiding and burrowing tunnels in the substrate.

In conclusion, the captive hatched Mandarin Ratsnakes have been relatively easy to raise. They were large babies that started feeding directly on pinkie mice. They have spent their first six months at room temperature range of 23°C-26°C (72°F-78°F) and without any special lighting. As captive born adults, they will probably do very well in captivity as has been the case with other European and Asian species. The key to this first captive breeding is attributed to the natural setting in a large terrarium with ample and secure hiding areas, a relatively cool temperature and adult snakes which have had the time to acclimate themselves to captivity.

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Louisiana Pine Snake (*P. m. ruthveni*)
Photo by Steven B. Reichling

REPRODUCTIVE BIOLOGY AND CURRENT STATUS OF THE LOUISIANA PINE SNAKES, *Pituophis melanoleucus ruthveni*

Steven B. Reichling

Pituophis melanoleucus ruthveni, the Louisiana pine snake, is one of the most infrequently seen snakes in the USA, and is the most poorly known subspecies of the eastern *Pituophis* complex. Conant (1951) provided a basis for all subsequent work with his comprehensive review of *P. m. ruthveni* and *P. m. sayi*. Thomas, et al. (1976) reported only thirty-nine specimens extant in collections since its description (Stull, 1929). Young and Vandeventer (1988) presented observations on the habitat and behavior of this subspecies but nothing has been reported on the reproductive biology of *P. m. ruthveni*.

The Texas Parks and Wildlife Department lists *P. m. ruthveni* as endangered in the state, and collection is prohibited without a special permit. In Louisiana, the state's newly-formed Natural Heritage Program considers the pine snake rare, and a Scientific Collecting Permit must be issued before any collection can be made. *P. m. ruthveni*, along with numerous other taxa, was proposed for listing as a Federally Endangered Species by the U.S. Department of the Interior in 1982, but after a field status study by Jennings and Fritts (1983), during which no specimen could be located, the subspecies was not afforded this protection.

In 1974 I began field work in Louisiana and east Texas, searching for specimens and surveying habitats within the snake's historical range. I initiated these efforts in hopes of determining the status of *P. m. ruthveni*, and to better clarify its distribution, which I expected to be spotty and composed of disjunct populations. If the reputed rarity of *P. m. ruthveni* seemed accurate, I hoped to identify the factors responsible. Another objective of this study was to collect enough individuals to form a breeding colony in order to establish a managed and self-sustaining captive population.

HABITAT AND DISTRIBUTION

All specimens of *P.m. ruthveni* seen during this study, and all verifiable sightings by local residents occurred within a distinctive plant and soil-type association. The areas favorable for pine snakes were small pockets of sandhill habitat dominated by a sparse overstory of *Pinus palustris*, *P. taeda* and *Quercus marilandica*, and an understory distinguished by the presence of *Yucca louisianensis* and *Opuntia drummondi*. Young and Vandeventer (1988) also recorded *Q. incana*, *Q. stellata*, *Rhus copallina*, *Ilex vomitoria* and *Vitis sp.* at the collecting sites during their study. The soil was extremely sandy at all collection localities, with many areas covered with pure, loose sand 20 cm in depth. This habitat has been virtually extirpated in Louisiana and east Texas (Maxwell, 1973). Consequently, the actual distribution of *P. m. ruthveni* appears to be composed of small, widely scattered and discrete populations within the range usually illustrated (Conant, 1975; Thomas, et al., 1976).

VARIATION

The nine wild-caught specimens secured during this study provided an opportunity to observe pattern and pigment variation within the subspecies. The absence of postocular stripes, cited as characteristic of *P. m. ruthveni* (Smith and Kennedy, 1951; Mitchell and Tinkle, 1960) is not always diagnostic of the subspecies, as indicated by two specimens with distinct postocular bars. Although *P. m. ruthveni* often have heavily blotched venters (Walker, 1965; Conant, 1975), this is also not without considerable variation. Two specimens from this study had virtually unmarked venters, resembling the subspecies *melanoleucus* and *mugitus*. The other specimens exhibited varying degrees of pigment on their ventral scutes, ranging from faint smears of reddish-brown to bold black squares. Variation in postocular striping and ventral pigmentation was also noted by Young and Vandeventer (1988).

A third character often commented on by other workers is a marked lightening of the posterior pattern elements (Conant, 1975). However, one specimen collected during this study exhibited no such lightening, but had uniformly dark blotches the entire length of its body.

ABUNDANCE

During five years of field work, no specimens could be located in the southern portion of the pine snake's historical Louisiana range. The apparent absence of *P. m. ruthveni* in this region can probably be attributed to the almost total destruction of the *Pinus palustris/Quercus* habitat association. The classic collecting localities in Vernon and Rapides Parishes are gone. Ironically, the most undisturbed area in central Louisiana is a military reservation, Fort Polk, which is also a Wildlife Management Area. Logging operations are active within Kisatchie National Forest.

P. m. ruthveni was found to still occur in very limited areas scattered within the northern portion of its Louisiana distribution, a fact first noted by Clark (1949). Quite surprisingly, *P. m. ruthveni* was discovered to be relatively abundant in pockets of very distinctive sandhill habitat described above. Residents of this area were generally familiar with the "bull snake," and several ranked it as one of the most commonly seen snakes, exceeded in abundance only by *Coluber* and *Elaphe*. From these areas, six specimens were collected during a six month period in 1988, and numerous sightings were reported by local residents. It must be emphasized, however, that all these specimens came from within an area of approximately 20 square miles, containing very small, fragmented pockets of sandhill habitat. The reason for all occurrence of sandhill habitat and *P. m. ruthveni* in this region may be that the forests are of a more mixed *Pinus/Quercus* composition, making them less attractive to lumbering companies. As a result, they were spared from the devastating lumbering activities of the 1920's that obliterated pine snake habitat to the south (Reichling, 1988a). Of great concern, however, is the clear cutting that was observed immediately adjacent to these remaining sandhills, and which threatens what may be the last stronghold of the subspecies in the state.

REPRODUCTIVE BIOLOGY

Field work in north-central Louisiana during 1988 resulted in the collection of six *P. m. ruthveni*. Three additional specimens were located and acquired from collections. The snakes were maintained in captivity and exposed to seasonal photoperiod and temperature fluctuations closely approximating the natural annual daylength and temperature rhythms occurring in the southern USA (Reichling, 1986, 1988b).

One female (154 cm TL) laid four infertile ova 1986, which were not measured. The same female laid four eggs on 26 May, 1987 (one fertile, three infertile). Parturition in the same female occurred again on 17 June, 1988, with four eggs (three fertile, one infertile) being laid. Egg dimensions for 1987 were [illegible] 3.0 x 11.5, 3.0 x 12.5 (infertile) and 4.0 x 11.0 (fertile). For 1988, egg dimensions were: [illegible] (infertile) and 3.75 x 12.5, 3.75 x 13.0, 4.0 x 13.0 (fertile). The mean clutch size was four eggs, and egg size range was 3.0 - 4.0 x 10.0 - 13.0 ($\bar{x}$ = 3.6 x 11.9). The single 1987 neonate measured 55.0 cm TL. The three 1988 neonates measured (cm): 52.0, 55.0 and 55.5 TL; mass (g): 108, [illegible] These measurements provide a TL range of 52.0 - 55.5 ($\bar{x}$ = 54.4) and a mass range of 104 - [illegible] ($\bar{x}$ = 106.7).

No other snake in the USA lays eggs as large as those reported above, nor does any other large native colubrid snake normally produce clutches as small as four eggs. Only in the small, fossorial colubrids - e.g., *Tantilla* (1 - 3 eggs), *Chionactis* (2 - 4 eggs) and *Rhadinaea* (2 - 4 eggs) are such small clutches produced routinely (Behler and King, 1979). Additionally, these neonates measurements are larger than those reported for any other North American snake. Only the other members of the eastern *Pituophis* complex approach, but do not match, *P. m. ruthveni* in these reproductive parameters (Table 1).

Although the biological implications for this egg size, neonate size, and fecundity pattern are not known, the present data suggest that *P. m. ruthveni* lays the largest eggs, but the smallest clutches, among North American colubrid snakes, and hatches at the largest size of any North American snake yet reported.

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Table 1 – Summary of egg and neonate measurements from four subspecies of *Pituophis melanoleucus*, from captive breedings at Memphis, Tennessee.

Subspecies	Female TL(cm)	Egg width range(cm)	Egg length range(cm)	$\bar{x}$ neonate TL(cm)	$\bar{x}$ neonate mass(g)
P. m. melanoleucus	158	3.75-4.00 (n = 8)	6.50-8.50 (n = 8)	51.8 (n = 8)	52.4 (n = 8)
P. m. mugitus	147	2.75-3.50 (n = 9)	9.50-11.75 (n = 9)	47.4 (n = 8)	58.5 (n = 4)
P. m. lodingi	159			52.5 (n = 7)	
P. m. ruthveni	154	3.00-4.00 (n = 8)	10.00-13.00 (n = 8)	54.4 (n = 4)	106.7 (n = 3)

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CAPTIVE REPRODUCTION OF THE BANDED ROCK RATTLESNAKE *Crotalus lepidus klauberi*

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ABSTRACT

Two male and two female Banded rod rattlesnakes, *Crotalus lepidus klauberi*, were collected in the Robledo mountains on 14 July 1985, and the Organ mountains on 12-13 September 1986. Both mountain ranges are located in Dona Ana County, New Mexico. Both pairs were collected as part of a captive maintenance and breeding project. They were bred in captivity on 26 June 1987, Robledo mountain pair and 31 July 1987, Organ mountain pair. Mating activities continued with both pair for many days after first copulations were observed. Neonate births were recorded on 8 June 1988 for the Organ mountain pair, and 24 June 1988 with the Robledo mountain pair. Observations and methods have been recorded to augment the available information on this species.

The banded rock rattlesnake, *Crotalus lepidus klauberi*, (Gloyd 1936) is a small montane form, with a range extending from extreme El Paso County, Texas, west across southern New Mexico, into the mountains of southeastern Arizona and south throughout the mountainous continental divide region of northern Mexico.

A collection of *Crotalus lepidus klauberi* was established on 3 August 1985 for an in-depth study of the natural history of the species, beginning with a single sub-adult male collected in the Florida mountains in southeast Luna County, New Mexico; more specimens were added over the subsequent twenty-six month period. As of August 1988 there were a total of 45 specimens, 14 adult pairs and 17 sub-adult and juvenile snakes. The purpose of this collection of a single species is to increase the understanding of the requirements for the captive maintenance and reproduction, and perhaps illuminate aspects of the life history of *Crotalus lepidus klauberi*.

Information on the captive maintenance and husbandry of the *Crotalus lepidus klauberi* are scarce. Courtship and mating behavior of many Crotalus species have been documented by (Klauber 1956, Armstrong and Murphy 1979) and others, but little specific information is available on the lepidus group in particular *Crotalus lepidus klauberi*.

Specimens were carefully selected and paired to maintain the unique genetic characteristics of each isolated population.

I began this project in hopes of increasing the available information on the subject of captive breeding of this species. Presented in this work are data on reproduction in captivity of two pairs of *Crotalus lepidus klauberi*.

MATERIALS AND METHODS

The two captive pairs of *Crotalus lepidus klauberi* to reproduce in this project were received separately on 30 September 1985 and 28 September 1986. One pair was collected on 14 July 1985 in the Robledo mountains, located in Central Dona Ana County, New Mexico. The second pair was collected in the Organ mountains, which are located in Eastern Dona Ana County, on 12-13 September 1986. Both pairs were field collected in talus slides.

All snakes in the collection are housed in cages constructed on ½" birch plywood measuring 48.3 cm x 34.8 cm x 30.4 cm) on a paper substrate. Sexual pairs of the snakes, from the same geographic localities are maintained together year round. The cages are designed with an upper and lower section. The lower section acts as a hide box and measures 45.5 cm x 27.1 cm x 7.6 cm) with a 2.5 cm diameter hole cut in the floor of the right rear corner which allows for access between the two compartments. This design is to allow for vertical movement by the snake through this small hole between the levels and into an area that is dark and secluded. This simulates movement through talus where escape is normally in a downward motion through the rock. A plexiglass window (45.5 cm x 18.4 cm) is used in the upper level for observation and display.

Access into the cage is solely provided by a hinged back which allows for simultaneous access to both levels of the cage. The back is keyed and locked for safety purposes.

No lighting, cooling or heating is built into the cages. Lighting in the room is provided by a single overhead light and one western exposure window. Snakes are exposed to the natural photo-period for southern New Mexico.

Cooling in the summer is provided by central air conditioning. Heating is not provided for the room in which the snakes are maintained. The only exception is in early spring when snakes start becoming active (mid-March through April) and only to aid in digestion. This is provided by a commercially available heating stone which is placed in the left corner of the upper level. Otherwise snakes are maintained at room temperature. Temperatures are variable but usually range in the winter months between 10°C to 19°C and from 20°C to 35°C during the summer months. Temperatures during the summer months have exceeded 37°C but for only short periods of time. Ambient temperatures fluctuate the most during the spring and fall months, usually from 15°C to 29°C.

Specimens are not offered food during cold months of the year. Feeding is usually begun about three weeks after the warm-up has started (mid-April). Snakes are fed laboratory mice of an appropriate size on a feeding schedule determined by the size and weight of the snakes; ranging from a meal each 7 - 20 days. In early spring snakes are fed smaller mice to aid in quicker digestion. All specimens are fed until mid-September. They are cooled off for approximately 6 months until mid-March. I believe this coincides closely with the natural cycle for most specimens are refusing food during this time, even if offered.

Cages and water dishes are cleaned using commercially available brands of amonia and dishwashing detergent and if needed, bleach.

RESULTS

Courtship and mating of the Robledo mountain pair was first observed on 26 June 1987 at 5:35 p.m. Courtship activity as ongoing at the time observation began with both snakes lying motionless in the cage. The males tail was under the females but the snakes were not coupled.

At 6:04 the snakes were intentionally disturbed by me; they separated and moved about the cage. The male was very alert and active. He was crawling around, flicking his tongue out rapidly, stopping in certain spots on the floor and placing his snout against the floor.

This behavior was observed until 6:06 p.m. at which time he again located the female, who was still motionless. The male immediately made body contact, crawling up on the females dorsum. He seemed very excited as he began crawling up the females body toward her head. He also seemed to be pressing down on the female as though he wanted her to move. When the female did respond and moved the male immediately slid the posterior half of his body down and along the side of the female. The male then slid his tail under the females tail, which was already slightly elevated approximately 10 mm off the floor. The male then used his tail to further lift the females tail to an almost vertical position at which time he slid his tail down to the cloaca region.

He repeated this action twice before copulation was achieved. At 6:09 p.m. copulation began (fig 1). The female lay motionless throughout the entire mating sequence until separation at 8:38 p.m.

The mating lasted for approximately 2 hours and 28 minutes. During copulation the male draped his body over that of the females in three places; approximately 60mm up from the cloaca area and about 105mm and again at mid-body. From 6:09 p.m. until 7:41 p.m. the male went through a series of movements which included rapid tongue flicking, head jerking and rubbing the chin area of his head against the females dorsum down to about the seventh band (mid-body).

This rubbing (fig. 2) seemed to stimulate a pulsating action in the male, which would involve his entire body and would get increasingly stronger, lasting approximately 45 seconds and would culminate in a sudden jerking or lifting of both snakes tails off the floor to an almost vertical position (fig 3), which would be held for 5 to 6 seconds. Then the male would assume a relaxed position with his head approximately 10 mm above the females dorsum, about 75mm back from the females head. No movement was observed at this time with either sex. This relaxed sequence (fig. 4) would last 2 minutes then the head jerking would begin again.

This action was repeated at approximately 3 minute intervals, until 7:42 p.m., when the males activity ceased, although they were still joined. Both lay motionless until separation at 8:38 p.m.

When separation occurred at 8:38 p.m. the female moved into the lower level of the cage while the male remained in the upper level. They remained in separate levels until 9:50 p.m. at which time the female reappeared in the upper level of the cage. The male again became very excited and began courting the female as before. At 10:04 p.m. the males activity slowed; he showed signs of wanting to mate but the female was not responding. The male had his body draped over the female but copulation was not observed. At 10:13 p.m. all activity had ceased. The snakes were laying together but no movement was noticed in either sex. Observations were ceased at this point. The snakes were checked again at 3:40 a.m. and 6:00 a.m. with no changes being noted. Subsequent breedings with this pair were noted on the following dates:

1 JULY 1987	9:45 A.M.
2 JULY 1987	8:00 P.M.
3 JULY 1987	6:00 A.M.
9 JULY 1987	10:00 A.M.
10 JULY 1987	6:00 A.M.
25 JULY 1987	8:56 P.M.

As mating activity continued, courtship and copulation intensity levels declined dramatically; copulation periods were only lasting between 45 and 60 minutes. The last visually confirmed breeding occurred on 25 July 1987 at 8:56 p.m.

The second pair observed breeding were from the Organ mountains. The courtship and mating sequences were very similar, with one exception, the male did not drape his body over that of the female but instead they lay side by side. The first observed mating occurred on 31 July 1987 at 10:40 p.m.

Breeding activity continued with this pair until 23 August 1987 at 8:57 p.m. Mating by either pair was not observed after the last date listed.

After being fed 2 to 3 times after breeding activities ceased the females were cooled off with the males.

After hibernation the females were weighed to determine weight gain or loss during hibernation period. The Organ mountain female gained weight from her pre-hibernation weigh-in. She was weighed on 1 September 1987 (140 grams) and again on 28 February 1988 (150 grams) and had gained 10 grams. Noted also was a pronounced swelling in the posterior half of this snake, first noticed January 1988. The Robledo mountain female was the opposite in that she lost weight from her pre-hibernation weight-in; 29 September 1987 (152 grams) and 30 March 1988 (140 grams) showing a loss of 12 grams. No swelling or increase in body size was noticed in the posterior half of this snake.

GESTATION

During the gestation period the females became very seclusive, remaining in the lower section of the cages about 90% of the time, moving into the upper level only for food and water. Both females refused food for approximately 2 months prior to parturition, although both females did feed twice after the initial warm-up period was begun. A noticeable behavioral change was noted in the Organ mountain female; she became very excitable, almost nervous; if she was discovered in the upper level of the cage she would quickly descend to the lower level, a dramatic change in her usually calm behavior.

There was no noticeable change of behavior in the Robledo mountain female or either of the males.

Between 312 and 362 days after the first observed matings the following neonates were born:

8 JUNE 1988	4 NEONATES	ORGAN FEMALE
24 JUNE 1988	2 NEONATES	ROBLEDO FEMALE

Weights and lengths are listed in Table 1. The Organ Mountain female also passed 4 infertile eggs.

DESCRIPTION OF NEONATES

Neonates were not offered food until after their first shed, which occurred 10-14 days after birth, at this time they were offered either pinky mice or previously frozen baby lizard *Uta stejenegeri*. Three of the Organ mountain neonates refused pinkies but did eat lizards; the other Organ neonate started off on pinkies. One Robledo mountain neonate started on pinkies, the other on lizards. One of the Organ mountain neonates was born with a spinal defect (posterior) and although he originally accepted food has since died.

Description of the neonates is as follow: (Fig. 5) Organ mountain neonates are a light gray ground color with black bands, the area between the bands are heavily mottled and speckled; mottling resembles secondary bands. Tails are yellow. Neonates do resemble adult snakes in being heavily mottled, although the color is noticeably lighter in neonates and the sexually dimorphic color difference of the adults are not evident.

TABLE 1	ROBLEDO MOUNTAIN PAIR		ORGAN MOUNTAIN PAIR	
	M-1	F-1	M-1	F-1
PARENTAGE	M-1	F-1	M-1	F-1
TOTAL LENGTH	567 mm	492 mm	552 mm	512 mm
SNOUT/VENT LENGTH §	511 mm	449 mm	500 mm	470 mm
TAIL LENGTH	56 mm	43 mm	52 mm	42 mm
WEIGHT	190 g	140 g (prior)	130 g	160 g (prior
		124 (After birth)		130 g (After
COPULATION	--------6/26/87--------		----------7/31/87----------	
GESTATION #		363 days		312 days
PARTURITION		6/24/88		6/8/88

NEONATES	ROBLEDO MOUNTAINS	ORGAN MOUNTAINS
NUMBER OF YOUNG	2	4
INFERTILE EGGS	0	4
TOTAL LENGTH	240 mm	193 mm *
	234 mm	207 mm
WEIGHT	7 g	6 g each
	8 g	
SEX RATIO	1.1	2.2

§ - Snout to vent lengths on neonates were not attempted for fear of injury to young.

- Not exact; Dates represent days from first observed copulation to birth.

* - Deceased neonate; one male.

Adult females are usually a dark silver-gray with black bands and are very heavily mottled and usually display a large amount of pink ventrally.

Adult males are usually a dark olive green with black bands and heavily mottled.

(Fig. 6) Robledo mountain neonates are a light-gray ground color with distinct black bands and no mottling; however there is a small amount of speckling evident between the bands. There is a noticeable pink or light red overall hue to these neonates. Tails are a bright yellow. Again, the neonates do not exhibit sexually dimorphic color differences noticed with the adults.

Adult females are usually gray with a bluish overcast and adult males are usually gray with green overcast.

I have observed this dimorphic difference in other rock rattlesnakes from other localities, where adults are green and exhibit a light yellow, one scale wide outline on all black bands. Females again exhibit a large amount of pink ventrally, especially in the head region. The neonates exhibit none of the green coloration, or the dimorphic differences of either sex. Neonates are a bright gray with some speckling between very vivid black bands. The above mentioned neonates were born July 1987 to two wild caught gravid females. At one year old they still do not show evidence of a green hue developing.

DISCUSSION

The main goal of this project is captive breeding in this species. Since the inception of this project 3½ years ago, other interesting observations of this species have been made which has led to a more comprehensive study of the life history of the species. Based on these observations the breeding season of *Crotalus lepidus klauberi* from West Texas and Southern New Mexico apparently begins in late June and ends in late August. Breeding and birthing activity or births of young have been recorded with this project at any other time of year. The initiation of courtship activity often appears to be dependent on the females shed cycles.

Both pair bred within 1-3 days after the shedding of the females. The Robledo mountain female shed on 25 June 1987 and first observed breeding activity was recorded on 26 June 1987. The Organ mountain female shed on 27 July 1987 and breeding with this pair was first observed on 31 July 1987.

Shed dates were recorded on 15 April 1988 for the Robledo mountain female and 31 March 1988 for the Organ mountain female. Neither female shed prior to parturition.

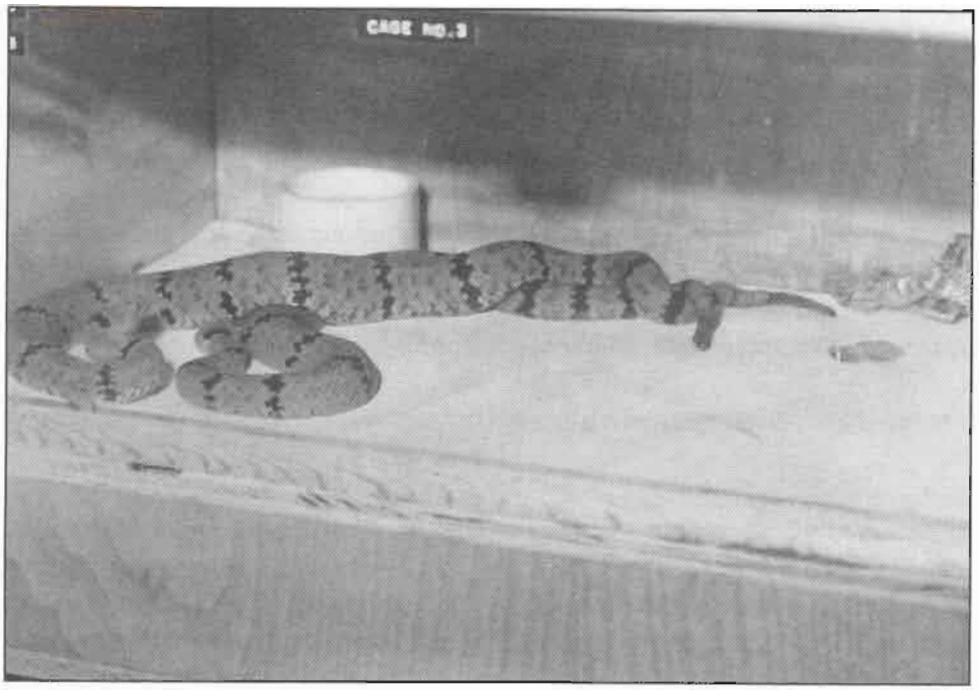

Figure 1. Copulation

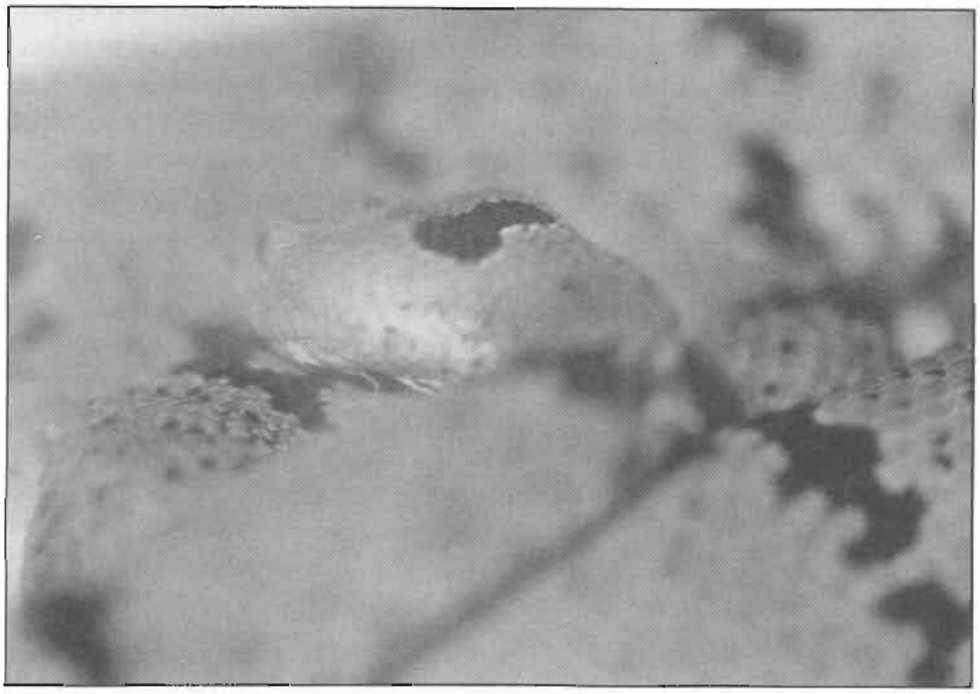

Figure 2. Chin rubbing

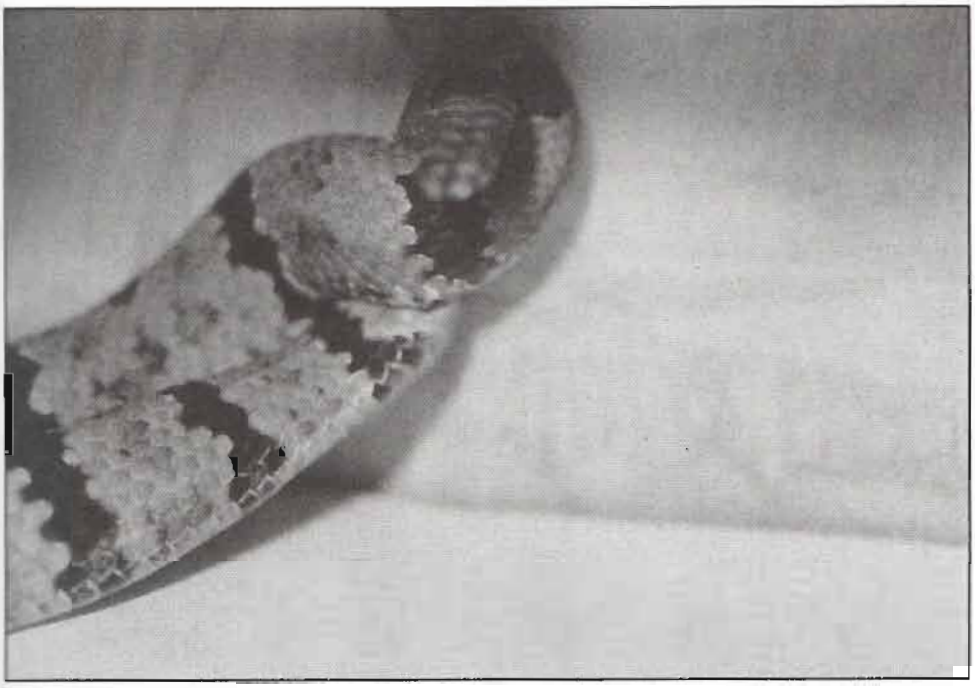

Figure 3. Tail lifting

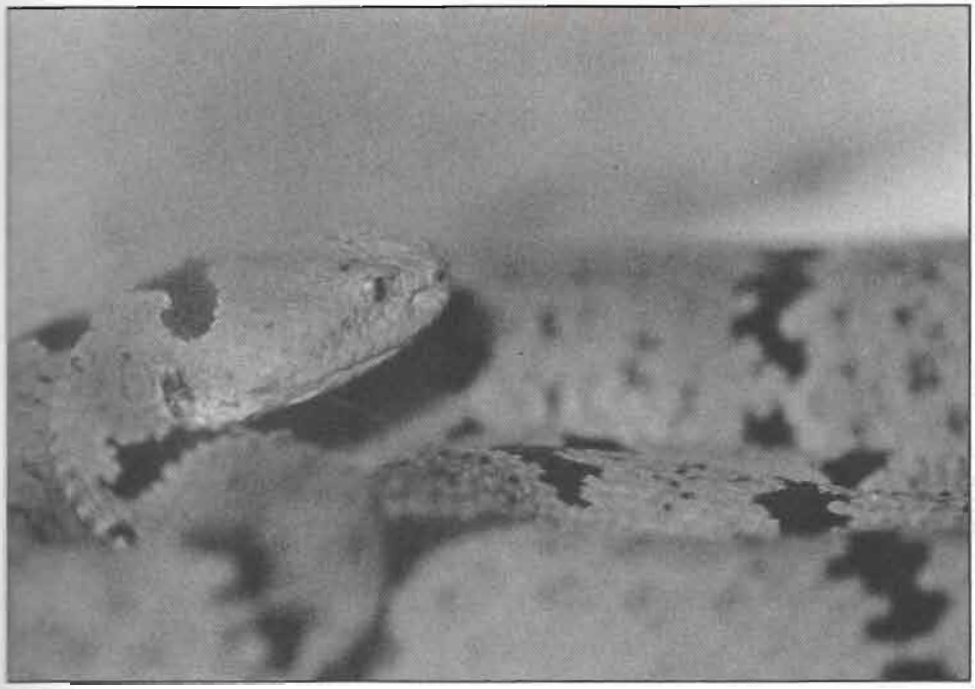

Figure 4. Relaxed position

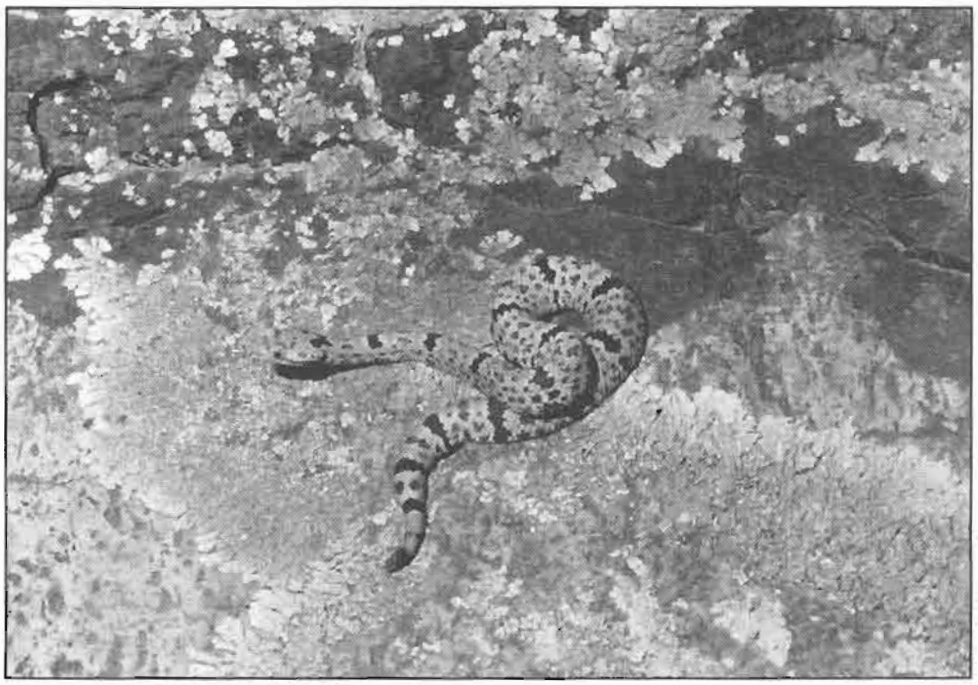

Figure 5. Organ Mountain Neonate

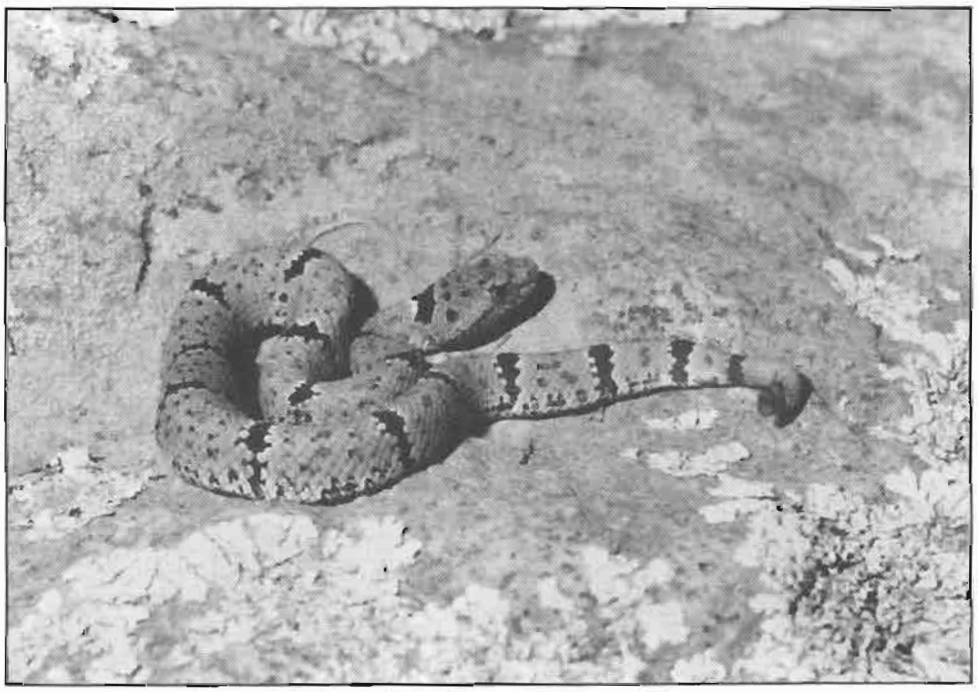

Figure 2. Robledo Mountain Neonate

Breeding activity was observed with the Robledo mountain pair on several occasions prior to parturition. Activity was first observed on 23 June 1988 and resumed after the birth of the two neonates. Activity observed again on 9 August 1988 and subsided about 10 days later, copulation was not observed. The male courted and tried to copulate with the female; nothing was observed that would indicate he was successful in his attempts.

Breeding has been recorded with 2 other pair. A second pair from the Organ mountains, cataloged as M-2 and F-2 were engaged in copulation at 6:12 a.m. on 30 August 1988; although this female had not shed. The last shed date was recorded on 28 April 1988. A pair from the Florida mountains Luna County, New Mexico cataloged as M-1 and F-2 were observed copulating at 4:47 p.m. on 8 July 1988 and again on 12 July 1988 between 10:00 a.m. and 11:00 a.m.; this female had shed on 5 July 1988.

In my collection, it appears that fertile matings are those during a period following the shed of a female occurring during the summer months of June, July and August. While I have observed copulation in pairs with a female that has not shed, it does not appear that they were productive matings.

Offspring are produced approximately one year after breeding. This would indicate that *Crotalus lepidus klauberi* in this area produce offspring every other year; more observations are necessary to substantiate this hypothesis.

I have been trying various methods, such as multiple pairings in a single large cage (91 cm x 45.8 cm x 45.8 cm) 3 males and 2 females; one male and 2 females, and introducing the female into the males cage at various times of the year; all without success. It seems that single pairing of a male and female has the greatest success. Banded rock rattlesnakes appear to easily adapt to captivity.

This work is by no means intended to state that my methods are the only approach to a successful breeding program for the Banded rock rattlesnake. Rather, I wish to report my methods and observations to augment and information available to others interested in this beautiful species.

I am continuing my work and observations with this species, to add more information to the captive maintenance and life history of the Banded rock rattlesnake, *Crotalus lepidus klauberi*.

ACKNOWLEDGMENTS

I gratefully acknowledge the assistance of my son Shane and friend Doug Duerre, without whose field collecting efforts this project would have been impossible.

My special thanks to John Hanson and Louis Porras for their advice, guidance and listening ear.

Grateful acknowledgments to the following individuals; Alec Knight for encouraging the writing of this paper, as well as his efforts reviewing it. Also, thanks, for having a car that was road worthy four years ago!

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A loving thanks to my wife Tracey for her understanding, and tolerance of snakes in the bedroom.

This paper is dedicated to my daughter Crystle.

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A SAFE, PRACTICAL PYTHON FACILITY

Ernie Wagner & Darcie Richardson

I have long felt that anyone keeping large pythons or venomous snakes should have a facility designed specifically for those animals, because of the potential dangers involved in their daily handling and management. The most important element is a clear, enclosed floor space with nothing for a snake to crawl under or behind. This was brought home a few months ago when a nervous ten foot burmese python, whipped out of my hands, hood around a cage leg and disappeared behind a row of cages, in spite of my efforts to stop her. Having a facility designed for handling these animals saves a great deal of trouble and reduces personal risk when handling big snakes.

My python facility is a large room approximately 15 by 40 feet square with two rows of cages, each 24 feet long, facing each other at a distance of about 6 feet. The end of the rows are partially closed off and this serves to form a smaller, clear work area within the room. The cages sit on the floor with all spaces in between the cages blocked off and all wiring is run along the back of the cages so when a large snake is taken out of its cage, there is nothing for it to crawl behind or under. This keeps the snake handler from getting into an unsafe situation when working alone. If a snake needs to be held out of its cage for any length of time, a large box with a screen top is used. This has a latching lid and rollers so that it can be easily moved about in the work area. For water changes or partial cage cleaning, I work with the snakes in their cages and to do this safely I use a couple of shields. One is a smaller, paddle shield designed to be held in one hand. It made out of half inch plywood with the center cut out and a solid plastic sheet attached. This way I can see the snake through the shield and in addition, the snakes tend to try pushing against the plastic window, rather than coming unexpectedly around the shield. The other shield is larger with a four inch lip all the way around. It is made totally of rigid plastic and resembles a shallow box with a handle. This is designed to be rested directly over the top of the snake and even if it only on the front part of the snake's body, the snake is confused by the clear plastic barrier it finds itself in. This can also be held upright and the four inch lip is very effective in keeping the snake from coming under, or over this shield. The final piece of safety equipment I have available is a four inch hunting knife which I always wear when working the big snakes alone. I don't ever foresee myself having to use it, but if needed some day, it will be there.

The cage design is fairly simple with the cages being constructed out of half inch plywood. Sheets of linoleum are bonded onto the plywood before the cages are assembled and then a bead of silicone is run around the joints making the floor practically waterproof. The cages are eight feet long, two and a half feet front to back and eighteen inches tall. There are two heavy glass doors across the front, which hinge down, two screen vents on the ends and a four inch lip across the front to keep drippings in. These cages are stacked three high, which makes the floor to the top cage a little over three feet off the ground, a safe working height for big snakes. Lighting is provided from a single incandescent outlet mounted on the back wall and all wiring is run through metal conduit to protect it. Light fixtures have plastic baskets around them to prevent snakes from breaking bulbs. Heat is provided from three strips of heat tape which run the full length of the cage. They are installed on the floor, next

to the back wall and covered with a piece of waterproof formica-type material. Each stack of three cages has its own rheostat to control the amount of heat coming from the tapes. Water is provided by using plastic dish pans set down inside two by six inch wooden frames to prevent spilling. all snakes are housed singly to prevent accidents or fights at feeding time and all food items (rabbits, chickens, rats) are offered dead.

Reproductive behavior in the pythons is stimulated by dropping the evening temperatures in early winter. The room is maintained at about 70°F and the lights and heat tapes turned off at night. In addition the light cycle is shortened from 14 hours in the summer, down to about 10 hours in the winter. After about a month of evening cooling, the males are introduced to females and copulation usually occurs. Several weeks following copulation a large, tight, mid-body swelling may be observed in gravid females. This bulge lasts 2 or 3 days and resembles a meal, even though the snake had not recently eaten. About three weeks after the mid-body bulge is evident, the snake will enter a shed and thirty days following the shed, she should lay. The eggs can be removed and incubated at 90°F in an incubator or they can be left with the female. If they are left with the female, she should have background cage temperature of at least 85°F and she should be sprayed down with water every day to provide moisture for the eggs. I have also found it useful to lightly drape a heavy piece of plastic over the top of the female and spray underneath it. This helps hold moisture around the eggs for a longer period of time. Incubation lasts about 60 days and just prior to hatching, the female will loosen her coils from around the eggs. I usually remove them at this time to prevent any babies from being crushed by the female in the confines of the cage. After shedding, babies are set up in individual shoe boxes and fed on just weaned mice.

This system of keeping large pythons has worked well but it is very important to set up your own safe working rules and always follow them. Taking shortcuts when you are in a hurry can often lead to trouble. Having a correctly designed facility and proper tools and then taking the time to use them are the most important factors in the safe handling of large snakes.

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CAPTIVE REPRODUCTION OF PYTHONS AT THE OKLAHOMA CITY ZOO

Scott Wheeler

Captive reproduction of pythons has become more successful in recent years. With increased, success common external physical indicators may be found in reproductively active female pythons. Osborne (1982) described common external physical indicators for reproductively active North American colubrid females. This paper will describe common external indicators of reproductively active female pythons observed at the Oklahoma City Zoo, with notes from other observers.

While working with an adult group of two male and three female *Liasis boa*, it was observed that after several copulations the females would develope a "lump" swelling mid-body. It was presumed the females were gravid at this point and introduction of males was stopped. Unfortunately no eggs were ever produced. Ross (1981) documented similar swelling and speculated that enlarging ova may produce a visible mass in pythons. He also recognized that the appearance of such a mass is not necessarily an indication that a snake is gravid. Slavens (1985) listed an entry from Sedgwick County Zoo in which they observed this lump in a female *Python reticulatus*, speculating "ovulation?" Clark (pers. comm.) also observed a similar swelling in *Python molorus bivittatus*, but had always left males with females during this swelling, observing continued copulations resulting in fertile eggs. Tosen (pers. comm.) observed a similar swelling in *Epricrates*. Using ultrasound he found the swelling was due to developing ova.

In 1986 this swelling was observed in a female *Liasis boa* on breeding load from the Reptile Breeding Foundation, Canada. After a week of daily copulations, the female began to swell bid-body. After four days the swelling progressed to a hard "lump" (Fig. 1). A male was introduced to the female during the appearance of this "lump." The female was more receptive than in previous copulations, prior to physical contact. Copulation occurred within two minutes. This "lump" lasted one day. The swelling decreased gradually within one week. Interestingly, the receptivity of the female to breeding decreased with the decrease in swelling. Within 20 days from the appearance of the "lump," the female shed. After this shed the female began basking belly up. The female slowly began to swell again until oviposition occurred, but no "lump" developed again. Fifty days after the appearance of the "lump," and 30 days after the shed, oviposition occurred. Seven eggs were laid and were artificially incubated at 86°-88°F in a vermiculite substrate. When the eggs failed to hatch, they were opened revealing fully developed dead embryos. Although this breeding was not successful, two successful breedings occurred in 1987. These two breedings followed the same "lump," shed, oviposition pattern as described (Table 1)

Two successful breedings of *Python amethystinus kinghorni* occurred in 1987 and 1988 (Grow, et al. 1988). Both of these breedings followed the same "lump," shed, oviposition pattern (Table 1). In both instances, the female showed a notable increase in receptivity to the male during the appearance of the "lump."

The "lump," shed, oviposition pattern has observed in other collections (Table 1); in *Pyth* *regius* (Van Microp and Bessett, 1981); *Python molurus bivattatas, Python sebe, Liasis albertisi* (Cla pers. comm.). Although there is no evidence of what is occurring internally, the "lump," she oviposition pattern can be used to determine the optimum period for fertilization, and to predict eg laying. It is hoped that this pattern can lead to physiological examination of reproductively acti females, providing a timetable for investigators.

TABLE 1

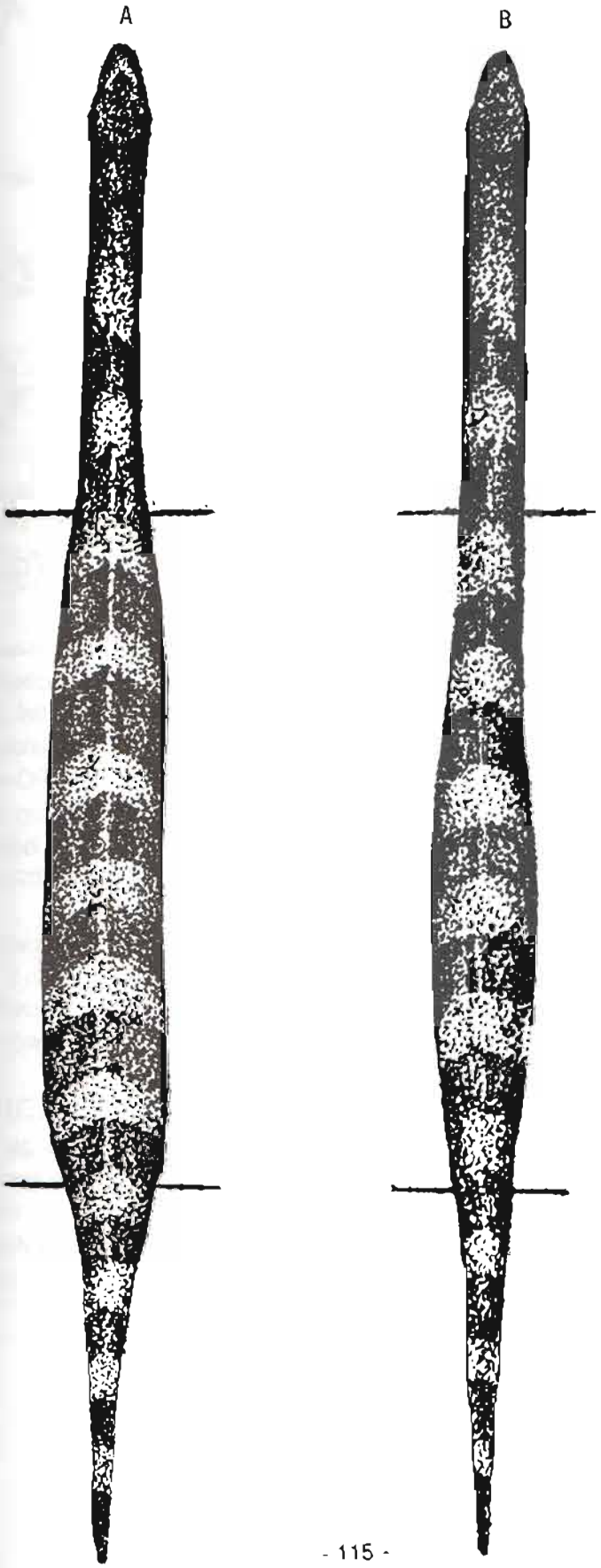
Comparison of the average number of days from appearance of the "lump" to oviposition, including "lump

to shed average, and shed to oviposition.

SPECIES	"LUMP" TO SHED	SHED TO OVIPOSITION	"LUMP" TO
Python regius (Van Mierop & Bessett, 1981)	?	?	53
P. reglus (Clark, pers. comm.)	?	27(±2)	?
P. molurus bivittas (Clark, pers. comm.)	17(±2)	31(±3)	50(±
P. sebe (Clark, pers. comm.)	17(±2)	35(±3)	52(±
P. amethystinus kinghorni (OKC Zoo)	20(±3)	20(±2)	50(±
Liasis boa (OKC Zoo)	20(±1)	25(±3)	45(±

Illustrates the "lump" as it occurred in *Liasis boa*.

Shows the area of swelling several days prior to, and after appearance of the "lump" in *L. boa*.



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Egg Collection and Head-Starting of the Pinzón Island Galápagos Tortoise *Geochelone nigra ephippium* - From Certain Extinction to Recovery!

Fred Caporaso, Ph.D.

INTRODUCTION

Pritchard (1979) presented an excellent overview of tortoises of the Galápagos, and a comprehensive bibliography was compiled by Beaman (1985).

Over the last two centuries an estimated 100-200,000 Galápagos giant tortoises *Geochelone nigra* have been slaughtered by whalers, fur sealers and colonists for their meat and/or oil (MacFarland, et al., 1974a). MacFarland and Reeder (1975) estimated the total surviving Galápagos tortoise population at less than 14,000 (Table 1). Three races of the original 14 are extinct (Figure 1) and one *G. n. abingdoni* has only a single known survivor, "Lonesome George" (Tierney, 1985). Of the remaining 10 races probably those from the three volcanoes on northern Isabela Island (Alcedo, Darwin and Wolf) have relatively stable populations capable of natural replacement. The others are still threatened by the presence of feral mammals or have a drastically reduced population (Table 1).

However, through the joint efforts of the Charles Darwin Research Station (CDRS) and the Galápagos National Park Service (GNPS), a tortoise conservation program has been established. This program was initiated in 1965, when tortoise eggs from Pinzón Island (Duncan) were brought to the CDRS for hatching and rearing to avoid black rat *Rattus rattus* predation. Señor Miguel Castro, the Conservation Officer for the GNPS, initiated some of these first rescue efforts (King, 1968). In December, 1971 the first group of 19 captive-raised tortoises was repatriated and each year since then another group has been released on Pinzón. Marquez, et al., (1987) reported that in the last 16 years (since December, 1970) 893 young tortoises, from 8 different races, had been released into their native habitats.

The tortoise conservation program has been plagued by a lack of staff and resources. Nevertheless it continues to be a major success with all but one of the remaining tortoise populations recovering (Metzger and Marlow, 1986). Indeed this program has to be an inspiration to all the new "Species Survival Programs" for other endangered fauna around the world.

THE SPECIFIC SITUATION FOR THE PINZÓN ISLAND TORTOISE

On August 5-26, 1986, I had the pleasure of visiting the Galápagos Islands with Dr. Peter C.H. Pritchard as part of a crew filming a documentary on the turtles and tortoises of the world. We were granted permission to film in areas not open to the general public. One of these areas was Isla Pinzón, an island which is home to some of the oldest tortoises in the Galápagos and therefore some of the oldest animals on earth. I find the Pinzón Island tortoise story unique and truly amazing!

Table 1. Status of 11 known, surviving races of *G. nigra*, November, 1971, when conservation work began

Race	Location	Number Marked	Population estimates: Total	Population estimates: Small-med. sized	Primary threats: Feral animals[a]	Primary threats: Stages affected[b]	Secondary and potential threats[a]
hoodensis	Española	11	20-30	None	G	Y	---
ephippium	Pinzón	100	150-200	None	R	Y	---
chathamensis	San Cristóbal	213	500-700	Very rare	D	N,Y	R
					C	Y	G
					DN	Y	---
darwini	San Salvador	389	500-700	Very rare	P	N, Y	R
					G	Y	DN
porteri	Santa Cruz	1460	2000-3000	Moderate numbers	P	N, Y	R
					C	Y	M
					G	Y	DN
abingdoni	Pinta	0	Very small	?	G	Y	---
vicina	Cerro Azul	196	400-600	Very rare	P	N, Y	R
					D	Y	M
					C	Y	CT
guntheri	Sierra Negra	219	300-500	Rare except in one area	P	N, Y	C, R
					D	Y	M, G, CT
							DN
vandenburghi	V. Alcedo	403	3000-5000	Numerous	?	?	C, R, M
							DN
microphyes	V. Darwin	65	500-1000?	Numerous	?	?	C, R, M
becki	V. Wolf	0	1000-2000?	Numerous	?	?	C, R, M

[a]C = cats, CT = cattle, D = dogs, DN = donkeys, G = goats, M = man, P = Pigs, R = rats
[b]Y = young, N = nests

Adapted from MacFarland and Reeder, 1975

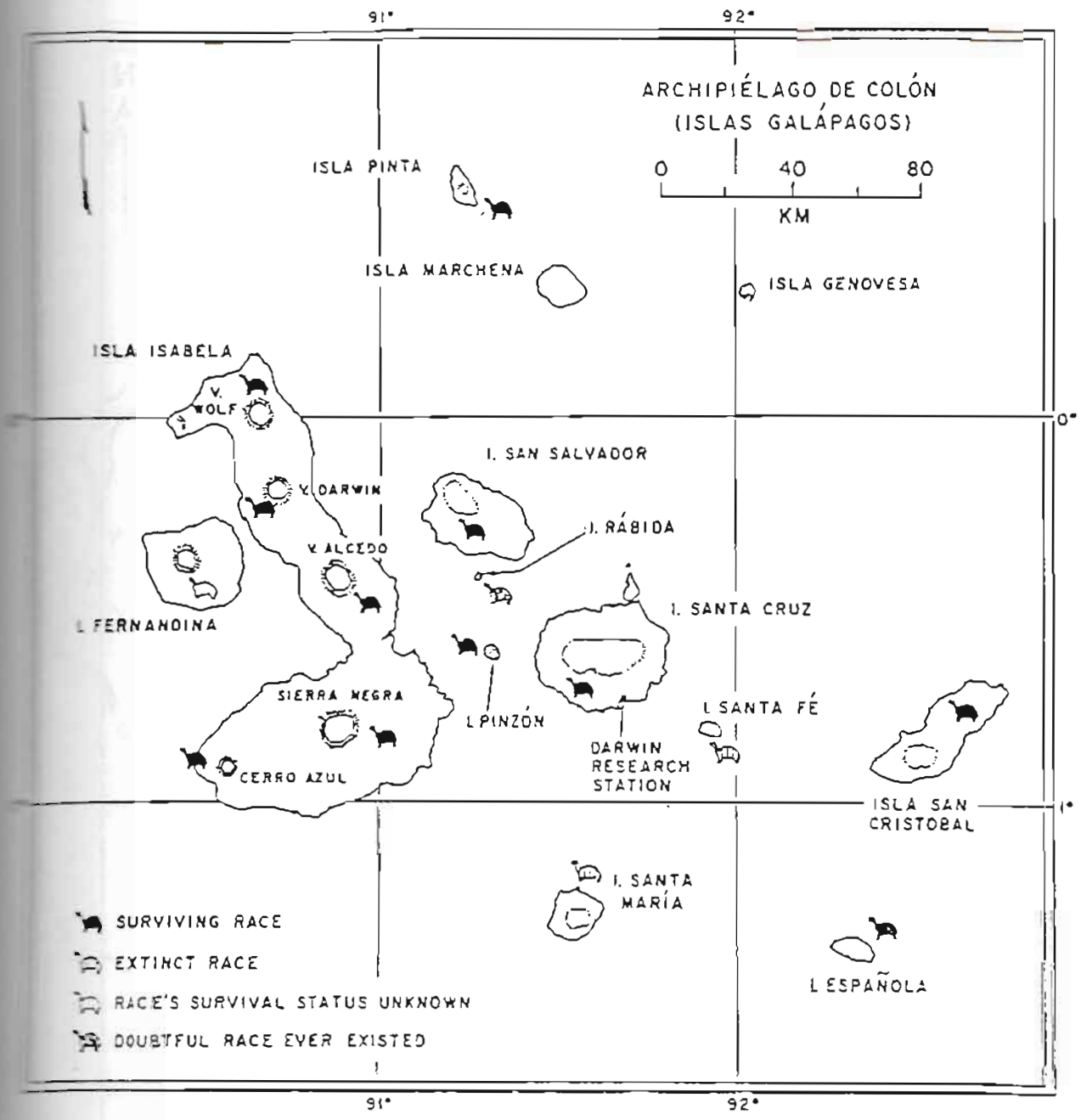


Figure 1. Distribution of the originally recognized 15 races of *G. elephantopus*.

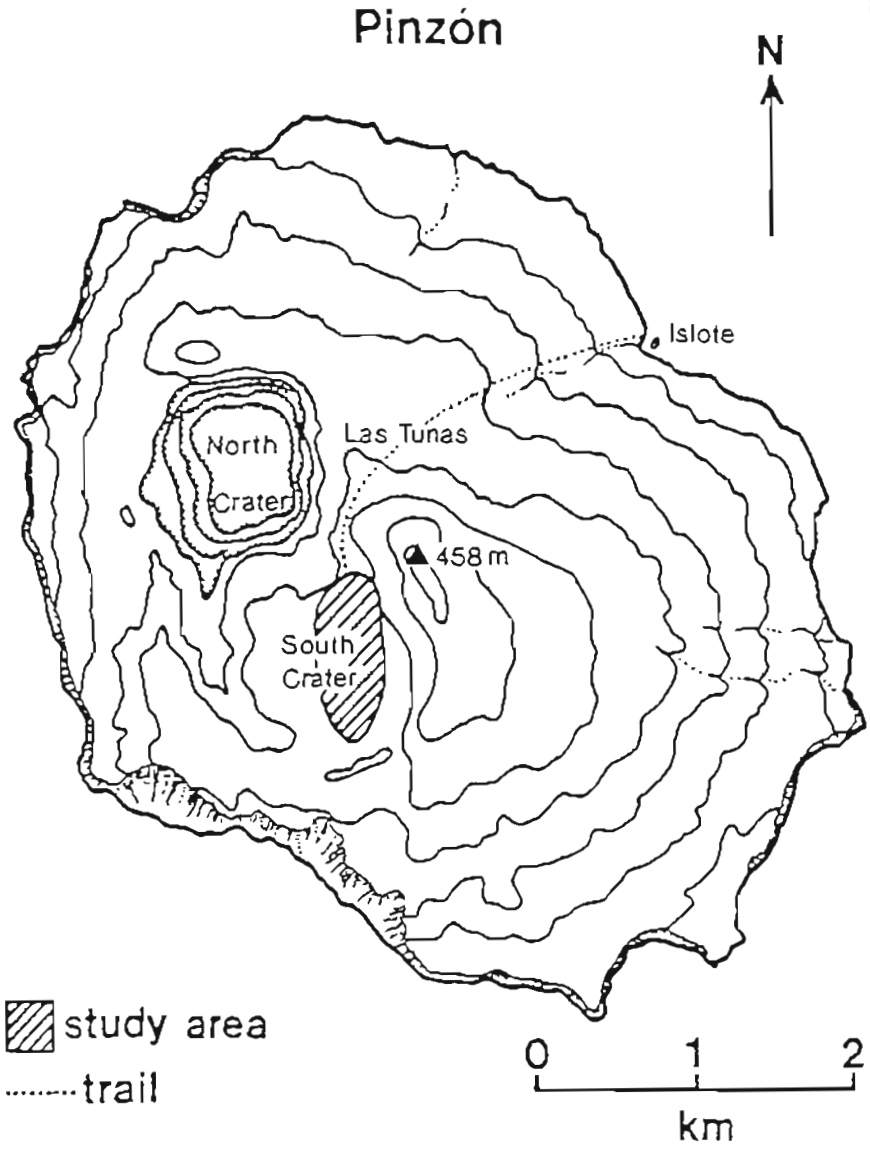

Pinzón
N
Islote
Las Tunas
North
Crater
458 m
South
Crater
study area
trail
0
1
2
km

Figure 2.

Table 2. Relationship of age of eggs at transport to fertility and hatching success, *G.n. ephippium* 1969-70 and 1970-71; data for undisturbed wild nests of *G.n. porteri*, 1969-70 and 1970-71 included for comparison.

Transport	No. nests	No. eggs	No. eggs excluded[a]	No. eggs incubated	% definitely fertile (No.)	% hatched (No.)	% dead embryos (No.)	% addled (No.)
G.n. porteri								
None	55	520	7	513	80·3 (412)	76·2 (391)	4·1 (21)	19·7 (101)
G.n. ephippium								
None	26	133	8	125	85·6 (107)	82·4 (103)	3·2 (4)	14·4 (18)
10-15 weeks old	16	71	13	58	82·8 (48)	74·1 (43)	8·6 (5)	17·2 (10)
7-9 weeks old	2	6	0	6	66·7 (4)	66·7 (4)	0 (0)	33·3 (2)
4-6 weeks old	6	29	3	26	50·0 (13)	19·2 (5)	30·8 (8)	50·0 (13)
0-2 weeks old	5	27	0	27	29·6 (8)	18·5 (5)	11·1 (3)	70·3 (19)

[a] Excluded for various reasons, i.e., broken in laying or by nest interference, or (for transported clutches broken by observer or found hatched in nest.

Pinzón is a low (458 m), dry and relatively small island (18.05 km^2) in the center of the archipelago. Tierney (1985) said that, "Pinzón Island is basically one large thornbush, and the bush covers a 1,300-foot-high volcano -- nine square miles of lava rocks and parched thickets." The trip from the small bay on northeast side of the island where boats can safely anchor, to the South Crater area, today home of most of the island's tortoise population, is a rigorous one (Figure 2). The initial ascent to the top of the island is like climbing a hill of bowling balls covered with thornbushes. The "path" is barely visible with an occasional pile of lava rocks to mark the way.

The Pinzón tortoises *G. n. ephippium* are saddlebacked, relatively small (adults curved carapace length (CCL) = 61 cm; Santa Cruz adults, one of the races typically found in U.S. zoos have a CCL = 75-150 cm) and light (maximum weight = 76 kg; Santa Cruz = 290 kg). In the 18th and 19th centuries this was certainly a liability as whalers preferred tortoises that could be carried by one man. The sparse vegetation offered less concealment than on other islands that have more moisture. These facts encouraged the collection of large numbers of tortoises and it was only the collapse of the whaling industry in the latter part of the 19th century that prevented the extinction of the Pinzón population (Metzger and Marlow, 1986).

In 1970 the Pinzón population was estimated to be 150-200 adults (MacFarland and Reeder, 1975). Today the adult population is believed to be 100-140 with a few more of the old individuals dying each year. Black rats were introduced to Pinzón before 1891 (the date they were first recorded; Patton et al., 1975), preying heavily on hatchling tortoises to the extent that it was thought that virtually no recruitment occurred during this century (MacFarland, et al., 1974a). In fact, the only reported observation of a wild Pinzón tortoise hatchling was made by deVries (1984). Imagine any animal population (an entire race in this case) having no surviving young for **70 years!** This would insure extinction for most. With the sparse rugged habitat, human slaughter and rat predation, one can easily see why Pritchard (1985) referred to the Pinzón Island saddlebacks as the "toughest tortoises in the Galápagos".

THE CONSERVATION PROGRAM

The Plan of Attack

The CDRS personnel began collecting eggs from natural nests on Pinzón in 1965 and transferring them to the Darwin Station on Santa Cruz Island for hatching and head starting until the young were large enough to be safe from rat predation (4-5 years). Since 1968 the program has been a co-operative effort between the CDRS and the GNPS. In December 1970 the first group of tortoises was repatriated and each succeeding year since another group has been released on Pinzón.

Reproduction of the repatriated tortoises and elimination of the black rats are the final stages in total recovery. It has been estimated that from 1964-1974, 7,000-19,000 hatchlings were produced on Pinzón and subsequently destroyed by rats (MacFarland, et al., 1974a). Recovery seems quite plausible when rats have been eliminated, Pinzón should once again have a natural self-sustaining tortoise population.

Egg Collection and Handling

Nesting areas are visited frequently (every 1-8 weeks) by trained park wardens or station personnel. The age of a nest is determined in part by the degree of moisture in the nest area (females excrete urine on the dirt as an aid in the actual digging of the nest and by careful "candling" of eggs against sunlight. After marking, weighing and measuring, the eggs, they are transported to the CDRS by padded backpack (1-2 hours) and boat (5-6 hours) (MacFarland and Reeder, 1975).

In order to evaluate the relationship between age at transport and addling (refers to a liquified egg, i.e., either infertile or the embryo having died before attaining sufficient size to be detectable), Pinzón tortoise eggs, were brought to the CDRS for incubation at various ages (0-15 weeks). The results of this study (Table 2) determined that transport at early stages of development destroyed a large percentage of the eggs. However, when eggs were transported at 10-15 weeks of age, at which time the embryos were well developed, the percentage of fertile and hatched eggs was much closer to that of eggs left in the wild. Hatching occurred at 12-17 weeks of age, the variability being due to the time when the nests were made and the continually rising temperature of Pinzón from August to March as the "garúa" season (June-December, frequent cloud cover and misty rain) ends and the hot season (January-May; infrequent cloud cover, occasional heavy showers (only in some years) and intense solar radiation) takes over (MacFarland and Reeder, 1975). Eggs laid later in the nesting season develop more rapidly because of the higher temperatures.

Incubation

The incubators are constructed of wood, the interiors being cement-lined cavities measuring 58x58x50 cm depth. The bottom of the cavity is filled with fine soil to a depth of 12 cm. The eggs are partially embedded in this soil. Level with the eggs are two insulated wooden doors, one with a glass panel behind it for viewing, the other for access to the cavity. Above the soil is a 15 cm air space, then a corrugated asbestos sheet 0.3 cm thick supporting 9 cm of soil, then a 13 cm air space. The chamber is topped by a metal sheet (0.1 cm thick) with its exterior painted dull black (Figure 2).

The incubators are naturally heated and continual humidity control is practiced. The soil is lightly sprinkled with water when the eggs are first placed in the chamber. Thereafter, a bowl of water is maintained in the chamber throughout incubation. Aeration occurs every 2 to 3 days when the access door is opened for a few minutes. A mercury thermometer, readable to 0.5°C through the glass panel, measures air temperature inside each chamber. (MacFarland and Reeder, 1975)

Table 3. Results of incubation at the Charles Darwin Research Station 1966-67 to 1970-71.

Race	Breeding/Nesting seasons	No. eggs incubated	% definitely fertile (No.)	% hatched (No.)	% dead embryos (No.)	% addled (No.)
G.n. ephippium	1966-67 to 1970-71	312	77·2 (241)	50·6 (158)	26·6 (83)	22·8 (71)
G.n. porteri	1970-71	17	35·3 (6)	35·3 (6)	0 (0)	64·7 (11)

MacFarland and Reeder, 1975

Table 4

Natural Mortality Rates and Age and Mortality Relationships for the Breeding and Rearing Program, 1965/66-August, 1972. Hatchlings which Died Accidentally are Excluded

Race and year class	No. hatchlings	Percent mortality (No.)	Number died					
			0-3	>3-6	>6-9 (months)	>9-12	>12-18	>18
G. n. ephippium								
			SEASIDE PENS					
1965/66	35	17·1 (6)			Not recorded			
1966/67	43	51·2 (22)	9	9	3	1	0	0
1967/68	46	50·0 (23)	9	2	4	0	8	0
			TORTOISE HOUSE OR LABORATORY					
1968/69	12	25·0 (4)	0	4	0	0	0	0
1969/70	38	21·1 (8)	4	3	0	0	1	0
1970/71	21	28·9 (6)	4	0	1	1	0	0

MacFarland et al., 1974b

Fertility and Hatching Rates

Fertility and hatching rates are high for eggs in undisturbed natural nests of *G. n. ephippium* and *G. n. porteri* (Table 3). And since these eggs had not been disturbed, the percentages of addled eggs can be used as rough estimates of natural infertility rates (14-20%).

Eggs incubated at the CDRS have demonstrated lower fertility and hatching rates and higher percentages of dead embryos and addled eggs than those left *in situ* (Table 3). Fertility and hatching rates of zoo breeding colonies have been quite variable, but lower than the CDRS rate (MacFarland and Reeder, 1975).

From July to October, the average temperature inside the solar incubators varies between 25°C and 26°C. When incubation is complete in March the average temperature is between 32°C and 34°C. It is believed that the low hatching success is the result of cool incubator temperatures. During the El Niño of 1982-1983 the incubators were several degrees warmer than normal and hatching success was higher. Currently, the impact of constant temperatures in electric incubators on the hatching success and sex of hatchlings is being investigated using equipment donated by Walter Allen and the Chelonian Institute.

Head Starting

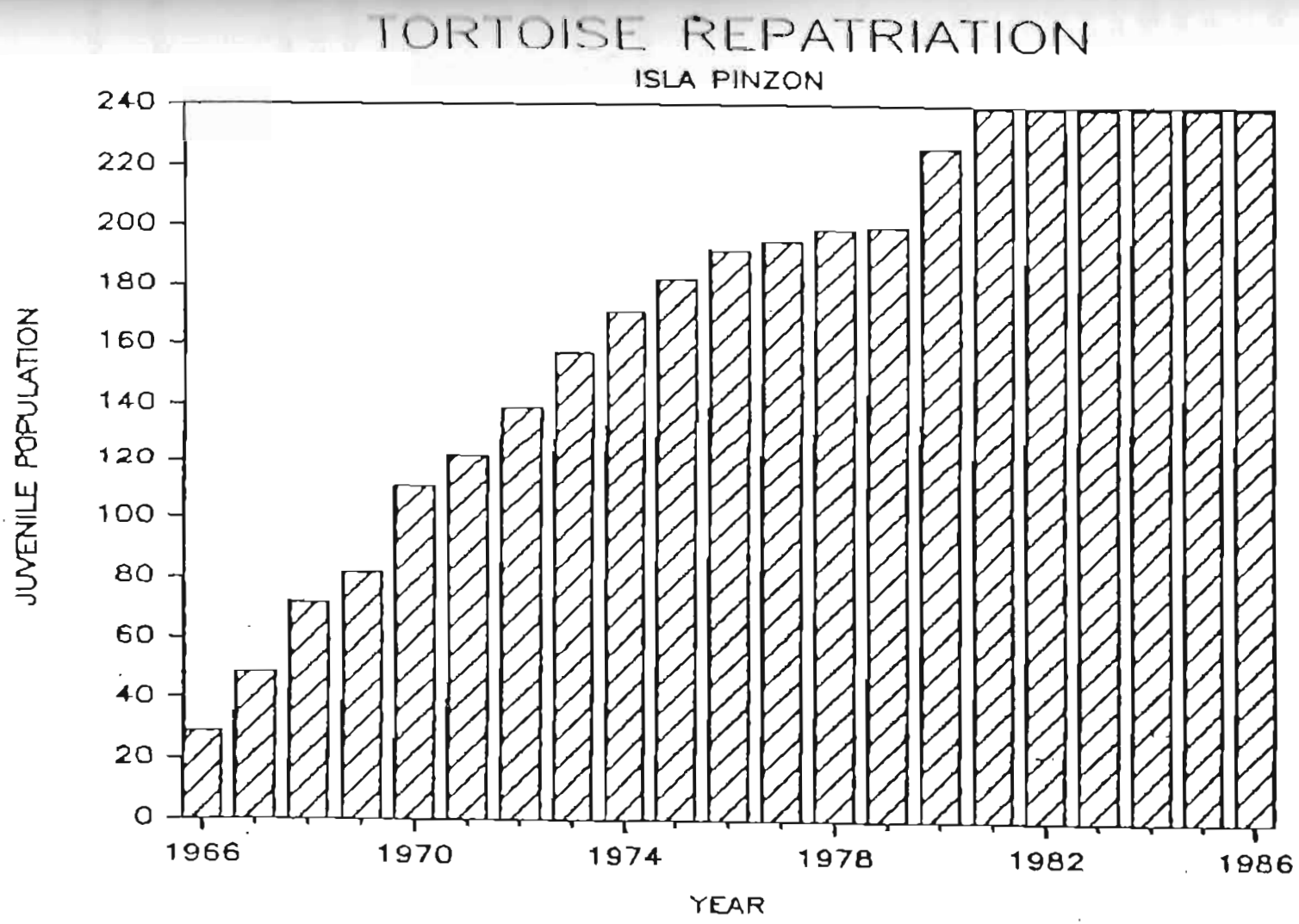
Young *G. n. ephippium* from the year classes 1965/66-1967/68 were raised, until January, 1970, in large chicken-wire cages located just above sea level and 25 m inland from the high tide line. Because of shading the pens received little direct sunlight. At night throughout the year and during part of most days during the garúa season, the pens were exposed to strong, cool breezes. Water was provided *ad libitum*. Food consisted of green roughage, native grasses, *Commelina diffusa*, introduced grasses, and occasionally, partially-dried *Opuntia* fruits.

The 1968-69 *ephippium* year class was raised in the laboratory; heat and light were provided 10 hours/day by two 60--100 watt tungsten light bulbs, and no exposure to cool breezes occurred. Food and water conditions were the same as for the previous groups.

In January, 1970 all year classes were moved to a new tortoise rearing center, constructed mainly with funds provided by the San Diego Zoological Society. Until recently, all year classes of 1969/70 and later, of all races, have been reared entirely within it. There is no exposure to sea breezes and a battery of six 100-watt tungsten light bulbs provides heat and light 10 hours/day in one corner of each pen. Water is provided *ad libitum* two days/week; food is as previously described.

Between early 1966 and November, 1971, 266 tortoises were hatched at the station and 67 hatchlings were brought there from nests in the wild. Of the 333 young tortoises, 104 (31.2%) had died by August, 1972. However, 3% of the deaths were due to accidents, *e.g.*, killed by rats.

Most natural deaths, regardless of race or year class, occurred during the first 9 months of life (Table 4). Mortality was apparently caused by digestive difficulties; food accumulated in the intestines, eventually resulting in infection and degeneration of the intestinal lining. Infrequent solar radiation and the cool winds at the earlier used seaside pens, increased the frequency of such digestive problems.


TORTOISE REPATRIATION
ISLA PINZON
JUVENILE POPULATION
240
220
200
180
160
140
120
100
80
60
40
20
0
1966
1970
1974
1978
1982
1986
YEAR

In general, survival rates were markedly higher for those year classes, regardless of race, raised from hatching in the tortoise rearing center or laboratory as compared to those raised in the seaside pens during the first 18 months or more of life (Table 4). (MacFarland, et al., 1974b)

Marquez, et al., 1987, reported a 49% mortality in 1984 for small tortoises (less than 1 year old) raised at the CDRS rearing center. They implicated the cement floor in the rearing center as being particularly cold during the "garúa" season. They described an experiment initiated in January, 1985 involving hatchlings of 3 races *G. n. hoodensis, G. n. darwini* and *G. n. guntheri.* Half were raised as previously in the CDRS rearing center and half were raised outside on a soil surface under natural light conditions to compare survival and growth rates. The preliminary results suggest that those reared outside have a faster growth rate, but no survival data have been published to date.

Repatriation

As mentioned previously the first captive reared tortoises were returned to Pinzón Island in December, 1970. At release, these 5 year old tortoises averaged 3.33 kg in weight and 33.4 cm in CCL. They were relocated, weighed, measured and examined 1, 2, 5 and 10 months after release. No sign of rat attack or injury was detected. After 10 months in the wild, every individual had approximately doubled in weight, and they were significantly ($p<0.01$) heavier than the control tortoises which remained at the CDRS (MacFarland and Reeder, 1975).

Not all repatriated tortoises have faired so well. DeRoy Moore (1979) showed the remains of a young repatriated tortoise, still bearing a latex painted number, which had been devoured by the introduced rats.

Dr. Thomas Fritts, U.S. Fish and Wildlife Service, graciously released current CDRS repatriation summary data to the author from an unpublished paper (Figure 3). The years shown in Figure 3 refer to the years when tortoises were hatched not the time of repatriation which was 2-5 years later. It should also be noted that additional tortoises have been released from the 1982-1986 hatching seasons since the 240^{+} reported by Fritts (1989).

PRESENT SITUATION AND OUTLOOK

As reported by Metzger and Marlow (1986) the success of the head-starting program in getting "rat-proof" tortoises back onto Pinzón is remarkable. These tortoises behave similarly to juvenile tortoises on San Cristóbal and Santa Cruz and have demonstrated good growth records, approaching and sometimes even exceeding full adult size. The fact that the number of repatriated tortoises are larger than Pinzón adults is an intriguing discovery discussed by Pritchard (1985). These tortoises are assuming the saddleback carapace shape characteristic of their population, and secondary sex characteristics have appeared.

In fact, the 18-23 year old repatriated tortoises have recently demonstrated normal breeding and preliminary nest building activity (C. MacFarland pers. comm., 1989). In addition the mortality of repatriated tortoises has been extremely low. The program has resulted in an impressive 200% increase in the Pinzón population and the outlook is good.

The lone remaining hurdle to make the population self-sustaining is the elimination of the introduced black rat population. Metzger and Marlow (1986) disclosed a promising development, the discovery of a non-toxic chemical compound, 300X, more bitter than quinine. Tests are presently being conducted to determine its suitability for use in protecting nests and hatchlings from rat molestation. Certainly, the captive rearing program has provided time for a solution to be found.

Another factor may prove crucial in rat control. It has been extremely dry on Pinzón for the last few years, and the rat population is the lowest it has been in years. With this in mind, in late 1988 a full-fledged campaign was initiated by the CDRS and GNPS to exterminate the Pinzón black rats. Approximately 60 full time people have been committed for several months using bait stations and traps. In January, 1989 the only sign of rats was in the high moist sections of the island (MacFarland, 1989). Hopefully, this effort will be successful and the path will be clear for a complete recovery of this persevering race of Galápagos giant tortoise.

It is noteworthy that as this proceedings goes to press, reports are coming out of the CDRS that **the Pinzón black rat population may indeed be exterminated!**

The CDRS and GNPS are to be commended. Working with a limited staff and resources in an isolated corner of our globe, they have sustained a program that will likely save the Pinzón and of other endangered Galápagos tortoise races.

For those interested, tax deductible contributions marked "for conservation and science in the Galápagos Island", may be made out to:

SMITHSONIAN INSTITUTION
c/o Secretary for the Americas (Administration)
P.O. Box 37481 - OBC,
Washington, D.C. 20013

or

WORLD WILDLIFE FUND - U.S.
1601 Connecticut Avenue, N.W.
Washington, D.C. 20009

Your donation will entitle you to receive *Noticias de Galápagos*, a routine periodical published by the Charles Darwin Foundation for the Galápagos Islands detailing conservation activities of the CDRS and GNPS.

MY PERSONAL EXPERIENCES ON PINZÓN ISLAND

My own trip to Pinzón was an unforgettable experience. The trek up and over the island was rigorous with all the filming gear we had to tote, but what we witnessed made it all worthwhile. We saw young repatriated tortoises of adult size grazing and looking healthy and robust (Figure 4), and we came across older ones with wrinkled skin and worn shells that looked ancient. The highlight of the trip had to be our seeing the most photographed of all the old Pinzón saddlebacks, Onan (Figure 5). He was first named Onan (taken from the son of Judah mentioned in Genesis) by Craig MacFarland when he was observed amorously mounting a large rock.

> Tierney (1985) described him best,
> "Onan was completely blind in the right eye, nearly blind in the left eye, and possibly deaf (Figure 6). His shell, once black, was bleached gray with patches of white lichen growing on it (Figure 7). He had an ingrown toenail on his left front foot. There was no trace of fat on him, only bones draped with dry, cold skin. There was no way to tell his age - in fact, no one even knows the life-span of giant tortoises - but he looked at least a century old, maybe two."

I often marvel at the fact that I may have seen the oldest animal on earth, that he lived through the deadly invasion of the whalers and colonists, and that he may date back to the time of Darwin's visit to the islands.

But don't let this description mislead you, Onan does not have the demeanor of an old animal waiting under an Opuntia cactus to expire. He's as fiesty as a young buck ready for any challenger. When he senses something or someone approaching he strains to get them in view of his good eye. And then assumes the male tortoise challenge position of high on all fours, mouth open, and neck outstretched to its fullest (Figure 8). The male who reaches highest shows dominance and wins. From my experience Onan is apparently king of the hill and still aggressively taking on all challengers.

ACKNOWLEDGMENTS

The author would like to thank: Walter B. Allen for encouraging me to go to Galápagos and being part of his film project; Dr. Peter C.H. Pritchard for inspiring me to put a little adventure into my life, letting me accompany him to Pinzón and other exotic places and reviewing this manuscript; Kent R. Beaman for manuscript review and for letting me use his reprint and slide library; Dr. Thomas H. Fritts for sharing unpublished CDRS tortoise data; Dr. Craig G. MacFarland for up-to-date information about Pinzón; Mark Switak for his photograph of Onan with the author; and Corlee Bosch, Paul Erdmann, Roger Diaz and Mike Warren for technical support.

Figure 4 ↑

Figure 5 →

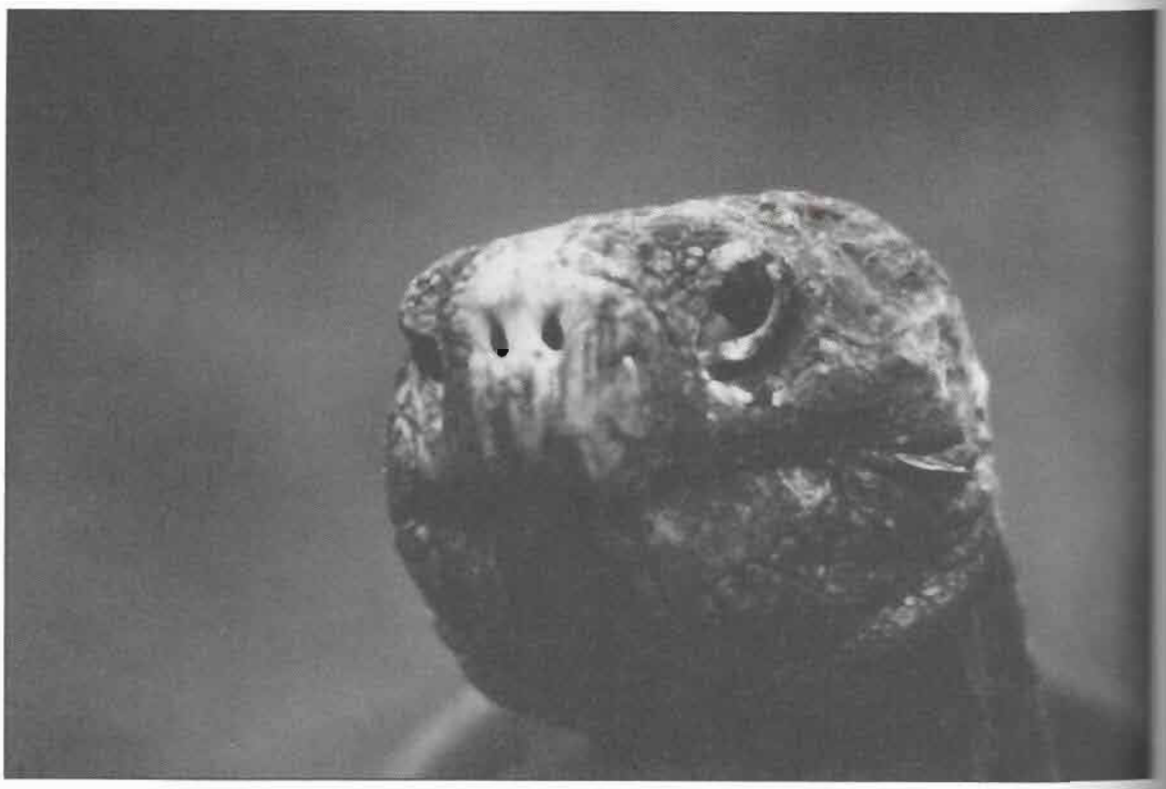


Figure 6 ↑

Figure 7 →

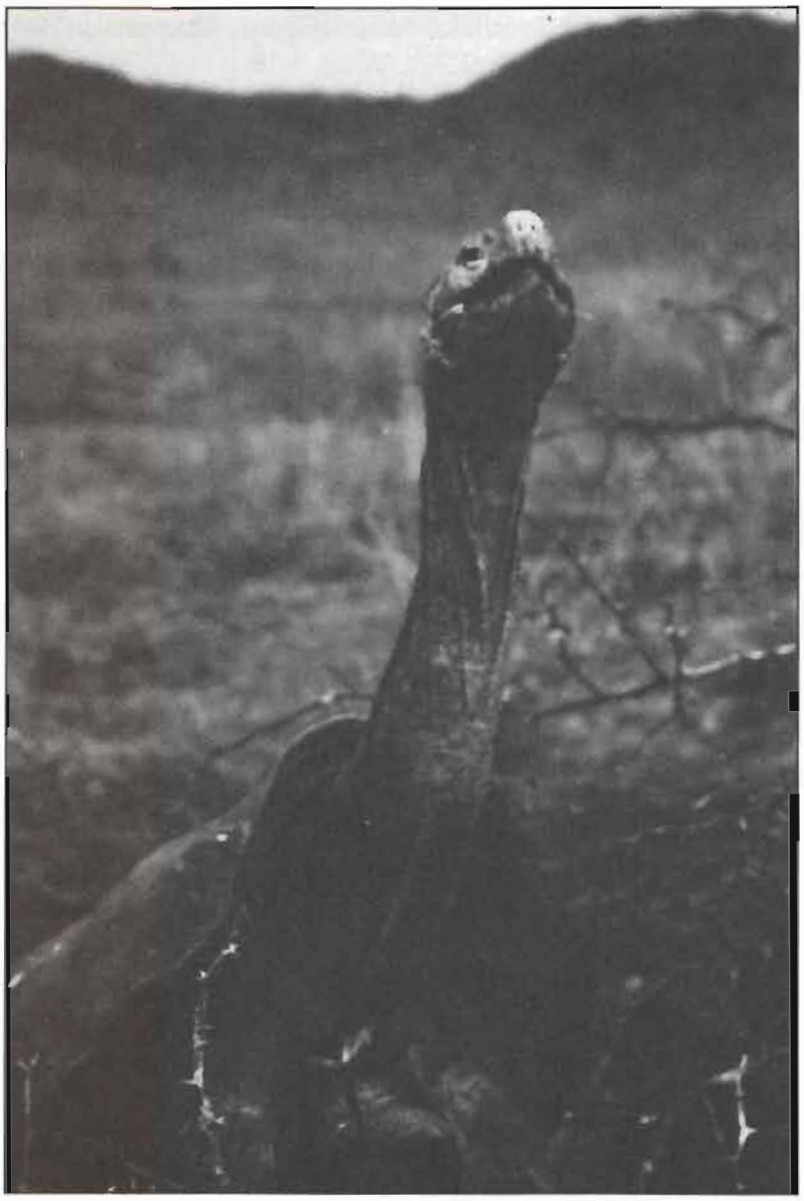


Figure 8 Onan Assumes the Male
Tortoise Challenge position

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CAPTIVE BEHAVIOR AND REPRODUCTION OF THE BURMESE MOUNTAIN TORTOISE

Richard Fife

ABSTRACT

The Burmese Mountain Tortoise, *Manouria emys nutapundi* is the largest species of tortoise that has a range which approaches the subtropical and temperate climates of the northern hemisphere.

For the past fifteen years I have observed the unique behavior of this tortoise including: Nesting behavior, nocturnal activities, hibernation, and other unique behavior.

Diets, enclosures and housing requirements, and climate control techniques have been developed to achieve long term well being of this species.

The Burmese Mountain Tortoise, *Manouria emys* is the largest specie of tortoise with a range that approaches the subtropical and temperate climates of the Northern Hemisphere. Its ancestors were large land tortoises of the genus *Manouria* which inhabited the damp forests of what is today Central Europe (Obst 1986). The Burmese Mountain Tortoise is considered to be one of the most primitive of living tortoises (Pritchard 1979).

There are two distinct subspecies of *Manouria emys*. Wirot Nutaphand (Nutaphand 1979) lists them as the species *Testudo emys* (Schlegel and Muller, 1844) and *Testudo nutapundi* (Reimann). John Iverson (Iverson 1986) recognized them as *Manouria emys emys*, and *Manouria emys phayrei*. Fritz J. Obst (Obst 1983) lists them as *Manouria emys emys*, and *Manouria emys nutapundi*. Since the term Nutapundi is most commonly used in the Zoological community I will use Obst's designation of the two subspecies. Peter Pritchard (Pritchard 1979) lists the tortoise in the genus *Geochelone* and the subgenus *Manouria*.

M. e. emys is the smaller of the two tortoises. It is found in the southern region of Thailand (Ranong and Nakorn Si Thammarat Provinces); Malaysia, Sumatra and Indo-Australia (Nutaphand 1979). The most important distinguishing feature is the Pectoral scutes which are small and do not meet at the central suture of the plastron. Sexual morphology is quite evident in *M. e. emys*.

M. e. nutapundi is found in northern Thailand (Tak Province) and western central region (Kanchanaburi Province); Assam, and Burma (Nutaphand 1979). It reaches a straight line carapace length of 65 cm and a weight of nearly 40 Kgs. The pectoral scutes are long and come together at the middle suture of the plastron. Sexual morphology is almost not evident in *M. e. nutapundi*. The major difference in the sexes is the configuration of the anal scutes. In males the anal scutes have a wider angle of separation than in females. In females the anal scutes are directed more toward the rear of the shell.

METHOD

I obtained my first Burmese Mountain Tortoise in June 1974 from an animal dealer in Phoenix, Arizona. This was a *M. e. nutapundi* which measured 57 cm and weighed 25 Kgs. It has increased in size to 63 cm and 32 Kgs. In order to begin a breeding program I began the search for a male tortoise.

Over a twelve year period I obtained either males of *M. e. emys* or females of *M. e. nutapundi* which were incorrectly identified as males.

In 1986 I purchased a male *M. e. nutapundi* from a Florida reptile dealer. It was represented as a long term captive animal, and commanded a premium price. It was in fact underweight, not feeding, and obviously blind in one eye. The dealer refused to make any compensation. The tortoise had a shell length of 48 cm and weighed 16 Kgs. After a period of hand feeding and special care it increased in weight to 20 Kgs.

Enclosures

My tortoises are maintained in an outside enclosure which measures 4 meters by 10 meters. The enclosure is separated from other tortoises enclosures by a 70 cm high plywood fence. The exterior of all tortoise yards include an additional 130 cm high chain link fence above the plywood. I have found that a solid barrier reduces animal pacing, retains hatchlings of undiscovered nests, and eliminates tortoises from breaking their beaks or tearing their neck on the chain link.

The enclosure is planted with giant reed *Arundo donax*. The tortoises have an above ground, earth covered hut, and straw and leaf-litter for retreats. The remainder of the pen is planted with bermuda grass *Cynodon*.

My compound is located in Phoenix, Arizona. Phoenix is located in the Sonoran Desert. Rain fall is 183 mm per year. I have recorded low temperature of -6 degrees centigrade and high temperatures of 47 degrees centigrade at my property. Relative humidity can be as low as 5%. I have found it necessary to mist the tortoises enclosure daily with water and provide water pools for the tortoises to soak in.

Diet

Grass is always available for grazing. The tortoises have also been observed eating the giant reed and in another yard they stripped the bark of a locus tree. The tortoise diet is regularly supplemented with carrots, squash, cabbage, various greens, tomatoes, prickly pear cactus; and occasionally moistened monkey chow, melons, and other fruits.

DISCUSSION

Thermo Regulation and Hibernation

The Burmese mountain tortoise comes from a climate type that is very different from Phoenix. In the southern part of its range it is found in tropical rain forest with rainy summers and warm winters. In the northern parts of its range and at higher elevations the winter temperatures are somewhat cooler and on rare occasion approach 0 degrees centigrade. *M. e. nutapundi* has been recorded as far north as 27 degrees north latitude (Iverson 1986).

Laschio, Burma has the typical climate for the northern range of *M. e. nutapundi*. Lashio is located at latitude 22 degrees 58 minutes north longitude 97 degrees 51 minutes east, and an elevation of 855 meters. This climate type duplicates that of Miami, Florida.

My tortoises burrow in mounds of moist leaf-litter and straw. Quite often they will make a small opening or window in the straw pile from which they survey the surrounding area. They also retreat to

their earth covered hut where they push earth or leaf-litter into the entrance as if to close the door. The tortoises spend many hours soaking in their pools of water. On occasion tortoises have been observed grazing just after dusk and late at night.

In 1981 I decided to allow my tortoises to hibernate. When night time temperatures dropped to below 10 degrees centigrade the tortoises retreat to their hut or piles of leaf-litter. Activity during the day is discontinued. The entrance to their hut is covered with a thick layer of straw and the tortoise don't emerge again until night temperatures are again above 10 degrees centigrade which is about March. Low temperatures of 4 degrees centigrade have been recorded below the straw piles where the tortoises are. All my Burmese Mountain Tortoise have been allowed to hibernate since 1981 without any problems.

Breeding

I have made many attempts to achieve captive reproduction with my tortoises. In early 1977 a male *M. e. emys* was introduced to my female *M. e. nutapundi*. Breeding activity was observed on numerous occasions and on June 1, 1977 eight eggs were laid. Several more eggs were laid there after until a total of about 40 eggs had been laid over a four week period. An accurate count was impossible because all eggs were laid on the ground and many were crushed. No fertile eggs were retrieved. This same routine was followed in 1978 and 1979. In 1979 a second clutch of ten eggs were laid in September. Still no fertile eggs were recovered.

Richard Galding of Phoenix informed me that he had similar experience from several years of breeding *M. e. emys* and *M. e. nutapundi* and no fertile eggs. I discontinued pairing these two subspecies. In 1980 my female again laid 20 to 30 eggs as she had done in the past.

In October, 1981, a 47 cm female, which was thought to be a male was introduced to my original female. My original female immediately began to follow the new tortoises until she had her cornered. My female then began to thump her chin on the rear of the new tortoise's shell. This thumping could be heard from some distance away. My female then began to push the new female around the yard. My female then mounted the new female as if to breed and went through all motions including emitting an audible grunting sound. My female continued to exhibit this dominate male behavior until in August 1983 the new female was found turned over dead.

In March, 1986, I received my present male as described earlier in this paper. After nearly a year of rehabilitation this male was introduced to my female. Breeding activity was not observed until after my female laid more infertile eggs. The male bred regularly all summer. In 1988 the male was removed from hibernation about two weeks before the female emerged. Again no breeding was observed. In May the female began gathering leaf-litter for nest building. The nest site was moved three times and finally abandoned. In June she again laid several eggs each day until about 30 eggs had been laid. Most of these eggs were laid in the tortoise hut and were broken. Of about ten eggs that were salvaged two proved to be fertile. The eggs were incubated at between 29 degrees centigrade and 33 degrees centigrade which is the temperature of our house in the summer. The two fertile eggs went full term and the neonates died before hatching. Sean McKeown (McKeown, Juvik, and Meier 1982) successfully hatched *M. e. nutapundi* eggs at 28.9 degrees centigrade. I believe my deaths were associated with too high of an incubation temperature.

In 1989, I again removed the male from hibernation a few weeks prior to the female emerging. This year some breeding activity was observed. Cynthia Finch of Houston, Texas reported to me that her female tortoise lost interest in nest building when there was not sufficient leaf-litter or straw available for nest building. I increased the straw to three bails. Again my female began nest building and lost interest. On May 21, 1989 she laid five eggs in her hut. An additional twenty-three eggs were laid over the next twenty-five days. Fertility has not been determined as of the writing of this paper.

Eggs are white, nearly spherical as reported by McKeown (1982). Eggs are 43-45 mm in diameter and weigh 55-55 g which is somewhat smaller than those reported by Mckeown (51-54 mm and 67-80 g). All the eggs that have been laid had a small dent on one side of the egg. This dent disappeared on fertile eggs during incubation. Dents were also reported by McKeown (1982).

CONCLUSION

I believe that there are still problems associated with breeding this species of tortoise in dry desert climates. Obviously humidity must be increased, and summer temperatures decreased. I will continue my work with this species until consistent results can be achieved.

Due to the destruction of habitat and the use of this species of tortoise for food throughout its range it is sure to become endangered in the near future.

CLIMATE CHART

BURMA

Lashio	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
High	29	29	32	35	34	31	31	31	31	30	28	25	36
Low	4	6	9	14	16	19	20	19	16	14	9	6	4
Precip	8	8	15	56	175	249	305	325	198	145	69	23	1574

Temperature in degrees centigrade
Precipitation in millimeters

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Phoenix, Arizona

THE INFLUENCE OF BAROMETRIC PRESSURE ON REPRODUCTION IN REPTILES

Richard Fife

INTRODUCTION

In 1975, while I was employed at the Gladys Porter Zoo, Pat Burchfield (the Zoo's general curator) remarked to me that during the onset of rain showers many of the Zoo's animals could be observed mating. This was also true of the reptiles in our reptile building.

A barometer was installed in the reptile building to determine if there was any correlation between breeding behavior and barometric pressure. Barometric pressure was recorded each time any breeding behavior was observed.

This work was presented at the 1976 Regional AAZPA Meeting held in Brownsville, Texas. The paper failed to be included in the proceedings of that meeting, and was never published.

The reptile department continued to record data and used the information to enhance breeding. Since leaving the Zoo in 1978 I continued to make observations in my private collection concerning barometric pressure.

DEFINITION

To understand how barometric pressure may affect reproduction in reptiles it is important to define barometric pressure. Barometric pressure or atmospheric pressure is literally the weight of the atmosphere around us. Because air is fluid as opposed to solid, it exerts pressure in all directions. This can be compared to the forces exerted on your body as you descend in a swimming pool.

Barometric pressure is measured in units of pressure called millibars or inches of mercury. Pressure is measured with the use of a mercury barometer or an anerold barometer.

There are two barometric pressure cycles which exist. The first is a diurnal cycle which peaks and falls twice each day. This diurnal cycle is most pronounced near the equator and almost absent at the poles.

The second barometric pressure cycle is an annual cycle which is affected by the warming and cooling of the continents. As the land masses are warmed in the summer the air becomes less dense creating an area of low pressure. The air from a high pressure area such as oceans flows to these low pressure areas to equalize the pressure. This air may be dry or may carry large amounts of moisture. A good example of this air flow is the moist air which flows from the ocean to India and Asia creating their well known rainy monsoon season.

HYPOTHESIS

Many reptile species have breeding seasons which are tied closely to annual monsoons or rainy seasons. Reasons for this may include cooler temperatures, water for drinking, moist earth for nesting, and more abundant food. It is my hypothesis that reproduction in many species of reptiles is stimulated by the annual barometric pressure cycles that control weather conditions.

If this hypothesis is true it may explain why some reptiles which have been transported to a new location fail to reproduce that year. It may explain why people in one part of the country have more success breeding a particular specie than people in another location. It may also answer the question why some species that normally breed during summer rains fail to reproduce in Phoenix during our dry summers, but readily reproduce during our rainy winters.

CONCLUSION

It is evident that the affect of barometric pressure on reproduction cycles in reptiles needs much more work. I would encourage anyone responsible for a large reptile collection to obtain a recording type aneroid barograph. Record the local annual pressure cycles and the dates and times of breeding activity, egg laying, and egg hatching. Use the results of the data to enhance reproduction in future years.

Those of us who do not have the means or time to record data can still benefit from barometric pressure cycles. There is not much that can be done to control our local pressure cycles, but our animals can be manipulated to take advantage of these local conditions.

First. Realize that new animals may need time to key in on local barometric pressure cycles. Just as some reptiles can't be expected to reproduce without an annual light cycle or hibernation period, barometric pressure cycles may be just as important to other species.

Second. Time the introduction of mates during the onset of weather changes.

Third. Egg laying and hatching seem to be stimulated by changes in the weather. Be sure to provide nesting boxes or inspect for neonates during these weather changes.

Fourth. Increase feeding, elevate ambient temperatures, raise the humidity in enclosures, and adjust light cycles in conjunction with local atmospheric conditions that correspond to the species' natural breeding season.

Phoenix, Arizona

TURTLE HIBERNATION

Steven D. Garber

Many vertebrates remain active and do perfectly well, operating at low ambient temperatures all winter. Some fish get "freezing cold," down to 0°C (32°F), and sometimes lower, while remaining just as active as any other time of the year. Most birds and mammals, though, that stay active all winter, do so by generating warm internal body temperatures. Many other animals that also survive the coldest of winters do so by hibernating.

Hibernation is thought of as a typically mammalian and sometimes reptilian behavior, but as it turns out, hibernation isn't particularly typical of either group. This "inherent, regular, and prolonged period of inactivity during the winter" (Goin and Goin, 1971) has yet to be systematically investigated among turtles. Since many turtles inhabit regions that reach temperatures well below freezing, these animals must have a behavioral and physiological way to cope. In an attempt to answer questions related to turtle overwintering strategies, I have been investigating what turtles do in the winter. Which ones hibernate? What do they do when they hibernate? What type of behavior fall under the aegis of hibernation? Why do turtles hibernate? How might turtle hibernation have evolved? And what, if anything, do those turtles that don't hibernate, do?

Physiologists typically view hibernation in relation to body temperature; however, it is helpful to think of it in terms of several related phenomena: estivation, daily torpor, and temporal heterothermy. I hope this paper helps to help clarify what this group of related and unrelated behaviors is.

It should be mentioned that some birds undergo a physiological state that's not altogether unlike hibernation, but it occurs on a daily basis, and is known as daily torpor. Birds, however, don't hibernate, nor do they become seasonally dormant. A suggested evolutionary explanation for this is that migration has been the avian strategy favored by natural selection. For comparative purposes, it should be added that birds belonging to at least three orders, Apodiformes, Caprimulgiformes, and Coliiformes, undergo daily cycles of torpor, and with the only possible exception of some Caprimulgids (goatsuckers and nightjars), there are no known cases of avian hibernation (Dawson and Hudson, 1970).

Hibernation is a group of different patterns of dormancy that occur under a variety of conditions, usually when it is cold. Even though hibernation occurs in a number of taxa, many of the first experiments were usually conducted on animals brought into the laboratory, where, unfortunately, the results were often misinterpreted. They were believed to be accurate representations of what happens in nature, which was rarely the case (Bartholomew, 1972).

Laboratory insights, combined with what was being observed in the field, led some researchers to realize that hibernation was far more complex than previously thought. Step by step, our observations have helped reveal the truth, that counters the previously widespread belief that hibernation was little more than a few, simple, genetically controlled behaviors. Although we're well on our way to understanding what hibernation really is, having studied it from the organismal level all the way to the molecular, the physiologist's results still don't always reveal very much about the organism's context in the environment. One thing that has become apparent, however, is that the animals hibernate as an evolutionary response to the ecological conditions they are adapted to.

During hibernation, animal metabolism slows down considerably, allowing these organisms to survive the cold months without eating and without burning up much of their precious reserves. In effect, then, hibernation is a type of temperature regulation, where instead of maintaining a core body temperature where the animal can eat and reproduce, the animal is basically just trying to get away with burning as little energy as possible.

TEMPERATURE

Long before the temperature regulation of reptiles and amphibians were studied, it was studied with birds and mammals. Because most of the subsequent reptile work was conceived in terms of what was learned about the way mammals physiologically adjust to the winter, it seems that somehow, most researchers missed the main biological points. The studies were mostly framed in terms of the physiological tradition instead of in terms of biological appropriateness (Bartholomew, 1986).

Cowles and Bogert's 1944 paper marked the beginning of what to date has amounted to 45 years of reptile thermoregulatory research. Their paper, a preliminary study of the thermal requirements of desert reptiles, led to a plethora of reptile thermoregulation studies, most of which were conducted on desert lizards. Some studies were also conducted on snakes, turtles, crocodilians, and even on the tuatara. Much of this work accounts for what we now know about reptiles' preferred body temperatures.

Some studies were aimed at identifying the triggering mechanisms of specific temperature related behavioral responses. It was found that certain behavioral patterns occurred within a very narrow range of temperatures; sometimes, the time of year was also a factor.

Though, what reptiles do during the winter isn't really controlling their temperature, it is often thought of in such terms. While active, many reptiles behaviorally regulate their core body temperatures within a relatively narrow range (about 4°C). Other reptiles were found to have no so-called temperature preference and were active over a wide range of body temperatures. When above, or below, this wide range, their behavior changed radically, usually leading to lethargy or death.

One of the mistakes has been to think of what reptiles do during the winter in terms of thermoregulation. The scientific literature states that during this time reptiles hibernate or brumate. Despite the fact that overwintering behavior represents a significant part of the life history of most temperate region reptiles, little work has been conducted on temperature related behaviors at colder temperatures, such as in the winter, when reptiles are relatively inactive. For most of these reptiles, what happens during the coldest months of the year remains somewhat of an enigma. Much of my fieldwork over the past several years has, among other things, been aimed at trying to discern what happens during this time in a reptile's life. The reptile I'm most familiar with is the wood turtle.

ESTIVATION, DAILY TORPOR, TEMPORAL HETEROTHERMY, INTERMITTENT ENDOTHERMY

Estivation is the regular retreat from hot, dry climatic conditions. Like hibernation, it is thought that estivatory rhythms are endogenous, or genetically based. Daily torpor is another energetically related phenomena. Like each of the others being discussed, daily torpor is a period each day when an

animal becomes dormant, sluggish, or inactive. Sometimes this inertia has been explained as a response some animals have to conserving energy by slowing down during part of the day. Temporal heterothermy means, instead of being like birds and mammals that naturally maintain a core body temperature of 98.6°F throughout their entire lives, some animals, such as reptiles that hibernate, switch to a considerably different core body temperature that might be maintained within certain limits for months each year. Hibernation has been viewed as a seasonal hypothermia. Another way of saying this is that some animals are intermittently endothermic.

Some scientists feel that reptiles are either true hibernators or they don't hibernate at all. They maintain that a subcategory of reptiles are those that merely undergo prolonged periods of retraherence, which is a temporary retreat from adverse weather conditions. In my opinion, it would be more useful to view reptile hibernation as a series of different solutions devised by a number of species that survive at colder core temperatures throughout the winter. Instead of viewing this behavior as hibernation, it is sometimes useful to be more flexible with the words that subconsciously restrict the way we think about a certain subject. For instance, rather than thinking of what reptiles do during the winter as hibernation, I sometimes find it useful to consider hibernation as a group of responses that fall under the aegis, adaptive hypothermia. That is, there are any number of different adaptations to the cold, where animals drop their temperatures way down, and yet the animals are in no greater danger than at any other time. It should be kept in mind that, unlike natural hibernation, hypothermia is sometimes thought of as an artificial, or accidental depression of body temperature from which an animal cannot always recover, without support. Also, just as endothermy almost certainly independently evolved in birds and mammals, many of the behavioral and physiological patterns described as hibernation also probably evolved independently.

Hibernation is not always an all-or-nothing response. Nor is it always present in some species that hibernate. That is, some species that hibernate in the northern part of their range, may not hibernate in the southernmost portion of their range. Since no one has established the full range of overwintering behaviors, in this paper I will categorize related ideas and information in a way that should present another useful step toward identifying and answering many of the reptile-related overwintering questions.

Across the board, among vertebrates, aestivation seems to be less common than hibernation. It does not occur among birds. Yet there are ten mammalian orders with species that estivate. With enough food and water available, most bird and mammal species that live at a low to middle latitudes are able to adjust to the heat, both physiologically and behaviorally, without having to estivate. However, the combination of high air temperatures, intense solar radiation, and seasonal drought present problems to most mammals. Certain fish, amphibians, reptiles, and mammals have solved these problems with prolonged periods of dormancy. I refer interested readers to a study of five turtle species during a drought in South Carolina (Gibbons, Greene, and Congdon, 1983). In some respects, the physiological demands for estivation overlap with those of hibernation, but not entirely. A comparison, though interesting and relevant to this discussion, will be discussed in another volume.

ACTIVE HYPOTHERMIA: SWIMMING UNDER THE ICE

There are some reports of turtles walking or swimming under the ice (Everman and Clark, 1916; Carr, 1952; Sexton, 1959; Gibbons, 1967; Lazell, 1976; Goff and Llen, 1988). Gibbons and Cagle (1944)

suggested that these turtles were, in some cases, basking underwater. In an attempt to describe this phenomenon, it should be pointed out that the water just below the ice never gets below freezing, 0°C (32°F). And it also needs to be stated that the ground stays practically the same temperature all year round (about 45°F up to temperatures above 32°F), once you dig below about 18 to 24 inches (45 to 60 cm). Likewise, groundwater flowing into a body of water, or any water that lies adjacent to this ground, will be considerably warmer than some much colder ambient winter air temperatures. Also, this warmer water is unlike warmer air, which rises. Instead, water is at its densest, and therefore its heaviest, when between 39°F and 40°F (4°C), and therefore it sinks. This is why the water, just below 40°F, settles to the bottom of all ponds, and this is why the coldest water, about 32°F, is just under the ice, the ice is the least dense, and therefore floats on the top. And in between is the warmest water; sometimes it's as warm as the ground temperature, approaching 48°F. That seems to help explain why we occasionally find turtles swimming under the ice.

Interestingly, adult wood turtles *Clemmys Insculpta* often hibernate in the deepest part of a stream bed, usually on the rocky or gravelly bottom (Garber, 1988b, 1989a, and 1989b). However, the younger turtles are usually found in the dead leaves and twigs, mixed with mud and other detritus, in shallower water on the side of the stream where groundwater seeps in. It may be that the slightly warmer groundwater is preferred by the younger animals. This is presently under investigation.

WINTER FEEDING BY AQUATIC TURTLES

Except for those turtles living in tropical (Moll and Legler, 1971) and subtropical waters (Jackson, 1970), aquatic turtles are usually said to be inactive during winter months (Bury, 1979). Reports of winter activity, such as basking behavior, are restricted to warm weather or calm, sunny days. It is not infrequent that I find overwintering wood turtles sunning on the river banks during the warmest, sunniest, least windy days from January on, though this behavior is more common later on in the winter and during the spring.

Records of turtles feeding during the winter are few and far between. Data showing that turtles slow down or stop eating altogether are largely a result of inference, that is, since fewer are caught in baited traps, it is taken to mean fewer turtles are feeding. There are also stomach content analyses (Cagle, 1950; Ernst, 1972, 1976) that indicate from the time the water temperature drops to about 14°C most turtles reduce their food intake, or stop feeding altogether (Ernst, 1972; Bury, 1979). When I brought wood turtles in from "hibernation" to find what was in their digestive tracts, passed scats showed water and mucus, but little actual food material (Garber, 1989b). Whenever wood turtles were brought inside during the winter, they only started to take food after kept indoors for several weeks. Their eventual taking of food may reflect their acclimatizing to captivity, rather than any significant winter feeding behavior, or lack of winter-feeding behavior.

Mahmoud (1968) observed that while kinosternid turtles primarily consume animal food during the summer, they mostly eat plant material in the winter. Schubauer and Parmenter (1981) found *Pseudemys scripta* actively feeding during the winter at Par Pond, an artificially warmed environment on the Department of Energy's Savannah River Plant. Instead of feeding on fish, invertebrates, and plants that constitute their summer diet, these turtles, however, ate far less than during the summer months.

Overwintering Par Pond turtles, ate some aquatic vegetation, but little else, possibly because other types of prey are either inaccessible or difficult to catch. For the effects of temperature on turtle digestive turnover rates, I recommend reading Parmenter's 1981 paper.

MOVEMENTS DURING WINTER

Each Autumn, after adult wood turtles *Clemmys Insculpta* have spent most of the summer foraging on land, they begin moving back to the streams, where they feed, court, mate, find a place to hibernate, and eventually spend the rest of the winter, usually underwater on the gravelly stream bottom. Although there is some movement from one preferred hibernaculum to another, most adults return to the same overwintering site with marked fidelity. Considerably slowed down by the cold water, wood turtles do remain alert all winter and maintain the capacity to, and sometimes do, move about. When they do move, it usually isn't very far, and it usually appears to be in accommodation to changes in river flow and microhabitat changes, such as the presence or absence of mounds of underwater organic matter. Such movements are usually within several meters, although occasionally I find overwintering turtles that have moved as much as a thousand meter, always staying in the stream. Usually these longer winter movements occur during the earlier or latter parts of the season. It is normal, during the coldest part of the season, for the turtle to remain within one general area.

Wood turtle courtship and mating occurs in the stream during the fall, winter, and spring, often near the hibernacula. However, little or no courtship occurs in water that is colder than 10°C (50°F) (Garber, 1988b).

HIBERNATION IN WATER

The wood turtles I study all hibernate under water, usually on stream bottoms, and often in groups. Diamondback terrapins have been observed hibernating in the mud (Hay, 1904; Coker, 1906; Hay and Aller, 1913; Pope, 1939; Carr, 1952). More recently Yearicks, Wood and Johnson, (1981) wrote about northern diamondback terrapins *Malaclemys terrapin terrapin* that hibernate individually and in small groups, either 1) resting on saltmarsh creek bottoms, 2) buried in creek banks, or 3) beneath undercut banks. Scanning pond bottoms by looking through the ice I have observed musk turtles, snapping turtles and painted turtles overwintering.

Even certain sea turtles become dormant during winter, during which time they are sometimes hunted where they are typically found each year lying on the sea bottom (Felger, Cliffton, and Regal, 1976).

HIBERNATION ON LAND

The mud turtle *Kinosternono subrubrum*, which is primarily aquatic, is commonly found wandering on land (Mount, 1975; Garber 1988a). Some leave the water in the fall and spend the winter on land burrowed in the soil. Burrows approximately 20 to 40 cm deep were reported in Illinois (Skorepa and Ozment, 1968), while Bennett (1972) reported burrows in South Carolina that were a maximum of 11 cm deep. The deeper the burrows, as it happens, were further north, which could be an adaptation to surviving the colder winters.

Ernst (1976) reported spotted turtles hibernating in pools, while Netting (1936) observed spotted turtles that migrated overland to terrestrial hibernacula.

Although diamondback terrapins often hibernate underwater, Lawler (1972) reported them hibernating in moist sand above water level.

Most temperate turtles species lay their eggs early enough in the season so the hatchlings emerge in the summer or fall. Some turtles, however, overwinter in the nest as eggs or hatchlings if the eggs are laid too late in the season (Conant, 1951; Sexton, 1957; Nemuras, 1967; Ernst, 1970; and Gibbons, 1970). Gibbons and Nelson (1978) co-authored an interesting paper about the evolutionary significance of delayed hatchling emergence from the nest. It appears the painted turtle hatchlings have what seems to be one of the most remarkable overwintering strategies: they freeze. In a laboratory experiment, Kenneth Storey and his co-workers (1988) froze 13 painted turtle hatchlings and found that when thawed out, all but one survived. This is the only reptile and the highest vertebrate known to survive freezing of its extracellular body fluids during winter hibernation.

WINTER AGGREGATIONS

In Woodbury and Hardy's Utah study (1940), they found that the desert tortoise, *Gopherus agassizi*, is solitary during the spring and summer but in the winter small groups aggregate in burrows, usually a few per burrow, with up to 17 having been reported by Woodbury and Hardy (1948). For months the tortoises remain dormant in their winter burrow, with little to no activity. They did find, however, that approximately 35% of the turtles studied changed burrows during the winter. They also found that the tortoises do not always use the same burrow each year, nor do they use the same burrow continuously throughout the summer. Some turtles always inhabited the same burrow, some alternated from year to year, and some lived in one area for several years and then moved elsewhere. The extent to which disturbance from capturing and recapturing affected their movements was not known, but the researchers felt the effect was significant. In the spring, the desert tortoises leave their winter burrows and move to nearby ranges where they spend the summer. In their 1948 paper, Woodbury and Hardy reported that the desert tortoises they studied had home ranges from 4 to 40 hectares (10 to 100 acres) with considerable overlap between individual home ranges.

Investigating what caused desert tortoise aggregation and dispersal, using captive desert tortoises Patterson (1971) concluded that fecal pellets where an important factor. When there are lots of fecal pellets, the turtles disperse. However, in colder weather, when the turtles eat and digest less, fewer fecal pellets are deposited, and this was when the turtles began to aggregate at their winter dens. Patterson also felt that the late entrance of dominant males into the den allowed for social aggregation in the winter hibernacula. I have conducted similar experiments with wood turtles and felt that temperature was the primary stimulus. I had the wood turtles in a pool of water. When I raised the water's temperature, the turtles spread out, and I lowered the water's temperature, the turtles drew closer to one another (1989b).

BROWN ADIPOSE TISSUE

Unlike all the other turtles observed, the leatherback turtle *Dermochelys coriaceae* is regularly sighted active in cold northern oceans (Bleakney, 1965; Lazell, 1980; Goff and Llen, 1988) where they feed on arctic jellyfish. Even though they're often swimming in ocean water that is near freezing, Frair

al. (1972) have reported leatherback turtles in 7.5°C seawater maintaining a body temperature of 25.5°C which is 18°C or 30°F above ambient sea water temperatures). Their ability to generate the heat necessary for such a feat is attributable to their brown adipose tissue (Goff and Stenson, 1988). Like some cold adapted mammals, these turtles are able to produce heat without shivering or using other muscular activity. In addition to leatherback sea turtle and some mammals, a similar thermogenic brown adipose tissue is found in some fishes (Carey, 1982).

CARAPACIAL ALGAE

Musk turtles *Sternotherus odoratus*, which are similar to mud turtles in many respects, especially size and shape, hibernate in the water, and they, unlike mud turtles, have considerably more algae growing on their shells. Whether the colonization of algae on the shells of aquatic turtles has anything to do with where they hibernate, has not been investigated. Nor, does anyone know if the algae has any positive or negative affect on the animals. When carapacial algae was looked at on painted turtles, Gibbons (1968) found that shedding the scutes in late summer and fall appeared to be the main factor controlling the algae. Ernst (1976) found algal colonies first appeared on spotted turtles *Clemmys guttata* in late April, and the algae continued to grow as spring advanced. The few turtles collected in the fall and winter lacked algae, however, which was thought to be due to the lack of sunlight during the time each summer when the turtles became inactive.

LEECHES

When turtles hibernate underwater, some become susceptible to leech parasitism. I have wood turtle data on seasonal leech *Placobdella parasitica* infestations in Connecticut. Koffler, Seigel, and Mendonica (1978), as well as Hulse and Routman (1982) have reported some of these findings. An interesting aspect of *P. parasitica* life history involves the role these turtles play in the leech breeding cycle. In addition, how the leeches know when to get off the turtles, and what they do when the turtles crawl out of the water, and how leeches that become marooned on land get back in the water, are all fascinating issues that I will write about elsewhere. In the meantime, it should be stated that turtle leech mating is one of the more bizarre aspects of leech behavior.

ANAEROBIC METABOLISM

The freshwater turtles investigated have a remarkable ability to survive long periods underwater, in part because they have a limited capacity to exchange respiratory gases underwater (Seymour, 1982). But this is not the only factor that explains how turtles can stay under water for so long. Freshwater turtles have been shown to survive long periods, either in 100% nitrogen, as well as when their aerobic metabolism was blocked from the injection of sodium cyanide. Both of the above show that anaerobic metabolism, primarily glycolysis, may also be involved in some turtles surviving prolonged periods of submergence (Bennett and Dawson, 1976). Previously thought to be an adaptation for long dives (Belkin, 1963), it's been found that this anaerobic capacity doesn't seem to be used during routine diving. Rather, recent measurements have shown that freshwater turtles diving and surfacing under natural, undisturbed conditions, remain aerobic, do not rely on glycolysis, and do not accumulate lactate in their blood or muscles (Gatten, 1981, 1984; Stockard and Gatten, 1983).

Investigators then asked the next logical question: If freshwater turtles don't use this extraordinary anaerobic capacity on normal dives, when do they use it? Gatten (1981), Jackson and Ultsch (1982), Ultsch and Jackson (1982a and b), and Jackson (1987) all concluded turtles use their anaerobic capacity when hibernating in the mud of ice-covered lakes. Gatten (1987) took this one step further and found that, unlike freshwater and marine turtles, box turtles *Terrapen carolina* do not experience hypoxia in their winter burrows, and generally they don't relay on glycolysis for their ATP supply during moderate weather conditions.

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STATUS OF THE DIAMONDBACK TERRAPIN
Malaclemys terrapin
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The diamondback terrapin is the only North American turtle with a life history confined to salt marshes and adjacent brackish and salt water. As a direct result of overharvesting and subsequent mismanagement, most populations were extirpated by the early part of this century. With very few surviving turtles left to eat, demand ended and diamondback terrapins were left alone. After years of slow recovery, many populations recovered, and now the turtles are back in the fish markets. Because the numbers currently being taken far exceeds the turtles' capacity to maintain a steady population, their numbers are rapidly declining. Without conservation efforts diamondback terrapin populations could suffer great losses again.

During Colonial times the diamondback terrapin was extremely abundant throughout the Atlantic coastal zone from Cape Cod to Texas. A major source of revenue for a multimillion dollar industry, they were carted off to fish markets and restaurants. In soup, as well as prepared several other ways by Chinese Americans, they are said to taste excellent. However, the preparation of diamondback terrapin soup is remarkably tedious, and the end result is not all that remarkable, although the mystique of turtle soup still allows the dish to command a high price.

When the turtles used to be more abundant, preparation time was not as important a fact as today. What was important, however, was the tens of thousands of these animals could be transported live and stored for months without refrigeration or costly packaging.

In 1896 Banges wrote that terrapins were "shipped by the barrel" from Buzzards Bay, Massachusetts (non occur there any longer). Colonel E.S. Clark of Sandwich, Massachusetts "recalls fifteen hundred a day, barrelled and shipped to Boston" (Lazell, 1979), however, today, the entire Boston market is nonexistent. No more turtles, except for a few tiny Massachusetts populations that were recently discovered (Garber, 1985).

By the turn of the century diamondback terrapins were rare throughout much of their former range. Of the populations that survived, pressures over the following decades from habitat destruction, pollution, and road-kills diminished the chances of recovery for some of the surviving populations.

STATUS OF THE NORTHERN DIAMONDBACK TERRAPIN

Throughout much of the 19th century most of the northernmost diamondback terrapin populations remained productive (Babcock, 1926). Of these, at last count, only three small populations survived. These are at Barnstable Harbor, Pleasant Bays, and Sandy Neck (Lazell, 1979).

Holbrook reported diamondbacks from Rhode Island (Linsay, 1842). Only a small number of isolated populations survive. In Connecticut there may be a small population at Stonington, and there is one in Stratford, as well as another nearer the New York border. Other Connecticut populations discussed by Finneran (1948) appear to have been extirpated.

Diamondback terrapins were still numerous on Long Island, New York when DeKay (18[illegible] they "bury themselves in the mud during the winter, from which they are taken in great numbers." New York and New Jersey diamondback populations were rare in 1906 when Fowler published "Amphibians and Reptiles of New Jersey."

Diamondbacks were common along the Atlantic and Chesapeake Bay marshes in Maryland [illegible] the species was of considerable economic significance (Pope, 1949), not only to those who brought them to market, but also to those who passed sliders (*Chrysemys spp.*) and map turtles (*Graptemys spp.*) for terrapins. "The tasty flesh and high market value of the diamondback has had far reaching effects upon several other species of turtles over a wide range" (McCauley, 1945).

Ducatel (1837) and Scharf (1873) told when Maryland's diamondback terrapins constituted an entire industry. However, by 1873 it had already become necessary for the Maryland legislature to pass a statute (Chapter 424 of the Acts of 1878) that provided a legal limit of 5 inches (=12.7 cm, this measurement is the length of the plastron). They also restricted the season from April 1 to November 1. Chapter 424 also prohibited any interference with nests and eggs. Subsequent pressure from the fishing industry initiated further legislation which granted or limited the catch according to local abundance.

The record is very clear that this attempt to protect the diamondbacks from their decline was not sufficient. Catch data from 1880 until 1897 show an average of 67,688 lbs. of terrapins caught each year (McCauley, 1945). However, from 1897 until 1936, Maryland's diamondback catch average dropped to 3,022 lbs/yr. This average is less than 4.5% of the catch only years later. The decline was precipitous. It is not possible for diamondback terrapin populations to sustain such harvesting. The resulting elimination of many local populations has persisted until now. Certain populations have slowly recouped their numbers. And only now are they returning in force in many localities.

Such an accounting of diamondback terrapin history can be repeated for each state, however, because the figures all tell the same story. However, there are several other related points that need to be made so the New York State Department of Environmental Conservation can adequately assess the situation before choosing the best route for diamondback terrapin protection.

Writing in the North Carolina Geological Survey of 1906, Coker said terrapins "are now so scarce that it rarely pays to hunt them, yet the market value is such that no chance individual observed will be passed by. In the exhaustive search of our waters for clams, oysters, crabs, and fish, individuals are not infrequently found, and thus the work of extermination proceeds without check."

Discussing the possibility for a recovery, Coker stated "the terrapin has not the power to regain its hold within a few years, as the oyster or the clam might do. Each female lays but a few eggs and the young that hatch from them undergo many perils. Those that survive the dangers of early life are slow to reach the state where they may start another generation, and before reaching this stage they may be captured and sold at a small price. The terrapin gets no opportunity to reestablish itself."

With demand for diamondback terrapins continuing unabated, laws enacted to protect this overfished resource were, across the board, too little too late. Demand continued until most populations were all but entirely eliminated. As a last ditch effort, the U.S. Government stepped in, not so much to

protect the turtles, as to provide more. A breeding program was established at the U.S. Fishery Biological Laboratory in Beaufort, North Carolina. Although initial results were encouraging, the effort was abandoned during World War II. Subsequently, with the turtles so rare, numbers being brought to market were insufficient to maintain supply, so demand eventually all but disappeared. After World War II the U.S. Government never reestablished their breeding colony. Additional information on attempts during the early 1900s to raise diamondback terrapins in captivity can be found in the following sources: Coker, 1920; Hay, 1904, 1917; Barney, 1922; McCauley, 1945.

That was the last time diamondback terrapins appeared in the markets in any numbers. Years passed with the turtles being not so much out of favor, so much as forgotten as a food item. It was during these years many depleted populations slowly worked their way back to the point that in some areas the turtles were well on their way to being common again (Ernst and Barnour, 1972). Their numbers increased, since the market for these turtles was now nonexistent, the diamondbacks that were caught, were thrown back.

RECENT HISTORY

This brief reprieve is over. With a rapidly expanding Asian American population, demand for turtles has resurfaced. The Chinese used to eat turtles that were imported to this country. However, now that their native species are rare and endanger, they are concentrating on North American species. Turtles, in Chinese lore, represent age and wisdom, and the flesh is highly praised for its medicinal value (Rudlow, 1979). For these reasons, the Chinese are willing to pay high prices for turtles to replace their Asian species, which has led to the resurgence of demand of diamondback terrapins.

In the late 1960s one could find a range of turtle species in the fish markets of New York's Chinatown, several of which had been imported from Asia. At that time there were already some diamondback terrapins available. However, during the past 20 years the composition of turtle species being offered in these markets has changed radically, and now, almost without exception, all the turtles are diamondback terrapins, with some snapping turtles, softshells, as well as red-eared sliders and yellow-bellies. Of, theses, the diamondback are definitely the favorite, and they are sold in the greatest numbers. Though some can be found year round, most are available during the summer.

Asian Americans, being more true to their palates than most ethnic groups, have been finding North American equivalents to many of their marine species, including mollusks, crustaceans, fish, and frogs. While Japanese merchants are paying high prices for yellow fin tuna caught off of Long Island, New York, other Asian businesses are purchasing Maine uni (sea urchin eggs). Of these species, the one that has already begun to decline in numbers from this increased demand is the diamondback terrapin.

Traditionally only the female diamondbacks were being saved and sent to market, because males, being so much smaller, usually aren't worth bothering with. The customer would pick out a big old turtle from the tank and the proprietor would take it in back and dunk it in boiling water for about 10 minutes where the scalding heat would just about kill it, without destroying any of the turtle's supposed medicinal qualities. The Asians believe turtles have curative powers, and that eating them can increase one's lifespan. The scalded turtle is then cut up and packaged for the customer.

Most of the diamondbacks finding their way into the markets and restaurants are caught in the Carolinas, Virginia, Maryland, and southern New Jersey. To a lesser extent, some are also caught on the south shore of Long Island. National Marine Fisheries data show that in 1984, 2,000 to 3,000 diamondback terrapins caught in New York appeared in local fish markets. However, because so few remain in Connecticut, Rhode Island, and Massachusetts, few are caught in these states.

Once the turtles arrive in the markets, in can be difficult learning the precise origin of these animals. Most vendors are hesitant about answering questions. In New York City's Chinatown, because of the language barrier and fear of being caught by the U.S. Fish and Wildlife Service or by the State Department of Environmental Conservation officers for the possession of illegal species, one must contend with a healthy amount of paranoia when asking questions. Because organized crime plays a noteworthy role in the dynamics of both the Fulton Fish Market and Chinatown, matters aren't made any easier.

During the 1960s any early 1970s, the threat seemed benign enough. After all, how many turtles could a relatively specialized market consume? However, each year the demand expanded, as did the prices, and the numbers of baymen supplying the turtles for market. With more turtles available, demand increased, and diamondbacks began to be sold beyond New York's Chinatown. Now they are common fare in fish markets across the country, particularly in those catering to Asian Americans. Having tracked the turtles back to their sources working to establish where they were being caught, and how many were being sold, I found 10,000 diamondback terrapins being sold each year at New York's Fulton Fish Market alone!

Each summer, the Fulton Fish Market dealers who sell most of the diamondback terrapins are

Behrens
Fred Mullan and Son
Galillee
Otto Raddatz
Royal

Galillee estimated thy sold 2,000 diamondbacks last summer. Raddatz thought he sold about 3,000. He said he could sell 1,000 a week when they are available during the season. They come in on consignment. The small ones go to the fish markets that sell them as pets. During the summer of 1985 he told me he got about $1.50 to $2.00 for the small ones. Raddatz says he has one fish market in the Bronx that will buy as many of the small diamondbacks as he can get. The larger ones bring in more money, depending on the demand. In Chinatown, the large females cost $10 to $20 each. So it came as no surprise when the vendors said they would love to sell far more, and would be able to, if only they could get their hands on them. However, already the suppliers are complaining that the populations are being depleted, so diamondbacks are becoming increasingly difficult to catch.

The most conservative estimate possible indicates well over 10,000 diamondback terrapins are sold at the Fulton Fish Market each summer. Many others are channelled through Baltimore and Philadelphia. In addition to the fish markets that were specifically catering to Asian Americans diamondback turtles were being sold in many other fish markets, and they are now turning up on menus of some well established restaurants around the country.

Since diamondback terrapins take several years to reach reproductive maturity, and since very few hatchlings ever survive that long, calculations indicate that diamondback terrapins are again riding a wave of popularity that will eventually beat back many of their populations to oblivion.

PET TURTLES

Fish market owners don't just sell the large females for food, however. They learned that when placed prominently in the front of the market, the turtles attracted people's attention, luring more customers into the store. Many of these customers would buy the turtles, not for food, but as pets. And the smaller, the better. This provided a ready market for the previously smaller males and juveniles, that used to be thrown back.

Banned from New York's pet shops since 1973 because they were considered a health hazard, pet turtles were in short supply. But this didn't stop vendors from selling turtles in the fish markets, even though these diamondbacks were as sick as any pet shop turtle and could probably transmit salmonella to any turtle owner. With the pet turtle trade being pushed from the fish markets, it was rapidly learned that even the small diamondback terrapins could be sold, providing an increased incentive for baymen and fishermen to save every diamondback terrapin caught. Most recently we've just started to see even one-inch long hatchling turtles being sold in fish markets!

CRAB TRAPS

As demand continued to grow, the increased prices encouraged baymen to work harder to catch more turtles. Making matters even worse, crabs were also rising in popularity, which contributed to the overall problem, since in addition to crabs, diamondback terrapins are also caught in crap traps. Just as the growing market for crabs led to increased prices, which is precisely what happened with clams, oysters, and lobsters, all of which used to be amazingly inexpensive. In response to the greater remuneration, baymen took their boats further and set more traps, working harder for these animals as their numbers declined.

With the increased effort came a new, more efficiently designed crab trap, which formerly was used only in the Deep South. These traps are baited and placed on mud flats, specifically hoping to catch crabs, but since diamondback terrapins also feed on the mud flats during the incoming tides, many turtles were also caught. Unlike the crabs, turtles must surface for air, so after being submerged during high tide, many turtles drown. When the crabbers tend their traps, the dead turtles are either discarded or used as bait, and now, since there's a market for them, the live ones are also sold.

A simple modification of the trap could eliminate the drowning. By attaching floats, the traps would rise to the surface with the incoming tide. But few baymen would be willing to convert their traps without an economic incentive, unless forced; fishermen are notorious for fighting anything that conflicts with their freedom or pocketbooks. Perhaps the best and most recent example has been the protracted fight waged by shrimpers (fishermen who catch shrimp) against using the turtle excluder device (TED) that allows fishermen to catch shrimp without drowning the Kemp's ridley turtles, which otherwise would drown in the nets. Having garnered enough congressional clout to keep this situation at bay, the fishermen continue to drown the remaining ridleys, which are endanger and closer to extinction, perhaps, than any other species of sea turtle. It might seem, that instead of enforcing the laws enacted to protect endangered species, congress prefers pandering to those who vote.

PROTECTION

Luckily there are some factors that have played in the diamondback's favor. With national and state parks, and wildlife refuges protecting specific coastal areas, some terrapin habitat happens to be located where it is possible to enforce laws restricting fishing and hunting. Such areas include New York's Fire Island National Seashore and Jamaica Bay Wildlife Refuge, New Jersey's Sandy Hook and Gateway National Recreation Area, Island Beach Park, and the Brigantine Wildlife Refuge. In Maryland and Virginia, diamondbacks are found at Assateague Island, and in North Carolina, they are found at Cape Lookout and Cape Hatteras National Seashores. In Georgia there is a large population at Cumberland Island National Seashore.

If diamondback terrapins in all their intervening areas are ever going to complete their comeback, without being beaten back part way there, it will not be with inadequate laws, inadequate enforcement, and the baymen's unrestricted right to drown thousands of turtles while shipping them off to market. Before anyone's livelihood depends too heavily on the diamondback terrapin, this species should be protected across the board. We need a total ban on the capture of diamondback terrapins. Crab traps which have not been modified to eliminate total submergence should be confiscated, and stiff penalties should be exacted for anyone found with improper traps or turtles in their possession. It is imperative that we move to protect these animals.

We know from past experience that the measures taken by individual states to save their dwindling turtle population proved too little too late to stem the species' decline. Loopholes and inadequate enforcement render many wildlife laws useless. Considering few states have officers trained to enforce the laws that were enacted to protect certain plants and animals, it is difficult to decide the best plan of attack.

Recently, the Turtle Task Force, an interdisciplinary group of representatives from environmental organizations convened to address these problems. Their first diamondback terrapin meeting was held on June 2, 1988 at the New York Zoological Society. In attendance were experts from the Bide-A-Wee Home Association, Center for Environmental Education, ASPCA, New York Zoological Society, People for the Ethical Treatment of Animals, the Sierra Club, Rutgers University, and the New York Turtle and Tortoise Society. The meeting's focus, problems pertaining to diamondback terrapin exploitation were discussed. The increasing market for turtle soup and related dished in this country, diamondback terrapin conservation, and cruelty were all on the agenda. It was at this meeting goals were set and a strategy was mapped out to gain legal protection for the diamondback terrapin in New York State.

Since New York is a major clearing house for diamondbacks, where more turtles are bought and sold than any other state, upgrading the diamondback's current status in New York, from a "Species of Special Concern," a listing that affords it no protection, to a position where it would be possible to get the diamondback's protection under Environmental Conservation Law ECL 11-0311, the turtle can be afforded much needed protection. We hope to make it illegal to catch, buy, or sell this animal anywhere in New York, and from there we will refocus our efforts on other important states.

I hope the special protection afforded to diamondback terrapins under Conservation Law 11-0311 will go further than merely paying lip service to the problem. With such a threat, and with the history as clear as can be, it is obvious that saving diamondback terrapins means eliminating the profit motive. Surely, turtles caught will not be thrown back if storing them in pens and basements a few

months is all that is need to bring them to market. Limiting the size of the turtles that can be sold, and season during which they can be sold is a step in the right direction. However, such a step is not enough. Loopholes have to be eliminated. Time and time again we see inadequate rules meant to appease both sides accomplish nothing. This is not politics, this is conservation.

ECOLOGY AND BEHAVIOR

In light of the above historical data, the following sources are provided for anyone wishing to research wild terrapin size data (Cagle, 1952, 1954), egg and nest characteristics (Reid, 1955; Montevecchi and Burger, 1975), determinants of nest site selection (Burger and Montevecchi, 1975; Burger and Ricklefs, 1977), behavior of hatchlings (Burger, 1976), or survival of nests (Burger, 1977). In addition a hibernator was described by Lawler and Musich (1972). For most recent information on diamondback terrapin populations and exploitation see Garber (1984a, 1984b, 1985a, 1985b, 1986a, 1986b, 1988a, 1988b, 1988c).

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MAINTENANCE STRATEGIES FOR LARGE PRIVATE COLLECTION OF CHELONIANS

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Although I am fascinated by computer controlled environmental chambers and raising gavials in indoor jungle lakes, I would like to address the needs of the basic basement or backroom herpetologist whose collection has expanded through impulse and opportunity and now finds him or herself with an inventory larger than a major zoo. The "curse" of the compulsive turtle collector is the relative paucity of living species, so that one could conceivably acquire and house all but a very few of the largest and rarest, given enough money and the right connections. However, I prefer not to moralize on the acquisitiveness but rather consider the strategies necessary to perform all the functions of a major zoological institution in your spare time, in your spare room, with your spare cash - strategies that emphasize the conservation of all three of these limited resources.

Unfortunately, attitudes of dogmatic intolerance toward others' methods occasionally surface in the "biological" hobbies, from gardening to reptile keeping. Rather than lay down strict rules of husbandry, I would like to emphasize "creative improvisation" in adapting to your special circumstances, which I will illustrate with workable ideas that I've tried or encountered over the years to meet the ultimate goal of maximizing enjoyment of your collection while minimizing the drudgery and expense of maintaining it.

SELECTION

With a large collection, some degree of community housing is a virtual necessity, so eventually you will have to take a hard look at the special care requirements of each new acquisition: can it be easily incorporated into a community tank, or must it be isolated and pampered, taking up extra space and time? There is considerable species variation in housing requirements and the labor intensity of their care. As a group, I find tortoises much more demanding than aquatics for indoor husbandry. Their space requirements are greater because terrestrials maneuver in only two dimensions, while aquatics can utilize a third dimension - depth - to avoid collision as they move about in a community tank.

During the winter months, a well-balanced vegetarian diet of fresh or frozen vegetables and fruits can be quite expensive compared to a commercial pelleted "chow", and is more time consuming to prepare, supplement and distribute to the animals. Even the commercial "monkey chow" biscuits must be soaked in water for a period before feeding to the tortoises. Although aquatics have their own unique medical problems, one can count on treating tortoises for respiratory disease on a regular basis. Also, the best watering method for tortoises involves soaking them in a container of water (which also aids in defecation) - another time-consuming procedure. Although I would never exclude tortoises from my collection because of labor and expense, I am generally forced to limit their numbers to twenty or less.

Vulnerability to injury is another major determinant of suitability for community housing. Soft-shelled turtles of the family *Trionychdae* are prone to shell damage by their tankmates. Turtles with very long tails, such as the Asian bigheaded turtle *Platysternon megacephalum*, the alligator snapper *Macroclemmys temminkii* and males of some other species are vulnerable to tail bites that are easily infected and slow to heal due to the limited blood supply to that appendage. Species with large webbed feet and fine scaled epidermis, such as the Australasia Chelids *Chelodina, Emydura*, are also susceptible to bite injuries.

Temperament is another factor in vulnerability. A shy species such as the twist-neck turtle *Platemys platycephala* may be unable to compete for food with more aggressive tankmates. Conversely, more aggressive individuals and species with powerful jaws, such as the snapping turtle *Chelydra serpentina* and the narrow-bridged musk turtle *Claudius angustatus* can easily injure their tankmates. Another type of aggression might be termed "sexual harassment." Certain males exhibit very aggressive courtship behavior which may involve neck-biting and relentless pursuit, often directed at members of different species and of the same sex.

HOUSING

If you live in a northern climate and keep tropical species, you must maintain them indoors for at least seven months of the year. A large collection cannot easily be moved in and out for a brief romp in the summer sun, so unless substantial secure outdoor facilities can be constructed, the animals will have to be maintained almost continuously indoors. Indoor housing depends upon your space limitations and personal aesthetics. Some collectors favor a naturalistic "showcase" display, while others opt for a strictly utilitarian setup that facilitates cleaning and maximizes occupancy. A middle group incorporates a moderately decorative land area with a bare aquatic area - an arrangement favored by many zoos.

Glass aquaria are attractive and provide easy viewing, but the larger sizes are very expensive and difficult to move. One strategy for maximizing water volume and facilitating filtration involves providing a basking area outside the tank itself with a partially enclosed attached platform. This can easily be constructed of plastic or wood and landscaped with rocks and plants. If the water depth is carried to the top of the tank, a removable barrier of clear plastic that fits into the recessed plastic lip of the tank can be added, with appropriate cut-outs for filtration.

Some species and individuals do not adapt well to deep water without a shallower resting area. For these, a shallow tank with high water volume can be created by using a false bottom of translucent or opaque plastic supported some distance above the glass bottom on inverted beverage glasses. In my own setup (Fig. 1), the false bottom is set on "egg crate" fluorescent diffuser and part of the open grid is left exposed at one end to permit free passage of water between levels. The filter intake tube passes through the false bottom and draws water from the lower tank to prevent stagnation. If desired, the entire lower tank can be masked out with opaque material for aesthetics. A third strictly utilitarian modification for high water volume that provides hiding areas, shallow resting areas and basking space involves a simple multi-level shelf structure made from untreated pine timber and initially weighted down with bricks or a concrete block.

For cost and portability, it is hard to beat the large plastic wading pools. Finding "smurf-free" models can be a challenge, although chelonian motifs are very common. The deeper models will contain all but the largest specimens and can be used for tortoises as well as aquatics. Circular pools offer freer movement because animals don't bunch up in the corners, but a circular design wastes floor space. One can increase the effective height of these containers to accommodate very large specimens by surrounding them with an 18-24 inch wall of some flexible material, such as vinyl or aluminum roof flashing.

Somewhat costlier than wading pools are the large galvanized metal stock-watering tanks. These are very durable, use floor space well and provide secure containment for large individuals, but are rather unaesthetic. A more attractive alternative for deep containers is the fiberglass and polyester resin kidney-shaped lily-pool. It is very lightweight for its size, but when used in a free-standing position is somewhat susceptible to fracture.

Tetra® heavy-duty vinyl outdoor pond liners are quite expensive, but are very durable and can be adapted for use in custom indoor setups. My personal goal was to provide maximum water volume in a given floor space and still provide the turtles with a relatively shallow area where many of them prefer to spend much of their time. This was accomplished with a rectangular design with a deep trough at the rear and shallower upward sloping floor towards the front (Fig. 2). This was framed in plywood, water sealed, stained and covered with the pond liner after first putting down a thin layer of insulating foam to increase resilience and resistance to claw damage. We were able to add a narrower second tier of similar design to further maximize floor space utilization.

In shallower tanks, basking platforms can be created from vegetable or storage bins with the side mesh partially cut away to allow free passage and access to hiding. Slanted ends provide access ramps, and the top surface can be covered with rubber stair or hall runner material, available in bulk in some hardware stores, for excellent traction with no abrasion. Small door mat rugs with the nap tightly imbedded in thick rubber may also be used, but most bulk indoor-outdoor carpeting tends to fray in time. The top material can be tied on easily with thin electrical wire known as bell wire. You can also custom make ramps by heat-bending plastic strips and covering them with stair runner. Lightweight plastic basking platforms are easily cleaned and slide around easily enough so that turtles can rarely use them to climb out.

For small turtles in shallow containers, structures assembled from plastic Loc-Rocks® are suitable for basking and hiding. A naturalistic touch can be achieved with solid plastic ramps by coating them with silicone adhesive imbedding aquarium gravel, but there is still some risk of the turtles eating both the adhesive and the looser pieces of gravel. Smooth natural rocks and finished bricks are relatively harmless to the plastron, but they are heavy to move and can injure or trap an animal if they fall.

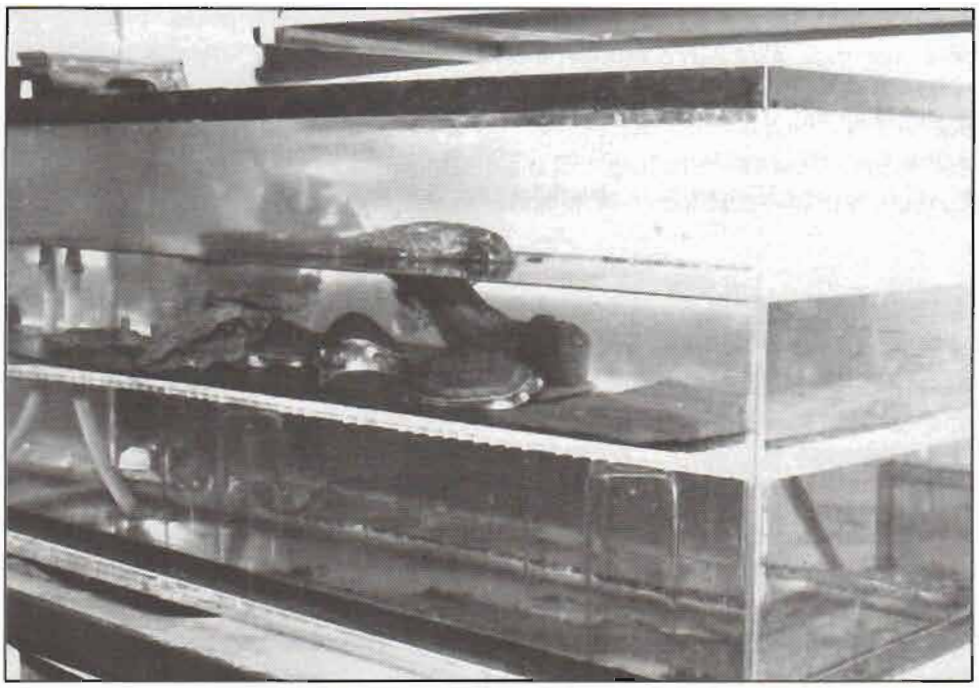

Figure 1

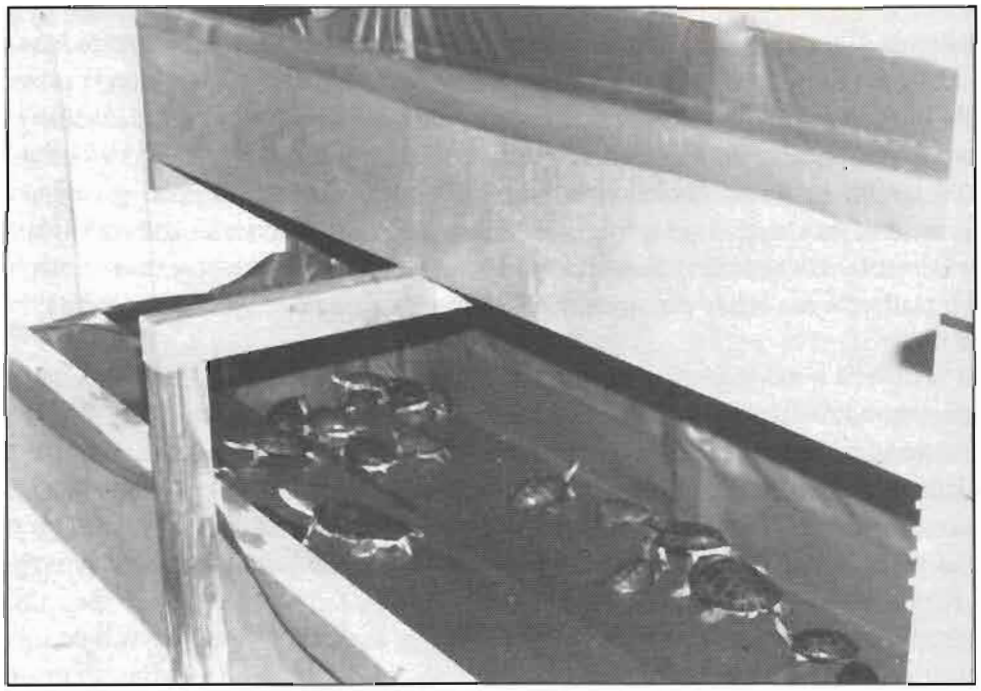

Figure 2

Isolation for quarantine, medicine treatment or special dietary demands is frequently necessary in a large collection. Small volumes of water are quickly fouled, so ease of cleaning should be a prime consideration in selecting smaller containers. The various polyurethane "bus tubs" or material storage containers are light, durable and easy to handle. Thin-walled "sweater boxes" of brittle polystyrene are useful for terrestrial herps but are very easily cracked when filled with water. If greater visibility is desired, transparent polycarbonate institutional food containers and rodent boxes are durable alternative to glass aquaria.

HEATING AND LIGHTING

A large indoor set-up consumes considerable electricity for lighting, supplemental heating and filtration and this must be allowed for in an honest estimate of your maintenance expenses. Regular household circuits may be overtaxed by this demand, so one should seriously consider installing a separate circuit with at least a 30 ampere capacity, number 10 wiring and several multiple outlets. Although the prospect of wiring your own circuit may be initially intimidating, a moderately-handy person can install a basement circuit with surprising ease, given a good how-to manual such as General Electric's Wiring for the Do-it-yourselfer (Anonymous, 1978) available in home improvement centers, and a little advice on supplies from an electrical supply store. Be sure you know building code requirements for your area, of course.

For temperature control it is usually much more convenient to heat the room rather than the individual tanks. Submersible heaters are expensive and fairly easily damaged, and I currently use them in only a few isolated tanks containing very valuable or temperature sensitive specimens. For portable supplemental heating, fluid-filled electric radiators and compact rotating ceramic disc heaters are safer and more aesthetic than the old bare-wire portable units with their noisy fans. Invest some time and money in good window insulation to retain your heat.

Many tortoises appreciate a locally-heated floor area for thermoregulation. My own tortoise enclosure is right next to the furnace where animals can utilize the retained heat of the concrete floor. Conversely, if cold floors are a problem for ground level set-ups, a layer of inexpensive insulating foam planks, joined with duct tape, can reduce heat loss considerably.

For area lighting, fluorescent tubes are the most cost effective, although 55-75 watt incandescent flood lamps provide good basking spots. Wide spectrum tubes that approximate natural sunlight, such as the Duro Test Vitalite®, are frequently recommended for the well-being of diurnal herps, but warm white/cool white standard and deluxe tube combinations may be a less expensive alternative for the less light sensitive species, including most aquatics. "Black light" ultraviolet tubes are used in some tortoise set-ups, but I personally believe that the dietary addition of vitamin D_3 in moderation is more reliable way to maintain shell growth.

Whatever system you choose, an automatic timer will make life much easier and maintain your desired day/night cycle in your absence. For large set-ups, the heavy-duty Intermatic model T101 Time Switch can be combined with a multiple outlet strip by removing the plug and wiring it directly into the timer. For a smaller number of lighting fixtures, the Intermatic EB11 Time-All has proven more durable than most portable units.

SANITATION

Turtles are notoriously "dirty" herps. Three options for water quality maintenance - perhaps the most time consuming aspect of husbandry - are: (1) Continuous water exchange; (2) Periodic complete water change; and (3) Filtration. Most collectors use a combination of systems. Automatic water changer systems such a the Python® are highly recommended by some, but these require a separate water connection and drainage tube for each tank. I personally utilize periodic drainage and refilling for the majority of my tanks and pools. In a basement set-up, I have access to a large recessed floor drain which greatly facilitates water exchange. For me, husbandry would be unthinkable without the Sears portable submersible pump or its equivalent, which can drain a large pool in minutes to within 1/8 inch of the bottom. This unit has proven durable over years of hard service and is also helpful in cleaning up the inevitable overflows and spills. A good quality large diameter rubber or rubber-combination outflow hose will improve pump output and reduce kinking. I find it convenient to have a separate set of drainage and refill hoses in different areas of my widespread set-up to avoid dragging the hoses over many obstacles. It is very important to have the outflow end of the hose securely anchored to your drain or it can become dislodged and quickly flood the floor.

If your water supply is a laundry sink with separate hot and cold taps, they can be connected with a Siamese Y-tube available in most hardware stores. A Y-type shut-off valve with a separate short piece of hose attached to one branch provides for clean-up and refill jobs in the sink area, and the long hoses may be attached to the other branch via a quick connect. Metal Y shut-off valves are more durable than plastic and are worth seeking out.

I have seen a custom-built diatomaceous earth filtration system that could handle a municipal swimming pool in one indoor set-up, but this is beyond the resources of many private collectors. Although some have used under-gravel filtration successfully, I and others have had multiple deaths associated with these systems. Aquarists indicate that shut-down of under-gravel filtration may result in rapid growth of anaerobic bacteria in the nutrient-rich subtrate, including those responsible for botulism poisoning *Clostridia spp*. Excessive ingestion of the gravel during feeding may also lead to intestinal obstruction.

Large canister filters, such as the Marineland Magnum 330®, used with a refillable charcoal cartridge and reusable filter sleeve, provide good water quality for a few animals, but are relatively expensive and time-consuming to clean. They will, however, work in tanks with low water levels or high sides. If the water level can be maintained within about 8 inches (20 cm) of top of the tank, the power lift hanging filters, such as the Marineland Auto-Flo® systems, are less expensive than canisters and

simpler to clean and set up. The flat filter inserts can be quickly rinsed and replaced, or one can make one's own filter medium inserts for the empty plastic mesh inserts provided. Many collectors have also shown great creativity in designing their own filtration systems from commercial and homemade components.

NUTRITION

The standard fare for medium and adult aquatics in many large collections is Purina Trout Chow® floating pellets, which are easy to store, use, and are very economical. Other commercial fish chows exist, but Purina is widely available in feed stores in 50-pound bags. Commercial dry pelleted cat foods are generally small enough for turtles as an alternative to fish chow. Purina Happy Cat® is a semi-moist pellet with a binder to delay drying out after serving, which incidentally helps hold it together in the water, unlike other semi-moist pellets that easily disintegrate and cause fouling. Trout chow pellets may be too large for juveniles and may not provide enough calcium in some instances. Repto Min® floating food sticks from Tetra provides a complete diet for many species and has a high acceptance rate, but it is very expensive and economics dictate limiting it to juveniles and a few special adults. Hikari Cichlid Gold® mini-pellets by Kyorin has also been used successfully in rearing juveniles, and has the added enhancement of red color. Nutra Fin has recently introduced a Turtle Pellet® that sinks, but I have not yet had much experience with this product. Cost and formulation appear to be comparable to Repto Min®.

Reluctant feeders must often be coaxed along with various live foods until they develop a taste for cheaper fare. Earthworms, mealworms, wax worms, "crippled" crickets and pinky mice are some of the alternatives, and live tubifex worms can often induce juveniles to feed when all else fails. The commonest fresh food for aquatics, however, is fish. Frozen smelt are popular, but I personally prefer live or freshly killed goldfish or minnows because they foul the water less and provide extra nutrients via the head and abdominal contents. *Gambusia*, the mosquito fish, is raised or harvested by some collectors in warmer climates. Whole fish may be stuffed with Repto Min® or injected with liquid vitamins for those turtles which refuse dry food, such as the mata mata *Chelus fimbriatus*. Some collectors prepare their own soft foods by combining whole fish or beef and a dry food, such as Repto Min®, with gelatin in a blender and then freezing the mixture. This has good acceptance for many picky eaters and holds together fairly well in water.

Unfortunately, there are few prepared foods suitable for tortoises. Zu Preem Primate Diet® ("monkey chow") biscuits can be fed after soaking in water, but this should be considered a supplement to a primarily vegetarian diet, rather than a mainstay, and not all tortoises will readily accept it. Occasionally, tortoises may be induced to eat rabbit pellets, also. Pre-packaged alfalfa for rabbits is available in most pet stores and will be consumed by grass-eating species. As mentioned above, fresh or frozen vegetables and fruits are fairly costly, and although one can economize by growing one's own produce or foraging for native plants and weeds, this is time consuming and somewhat risky in an age of frequent herbicide and pesticide use. I personally prefer frozen mixed vegetables as a staple, with Romaine lettuce and Zu Preem Primate Diet® offered several times a week. All items are dusted with Reptivite®.

A number of these supplement powders are available to add vitamins, minerals (especially calcium) and essential amino acids to the reptile diet. Most, but not all, collectors favor their use in the tortoise diet.

MEDICATION

Although a veterinarian knowledgeable in reptile medicine is a great asset to a large collector, economic and time constraints dictate personal involvement in the medical treatment of your animals. Surgical procedures, X-rays and complex laboratory analyses are best left to the professionals, but many problems can be successfully treated at home. This is not intended to be a comprehensive treatment of chelonian diagnosis and treatment, but rather a discussion of the resources needed to deal with common illnesses. The first and most important of these resources is knowledge - a sound understanding of the causative agents and remedies that can only be gained from extensive reading, from workshops and discussions with knowledgeable persons, and from actually working with sick animals. When reviewing the available literature, one must always keep in mind that some of the advice published by "experts" is inaccurate or outdated. Some of the books and articles dealing with chelonian medicine include Frye (1981), Mader (1989), Murphy et al (1983), Ross et al (1984) and Ververka et al (1986).

Much of your treatment will, by necessity, be empirical, i.e., without precise laboratory identification of the causative agent. Blood, wound and lung washing specimens are difficult to obtain, expensive to culture and subject to ambiguity in interpretation. The value of your animal (monetary and sentimental) will to some degree dictate your expenditure on diagnosis. The commonest chelonian medical problems are gram negative bacteria, superficial fungi, amebae, various parasitic worms and nutritional deficiencies. Serious progressive infections such as pneumonia, deep shell rot, jaw rot, tail rot, swollen feet, septicemic ulcerative cutaneous disease and some parasitic infestations will required injectable antibiotics and you will need someone in the medical field who can provide these drugs for home use. Many gram negative organisms are susceptible to aminoglycoside antibiotics, and the most commonly used agents are amikacin (Amikin®, Amyglide®) and gentamycin (Gentocin®, Gentavet®, Garamycin®,etc). Amikin is the drug choice because it is much more effective against *Pseudomonas aeruginosa*, a common pathogen of reptiles (Ross et al, 1984) and has been demonstrated in large mammalian trials and clinical studies to be significantly less toxic to the kidneys, the most dangerous side effect of the aminoglycosides (Lerner, 1983). Unfortunately, amikacin is still strictly a proprietary drug with no generics and an equivalent therapeutic dose is more than 50 times the cost of the cheapest generic gentamycin.

For those concerned with the toxic side effects of the aminoglycosides or wishing to increase their effectiveness, the modern antipseudomonal penicillins, piperacillin (Piperacil®) and mezlocillin (Mezlin®) produce a strong synergistic effect that can reduce aminoglycoside requirements, but both are fairly expensive and don't have a long shelf life once reconstituted. Shelf life can be increased by freezing the suspension between uses, however.

Tylosin (Tylan®) is a veterinary macrolide antibiotic that is fairly benign and sometimes effective against pneumonia in chelonians, for those reluctant to use or without access to aminoglycosides. It is also sold over-the-counter in some feed stores that cater to livestock raisers.

For gut infections, particularly *Salmonella* and *Arizona* and anaerobic bacteria such as *Clostridium* which produces botulism and gangrene, chloramphenical (Chloromycetin®) is usually the drug of choice. It is relatively cheap, widely available and has a very long shelf life once reconstituted. Metronidazole (Flagyl®) is also active against anaerobic bacteria, but the injectable form is difficult to reconstitute and pH balance for intra-muscular use, and is best reserved for use against amebae, where it produces excellent results. The oral form may be used in this capacity.

The efficacy of the various worming medications for turtles is widely debated and subject to "fads." Be very careful to study the spectrum of activity and potential side effects before you unquestioningly accept someone's glowing recommendation. Veterinary Pharmaceutical and Biologicals (Aronson, 1985) may be helpful in identifying and analyzing these drugs. My personal experience in this area is limited. Levamisole (Tramisol®) is effective against round worms and niclosamide (Yomesan®) is a standard drug for tapeworms.

In addition to the basic drugs, one must also find a source of syringes and hypodermic needles. One ml tuberculin syringes marked in gradations of 0.01 ml are best for precise administration of antibiotics for all but the largest specimens. 23 and 25-gauge hypodermic needles produce minimal trauma and are still large enough to draw up drugs and inject rapidly. The attached fine needles that come with insulin syringes are difficult to use on reptiles, but this type of syringe is most readily available to lay persons.

Another very important tool in medication is an accurate weighing device, so dosages can be calculated precisely. I am very satisfied with the Ohaus Lumiline® battery powered scale with its large digital display, automatic shut-off and uncluttered top for weights up to 1 kg. Others prefer the accuracy of a triple beam balance. A spring-loaded kitchen scale may be adequate for turtles over 1 kg in weight, but the small, spring-loaded diet scales are hard to zero and difficult to read.

For superficial injuries and infections, a wide variety of excellent topical medications are available over-the-counter. These include iodine-providone solution (Betadine®), boric acid, bacitracin-neomycin-polymyxin b ointment (Neosporin® and many generics) and bacitracin-polymyxin b ointment (Polysporin® and generics). Polymyxin b is active against *Pseudomonas aeruginosa*. Several effective topical antibiotics are available as aquarium remedies. Minocyline, a wide spectrum tetracycline, is available as Maracyn II® (Mandel Lab Inc.) and Nitrofurazone and Furazolidone are available as Furan-2® (Aquarium Pharmaceuticals Inc.). If a careful differential diagnosis indicate a true fungus is involved (many superficial bacterial lesions and bacterial shell rots are incorrectly referred to as "fungus"), Fungus Cure® (Aquarium Pharmaceuticals Inc.) containing Victoria green B and neutroflavine produces excellent results. Several large-scale collectors, one of whom is a veterinarian, highly recommend Acriflavin as a remedy for many fungal and bacterial skin and shell lesions.

CONCLUSION

The private chelonian collector can save considerable time and money through creative planning, research and improvisation with available resources and maintain satisfaction and enjoyment of his hobby and his collection expands.

ACKNOWLEDGEMENTS

I would like to thank the many fellow herpetologists with whom I've shared ideas on husbandry over the years, including Walter Allen, Harold Carty, Bruce Chmura, Phillip Drajeske, David Fogel, James Harding, William McCord, Hank Molt, Ellen Nicol, Rennell Pierpont-Sweeney, Al Redmond, Robert Reinhardt, Richard Ross, Sandra Veverka, Harold Wahlquist and Marc Weiss.

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THE GOPHER TORTOISE - KEYSTONE SPECIES OF THE SAND HILL ECOLOGICAL COMMUNITY

Harold Wahlquist, Ph.D.

The evolution of sand hill ecosystems originated from marine sand deposits in the Pllo-Pleistocene geological period over five to fifteen million years ago. These coastal sands eventually mixed with soils to provide the growing base for arid-type plants that preferred sandy, well-drained soils. The primary plant community is composed of longleaf pine, turkey oaks, and wiregrass. These plants are fire resistant, and in fact the entire community is called a fire subclimax forest. Burning every eight to fifteen years is essential to the character of this habitat. Other prominent plants include lichens, yuccas, palmetto, schrubs, wildflowers, gopher apple, and prickly pear cactus.

The most important animal in this ecocommunity is the gopher tortoise. Its presence is apparent from the many burrows which it digs in the sand hill areas. Its burrow may be ten feet deep and twenty to 35 diagonally long, providing a well insulated refuge for the tortoise as well as 358 other species including 301 invertebrate and 57 vertebrate species. The creation of the burrow refuge has acknowledged the gopher tortoise as the keystone species for its habitat.

The gopher tortoise ranges throughout the coastal sand hill habitats of the five southeastern states (Fig. 1). Next to Florida, Georgia probably provides the most habitat. Unfortunately, no recent status survey has been performed in Georgia. Florida researchers have estimated a gross population of 1.3 million tortoises for the sunshine state.

The best way to sex a gopher tortoise is to flip one on its back and inspect its ventral surface or plastron. For adults, if the plastron is flat, it is probably a female. A concave plastron indicates a male. Juveniles cannot be sexed except by an expert. Adults require sixteen to twenty one years to mature and may live forty years or longer. The extremely low reproductive rate is a major limiting factor. Mating occurs during April to June, with females digging their nest cavity in the mouth of their burrow only once per year. There is a very high nest loss to predation of approximately ninety percent. Incubation period averages 102 days for a single clutch which averages seven eggs. The female is successful in producing young only once in ten years that may reach adulthood. All these limiting factors have led to the decline of the gopher tortoise throughout its range. Human consumption, abuse and habitat loss accelerated this decline.

An average colony is comprised of 10 mature individuals on approximately 10 acres of suitable habitat. This number is required to maintain recruitment levels where offspring reach maturity and replace lost adults. Adults occupy a minimum of three burrows and will cohabitate during the active mating season.

The lack of fire to control scrub oaks and pines causes tortoises to move to roads and fire lanes where mortality and human harvest increase.

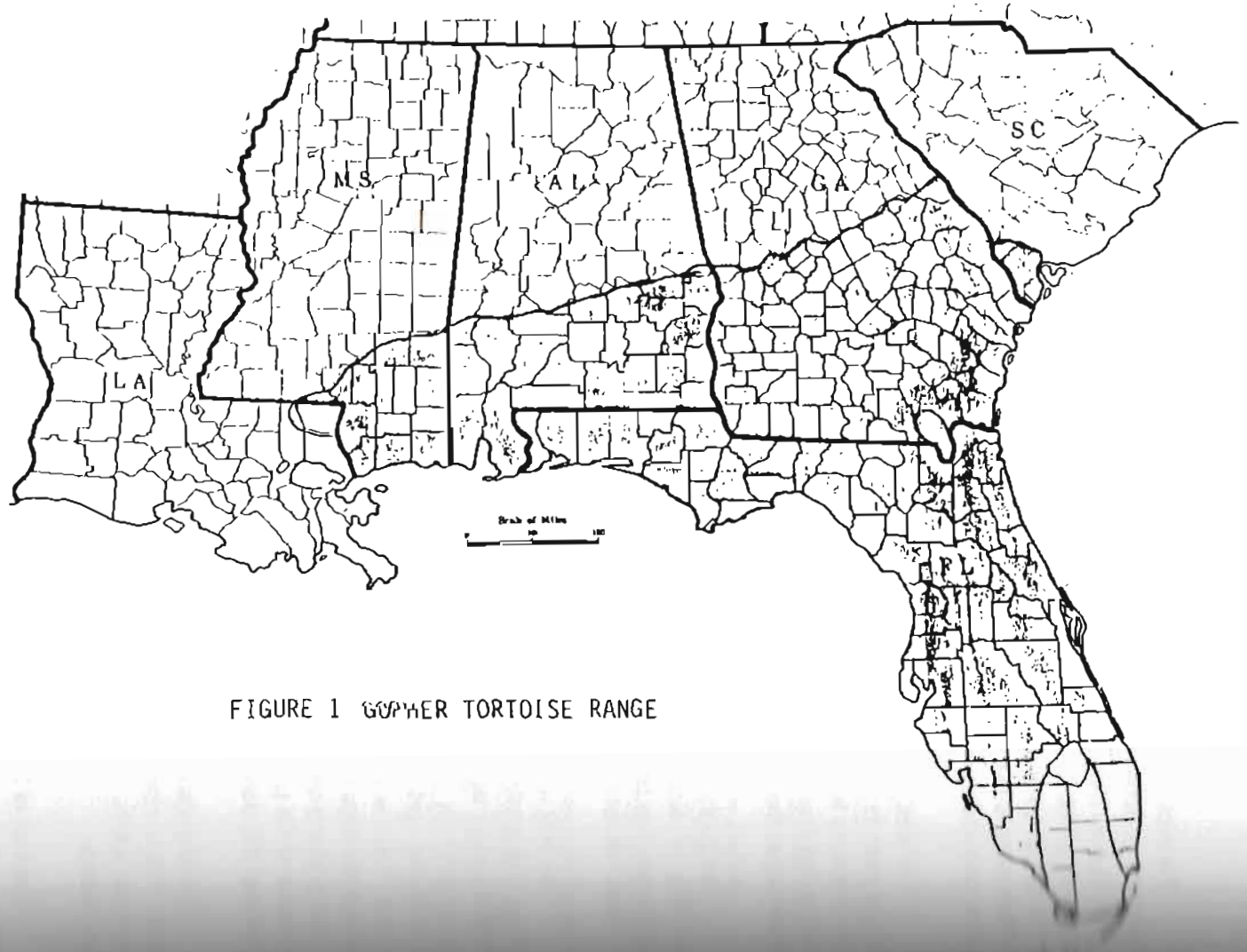

FIGURE 1 GOPHER TORTOISE RANGE

Already mentioned are the 358 coinhabitants or inquilines or users of abandoned burrows including dung beetles which convert the dung into soil nutrients, the gopher frog which is found nowhere else but the burrows, the pine snake, coachwhip racer, red rat snake, gray ratsnake, fox squirrel, opossum, raccoon, red and gray foxes, bobcat, armadillo and bobwhite quail. Based on this inventory, the tortoise is certainly the keystone species of this habitat. Two other reptiles that figure prominently in the sand hill story are the eastern indigo snakes and the eastern diamondback rattlesnake.

The eastern indigo snake was designated a threatened species by the U.S. Fish and Wildlife Service during 1978. Without help from mankind, this beautiful and important species could become extinct. In Georgia, it lives in gopher tortoise communities during certain seasons of the year, and uses the burrow as a winter refuge. Conservation of sand hill ecosystems is very important to the snake, gopher tortoise and the other species that are dependent on the burrow for refuge. The indigo snake and tortoise have declined in Georgia because sand hill terrain makes good pulpwood commercial forests, agricultural and pasture lands and home construction sites. If sand hills are clearcut and bulldozed, the ecosystem is destroyed. In some situations where light to moderate mechanical forest site preparation was performed, researchers found that significant mortality for adult tortoises in deep sand sites was reduced. Adults were able to dig out and travel to other sites. Some forest management practices actually enhance populations such as: controlled burning every one or two years, low intensity site preparation, planting fire tolerant commercial trees such as longleaf pine, and wide spacing of planted trees to allow preferred vegetation species of vegetation to grow.

More roads through sand hill areas means more animals will be killed by automobiles, irresponsible shooters, and those ignorant of the beneficial use of snakes will kill them on sight. Even people who like snakes have inadvertently contributed to the decline of indigo snakes by creating a lucrative commercial pet trade in these large, gentle reptiles. This has been largely curtailed by state and federal laws and prosecution of illegal offenders. Indigo snakes often do not fare well in inexperienced hands.

The presence of another dynamic and potentially dangerous snake, the eastern diamondback rattlesnake, brings yet another human pressure to the sandhill ecosystem. Because of man's fear of the rattlesnake, socialized events called rattlesnake roundups have sprung up in south Georgia, Alabama, and Florida. These events bring money to communities, encouraging the widespread collection and eradication of rattlesnakes. There is scant documentation of the infrequent bites to man and hunting dogs. Most of the snakes are processed for their meat, hides and other parts are processed for curios. The collection of the venom for processing into antivenom is a very minor economic gain to the profiteers.

Snakes are collected in the fall and winter while congregating in gopher tortoise burrows, and kept in various boxes, cans, and other makeshift receptacles. While the annual removal of large numbers of rattlesnakes is a cause for conservation concern, the greatest threat is posed by the commonly accepted method of capture by gassing. Gasoline or some other petroleum distillate chemical is routinely poured and subsequently blown through a long plastic hose into any gopher tortoise burrow thought to contain a rattlesnake. This method flushes the snakes to the surface where they are easily captured in a stupored state. The process is so simple that a child could accomplish the

act with ease. The results is a widespread elimination of the rodent eating rattlesnakes, with little [illegible] public safety benefit, and massive chemical contamination of subsoils and the delicately balanced gopher refuge. There is no documentation that contaminated burrows are reinhabited by the tortoises' coinhabitants. The practice continues unrestricted in Georgia, bus has been banned in adjoining states and on federal public lands. Research performed by Drs. Mount and Speake at Auburn University has shown that most snakes including the threatened indigo snake will succumb to the toxic fumes. No long term studies have been performed to measure the effect on the tortoises. If the snake fail to exit from the burrow, it is often dug up, destroying the burrow as a refuge for 358 other species.

The sand hill ecosystem is important to the survival of some of Georgia's most unique and specialized animal and invertebrate species. Without rational management and protection, this unique environment will be lost forever.

The sand hill ecosystems are ecological classrooms where the wonders and balance of nature are exemplified for youth and adult alike. Like all other facets of our natural world, portions must be preserved intact as indicators of ecological change and for posterity. If you want to conserve and manage sand hill ecosystems, indigo snakes, gopher tortoises and other denizens of the burrow, express your concerns to your elected and appointed officials who control state fish and wildlife agencies. Give your support to your state nongame wildlife and heritage inventory programs and encourage the agencies to give high priority to conserve and manage nongame species on public lands that they manage such as state parks and wildlife management areas. Above all, your personal commitment and involvement in nongame species conservation can make a difference to perpetuate our watchable wildlife and their unique habitats.

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THE CAPTIVE HUSBANDRY AND BREEDING OF THE GREEN IGUANA
Iguana iguana

Roger C. Cogan

INTRODUCTION

The green *Iguana iguana* is native to tropical America from central Mexico southward to northern South America. Reaching a fairly large size, with a stocky body and long tail. Some individuals have approached two meters in length. More commonly, however, adults are slightly over one meter long and weigh from 1.8 to 3.6 kg.

Contrary to popular belief, iguanas are not strict vegetarians. A fair amount of animal matter in their diet, in addition to leaves, blossoms, and fruits. They are excellent climbers and swimmers, and preferred living areas included large trees overhanging waterways. (Allen, 1951). They may dive from great heights to escape predators, including man. In protein-poor tropical America, iguanas are often featured on the menu.

Green iguanas have long been a common item it the pet trade with thousands of babies and juveniles leaving their home countries every year. The majority do not survive. Of the ones that do find their way into good homes, and reach adult size, most are kept singly. It is an enigma that a species as common and prolific as the green iguana rarely reproduces in captivity, even in those facilities where pairs or colonies are housed.

MATERIALS AND METHODS

In June 1984 a twelve year old captive male was acquired. It measured 91.4 cm. with incomplete tail and weighed 2.3 kg. Later, in September 1986, a nine year old captive female was also acquired. It measured 99 cm., also with an incomplete tail, and weighed 1.9 kg.

The animals are fed two to three times per week throughout most of the year, and every other day during the hot summer months. The diet includes, in-season fruits and vegetables (apples, pears, oranges, bananas, carrots, squash, etc.), cut into bite size pieces, various greens, dry and canned dog food, and spineless prickly pear cactus *Opuntia ficus-indica*, with occasional vitamin supplements.

During warm weather they are housed in an aviary measuring 3.7 x 2.4 x 1.8 m covered by 1.3 cm. hardware mesh. Logs and branches provide vertical climbing structures. Water is provided in a .9 x .6 x .6 m. concrete pond, with sprinklers supplying a cooling bath on hot days. Two pair of red-foot tortoises *Geochelone carbonaria* also share the enclosure. Fountain grass, bermuda grass and aloe vera are some of the hardier plants that co-exist with the reptiles.

During the winter the iguanas become household fixtures, often being perched on a table top or couch. A heating pad, set on low, makes them quite happy just to lie there. On warm sunny days, they are moved outside to be fed and to defecate, and brought back in at night.

BREEDING OBSERVATIONS AND EGG INCUBATION

During March 1987, when the nightly low temperatures began to stay above 15°C., both animals were left outdoors full time. As spring warmed up, the pair spent most of their time basking and consuming whatever food was offered. Courtship and breeding behavior was first observed during mid-April, and continued for almost three weeks. Usually around midday or early afternoon, head bobbing was observed. The male would often be near or on top of the female. When she was able to retreat he would rush toward her, and on occasion, violently bite the back of her neck trying to position his hindquarters beneath her. Actual copulation was not observed.

In Mid-May, no further courtship was observed. At this time, the female started digging burrows in three different locations, and on two occasions actually tunneled out of the enclosure. Although it was the best constructed burrow, it had to be closed off. On June 6 a new burrow was dug, 39 eggs were laid, and the nest site was completely covered.

The nest cavity was roughly 35.6 cm. deep and 30.5 cm. in diameter. The eggs were tightly packed together, with some soil in between the layers of eggs. The female vigorously guarded the nest site, thrashing her tail whenever approached. The eggs were removed during the night to prevent stressing her any further.

After the eggs were laid, she appeared extremely thin and exhausted. Although the eggs might have been hatched without problems in the nest, frequent temperature and humidity fluctuations can occur in sunny locations in Phoenix, and the decision was made to incubate the eggs indoors.

The eggs were placed in a large coffee can, one-third filled with moist vermiculite. The egg can was covered with alternate layers of vermiculite and soil from the nest site, and then the can was covered with a plastic lid. The egg can was then placed in a closet with a fairly constant temperature of 27°C to 29°C.

The eggs were checked weekly for development, humidity and to fan in fresh air. During the last two weeks of incubation, they were checked daily for early hatching. The first hatchling emerged on August 30, after 85 days of incubation.

With other species of reptiles, infants usually hatch and emerge within three days after the first hatchling cuts the egg shell, possibly to avoid predators from locating the nest site and consuming the hatchlings one by one. However, the clutch of iguana eggs hatched at a staggered rate in the following order; first day - one, second day - two, third day - one, fourth day-two, fifth day - four, sixth day - one, seventh day - two, and eighth day - one.

Fourteen of the 39 eggs successfully hatched with the hatchlings having an average length of 24.1 cm. After a week had passed, the remaining eggs were opened. Nine contained dead embryos in various stages of development, and 16 showed no evidence of embryos.

With few exceptions, the spring of 1988 was a re-play of 1987. Early warm temperatures allowed the pair to remain outdoors from the end of February. Courtship behavior was observed in early March. On March 19, copulation was observed. The female did not explore other nest sites, but on May 22 she laid 25 eggs in the same location as the previous year.

The hatching media, and temperature range were nearly identical from 1987, and August 21 to 25 hatching occurred. Again, the hatching was staggered; first day - one, second day - four, third day - two, fourth day - three, fifth day - four.

Fourteen of the 25 eggs successfully hatched with one egg containing a dead embryo and the remaining ten eggs showing no evidence of development.

HATCHLING CARE

Both clutches of hatchlings were housed and cared for essentially the same. The newborns were divided into two groups and housed in separate 1.2 x .4 x .4 m. aquariums, located out doors to catch the morning sunlight. Branches were added for basking and sleeping. Forest mulch was used for substrate and a small dish was provided for water. A large water dish had been tried but only succeeded in getting water and wet mulch throughout the cage and hatchlings.

The hatchling diet was similar in content and consistency as the diet given the adults. Fruits, vegetables and various greens were cut into bite size pieces (dusted with vitamin and calcium supplements), and offered every other day. Instead of dog food, game bird hi-pro crumbles were offered and readily accepted.

It had been reported (source unknown), that wild newborns are often found in association with adults and have been observed eating adult fecal, possible to obtain bacterial flora to aid digestion. To test the theory, on both years the hatchlings were divided into two groups. Group one was fed the standard diet listed above, while group two's diet was dusted twice with dried, ground adult fecal. No difference in growth or development was noted and neither group appeared to have problems assimilating food.

CONCLUSIONS

There are a wide variety of styles, approaches and techniques to achieve the goal of captive reproduction. The successes outlined by this paper were the results of sticking to the basics.

The animals were housed in a comfortable, stress-free environment. A varied diet, with vitamins as an additive not a substitute were offered and exposure to natural sunlight provided the appropriate cues needed to give the desired results.

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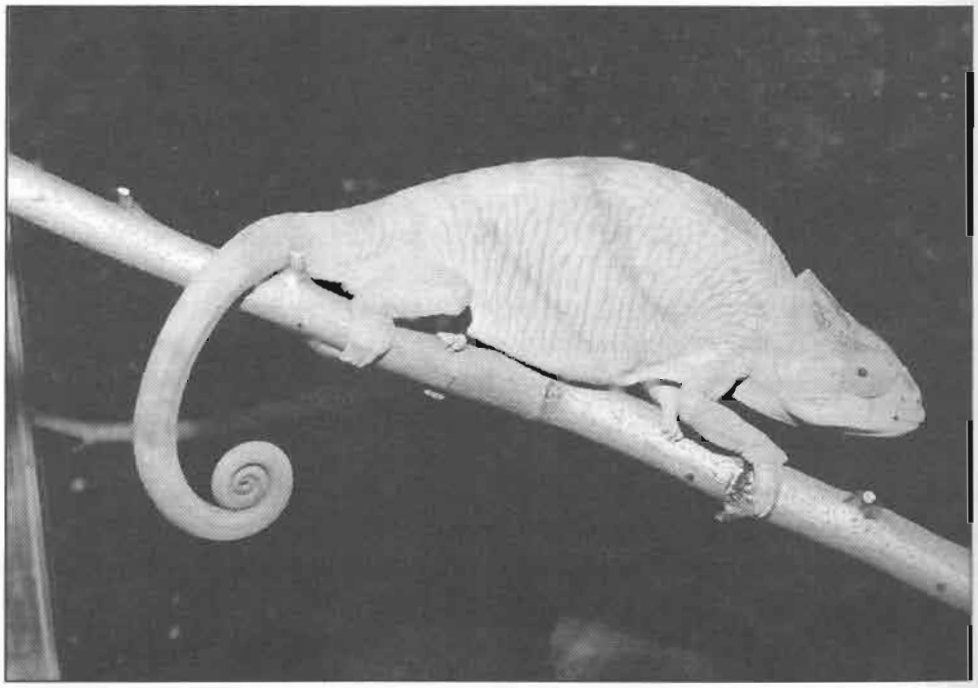

Parson's Chameleon (*Chamaeleo parsoni*)
Photo by Dr. M. J. Uricheck

POSSIBLE FIRST CAPTIVE BREEDING OF THE RARE OKINAWAN FROG *Rana ishikawae*

Philippe de Vosjoli and Robert Mailloux

In 1987 we were able to obtain six specimens of the rare Okinawan ranid *Rana ishikawae* from Pet Farm Inc. in Miami, Florida. We were told that three pairs of this frog were available but upon receipt of the animals and after close inspection we discovered that the group consisted of a single male and five females.

GENERAL INFORMATION

Name: *Rana ishikawae*, in the subgenus Hylarana, part of the *Rana chalconota* group.

Distribution: Amami Oshima I. and Okinawa I., Ryukyu Is., Japan

Size: We did not actually measure the animals prior to their release in a large enclosure. The females have an SVL of approximately 4 inches and the smaller male an SVL of approximately 3½ inches.

Secondary sexual characteristics: Females are larger than males. Upon close inspection one can notice posteroventral to the angle of the jaw, on either side of the head, the openings of the paired external lateral vocal sacs.

Habits: As suggested by their subgeneric name Hylarana, these frogs have features and behaviors characteristic of both hylids and ranids. Though ranid like in general form, they have well developed toe pads and less developed hind limbs than typical ranids. Behaviorally these animals are semi-aquatic as well as semi-arboreal.

HUSBANDRY

These frogs require very large enclosures to fare well in captivity, partially because they are active at many levels requiring a large water area, a shoreline section and a planted land area.

Our animals are housed in a section of a greenhouse 10 feet x 6 feet of which nearly half consists of a shoreline and extensively planted land area (bromeliads, Philodendron, Monstera) while the rest is a water area ranging from 12 inches to 1 inch in depth containing aged water recirculated through a water pump to create a small waterfall.

The temperature of the greenhouse ranges from 60°F as a winter low to 85°F as a summer daytime high. The frogs are exposed to the natural photoperiodicity of Southern California from exposure to sunlight filtered by fiberglass greenhouse panels.

MAINTENANCE

A 10% water change with tap water is done every 2 - 3 weeks as well as occasional flushing with aged pond water.

FEEDING

The frogs are fed 3 - 4 times a week, adult crickets coated with a 2 to 1 mix of Super Preme[illegible] calcium carbonate.

BREEDING

We initially had no breeding information on this species so decided to experimentally [illegible] for captive propagation. After a period of acclimatization, we attempted to breed *R. ishikawae* in the[illegible] of 1987 by placing the single male and two females in a rain chamber. After 24 hours the male was calling but no breeding observed. After 48 hours it was decided to inject the female with 0.1 mg/kg of LHRH. Eight hours later the male was injected with 0.01 mg/kg of LHRH. Within 12 hours the male was in amplexus and within the next 24 hours numerous eggs were laid in the rain chamber both in the water and on the foam rubber land section. The eggs were white with a tiny black spot on the upper surface of the nucleus. The adults were removed and the eggs monitored. After two weeks, none of the eggs showed signs of development and many were beginning to deteriorate. By the third week, it became clear that the eggs were either infertile or had for one reason or another failed to develop.

That winter we obtained with the help of Tamir Ellis of UC, Riverside translated a[illegible] brief paragraph on the natural history of this species. We also obtained from Corey Blanc, an Ameri[illegible] residing in Japan, information he had gathered on the northern Okinawan population of *R. ishikawae*.

In this population, breeding usually begins in January. Eggs are laid in chambers near pond shorelines (small cavelike depressions) containing shallow water. Egg development is very slow and the tadpoles remain in the chambers until rainfall flushes them out to larger more permanent bodies of water.

Based on this information we modified the Ishikawae vivarium by segregating a section of the shoreline with shallow water by overhanging black polyethylene plastic to create a dark cave like area with a low water section. The frogs rapidly adopted this "cave" as their favorite "niche" and from then on have been seldom seen in the open except at night which appears to be their favorite activity and feeding period.

In early February of 1988 after one of our occasional examinations of the cave section, we noticed for the first time a large clump of eggs numbering 1000 or more in a very shallow (approximately 1 inch) section. A week later a second clump was noticed. Two and a half weeks later a few tadpoles hatched from the first clump of eggs. Eventually a few also hatched from the second clump. Fertility and hatch ratio were very low with only 40-50 tadpoles hatching.

For almost a week after hatching the tadpoles remained in the cave. Eventually they ventured out into the larger and deeper water section.

REARING THE TADPOLES

During the day the tadpoles remained concealed under wood or rocks arranged at the bottom of the water section. Though offered fish flakes and vegetable matter, they were not observed to feed on these but at night they sifted what we assumed was nutritious sludge at the bottom of the water area. We removed four tadpoles and kept them in 20 gallon aquarium for observation. Again we noticed the

fact that the tadpoles fed at night on the residual sludge at the bottom of the tank. After three and a half months, the hind legs appeared. At that time momentary carelessness caused us to forget to turn off the water during a water change and all the tadpoles in the main area died probably because of the chlorine in the tap water. In a period of about an hour all our hopes of successfully breeding fell down the tubes. Except that we still had four remaining tadpoles. These had grown at a much slower rate than the group in the large water section. By the end of the fifth month the four tadpoles eventually metamorphosed into miniature *Rana Ishikawae* ( ). They were transferred to a 100 gallon custom made vivarium designed to provide as wide of a range of microhabitats as the large vivarium ion the greenhouse. The froglets have fed readily on half grown crickets and at the time of writing, nearly a year after they metamorphosed, they are almost half the size of their parents.

CONCLUSION

We hope that this partial success at breeding *Rana Ishikawae* may serve others who may have the opportunity to work with this rare and beautiful ranid. We also hope that some of the methods presented may serve as models for the breeding of other anuran species and that other herpetoculturists may learn from our mistakes. Don't forget to turn off the water.

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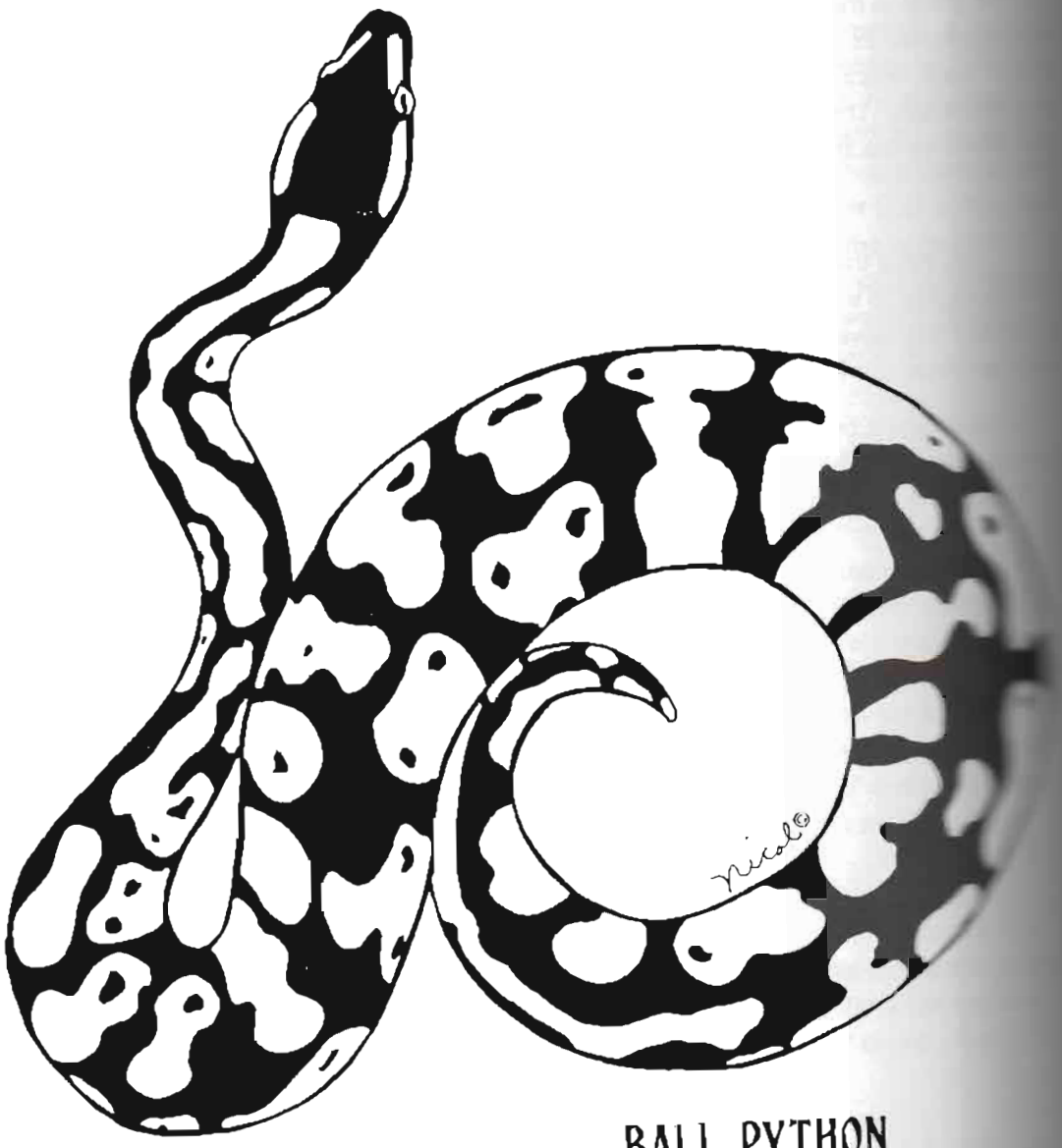

BALL PYTHON
(Python regius)

BREEDING ON THIN ICE: THE HUSBANDRY AND PROPAGATION OF THE MALAGASY TOMATO FROGS *Dyscophus antongilii* and *D. insularis*

Philippe de Vosjoli and Robert Mailloux

In 1986 we were fortunate enough to obtain some of the last legally imported tomato frogs *Dyscophus antongilii* before their listing as a CITES Appendix 1 animal. After some initial failures we eventually developed methods that have allowed us to successfully breed this species 15 times of which 9 eventually yielded a total of more than a thousand froglets that were distributed through commercial and noncommercial channels to both private individuals and institutions.

In 1988 we were also able to obtain adult specimens of the Southern tomato frog *Dyscophus insularis*. At the time of writing we have bred this species twice. Recently we have obtained a single pair of the third species of tomato frogs, *Dyscophus guineti*, but the single female in our possession arrived injured and may not survive.

This paper is a summary of our observations and the methods we have developed for successfully maintaining, propagating and rearing tomato frogs. In spite of our relative success with these species, the long term status of *Dyscophus antongilii* in herpetoculture rests on very fragile ground. The genetic pool of specimens being bred in the U.S. is precariously small. Of the few hundred adults originally imported from Madagascar, few are still alive. Of the captive bred specimens that have been distributed, few have been successfully raised to reproductive maturity. With some luck, the first F2 *D. antongilii* will be produced in late 1989 or early 1990 probably the result of a brother to sister cross. Taking all of these factors under consideration, combined with the fact that female Dyscophus may require three or more years to reach sexual maturity, it will require many years before steady large scale production of these frogs become feasible in the U.S.

In our opinion, efforts should be made to import wild caught specimens of *D. antongilii* from Madagascar to be distributed to qualified institutions and individuals for the purpose of propagating and distributing captive bred froglets from a diversified genetic pool. Adult specimens would also allow for research to determine reproductive capacity of the species and to identify some of the biochemical factors associated with the egg mass as well as tadpole development.

GENERAL INFORMATION

The frogs popularly know as "tomato frogs" in herpetoculture consist of 3 species of Dyscophine microhylids from Madagascar, a large island off the southeast coast of Africa. All belong to the genus Dyscophus.

The three species and their distribution are as follows:

Dyscophus antongilii. (Grandidier 1877)
Distribution: Northeastern Madagascar

Dyscophus guineti (Grandidier 1875)
Distribution: Eastern, northwestern, and central Madagascar

Dyscophus insularis (Grandidier 1972)
Distribution: Southern and western Madagascar

All above information from Frost 1985

HUSBANDRY AND PROPAGATION OF THE TOMATO FROG
Dyscophus antongilii

The information contained in this section is applicable to the two other species of tomato frogs and should be referred to for information on husbandry and propagation of those species.

GENERAL INFORMATION

Common name: Tomato frog
Scientific name: *Dyscophus antongilii*
Size: Females up to 10 cm SVL, males smaller up to 5.5 cm SVL.
Secondary sexual characteristics: Females larger than males. Wild caught adult females are a bright tomato red while males are a dull orange or a faded red or reddish brown in coloration.
Females have a whitish throat with some red only along the margins while males have an orange throat.
Reproductive maturity: This is the age at which given species is capable of successfully reproducing.

In frogs size is not necessarily a good indicator of reproductive maturity when one is dealing with captive raised animals. Under the conditions of captivity frogs will often grow at a rate considerably greater than animals in the wild. Physiological maturity however will not always correlate with external appearance. This became obvious to us in the course of working with Budgett's frogs *Lepidobatrachus laevis* and African Bullfrogs *Pyxicephalus adspersus*. A Budgett's frog we raised from a captive bred tadpole achieved the size of a very large wild caught female by 14 months. Yet we were unable to obtain eggs from this animal until the age of 26 months. On the other hand some smaller females laid very small numbers of eggs by the age of 20 months.

The African bullfrog in the wild usually does not breed until at least 4-5 years old. In captivity specimens will reach adult size in just a little over a year but will not reproduce successfully until at least two years and preferably three years old. Furthermore inducing these frogs to breed at a younger age with the use of hormones may still not indicate sexual maturity in a practical sense. It may not be healthy for females to breed as soon as they are physiologically sexually mature. In the wild environmental factors may not necessarily induce reproductive activity in females that are just beginning to become physiologically mature. In captivity, inducing breeding in "young" females usually results in very small numbers of eggs with relatively small diameters.

The point is that all frogs are not Argentine Horned frogs that can reproduce by the age of 12 months. In fact many species may require three or more years to achieve effective reproductive maturity.

Using LHRH to determine sexual maturity in female *D. antongilii*, we were able to obtain eggs from one out of four females attempted at an age of 19 months. The same female laid a very small number of eggs at an age of 26 months which were successfully fertilized by a wild caught male. The three other females at 26 months still failed to produce eggs. To minimize stress on these young animals we have decided to postpone further experimentation until the animals are at least 32 months. We feel, at this point in time that Dyscophus, even in captivity should probably not be bred until at least 36 months of age.

Our experiments with males yielded more or less similar results. One out of four males performed amplexus at an age of 16 months but failed to fertilize the eggs of the female with which it attempted to reproduce. At 24 months the other three males still failed to respond to a low dose of LHRH (0.001mg/kg) which readily elicits amplexus in wild caught males.

The age of reproductive maturity in Dyscophus is probably the single most critical factor other than the limited gene pool of captive animals likely to affect the future of *D antongilii* in captivity. In the course of three years a lot of things can go wrong particularly when dealing with frogs, animals with tedious husbandry requirements and high mortality rates both in the wild and in captivity.

Note: To determine sexual maturity in frogs via the use of hormones we recommend using half the standard dose used to induce breeding in adults to minimize stress in immature animals. LHRH affects the sympathetic nervous system in a manner similar to norepinephrine (which can be used to induce breeding in certain species). Accompanying symptoms include increased breathing rate, probably increased heart rate, enlargement of the pupils, increased energy expenditure and depressed immune system. An overdosed male for example may amplex a female for days causing stress in both the female and itself. Often if too high a dose of hormone is used, the animals may succumb to a disease frequently with the symptoms of "Red leg" after the overdose symptoms subside. Used properly gonadotropic and pituitary stimulating hormones are invaluable tools in herpetoculture. For further information on methods for breeding tropical frogs see De Vosjoli et al. 1988.

Skin: When subjected to trauma all Dyscophus, particularly females will release through the dorsal skin of the body a thick sticky white secretion. When handling one of these animals this feels like someone suddenly released a tacky glue in the hand impairing the free movement of the fingers. Interestingly within a couple of minutes the secretion loses it adhesive qualities and simply becomes mucoid. Whether the secretion is also toxic or an irritant has not yet been determined. Nonetheless the dorsum is not a recommended site for injection in this species.

The ventral skin of Dyscophus when the animal inflates itself is extremely turgid and strong. Even a tuberculin needle will usually fail to penetrate the skin but instead simply scratch the surface. For the purpose of injection the best method is to find an area where the skin forms a wrinkle preferably when an animal is not fully inflated. Even then a new and well sharpened needle must be used.

HUSBANDRY OF *Dyscophus antongilii*

The tomato frog is a terrestrial anuran which is relatively hardy and easily maintained in captivity. For both institutions and private herpetoculturists this species makes an outstanding display animal in naturalistic vivaria.

Size of enclosures

A safe guideline is one square foot of floor surface for the first animal and an additional half square foot for each additional animal.

Number of animals per enclosure

We recommend that tomato frogs be housed in pairs. Single animals tend to become [illegible] and become prone to obesity. If kept in enclosures that are not too large, interactions between a pair tend to cause a certain degree of activity which we felt is beneficial. On the other hand housing large numbers of adult animals together increases the probability of disease (increased wastes and increased stress). And if one animal does become ill, one risks losing the entire group.

The design of naturalistic vivaria for the display of tomato frog

For display purposes tomato frogs can be housed in naturalistic vivaria with either a soil/peat mix or pea gravel as a ground medium. If a soil/peat mix is used, a drainage layer consisting of [illegible] inches of pea gravel should underlie the ground medium. Shelters make of bark, hollowed out wood sections or carefully arranged rocks (held in place with silicone sealer) can be placed in vivarium as well as wood sections or rocks for decorative purposes. Sturdy plants can be planted directly into the ground medium or introduced in their pots which can be buried in the medium or strategically placed so that they are concealed by rocks or wood. Suitable species include larger Philodendron species, *Monstera deliciosa*, broad leaved Sanseverias as background plants. Ground cover species should not be used as they tend to become dense and can interfere with the frogs ability to move about the enclosure and with their feeding.

Water

A water area equivalent to 25% of enclosure surface should be provided. This can be done by sinking a pan into the ground medium or by sloping pea gravel (if this is used) to create a water area or by creating a water section in the enclosure by siliconing a strip of plexiglas to the bottom and sides of the enclosure to create a water area. In any case a procedure should be developed to be able to regularly and easily change the water and clean out the water area.

The water should be of good quality moderately hard and slightly alkaline. The depth of the water should be no more than two thirds the height of the smallest frog when at rest. Tomato frogs are poor swimmers and if unable to rest on the bottom of the enclosure with their nostrils clearly above water will drown unless there is easy access out of the water section.

Enclosure cover

The enclosure of a tomato frog should be covered with either a screen top or some other perforated top. Tomato frogs, particularly males can jump quite well when they want to.

Temperature

Tomato frogs fare well at a temperature of 78°F - 82°F. During the winter the frogs can be maintained at temperatures of 70°F - 74°F and will survive short periods at 65°F.

THE DESIGN OF FUNCTIONAL VIVARIA FOR THE MAINTENANCE OF TOMATO FROGS

For commercial and research purposes tomato frogs can be maintained in more easily cleaned and controlled vivaria.

Housing

One pair of tomato frogs can be kept in Rubbermaid semi-translucent (polypropylene ?), semi-flexible storage boxes. These boxes are ideal for housing large numbers of frogs. They are light, easy to clean and disinfect and do not break or crack easily (unlike the polystyrene clear plastic boxes).

Design

Inside each box we place over 50% of the bottom a 2 inch layer of foam rubber with the edge toward what will be the water area sloped by cutting with a single edge razor blade. We then add water to the appropriate height (no more than two thirds of the height of the smallest frog when at rest). The lid of the box is perforated with a drill, the frogs introduced and the box placed on a shelf. A new taller box is now available from rubbermaid which allows for good visibility and easy observation of the animals. The same boxes with thinner layers of foam and lower water depth can be used to house subadult froglets.

FEEDING TOMATO FROGS

Tomato frogs at all sizes should be fed a varied diet as follows:

Adults

Twice a week, an amount equivalent to a level tablespoon of any of the following to be varied and/or alternated; 3-4 day old "pink mice" with their rumps dipped either in Osteoforme or in calcium carbonate. Crickets, waxworms, just molted king mealworms (Zoophobas) coated with either Osteoforme or a two to one mix of a powdered multivitamin such as Super Preen or Reptivite and calcium carbonate. If animals appear obese then amount should be cut down.

Subadults

Three times a week as much as they will eat a varied diet of the following: 1-2 day old "pink mice", smaller crickets, waxworms, just molted standard mealworms (Tenebrio) supplemented as mentioned above. Remove all excess food by twenty minutes after introduction.

Juveniles

Every one or two days, as much as they will eat a varied diet consisting of pinhead to week old crickets, tiny mealworms (must be cultivated), small wax worms (must be cultivated), wingless fruit flies, fruit fly larvae, black ants (introduce in small numbers only to prevent swarming) all supplemented as mentioned above under Adults. Most excess food should be removed within twenty minutes of introduction.

BREEDING

Our approach to captive propagation is to establish methods for consistent and predictable breeding of herptiles. We often use a combination of methods including environmental conditioning and the use of gonadotropic and pituitary stimulating hormones.

Breeding by environmental conditioning

D. antongilii can be bred using only environmental conditioning but breeding in this manner is not usually consistent. For those interested this can be done by introducing adult healthy animals in a rain chamber with a foam rubber land area and a water area no more than two thirds of the height of the smallest animal when at rest. A shelter should be placed on the foam section so the animals can remove themselves from the simulated rain. The animals should then be exposed to a schedule of 3-4 hours with rain alternated with 18-24 hours without rain. If a pair is in amplexus in the water, the rainchamber water pump should be turned off. Successful breeding will occur during the off cycle of the rain chamber when the female may lay up to three thousand floating eggs. Once laid these floating eggs should not be exposed to rain or they will sink to the bottom of the rain chamber. Hatching success with submerged eggs is often poor.

The above mentioned rainchamber schedule can be applied for up to a week until a pair successfully breeds remembering that the chamber should be turned off when a pair is in amplexus in the water. We suspect that in the wild actual egg laying may occur in a sheltered shoreline area and that the purpose of floating eggs is for dispersal.

This same method can be used to breed the common Kaloula pulchra from Southeast Asia, a species whose breeding habits appear to be very similar to those of *D. antongilii* (See Zimmerman).

Breeding by injection with LHRH

The first breeding of the tomato frog using LHRH was done by Ernie Wagner of Seattle, Washington (Wagner 1988). Using our own methods for determining breeding schedules we have modified Ernie Wagner's schedule in a manner which we believe leads to greater breeding success with this species. Our recommended schedule is as follows:

Day 1

Inject an adult female healthy, acclimated and not obese with LHRH, subcutaneously and ventrally at a dosage of 0.1 mg/kg. Place the female in a large aquarium with a bottom surface of 4 square feet or more and introduce a mature male. On one side of the aquarium place a sloped land area of foam rubber covering 20% of the length of the aquarium. Add aged dechlorinated/dechloramined water with a Ph of 7.4 to 7.6 and moderately hard to a height two thirds of the height of the male when at rest. Water temperature should be 76°F-78°F degrees Fahrenheit.

Day 2

At 24 hours after initial injection of female, the male without injection of LHRH will often be in amplexus with the female on the land area. If the male is not in amplexus, reinject female with LHRH at a dosage of 0.01 mg/kg. Inject the male with LHRH at a dosage of 0.001 mg/kg. To be effective at this dosage LHRH must be fresh. Mature males will usually amplex the females within two hours of injection. Amplexus must normally occur on the land area prior to actual breeding. A female ready to breed will normally accept a male while females not ready to breed will inflate with air and emit release calls.

Actual breeding and egg laying usually occurs between 36 and 48 hours after initial injection of females. Eggs float on the surface and can number from a few hundred to 2 - 3 thousand.

Evaluating the egg mass

Floating eggs with the dark poles up will usually be fertile and successfully hatch as long as the floating mass is single layered. If the egg mass is disturbed so the eggs become multi layered or clumped then hatch rate will be poor presumably because of diminished O^2 availability to eggs. Eggs with white poles up with usually prove to be infertile. Submerge eggs have a poor hatch rate and larval survival rate.

Behavior of the egg mass

The egg mass of *D. antongilii* and other species of Dyscophus is capable of motion. If water is poured at one end of the enclosure then the egg mass moves toward it. We suspect this plays a role in egg dispersal.

After egg laying is completed, the adults should be removed and by using a thin plastic hose, water gradually added very slowly to the bottom of the container to a height of 8 inches. Extreme care must be given not to disturb the floating eggs. If the breeding container is small the water can be aerated without disturbing the eggs by placing an airstone between the foam land area and the wall of the enclosure. Thus aerated water will trickle through the foam to the main water section without causing any surface disturbances.

The next herpetocultural step will be critical if one is to successfully rear a large number of Dyscophus tadpoles.

Inhibitory factors

We have not yet been able to isolate what we suspect is an inhibitory factor in either eggs and/or tadpoles of Dyscophus species. This a project that we hope to complete in the future. Nonetheless these are the facts that we have observed.

If a hatch of tadpoles is left in relatively small volume of water for 12-24 hours in the breeding enclosure with egg remains their growth with be critically limited. If left for 48 hours, growth and health of tadpoles will be so inhibited that most will die in a few days without any signs of attempting to feed. After the above mentioned periods, transfer to large containers of clean water will not change the course of the deterioration.

Raising Tadpoles

As a rule the sooner Dyscophus tadpoles are transferred to rearing containers and the less crowded the rearing conditions the better they will fare and the larger they will grow. Again, as with fish there appears to be an inhibitory factory released under crowded conditions (volume of animal(s)/ volume of water).

To successfully rear Dyscophus tadpoles they should be transferred as they are hatching or even by removing carefully with a container floating eggs near hatching and transferring them to rearing containers at a density of no more than 10/gallon of water. (for a good hatch this can mean 200 - 300 gallons of water). We use up to twenty five 20 gallon polypropylene bins to segregate the tadpoles as much as possible. If reared in a single container the risk of losing an entire hatch to a disease or other problem is high.

Carefully removing larvae on the bottom of the enclosure with a container by using water displacement also works well.

If no other containers are available then water in the breeding container should be flushed at regular intervals by introducing water slowly to the bottom of the tank through a plastic hose so that eggs on the surface are not disturbed. Water, bad eggs, dead larvae and egg debris should be carefully siphoned using a thin plastic hose. Flushing in this manner 3-4 times a day combined with increasing the water level by carefully adding water to the bottom of the enclosure can control inhibitory effects until the rearing enclosures are set up. After eggs are hatched the water should be aerated by addition of an airstone (very slow rate) at one end of their enclosure.

Setting up the rearing containers

The rearing containers should initially have a water height no greater than 8 inches of water identical to that of breeding container. The water must be aged at least 48 hours to eliminate dissolved gases.

For a day following hatching the larvae tadpoles will lie on their sides with occasional movement. On the second day most tadpoles will begin swimming and assume the typical Dyscophus tadpole shape. After day three, the water level can be slowly raised to 12 inches. A sponge filter should be set up for filtering water. We use the large Tetra Billi filters because they are easily cleaned. The sponge units should be thoroughly cleaned every 2-3 days. The temperature should be 78°F-82°F. A 10% water change should be made every 2-3 days with water conditioned as mentioned above.

Remove dissolved gasses is critical.

Rearing tadpoles

The choice food for rearing Dyscophus tadpoles is Tetramin Basic Flakes. Another food which also works Hi Promin by Wardleys. Bulk tropical fish flakes sold in most pet stores were for the most part refused.

The tadpoles are offered a pinch of flakes per 150 tadpoles twice a day, morning and evening. We also add a half dozen small ramhorn snails in each enclosure.

The tadpoles do not usually feed from flakes on the surface but rather consume them on the bottom after they form a type of sludge. For reasons which need to be clarified, tadpoles with snails in their containers (as long as snail numbers are controlled) appear to fare better and grow better than tadpoles raised without snails. The snails through their feeding and defecating seem to contribute some nutritious sludge that these tadpoles feed on. Furthermore the snails will consume excess flakes that fall to the bottom and thus reduce fouling rate of the water.

Gas bubble disease

Of all the problems one is likely to encounter when raising tomato frog tadpoles, gas bubble disease is possibly the most decimating. If tap water containing a high level of dissolved gases is used when changing water, particularly if the temperature of the new water is higher than the temperature of the water in the rearing container, within an hour every tadpole in the container will manifest symptoms

bubble disease. In Dyscophus tadpoles this manifests itself by either the formation of gas bubble(s) under the dorsal skin or in extreme cases by the formation of a gas bubble ventrally in the area surrounding the heart. In these extreme cases the tadpoles lie on the surface belly up and eventually the skin over the heart ruptures exposing the beating heart. These tadpoles soon die. Tadpoles with gas bubbles forming in the dorsal area will often swim on the surface for hours or a few days. Some survive but many will eventually die. To have all of one's efforts end up literally belly up can be quite discouraging. One cannot emphasize enough the susceptibility of these tadpoles to gas bubble problems.

Following the above mentioned procedures, the first tadpoles will metamorphose by the fifth week following egg laying.

Rearing the froglets

Metamorphosing froglets of *D. antongilii* must be transferred into a tilted shallow water container (with water on the deep end just barely covering the heads of the animals) as soon as the forelimbs emerge. If not removed from the rearing container within a few hours of forelimb emergence, the froglets will drown. Two days after forelimb emergence the tail is mostly reabsorbed and the tiny Dyscophus froglets (approximately 3/8 of an inch) are ready for transfer into froglet rearing containers.

Rearing of Dyscophus froglets is essentially the same as rearing newly metamorphosed Bufo. Because of the numbers and small size of these froglets, using containers with paper towels or foam rubber as a ground medium quickly becomes problematical since all froglets have to be removed every time the container is cleaned out. After several experimental enclosures we have arrived at a basic rearing enclosure design which yields good results with minimal maintenance for the housing and rearing of froglets. First a large enclosure is required. We recommend an aquarium with at least four square feet of bottom surface with a screen top. On the bottom of the aquarium, place a 1 inch layer of pebbles for drainage and above that 1-2 inch layer of a mix consisting of 50% peat moss and 50% potting soil, evenly moistened but not soggy (Potting soil must not contain perlite). The surface should then be compacted by patting it down with the palm of the hand so that it is smooth without multitudes of soil particles that could adhere to the froglets as they move about the enclosure. Toward both ends of the enclosure low shelters should be constructed by placing either a thin wood board or sheets of dark Plexiglas over ½" strips of wood. Openings to the shelters should be directed along the length (not the width) of the enclosure. In the middle of the enclosure a plastic sweater box lid should be partially sunken into the ground medium and water equally ½ the height of a froglet should be added. If necessary a drain hold should be made at this level.

Up to 20 newly metamorphosed froglets per square foot can be added to the enclosure. The top should be covered with a screen because the froglets can walk up glass sides and escape. After 4-6 weeks the froglets will have more than doubled in size and will have be segregated in correspondingly larger enclosures.

Feeding of froglets

For the first 4-6 weeks, the froglets should be fed every 1-2 days, pinhead to week old crickets, tiny waxworms and mealworms, wingless fruit flies, fruit fly larvae; all coated with either Osteoforme or a mix or 2 parts Super Preen to 1 part calcium carbonate. If introduced in small numbers small black ants

are also readily eaten by these froglets. As the tomato froglets grow, food size should be correspondingly increased. By the time they are 1 3/4 inches long they should occasionally be offered day old pink mice with their rumps dipped in calcium carbonate.

DISEASES AND DISORDERS

After our initial breeding of *D. antongilii* we gave away various hobbyists over 100 four week old froglets which we considered established. At the end of one year only a single frog remained alive. Some of the froglets died of neglect, others from overcrowded rearing conditions but many of the animals died when they were older and larger. Among the froglets that we have held back the majority have been successfully raised to adult size. But a number of specimens from our initial breeding showed clear signs of early dietary deficiency. These played a key role in our modifying our diet and feeding procedures to assure proper calcium and D3 intake. From information gathered from hobbyists and from our own observations and records we have concluded that in captivity, the single most important factor likely to affect the survival of Dyscophus froglets is diet.

The following is a list of problems we have observed and/or recorded from reports on captive raised Dyscophus.

1. Hind limb paralysis: This is one of the most frequently reported symptoms preceding death of larger captive raised frogs. The paralysis may last for days or even weeks before the animal dies.

Feeding is critically impaired. In once case where we administered twice a day calcium with liquid vitamin by stomach tubing, the frog regained use of its hind limbs after three days. This was one of three cases of hind limb paralysis we have observed in our animals. Other hobbyists have had 100% mortality in groups of up to 8 animals preceded by this symptom. We suspect that the cause may be calcium deficiency but another possibility may be a calcium defficiency but another possibility may be the absorption of a toxin or excessive calcium intake.

2. Skeletal deformities: These can almost always be attributed to inadequate calcium intake. They can usually be prevented by proper feeding procedures including use of supplements and the removal of uneaten food within 15 minutes of introduction.

Types of deformities

a. Pelvic deformities: These are frequently observed deformities in frogs raised on a calcium deficient diet or on a diet with improper calcium to phosphorus ratio. Externally these often appear as dorsal deformities with prominence of the sacral diapophyses we suspect caused by fused ilia and coccyx or abnormal skeletal development.

b. Hindlimb deformities: Often these are not so much hindlimb deformities as the result of pelvic deformity modifying the articular position of the femurs which ends up causing deformities in the hind limb themselves.

c. Drooping lower jaw: This is a common symptom in calcium deficient frogs with thin boned mandibles (e.g. Lathery caerulea). If diet is not properly modified, these frogs eventually cannot

longer able to capture prey because the lower jaw is so decalcified that it becomes flexible. Another possibility is skeletal deformity caused by inadequate calcium phosphorus ratio.

Other diseases and causes of death

a. A type of "red leg," possibly caused by Aeromonas, sometimes occurs when frogs are maintained under unsanitary conditions. Symptoms include extensive enlarged and broken capillaries on the ventral surface of the body and limbs. This may be treatable by Tetracycline administered orally but the stress of administering medication further contributes to the decline of affected animals. Improving sanitation is an obvious course of action. Occasionally frogs with these symptoms will improve on their own but more often than not end up dying.

b. Stress and stress related death: Dyscophus are not very tolerant of extended stress through handling or stressful environmental factors. They are for this reason difficult to medicate either orally or through injection. When handled many specimens readily secret a sticky white mucus from the dorsum. Dyscophus will also resist forcefully and stubbornly stomach tubing.

Frogs subjected to prolonged stress may also die suddenly from a type of stress syndrome we have also observed in other species where a stressed animal suddenly extends the hind limbs, becomes rigid and dies. We suspect this to be the result of metabolic demands made by noepinephrine or similar substance that are greater than a given animal can accommodate at the time.

HUSBANDRY AND PROPAGATION OF *Dyscophus insularis*

General information

Common name

On the rare occasions when it is available in the trade this species is often listed in the trade as the northern tomato frog, a name more appropriate for *D. antongilii*. *D. insularis* is in fact a southern species.

Size: Females up to 10 cm SVL
Males up to 5.5 cm SVL

Secondary sexual characteristics

Females are larger than males. Adult females are a dull to bright orange with fine reddish brown vermiculation. Males are similar but with duller background coloration. Some of the males we have obtained as *D. insularis* have lacked any vermiculations while others have been an even dull reddish brown rather than orangish. The latter we believe are probably not *D. insularis*. All adult males have an orangish throat while the throat of females is whitish with an orange border. Reproductive maturity: Probably the same as for *D. antongilii* but this has not yet been determined.

HUSBANDRY AND PROPAGATION OF *D. insularis*

The husbandry and propagation of *Dyscophus insularis* has proven to be virtually identical to that of *D. antongilii*. Newly metamorphosed froglets appear to be slightly larger than *D. antongilii* froglets. Dorsal coloration of 3/4 inch froglets is a bright almost golden yellow compared to the copper gold of similar sized *D. antongilii*.

The case of the blind *D. insularis*

Our initial breeding of *D. insularis* was between a typical female and what we believed to be the time a typical male, the male was a dull reddish brown with no vermiculations. Having had no experience with this species, we had trusted the reputable seller's identification of the male. The result of the first breeding were several hundred vigorous and comparatively dark tadpoles. These larger than any *D. antongilii* we had previously reared. However as the tadpoles approached metamorphosis the eyes began to atrophy. Eventually the eyelids extended beyond the atrophied and by the time the forelimbs emerged had completely covered the eyes and fused together. This occurred to all tadpoles/froglets in that group. We now are convinced that we inadvertently hybridized *D. guineti* with *D. insularis* since subsequent breeding of *D. insularis* where the male was similar to female in appearance resulted in light honey yellow tadpoles similar to those of *D. antongilii*.

The most remarkable aspect of this story is that many of these froglets are still alive, and healthy and are growing.

They have in fact demonstrated an adaptive ability which one would not expect in a species where vision is so necessary for prey capture as it is in the great majority of frog species.

At first after having observed the froglets flicking their tongues and capturing pinhead crickets we had suspected that maybe a highly sensitive olfactory ability was involved but subsequent experiments using live blackworms (which are very odorous) disproved these notions. Only careful observations revealed that these frogs fed readily only when the crickets were introduced at high densities and that they were able to capture with precision from tactile cures crickets that inadvertently touched their anterior digits. Aside from the remarkable indication of adaptability in these frogs, many questions are raised as to role of the anterior digits in conveying information to these species.

CONCLUSION

Both *Dyscophus antongilii* and *D. insularis* can be propagated with consistency and predictability in captivity with the use of the pituitary hormone LHRH. However, the several years required for these species to attain reproductive maturity will delay the establishment of these species herpetoculture. The future of *D. antongilii*, now an Appendix 1 species also appears precarious because of the limited gene pool established in captivity. Until F2 and F3 generations are produced diligent efforts must be made to propagate remaining imported specimens and to diligently maintain and breed maturity captive bred animals.

Furthermore, Dyscophus species have yet to reveal their physiological and biochemical secrets. As with hundreds of other frog species, the potential of these animals as sources of pharmaceuticals and new biochemical pathways remain untapped.

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CAPTIVE REPRODUCTION OF THE BLACK-EARED FROG *Leptodactylus melanonotus* AT THE ARIZONA-SONORA DESERT MUSEUM

Craig Stephen Ivanyi

Twenty one species of amphibians are currently maintained at the Arizona-Sonora Desert Museum (A.S.D.M.). Most of these are anurans (frogs and toads):

Canyon treefrog (*Hyla arenicolor*)
Mounting treefrog (*H. eximia*)
Burrowing treefrog (*Pternohyla fodiens*)
Mexican treefrog (*Smilisca baudini*)
Mexican leaf-frog (*Pachymedusa dacnicolor*)
Chiricahua leopard frog (*Rana chiricahuenis*)
Tarahumara frog (*R. tarahumarae*)
Barking frog (*Hylactophryne augusti*)
Black-eared frog (*Leptodactylus melanonotus*)
Couch's spadefoot (*Scaphiopus couchi*)
New Mexico spadefoot (*S. multiplicatus*)
Sononran desert toad (*Bufo alvarius*)
Great Plains toad (*B. cognatus*)
Western green toad (*B. debilis*)
Giant toad (*B. marinus*)
Sinaloan toad (*B. mazaltlanensis*)
Red-spotted toad (*B. punctatus*)
Sonoran green toad (*N. retiformis*)
Woodhouse's toad (*B. woodhousei*)

Additionally, a few caudatans (salamanders and newts) are represented:

Tarahumara salamander (*Ambystoma rosaceum*)
Tiger salamander (*A. tigrinum*)

These animals are used primarily as subjects for educational exhibits, presented in correct ecological contexts. Secondarily, selected species with tenuous futures and/or which are difficult to obtain are targeted for captive reproduction. Among these are a number of species occurring in Sonora, Mexico, which in recent years, have become difficult to acquire. One such species is found in the Family Leptodactylidae, which is comprised of 50 genera and approximately 650 species, only 7 of which occur in the United States (Behler, 1979). Leptodactylids occupy a variety of aquatic, terrestrial and

arboreal habitats. In addition, they exhibit numerous reproductive strategies. Some lay eggs in water while others, like the barking frog *Hylactophryne augusti*, lay eggs on land and guard them. The young emerge as fully formed terrestrial froglets. Still others lay their eggs in foam-like nests in ground depressions where subsequent rains wash hatching tadpoles into adjacent pools (Stebbins, 1985). The black-eared frog *Leptodactylus melanonotus* is one species that reproduces in this fashion. This diminutive amphibian ranges from northwest Mexico, south through Middle America into South America west of the Andes. It is found from sea level up to 1440 m elevation (Heyer, 1970). Black-eared frogs rarely achieve sizes over 50 mm in length with males tending to be smaller than females. Males are easily distinguished from females by the presence of 2 large black spikes on the inside of the base of each thumb. Color varies, but is usually brown to gray with dark spots, blotches, bands or stripes dorsally (occasionally patternless), and creamy colors ventrally with few melanophores.

The black-eared frog is an inhabitant of short-tree forest, which is characterized by figs *Ficus spp.*, palms *Sabal spp*, *Erythea spp*, Montezuma Cypress *Taxodium mucronatum* as well as other trees as an overstory, and Garabato *Celtis iguanaea* as the typical understory (Minckley and Brown, 1982). Usually found in riparian habitats, black-eared frogs have been observed mainly in red-algae covered pools of arroyos with high amounts of leaf litter. They have also been found along muddy arroyo banks (Herenghi, 1969). Gregory (1983) reported observing this species at pond margins and taking refuge under moist rocks or between shoots of vegetation and litter.

Black-eared frogs have been maintained at the A.S.D.M. for several years and have reproduced on four occasions, all while on exhibit. Breeding took place twice in November, 1984, once in April, 1985, and once in August, 1986. These breedings almost completely cover the year seasonally, indicating a possible acyclic reproductive cycle. Southern Sonora has two distinctive rainy seasons, much like the Tucson vicinity, and one might expect that local anurans there would have coincidental reproductive cycles with these seasonal rains. Heringhi (1969) reported calling males throughout the summer months and collections of adults and tadpoles from June through August and in January, all in or around pools and muddy banks. This seems to indicate a cyclic cycle in conjunction with the rainy seasons. Perhaps, however, this tropical species takes advantage of whatever there are for breeding. Numerous factors (photoperiod, temperature cycles, diet, substates, etc.) could have an effect on the periodicity of reproductive activity in captivity. Careful comparisons of natural and captive conditions must be done to ascertain if the apparent acyclic reproductive pattern observed at ASDM reflects normal reproductive activity for *L. melanonotus* in the wild.

The August, 1986 breeding was the most recent reproduction and the following chronology is from this event.

August 4:	One adult male died, cause unknown. Six adults remain.
August 5:	A male called from a grass clump. A recording of this call, which consisted of repeated, short, singular clicks, was made and played back near the animal. The calling ceased. A male called apparently in response to the recorded call.
August 6-13:	No activity (at least during working hours).

August 14:	Another male died.
August 15:	Calling commenced and the recording was played back for a possible competitive effect.
August 16:	(0800 hrs.) Calling continued. (1300 hrs.) A foam nest was constructed amid emergent grasses and large rocks (15-30 cm in diameter). The nest rested on the water surface, above 55 mm of water (maximum water depth in the exhibit was 56 mm). The nest was 77 mm x 50 mm x 19 mm high. Five very dark eggs, 1 mm in diameter, were visible in the top of the nest. The nest was white in color and heavily aerated. The exhibit was 77.5 cm x 45.0 cm x 22.5 cm high in front, slanting up to 40 cm in back. Water surface area was 37.5 cm x 25.0 cm and substrates consisted of mixed gravels and rocks. Air temperature was 28.5°C, water temperature was 27.0°C, and relative humidity was 57%. Initially a male and female remained in or near the nest. Later on only the female remained, referred to here as (presumably) the "dam."
August 17:	Male calling continued, the dam was still residing near the perimeter of the nest, body submerged in water, head and neck elevated above water line. This behavior continued while the nest remained intact.
August 21:	Tadpoles were first observed at 0600 hrs and the nest no longer remained. They were 3 mm long, very dark in color and were staying in the area the nest previously occupied. No adults were nearby. One day later, 125-150 3-6 mm tadpoles were present in dense subgroups. Artificial feeding began with trout chow (floating fish pellets) and chopped spinach. Tadpoles seemed to prefer pellets. One female was in the water among the tadpoles with many of them under her venter. They appeared to be feeding off of her venter (perhaps removing mucous, algae, or some other substance that coated her skin).
August 23:	All adults, except the dam, were removed due to the apparent stressful situation of being grouped together post-breeding. The adult frogs appeared to be losing weight despite heavy feeding.
September 1:	Tadpole size range was 7-15 mm in length.
September 12:	Dam removed to prevent possible predation on tadpoles. (Is mom eating the children?)
October 3:	First tadpole with hind legs appeared (tadpole 20 mm long).
October 4-18:	Tadpoles developed hind legs and some developed front legs. Many different stages of development were present (in different tadpoles) at the same time.
October 19:	First fully metamorphosed froglet appeared. Initiated *Drosophilia* feeding twice daily.
Oct. 26 - Nov. 24:	Began with 7 froglets and ended with 45 froglets at the end of this time period. Initiated feeding by forceps. More aggressive froglets were eating almost all food items, leaving little for slower "runts."

December 12: Total of 50 froglets were present. Froglets were divided into smaller subgroups to reduce resource competition.

Froglets were reared in shallow (50 mm deep) sweater boxes on gravel substrates with small broken pieces of clay pots for hiding areas. Water levels were maintained at 20-25 mm and covered the remainder of the box floor. Froglets densities were frequently adjusted to reduce competition.

Some smaller froglets died even though they were individually fed. This may indicate that these individuals were debilitated or genetically weak and would not have survived in the wild either.

During the course of tadpole development, some interesting behaviors were exhibited by the dam. For the first few weeks of their lives the tadpoles would feed near or off the dam. At time she would suddenly raise or lower her abdomen in and out of the water approximately six times. Within minutes the tadpoles dispersed and fed on decaying plant material or trout chow away from the dam. With the tadpoles dispersed, the dam would again raise and lower her abdomen and the tadpoles gradually regrouped around her. The raising and lowering of the body appeared to be some sort of signal to the tadpoles. Additionally, the dam was observed fending off predatory attempts by the other adults while they were still present. When an adult would jump towards a tadpole the dam would leap the would be predator, issuing a "chirp" as she jumped. The other adult frog would then abandon its apparent predatory attempts.

It is difficult to say whether or not these behaviors constitute natural black-eared frog behavior. Perhaps they were induced by the small, captive environment, which precluded emigration, and would not be observed in the wild.

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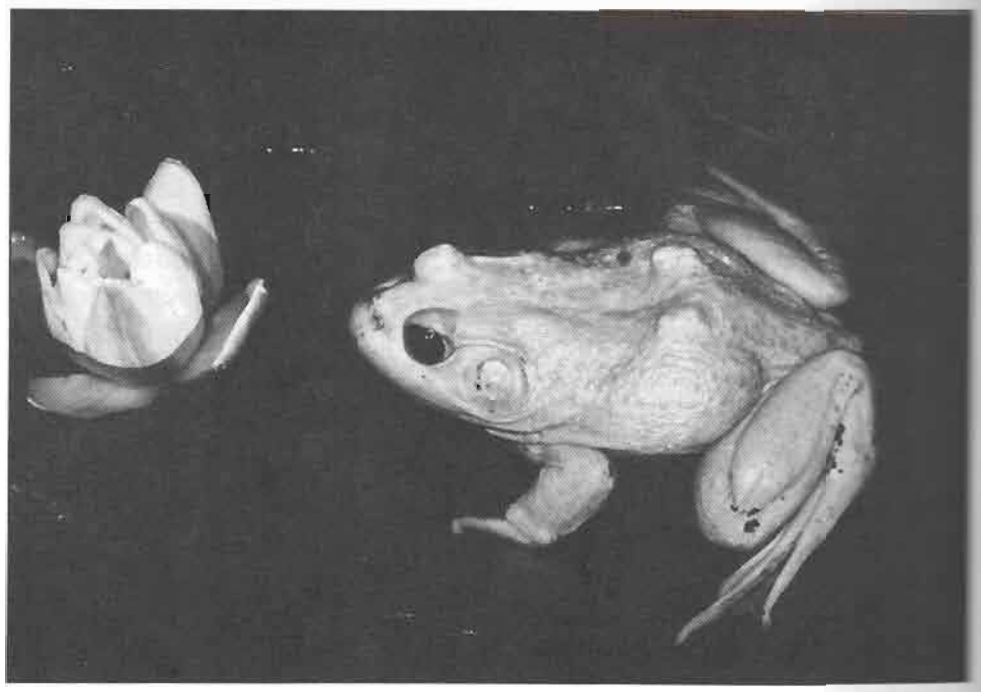

Bullfrog (*Rana catesbeiana*)

Photo by C. R. Schwalbe

KEEPING AND BREEDING *Dendrobates azureus* AND SOME OTHER POISON-DART FROGS IN EUROPE

Erik Wevers

The keeping of Poison-Dart Frogs is a hobby that some of us in Europe have enjoyed for almost twenty-five years now. Especially in the last few years there has been a great increase in interest in these beautiful jewels of the tropical rain forests of Central and South America.

Most Europeans like to keep their frogs in rather large terrariums; the average is about 70 x 50 x 70 cm (length x depth x height). This corresponds roughly to what you call a forty gallon-breeder size aquarium. This, of course, varies depending upon the species. In general, however, the bigger the better.

Our terrariums always have a water pool, and if possible we like to have water falls. This is aesthetically pleasing and also it is functional in as much as it helps to maintain a high level of humidity.

It is important that the frogs have a sense of security in their environment. Therefore, we use stones and wood quite liberally to provide hiding places for the frogs. Also we plant the terrariums with a dense growth of vegetation. In such a terrarium the frogs can feel at home, and they can move freely from hiding places to water and to dry land. Poison-Dart frogs are intolerant of stress. A well built terrarium will allow the frogs to live and thrive for many years. A terrarium that is proving itself to be successful should never be disturbed. Similarly, frogs that are doing well in a terrarium should not be moved to a different one. In the wild, most Dart frogs live out their whole lives in one place. Moving them from a safe and secure home to another terrarium, even if the second one is likewise well constructed, is very stressful to the frogs.

Europeans generally light their terrariums about 16 hours per day. The ideal temperature for most frogs is about 25°C to 27°C in the day time and about 20°C to 22°C during the night. In a terrarium that is of the dimensions that I have already mentioned (that is, 70 x 50 x 60 cm) we like to keep no more than 6 animals. Most Dart-Frogs are territorial and if the population density is greater than this there will no doubt be stress on the animals. This of course varies depending upon the species being kept in the terrarium. We consider it an error to keep community terrariums. Ideally there should not be mixing of species. Community set ups may go well enough for a while but in the long run it will be detrimental to all the species being kept together. Different species being kept together will increase their territorial defenses and this behavior is in fact a sign of the stress that they are being subjected too. Also, it is unlikely that breeding will occur in a community terrarium. Another reason that community set-ups should be discouraged is that there is the risk of inter-breeding and it is more difficult to keep track of the blood-lines. If we are to keep our frogs in the future we must take care to maintain genetically pure populations. If things continue as they are, there is a good chance that the rain forests will be destroyed so the Dart-Frogs that survive will be the ones we keep in our terrariums. We should take great care to breed them well.

In Europe we generally feed our frogs with various species of drosophila. It is also quite popular to heavily supplement them with wild collected insects in the summer time. Most frogs will take insects up to 30 mm, and a few of the large species will take insects up to 1 cm. Of course one must take care to collect insects from areas where insecticides have been sprayed.

Now I would like to talk more specifically about my favorite frog, *Dendrobates azureus*. I have been keeping them now for almost six years. In my opinion they are the most beautiful of all frogs. This species originates in Surinam and it is known only from a very limited and isolated forest island on the Sipaliwini - Savannah. They are found at an elevation of 315 - 430 meters. Within these forest islands they are found only in creek valleys which are littered by large moss-covered boulders, between which they live. Why they restrict themselves to this particular micro-environment is not known. In my terrariums the frogs seem to do just as well with or without the rocks. In the natural environment the daytime temperature averages 27°C - 32°C, and at night it falls to about 20°C.

Dendrobates azureus has a smooth skin, the background colour of which is black. They are covered with blue spots sometimes so close together that they appear as if the pattern is actually black on blue rather than the other way around. In some sense it is rather like the zebra - is a zebra a white horse with black stripes or a black horse with white stripes? Whatever it is, the result is a stunningly beautiful animal! The pattern of the markings is not consistent. I have some animals that are almost completely blue and I have other with rather large areas of black. *D. azureus* is one of the largest of the poisonous frogs. The females are larger than the males (about 45 cm) and they are usually quite plump. The males grow to about 38 cm. In most cases the males can be recognized by their relatively larger front feed toepads.

These frogs are very active, especially during the sprinkling of water and during the feeding time. It is maintained in the literature that the females are quite aggressive, my observations confirm this. The males are also somewhat aggressive at times. This behavior is affected by the size of the terrarium. It is not necessarily bad, with these behaviors they interact with each other to establish territories - this is important in the natural breeding relationships. However in a terrarium that is overcrowded it can be detrimental. The call of *D. azureus* is very inconspicuous. It will not usually be noticed unless one is specifically listening carefully for it. It is a very faint low-pitched buzzing sound rather similar to the call of *Dendrobates tinctorius*.

These frogs are easy to feed. They eat almost any insects, from tiny drosophila to spiders up to 15 mm long. Reproductive activity is linked quite recognizably to the quality and quantity of food available. In the winter I feed them with fruit-flies and I get 2 to 4 eggs once each week or two. In the summer I feed them with "pasture plankton" and I usually get 3 to 5 eggs twice per week. It has been stated, and is true, that success is the first instance is food dependant. Occasionally I supplement their food with a dusting of vitamins. I do this more in the winter when pasture plankton is not available. I feed the growing young frogs almost exclusively with pasture plankton when it is available. I screen the collection to select the smaller insects. This is a laborious process but as a result I realize larger and more beautiful frogs. The young frogs grow better than if they are raised on vitamin-dusted fruit flies. In this manner I get healthy adults and, in turn, from them I get healthy baby frogs.

Dendrobates azureus does not produce many eggs. Clutches average from 2 to 5 eggs depending upon the season. They produce the largest eggs of any of the poisonous frogs. Likewise, the tadpoles are very big. It is the male who decides where the eggs will be layed. The eggs may be deposited in a petri-dish under a coconut or on a bromiliad leaf. Both the male and the female clean the nesting site before the eggs are layed. After the eggs are layed, or sometimes during the laying of the eggs if there is enough room, the male fertilizes them. Sometimes a second male will also fertilize the eggs, and occasionally both will do so simultaneously! I leave the eggs in the terrarium until the larvae are almost ready to emerge from

the eggs. The males clean and water the eggs at least every other day. In the natural habitat it is the male who transports the eggs. I have found that the eggs are less likely to mold if they are left to the care of the males. I have found that in clutches where some eggs have become mouldy, the fertilized eggs remain unaffected. The tadpoles are cared for in a special tank with thirty separate compartments. The tadpoles are cannibalistic. The water is free to circulate but the tadpoles cannot come in contact with each other. The water circulates through a biological filter beneath the tadpole compartments. The water temperature is maintained at about 22°C. Higher temperatures result in faster growth and early metamorphosis. Frogs which metamorphosis early are small and usually will not attain the same full natural size as those which develop more slowly. I feed the tadpoles with fishfood and sometimes with crushed snails. During the first few days after they emerge from the eggs, I feed the larvae with liquifry Red and Green. The tadpoles grow well on this diet so I do not use any other types of food. The incubation period from fresh fertile egg to free swimming tadpole is from 16 to 18 days. The larger larvae can measure up to about 2 cm long. The development of the tadpoles from the time of hatching to metamorphosis take about three months and the tadpoles reach an average size of about 4 to 5 cm. When the front legs emerge, the tadpoles are moved to a plastic box. When the tail is completely resorbed they are removed to small terrariums which contain peat moss and leaf litter and a small water dish. The temperature is maintained at about 22°C and the humidity is kept as high as possible. After a few weeks I raise the temperature to 25°C. The froglets are fed small arthropods, fruitflies and baby spiders. The young frogs grow very fast and become sexually mature in about one year.

It is quite likely that *Dendrobates azureus* is related to *Dendrobates tinctorius*. It is possible to cross-breed *D. azureus* with both *D. tinctorius* and *D. auratus*. I think that this practice should be discouraged because the blue frog is so rare. Rather, the genetic line should be maintained pure and guarded carefully. When available, the blue poisonous frog is not difficult to raise and to keep. However, we need to exercise good stewardship of the specimens already entrusted to us because new imports are not now, and may never again be possible! The species is now listed as endangered and is felt to be threatened with extinction to the wild.

Wierden, Holland

THE SKIN TRADE IN WESTERN CANADA; IMPORTATIONS OF REPTILE PRODUCTS FROM 1986 TO 1989

Ernest W. T. Cooper

It will come as no surprise to anyone who has frequented the typical shopping mall that the trade in reptile products is a thriving industry. Goods such as lizard and snakeskin shoes, purses, and belts are prominently displayed in many shops. The abundance of these items and their apparent popularity makes the threat of over-exploitation a valid concern for many species.

The primary control on the importation and exportation of these items is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This is an international agreement that regulates the trade in rare species of animals and plants through an import/export permit system that becomes stricter for more endangered species. Those species requiring protection are classified into one of three Appendices. Appendix I species are considered rare and endangered, therefore trade is severely restricted. Appendix II species are not considered endangered, but they may become so if trade is not regulated. Appendix III animals and plants are also not considered endangered, but their export is controlled from certain specific nations.

In Canada, the enforcement of CITES regulations is provided by Canada Customs and the RCMP, in conjunction with the Canadian Wildlife Service. To ensure the accurate identification of exotic animal products, the Canadian Wildlife Service utilizes the expertise of biologist from zoological institutions. In Vancouver, the major port of entry for Western Canada, the Canadian Wildlife Service has maintained such a contract with the Vancouver Public Aquarium since August 1986. Since the beginning of 1988, the contract has been the responsibility of the author.

From the beginning of the contract, a record has been kept of all items requiring inspection. Compiled together, these data offer a summary of the importation of reptile products into Western Canada between August 1, 1986 and January 1, 1989. The purpose of this study therefore, is to utilize this information to identify examples of potential over-exploitation of specific reptile species. These data may then be used in turn to suggest areas requiring additional research.

Although the importations examined have occasionally included large commercial shipments, the vast majority have been composed of the few items brought in by individuals for their personal use. Commercial shipments are usually accompanied by sufficient documentation to allow customs to process them the directly. The data from the few such shipments which have been examined , have therefore been excluded to prevent their large numbers from skewing the results of this study. The intention is to attempt to identify those species undergoing the greatest exploitation, rather than discuss and tally the volumes of importations.

For the purpose of this study, the term "skin trade" refers not only to clothes and accessories made of reptile skin, but also to stuffed and dried animals, lotions, and pharmaceuticals derived from reptiles. Furthermore, a given number of items does not represent an equal number of animals. For example a single purse may be manufactured from several small snake skins or part of one large snake skin. The number of imported items does however indicate the market interest for a particular species or group of species. This then is indicative of the present and potential future exploitation of those species.

The total number of all items examined has increased each year since 1986 (Cooper, 1989). Unfortunately it is not clear whether this is due to increasing numbers of importations or an increased effort in enforcement by Canada Customs, resulting in greater number of items being discovered and confiscated. This makes it impossible to compare the actual yearly numbers of importations per of any particular groups of items. Therefore all further data have been converted to a percent of the total importations per year. If the enforcement effort increases, the percent of the total importations for any group of items should stay constant, unless the rate of their importations also changes. Once again this is a study of exploitation and market interest rather than sheer numbers of items.

Due to the late beginning of the contract (August), only five months of data were available for 1986. Therefore the totals for 1986 were compared to those of the same time periods (August through December) of 1987 and 1988. This then made it possible to extrapolate the numbers for the entire year of 1986.

Figure 1 shows the number of reptile products imported in each year of the study compared to all other animal products. Although there has been considerable variation between the years, reptile importations have consistently made up a large proportion of each year's total. They were the most common products imported into Western Canada in 1986; in 1987 and 1988 only items made of elephant ivory were more numerous (Cooper, 1989).

In Figure 2, the total number of reptile importations for each year has been divided into four main groups: lizards, turtles, crocodilians, and snakes. Clearly, snake products have been the most common. However, this dominance appears to be on the decline. The three year trend has been a steady decrease in the proportionate number of snake products and a marked increase in lizard material. Crocodilian and turtle items have also shown increases in importations which may or may not prove significant over a longer period. The yearly changes of these major groups are presumably due to the whims of fashion rather than decreasing or increasing populations.

Items created from lizard material have been the least commonly imported reptile product, as shown in Figure 2. These goods are typically composed of one of thee different groups: monitor *Varanus spp.*, tegu *Tupinambis spp.*, or iguana *Iguana iguana*. Monitors and tegus are used predominantly as sources of exotic leathers (purses, wallets, shoes and belts), while iguana products are usually in the form of whole stuffed animals. The proportionate numbers of these items imported each year are shown in Figure 3. Two other types of lizards were also identified: the spiney tailed iguana *Ctenosaura pectinata* and the tokay gecko *Gekko gecko*. However, each was represented by only a single importation, and therefore has not been included.

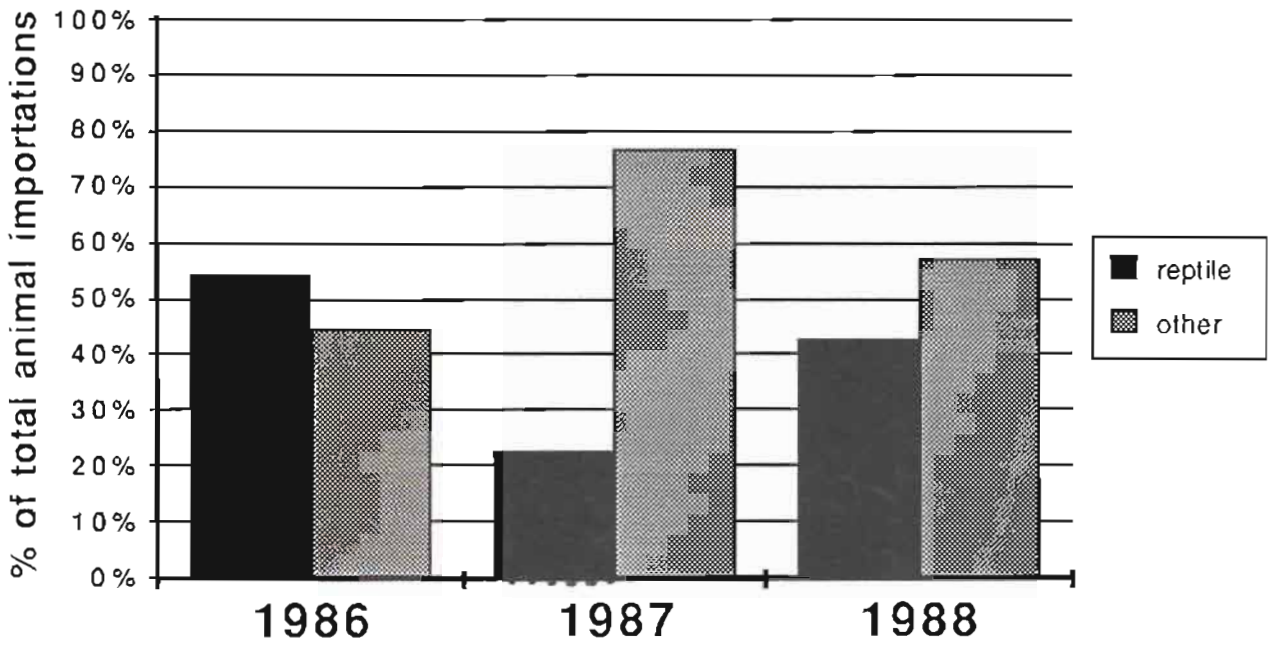

Figure 1. Total number of reptile products imported per year compared to all other animal products. Each expressed as a percent of the total importations per year.

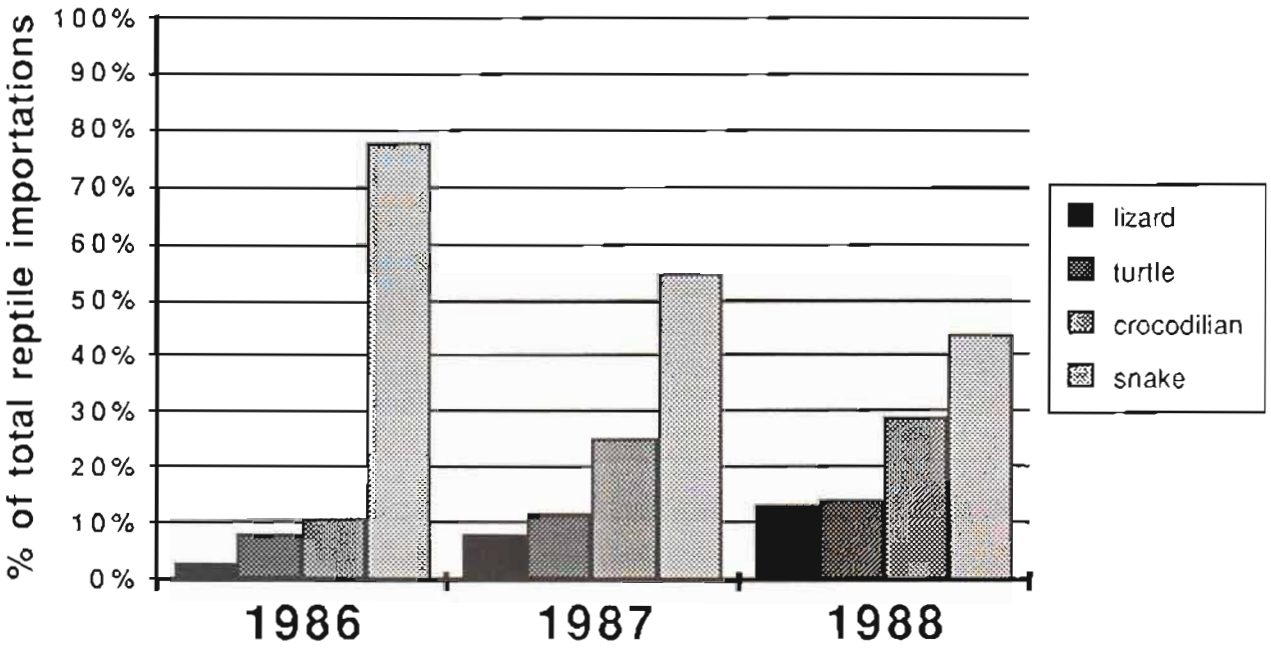

Figure 2. Total number of reptile products imported per year, divided into four main groups. Each expressed as a percent of the total reptile importations per year.

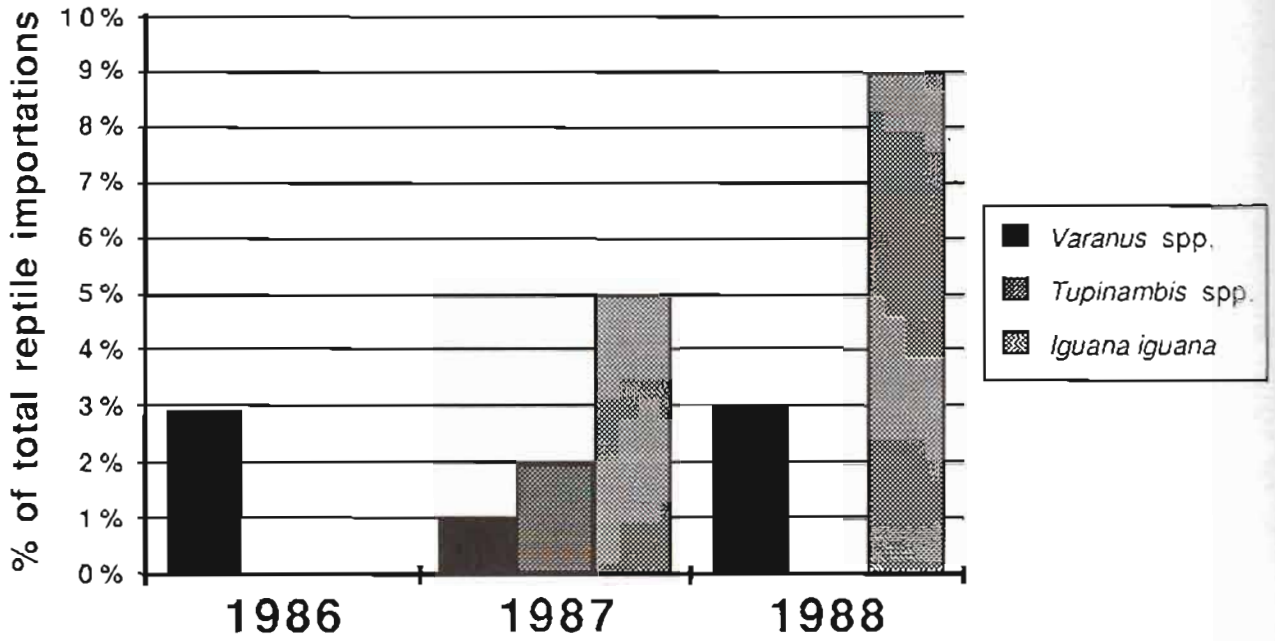

Figure 3. Total number of the most common lizard products, each expressed as a percent of the total reptile importations per year.

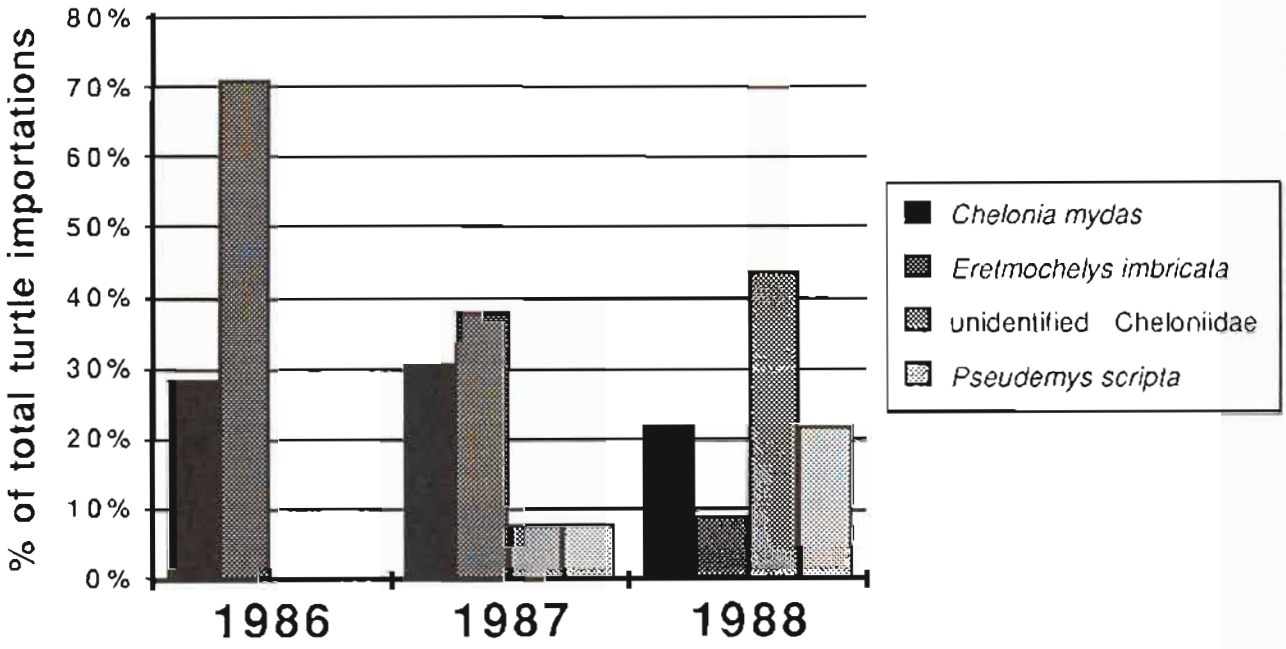

Figure 4. Total number of the most common turtle products, each expressed as a percent of the total turtle importations per year.

Figure 3 does not suggest any obvious trends in the importation of lizard materials, although it is interesting to note that iguana products, unreported in 1986, formed 5% and 10% of all reptile importations in 1987 and 1988 respectively.

A special problem exists when attempting to identify items manufactured from monitor skin. The majority of these products are made from relatively small pieces of skin that have been dyed, thereby obscuring their natural patterns. Thus it is very difficult to identify them beyond *Varanus spp.* Unfortunately while most of the members of this genus are listed in Appendix II, there are also four very endangered Appendix I species (*V. bengalensis, V. flavescens, V. griseus,* and *V. komodoensis*). Unless these items are accurately identified as such, they must be classified as Appendix II. Thus the Appendix I species may not be receiving the protection of such a designation.

Although turtle products compose a small proportion of imported reptile goods (Figure 2), their numbers should not be considered insignificant. Figure 4 shows that the majority of these items originate from seaturtles, all of which are listed under Appendix I by CITES. All turtle products examined in 1986 (4% of all reptile products), and just under 80% in 1987 and 1988 (10% and 7% of all reptile products, respectively) were composed of seaturtles. These items typically consist of either a whole stuffed animal, or just the detached carapace. Some seaturtle skin items have also been examined, but these were usually small and could not be identified beyond Cheloniidae. In addition, lotions and creams that contain turtle oils were not uncommon. These were impossible to identify and therefore were excluded from the data.

As Figure 4 indicates, seaturtle products imported into Western Canada essentially involve two species; green seaturtles *Chelonia mydas* and hawksbill seaturtles *Eretomochelys imbricata*. The only other species of turtle to be imported with any regularity was the pond slider *Pseudemys scripta*. Importations of this unlisted species was incidental in 1987, but rose to over 20% of all turtle products in 1988 (2% of all reptile goods for that year). Four other species were identified during the study period--the flatback seaturtle *Chelonia depressa*, the three-banded box turtle *Cuora trifasciata*, the Malaysian box turtle *Cuora amboiensis*, and the yellow footed tortoise *Geochelone denticulata*. However, each of these species was represented by only a single specimen, and therefore not included in Figure 4.

Crocodilian products, in the form of leather goods and stuffed juveniles, have been the seconds most common reptile items imported into Western Canada. Nine different species were represented, including at least four subspecies of *Caiman crocodilus*, as shown in Table 1. All species of crocodilian are listed by CITES and all may be considered endangered, many critically so.

By far the most common items imported were made from caiman, primarily of *Caiman crocodilus*. This is shown in Figure 5. In comparison, alligator and crocodile materials are in a distinct minority.

A further division of the *Caiman crocodilus* subspecies identified is shown in Figure 6. This graph does not reveal any obvious trends in the importation of any particular subspecies. Presumable they are all equally suitable for the goods that are produced.

The great majority of the caiman skin items examined during this study were imported from South-East Asia, usually Hong Kong, Singapore or Thailand. Of these items, almost all were mislabeled as crocodile skin, and most were manufactured in Thailand. Travelers attempting to enter Canada with these goods commonly report that the products were sold to them as skins from "farmed" animals, rather than wild caught ones. This unfortunately is not the case since caimans are not commercially farmed in Thailand (J. L. Behler, Curator of Herpetology, New York Zoological Society, personal communication). Caiman skins produced an inferior product in comparison to alligator or crocodile (J. L. Behler, personal communication, and Brazaitis, 1987). Skins from hunted animals are imported from Central and South America to Southeast Asia. There they are made into cheap products to be sold at "bargain-prices" (Barzaitis, 1987). This helps to satisfy the market created by the high priced crocodile goods manufactured in Europe and the USA (J. L. Behler, personal communications).

Figure 2 shows that snake products have been the most common reptile items imported, although the total proportion has decreased yearly from a high of almost 80% in 1986, to a low of 45% in 1988. The majority have been in the form of snakeskin fashion accessories such as shoes, boots, purses, wallets, belts, watch straps and briefcases. In addition, dried snakes mounted as curios or chopped-up for oriental folk-medicines, have not been uncommon.

A total of 21 different species have been identified during the study period. These are listed in Table 2. Most of these species however, comprise only a very small portion of the total number of snakes importations. The bulk of all snake products has consisted of four individual species: Indian cobra *Naja naja*, puff-faced water snake *Homalopsis buccata*, Indian ratsnake *Ptyas mucosus*, and reticulated python *Python reticulatus*. The relative proportions of these species imported each year is shown in Figure 7.

Although importations of *H. buccata* and *P. mucosus* products show considerable variation during the study period, importations, of *N. naja* and *P. reticulatus* show distinct trends.

The percentage of snake items made from *N. naja* has shown a steady decline over the three years studied. To determine whether this is due to a decrease in market interest, a decline in population, or stricter export enforcement, requires additional information. However, during the study period, the majority of *J. Naja* products were imported from India, the only country to regulate the export of this species. Hopefully therefore, the wild populations in India are being properly managed. But the over-exploitation of this species in other countries is a distinct possibility.

In contrast to *N. naja*, the importation of *P. reticulatus* goods has shown an average 5% increase in market share per year. The "exotic" pattern of this species' skin, as with other members of the Boidae (boas, pythons and their kin), makes them highly desirable according to exotic leather dealers in Vancouver (person communication). This suggests that their increasing importation is the result of greater exploitation, rather than rising populations.

Table 1. Species of crocodilians identified from imported products.

LATIN NAME	COMMON NAME	CITES LISTING
Alligator mississippiensis	American alligator	Appendix II
Caiman crocodilus apaporiensis	Rio Apaporis caiman	Appendix I
Caiman crocodilus crocodilus	Common caiman	Appendix II
Caiman crocodilus fuscus	Northern caiman	Appendix II
Caiman crocodilus yacare	Southern caiman	Appendix II
Crocodylus cataphractus	African slender snouted crocodile	Appendix I
Crocodylus niloticus	Nile crocodile	Appendix II
Crocodylus novaeguineae novaeguineae	New Guinean crocodile	Appendix II
Crocodylus porosus	Saltwater crocodile	Appendix I
Crocodylus rhombifer	Cuban crocodile	Appendix I
Crocodylus siamensis	Siamese crocodile	Appendix I
Melanosuchus niger	Black caiman	Appendix I

Table 2. Species of snakes identified from imported products.

LATIN NAME	COMMON NAME	CITES LISTING
Acrochordus javanicus	Elephant's trunk snake	unlisted
Agkistrodon acutus	Chinese copperhead	unlisted
Boa constrictor	Boa constrictor	Appendix II
Bungarus fasciatus	Banded krait	unlisted
Candoia carinata	Pacific ground boa	Appendix II
Cereberus rhynchops	Dog-faced water snake	Appendix III (India)
Crotalus atrox	Western diamondback rattlesnake	unlisted
Crotalus durissus	Cascabel	unlisted
Cyclagras gigas	False cobra	Appendix II
Elaphe taenuira	Taiwaniese Beauty Snake	unlisted
Enhydris bocourti	Bocourt's water snake	unlisted
Homalopsis buccata	Puff-faced water snake	unlisted
Lapemis hardwicki	Hardwick's sea snake	unlisted
Naja haje	Banded cobra	unlisted
Naja naja	Indian cobra	Appendix III (India)
Python curtus	Blood python	Appendix II
Python molurus bivittatus	Burmese Python	Appendix II
Python reticulatus	Reticulated python	Appendix II
Python sebae	African rock python	Appendix II
Ptyas mucosus	Indian ratsnake	Appendix III (India)
Vipera russellii	Russell's viper	Appendix III (India)

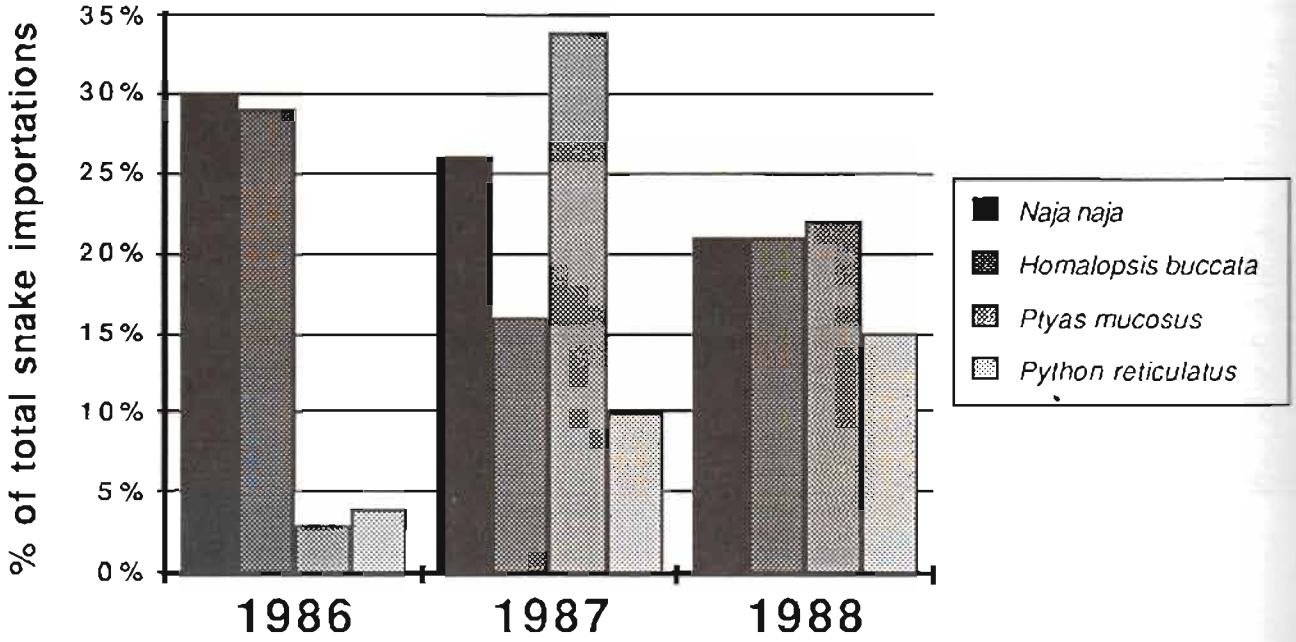

Figure 7. Total number of the most common snake species imported, each expressed as a percent of the total snake importations per year.

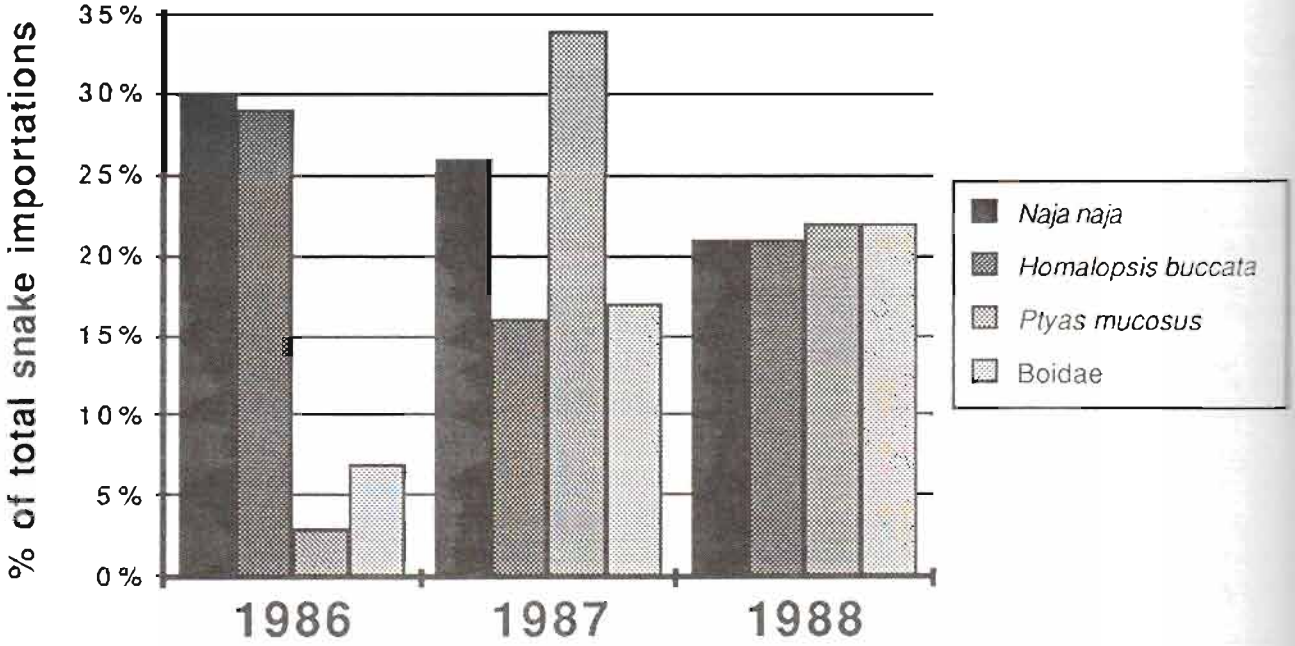

Figure 8. Total number of the most common snake species imported, with the Boidae included as a single group. Each expressed as a percent of the total snake importations per year.

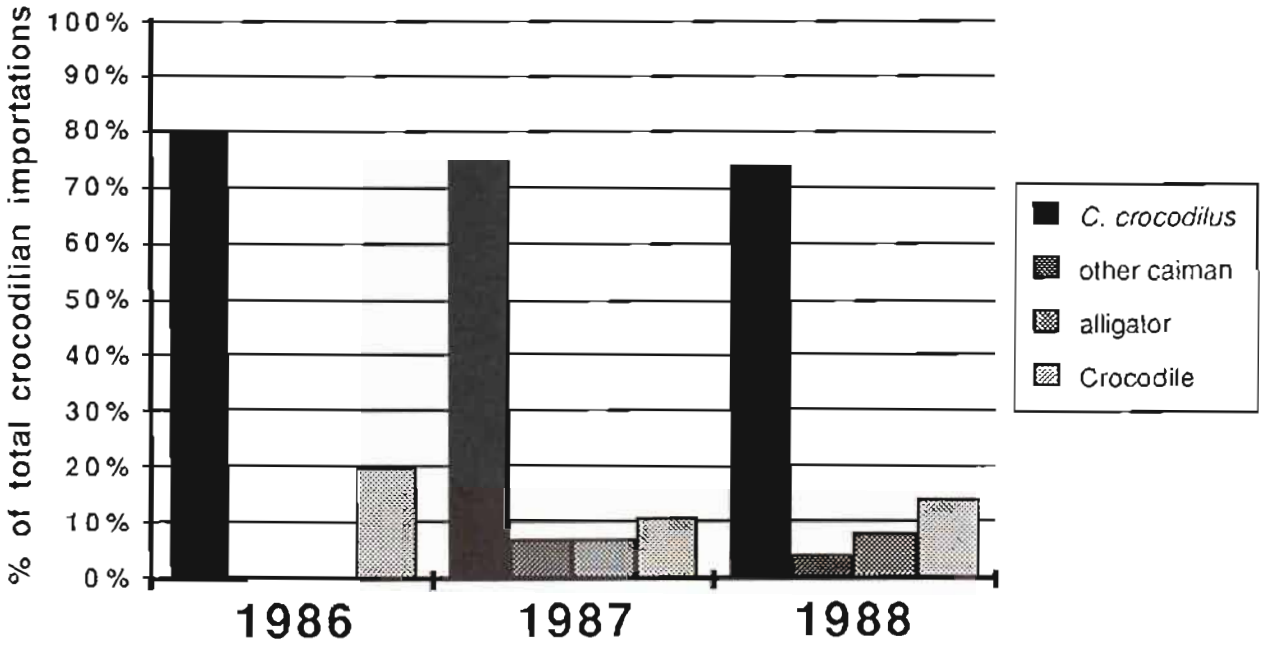

Figure 5. Total number of crocodilian products imported per year, divided into four main groups. Each expressed as a percent of the total crocodilian importations per year.

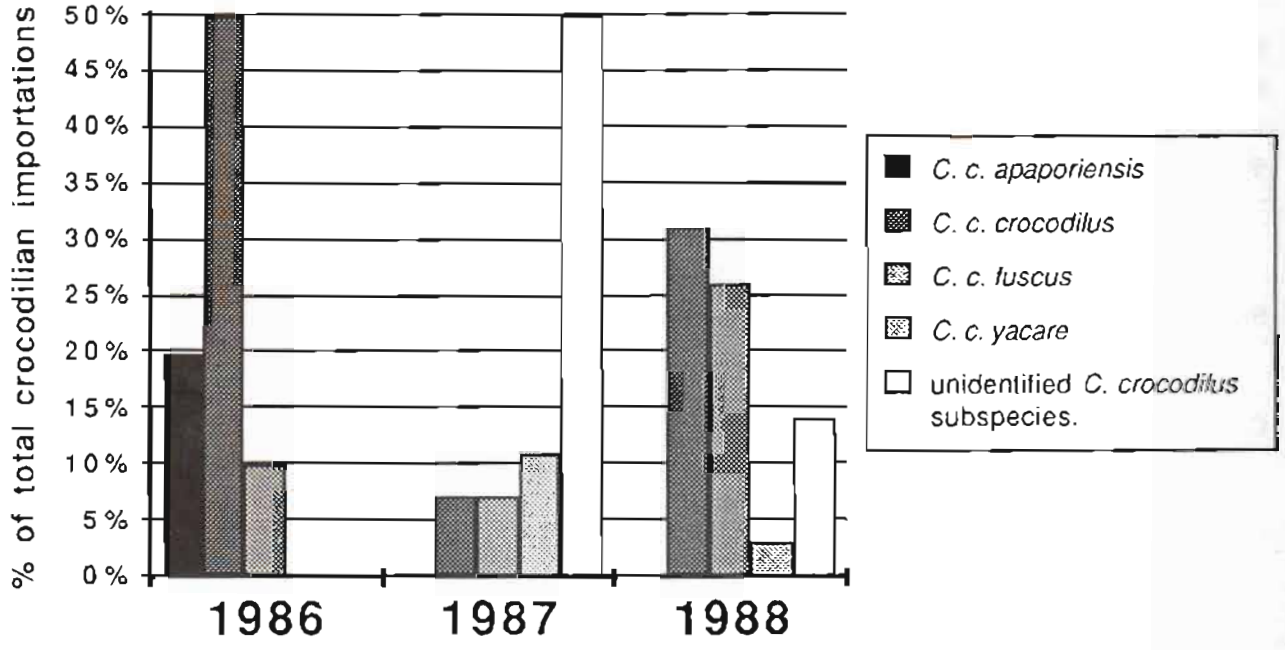

Figure 6. Total number of *Caiman crocodilus* products imported per year, divided into subspecies. Each expressed as a percent of the total crocodilian importations per year.

Among the Boidae, those species that are regularly exploited for their skins are all large snakes with attractive, intricate dorsal patterns. Their skins are utilized for the manufacture of essentially the same products. Thus the total number of all Boidae items imported during the study period could be considered together as a single group. A comparison of this group to the other three species (*N. naja, P. mucosus and H. buccata*) is shown in Figure 8. Initially this graph suggest a three year convergence of the market shares of all four. However, if the trends discussed for *N. naja* and *P. reticulatus* continue (and so far the data for 1989 suggest they will) then this convergence is only coincidental.

In conclusion, the herpetolculturist may assist with the control and eventual reduction of the reptile skin trade in several ways.

Regulation of the trade is dependent on the accurate identification of the material being imported or exported. Unfortunately this is often very difficult, especially when the items are composed of only small portions of the animal. In addition, taxonomic keys specifically directed towards the identification of reptile products (as opposed to live animals) are lacking for many important groups (i.e. the monitor lizards). These could be developed from detailed examinations of captive animals, while rare and endangered species that perish in captivity could be utilized to provide reference collections for the identification of reptile products.

Furthermore, studies such as this one, when compared to similar records from other regions could be used to anticipate trends in animal exploitation and direct efforts in captive husbandry. The careful management of genetically diverse captive animals would prevent the over-exploitation of wild stocks from being synonymous with their extinction.

Lastly, while the general public will readily jump to the defense of animals that are "warm and fuzzy", they tend to be apathetic about the exploitation of reptiles (especially snakes). Therefore herpetoculturists as individuals, and in groups, should use their knowledge and enthusiasm to enlighten the public about the true nature of reptiles. Only in this way can the market for reptile products be eliminated.

LITERATURE CITED

Brazaitiz, P., 1987. *Identification of Crocodilian Skins and Product.* In: Wildlife Management: Crocodiles and Alligators. Surry Beatty and Sons Pty Limited. pp. 373-386.

Cooper, E.W.T., 1989. *Exotic Species Identification by the Vancouver Public Aquarium for CITES Enforcement.* Proceedings of the Western Regional Conference of the AAZPA (in press).

Research Assistant
Vancouver, B.C. - 1989

Tuesday, June 20th

9:00am - 4:00pm REGISTRATION

WORKSHOPS

12:00pm Construction of Terrarium Environments Suitable for Amphibians - Dale Bertram, M.D., Dendrobatid Society, Madison, WI

2:00pm BREAK

2:15pm Husbandry and Breeding of Turtles - Brett Stearns, Institute for Herpetological Research, Stanford, CA

2:15pm The Captive Breeding of Rare Pythons and Boas - Don Hamper, Private Breeder, Columbus, OH

6:00pm ICE BREAKER (2 hour open bar)

Wednesday, June 21st

8:00am -	9:00pm	REGISTRATION
	9:00am	Trip to Arizona-Sonoran Desert Museum (Buses will leave at 9:00am)
	3:30pm	Tour Reid Park Zoo
	5:00pm	Mexican Buffet Dinner - Reid Park Zoo

Thursday, June 22nd

8:00am - 9:00pm **REGISTRATION**

8:30am Welcome and Opening Remarks - Brian P. Backner, M.D., President, IHS, Inc.

Moderator: Michael J. Uricheck, Ph.D.

8:50am On the Crawl! A Herpetological look at Arizona - Cecil R. Schwalbe, Ph.D., Arizona State Herpetologist, Phoenix, AZ

9:40am Captive Husbandry and Breeding of the Green Iguana - Roger Cogan, Phoenix, AZ

10:05am Pharmacokinetics of Gentamicin and Piperacillin in Blood Pythons -- A New Dosing Schedule - Robert Wagner, D.V.M., Pittsburgh Zoo, Pgh, PA

10:30am **BREAK**

10:45am Regurgitation Syndrome in Boids - Richard A. Ross, M.D., M.P.H., Institute for Herpetological Research, Stanford, CA

11:00am Reproduction in Pythons at the Oklahoma City Zoo with Emphasis on Liasis and Morelia - Scott Wheeler, A.H.T. I, Oklahoma City Zoo, Oklahoma City, OK

11:30am The First North American Breeding of the Mandarin Rat Snake, Elaphe mandarina - William B. Gillingham, Jr., Private Breeder, Stockton, CA

11:50am **LUNCH**

1:00pm Captive Behavior and Reproduction of the Burmese Mountain Tortoise - Richard Fife, Private Breeder, Phoenix, AZ

1:25pm The Pathological Findings of Failed Reproduction in Kingsnakes: Ideas on Reproductive Medical Problems - Roger J. Klingenberg, D.V.M., Private Practitioner, Greeley, CO

1:50pm Treatment of Dehydration and Starvation in Reptiles Thomas Boyer, School of Veterinary Medicine, Colorado State University, Fort Collins, CO

2:15pm Captive Husbandry and Breeding of Dendrobatid Frogs - Erik Wevers, Wierden, Holland

3:00pm Buses leave for World wildlife Zoo

4:00pm Tour World Wildlife Zoo

6:30pm Rawhide -- Cowboy Cookout

Friday, June 23rd

8:00am - 9:00pm **REGISTRATION**

Moderator: David Hulmes

8:30am Captive Reproduction of the Banded Rock Rattlesnake, Crotalus lepidus klauberi - Gray Swinford, Chapparel,NM

8:55am Diagnostic Techniques in Reptile Medicine - Howard Martin, D.V.M. Assistant Professor of Zoological Medicine, Colorado State University, Fort Collins, CO

10:10am **BREAK**

10:25am Captive Propagation of the Black-Eared Frog, Leptodactylus melanonodus - Craig Ivani, Arizona Sonoran Desert Museum, Tucson AZ

10:45am The Influence of Barometric Pressure on Reproduction in Reptiles - Richard Fife, Private Breeder, Phoenix, AZ

11:00am Hibernation in Reptiles: A Review - Steven D. Garber, Department of Biology, Rutgers University, Piscataway, NJ

11:25am Diamondback Terrapin Status - Steven D. Garber, Department of Biology, Rutgers University, Piscataway, NJ

11:50am **LUNCH**

Moderator: Ed Tunstall

1:00pm A Safe Practical Facility for Breeding Large Pythons - Ernie Wagner, Captive Bred Reptiles, Seattle, WA

1:25pm Venomoid Surgery - Richard S. Funk, D.V.M., University of Tennessee, Knoxville, TN

1:50pm Maintainence Strategies for Large Private Collections of Chelonians - Eric Olsen, Cleveland, OH

2:15pm The Possible First Captive Breeeding of Rana ishikawae, A Rare Ranid Frog from Okinawa - Phillipe de Vosjoli and Robert Mailloux, Private Breeders, Lakeside, CA

2:40pm Bacteriology of Sterile Sites in Wild and Warehouse Red-eared Slider Turtles, Trachemys scripta elegans - Barbara Bonner, M.S., University of Massachusetts, Amherst, MA and Tufts University School of Veterinary Medicine, North Grafton, MA

3:05pm The Effects of E.L.M. on Incubating Turtle and Tortoise Eggs - Chris Dodge, Washington, D.C.

4:00pm Buses Leave for the Phoenix Zoo

5:30pm **COOKOUT**

Saturday, June 24 th

Moderator: Brian P. Backner, M.D.

8:30am Breeding on Thin Ice - Husbandry and Propagation of the Malgasy Tomato Frog - Phillipe de Vosjoli and Robert Mailloux, Private Breeders, Lakeside, CA

8:55am The Last Resort - Techniques Used to Tube or Force Feed Chelonians - Ellen Nicol, Artist/Author/Reptile Breeder, Anthony, FL

9:45am Reproductive Biology and Current Status of the Louisiana Pine Snake, Pituophis melanoleucus ruthveni - Steven B. Reichling, Assistant Curator, Memphis Zoo and Aquarium, Memphis, TN

10:10am BREAK

10:25am The Care and Breeding of the Gargoyle Gecko, Rhacodactylus auriculatus, with Suggestions on Breeding Rhacodactylus chahoua - Jeffrey Nunan, San Diego, CA

10:50am Update on Pharmaceuticals Useful in Reptile Medicine - Scott Michaels, D.V.M., R.Ph., Private Practitioner and Reptile Breeder, Urbana, IL

11:15am The Gopher Tortoise - Keystone Species of the Sand Hill Ecological Community - Harold Wahlquist, Ph.D., Gopher Tortoise Council, Lilburn, GA

11:40am Egg Collection and Head-Starting of the Pinzon Island Galapagos Tortoise Geochelone elephantopus ephippium ; From Certain Extinction to Recovery! - Fred Caporaso, Ph.D, Chapman College, Orange, CA

12:00 LUNCH

WORKSHOPS

1:15pm Parasitology for the Serious Herpetoculturist - Richard S. Funk, D.V.M., Knoxville, TN - Roger Klingenberg, D.V.M., Greeley, CO

1:15pm Breeding Strategies for Colubrid Snakes - Robert Applegate, Private Breeder, El Cajon, CA

3:15pm BREAK

3:30pm Crimes of Fashion - Striking Back at the Skin Trade Dez Crawford, President, Louisiana Herp Society, Baton Rouge, LA

3:30pm Husbandry and Breeding of Turtles - Brett Stearns, Institute for Herpetological Research, Stanford, CA

4:30pm ADJOURNMENT