15th INTERNATIONAL HERPETOLOGICAL SYMPOSIUM ON CAPTIVE PROPAGATION & HUSBANDRY

SEATTLE, WASHINGTON
June 20-23, 1991

EDITED BY
MICHAEL J. URICHECK, Ph.D.

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15TH INTERNATIONAL

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on

Captive Propagation

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Photo by Bill Love, Glades Herp, Inc.

Back Cover: Top: Dart-Poison Frog (*Dendrobates granuliferus*)
Photo by David Hulmes
Bottom: Boa Constrictors (*Boa constrictor constrictor*)
Photo by G en J. Carlzen

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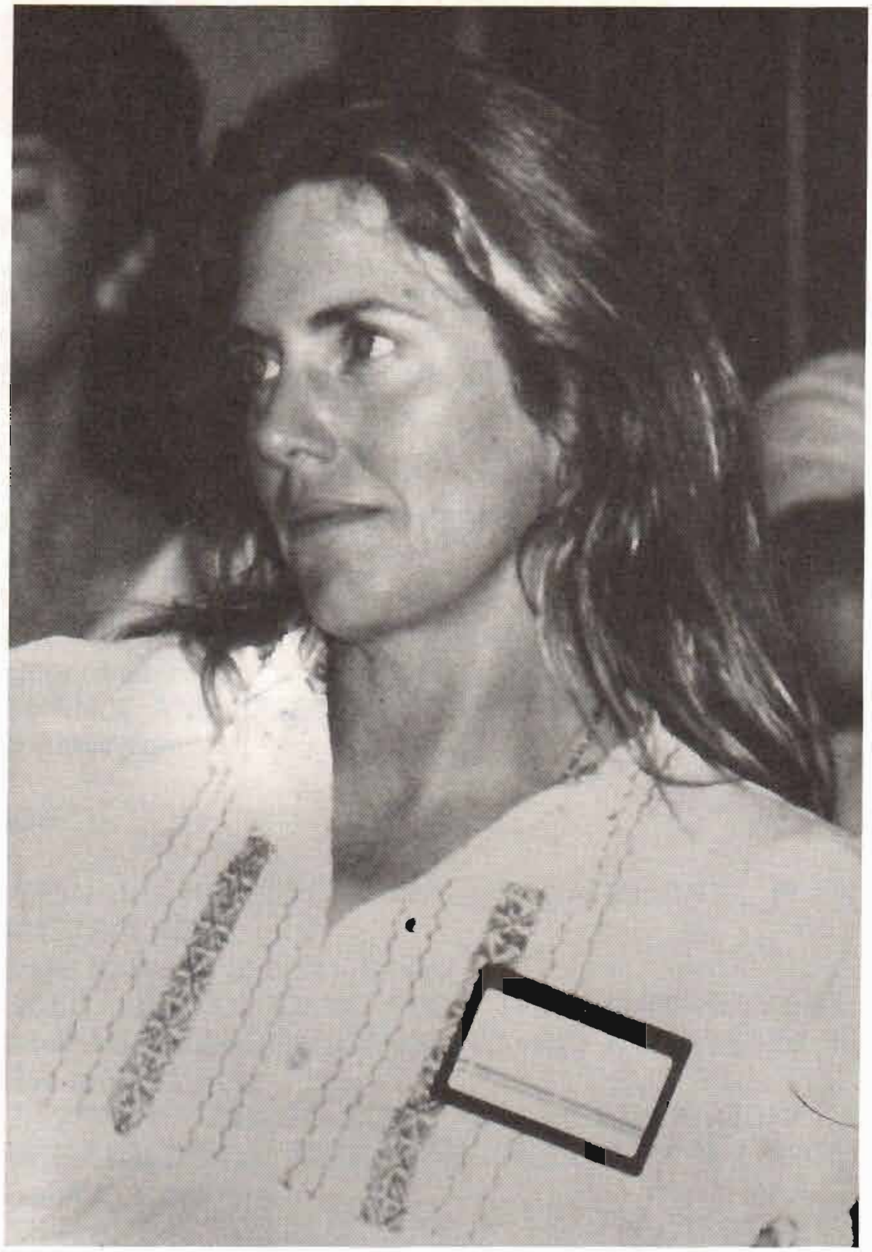

Photo by William S. Brown

RUTH M. ZANTZINGER

June 2, 1941 - November 8, 1991

POISON-DART FROGS - WILD AND CAPTIVE

John F. Cover, Jr.

INTRODUCTION

The poison-dart frog family (*Dendrobatidae*) contains over 117 species and occurs from Nicaragua to southeastern Brazil and Bolivia (Duellman and Treub, 1986). The number of species of dendrobatids continues to grow as formerly inaccessible areas in the neotropics continue to be penetrated by road systems and field biologists. Unfortunately, at the same time, some species that many years ago occurred on the edges of civilization (i.e., *Dendrobates lehmanni*) now can only be found in a few remaining forest fragments and may eventually be lost as human expansion and habitat destruction continue.

To discourage predators, many species in the family produce toxic skin secretions (alkaloids) and also exhibit bright warning colorations. The intensity of colors and patterns displayed by dendrobatids rival those of coral reef fishes and tropical birds. This, coupled with their active, diurnal behavior, has made them desirable captives for zoo/aquarium displays and private hobbyists.

The National Aquarium in Baltimore (NAIB) maintains a large collection of dendrobatids and they are featured in our "Hidden Life Hallway" (Wisnieski and Cover, 1989; Barnett, in press). To date, we have successfully bred 19 species of poison-dart frogs and have made captive-born frogs available to numerous other institutions. The wild-caught populations of frogs, that has been the founder stock for breeding and display at NAIB, have largely been field collected by our staff and colleagues. This effort has not been without its trials and tribulations.

COLLECTION

My first field encounter with a poison-dart frog occurred in late morning while walking down a path through an abandoned, overgrown cacao grove in Costa Rica many years ago. Hopping across the path, in full sunlight, was a beautiful green and black poison-dart frog (*D. auratus*) foraging for tiny insects. I quickly learned two things about poison-dart frogs - they are bold and stand out visually in their environment and they can be very fast and elusive when attempting to capture them!

Another early encounter with a dendrobatid that made a lasting impression on me occurred while climbing to get past a 50 ft. waterfall (also in Costa Rica). About halfway down, I stopped to get a better grip on the tree roots that supported me. While nervously hanging on for dear life, I noticed a tiny strawberry poison-dart frog (*D. pumilio*) passing by me, hopping carefree and confident up on the cliff face. Over the years, I have gained a lot of respect for these determined little frogs and admire them as much for their attitude as for their beautiful coloration.

Like other rain forest inhabitants, such as the leaf cutter ants, many species of dart frogs often seem so preoccupied with their own agenda, the business of life, that they largely ignore your presence. Many aspects of their life histories can easily be observed, such as foraging for insects, calling to attract mates, courtship, defense of territories, transportation of tadpoles, and in some species (*D. pumilio, D. granuliferus*) parental care of tadpoles. Other species (*Phyllobates lugubris, P. vittatus*) tend to be more wary and are more challenging to observe and collect.

Dendrobatids tends to be locally abundant once you have reached their particular micro-habitat (Hiler, 1988). Some species are ridge dwellers (*D. auratus*), others prefer living along steep slopes and streamsides (*D. granuliferus* and *D. pumilio*). Still others are more secretive, living in heavy streamside vegetation and under large fallen logs (*P. vittatus* and *P. lugubris*), and some are completely arboreal (*D. arboreus*). The trick is getting to these areas. Sometimes this is easy and specimens can be collected roadside or even when crossing newly cut dirt roads. However, other times habitats can only be reached by driving long distances along muddy, hazardous roads and then walking up and down steep, slippery hillsides. The things we go through to collect colorful little frogs only reinforces my belief that "herpers" are truly a different breed. The occasional hazards that are endured for the opportunity to collect small samples of dendrobatids would most definitely qualify us for permanent residence in a mental institution by the average person's standards.

Hazards include that of poor diet, stinging insects, spiny noxious plants, diarrhea, roads and bridges only a fool would attempt to cross, falling branches, landslides, foot fungus, earthquakes, floods, parasites, etc. Field workers tend to take all of the unpleasantries in stride and, at the end of the day when gazing at a bag full of specimens, tend to have a gleam in their eye that is truly unique to their breed.

While collecting specimens for NAIB, clear polyethylene plastic bags are used to house the frogs. Before venturing out into the field, each collector takes a good supply of empty bags. As frogs are encountered, they are placed in inflated bags under one's belt. A small amount of water is added to each bag to keep the specimens moist. When moving out of the forest into open terrain, a moist cloth bag must be placed over the clear bag to keep out direct sun and for evaporative cooling.

Dart frogs, like many other frogs, can often be located by tracking calling males. This is often the only means of finding specimens in thick vegetation. If the frog stops calling, it will many times start again if you remain still and are patient. In Pèru, we have collected dendrobatids at night while they are sleeping on broad leaves (Wisnieski and Nishihira, personal comm.).

Plastic bags are convenient as they can be quickly removed from under one's belt to add additional specimens as they are encountered. It is important that species be segregated due to the possibility that one species' skin toxins (which are actively relaeased during collection) may be lethal to another species in the same bag. One drawback with plastic bags is that they may be torn by plants while walking through the forest and must be checked periodically.

Once back in camp, the frogs are sorted according to species, size, and locality, and placed in new bags. Again, these bags are inflated and contain a small amount of clean water.

Daily care consists of rinsing the bags with clean water twice a day. Again, deflated punctured bags must be replaced. This simple temporary housing technique has been utilized by Dr. John Daly, National Institute of Health (NIH), over many years of dendrobatid collecting with great success. Although this may seem like a somewhat "sterile" environment for the frogs, use of this method has resulted in very low or no mortality.

If you are in the field for several weeks, you should make an attempt to feed the frogs to prevent severe weight loss. Termites can be collected in great quantities from active arboreal nests and fruit flies can also be obtained by setting out ripe fruit. These should be offered directly into the bags housing the frogs.

For final shipping, the frogs are packed in various size plastic boxes with flexible snap-on lids. Several air holes are drilled in the sides of the containers and a damp piece of foam rubber is added to each container for padding and moisture.

These containers are then packed into styrofoam shipping boxes. Handling instructions should be printed in both English and Spanish. If outside temperatures are above 90 degees Fahrenheit, you may wish to pack a small amount of ice in a plastic bag wrapped in newspaper. This should be taped to one inside corner of the box and not be in direct contact with the frogs' containers.

QUARANTINE

Upon arrival at NAIB, the frogs are immediately unpacked and placed into awaiting cages in a quarantine area. Aquaria with sloping pea gravel substrate topped with sheet moss, live potted plants, and hiding areas consisting of cork bark and the inverted bottoms of 2 liter plastic soft drink bottles are provided for the new arrivals. The frogs are maintained in small groups of 10 individuals or less, to limit competition between cage mates. Feeding begins immediately after the frogs arrive and they are fed heavily on fruit flies and newly hatched crickets.

During the quarantine period (30+ days), the frogs are watched closely for weight loss, skin lesions, etc. Stool samples are examined to establish baseline data on gut fauna, such as species present and relative quantity. Thin individuals are separated from the groups and, if further examination of stool samples reveals a heavy parasite load, the frog is treated accordingly. The frog's mouth is opened very delicately by using a thin, flexible polyethylene strip, and the medication is delivered, via a small catheter syringe, to the back of the mouth.

Only frogs that are exhibiting clinical signs of illness are treated to remove parasites. Preliminary work by Poynton (in preparation) at NAIB has demonstrated that dendrobatids have varied protozoan gut fauna. The harm or possible benefit to the host frog from these protozoans is not known at this time.

CAGING, MAINTENANCE, AND BREEDING

Caging and captive care have been described in detail by Cover and Wisnieski (1989). Having just renovated our frog rooms, I strongly believe that materials used in amphibian rooms should be rust-proof. High humidity and wetness from cage misting will eventually corrode all ferrous metal materials. Currently, there are many types of non-corrosive shelving and light fixtures available.

From the beginning, I suggest you plan your cage designs for easy access and easy maintenance. We have redesigned the lids of our tanks from solid screen lids to ones that are hinged in the center and made from non-rusting vinyl framing. The new lids eliminate escapes out of the rear of the tanks when they are serviced.

I also cannot emphasize enough how having drain openings present in the tanks makes draining and rinsing much easier and less time consuming. Usually, you can find someone through a local tropical fish store or glass company who will drill drain/filter holes in an aquarium for a small fee. We have 1" holes drilled in our tanks and then cement a permanent plastic hose adapter to the bottom using a two-part adhesive epoxy (PC-7, Protective Coating Co., Allentown, Pa).

Currently, our frogs are maintained on a diet of newly hatched to one week old crickets (*Acheta*) and flightless fruit flies (*Drysophila*). The crickets are dusted with a vitamin mineral supplement D-Ca-Fhos (Fort Dodge Laboratories, Inc., Fort Dodge, Iowa).

Breeding techniques are described in detail by Cover and Wisnieski (1989). We are currently studying the effects of water parameters on the growth and normal development of tadpoles. Other research interests include the loss of toxicity in captive-bred dendrobatids, use of olfactory cues by dendrobatids, and territorality in dendrobatids.

CONCLUSION

Although there have been many improvements in the husbandry and captive breeding techniques of dendrobatids over the years, there is still much to be learned. Ideal water parameters, temperatures, etc., need to be established for many species. There is also still much to be learned about the nutritional and lighting requirements of both frogs and tadpoles. Other problems still not completely understood include causes for the developmental abnormalities of metamorphosing tadpoles (spindly leg syndrome), color differences between wild-caught and captive-born conspecifics (i.e., *Epipedobates tricolor*), etc. I urge all of those working with dendrobatid frogs, both in zoos/aquariums and the private sector, to continue to work to solve these problems and, most importantly, to publish the results.

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DART-POISON FROGS (*DENDROBATIDAE*): BIOLOGY, BREEDING AND CONSERVATION

Elke Zimmermann[1] and Helmut Zimmerman[2]

INTRODUCTION

Dart-poison frogs (*Dendrobatidae*) are small 2-5 cm sized frogs with often interesting colors and patterns which contrast from other anurans by their more or less poisonous skin toxins (Myers & Daly 1976), their diurnal activity patterns and their highly elaborated reproductive behavior with terrestrial oviposition (Zimmermann & Zimmermann 1981, 1985, 1988; Wells 1980; Weygoldt 1987). Actually, more than 120 different dendrobatid species are described (Zimmermann & Zimmermann 1988). They often occur in a quite patchy distribution and with sometimes fairly restricted range (e.g. *Dendrobates azureus*, Hoogmoed 1969; *Dendrobates speciosus*, Jungfer 1985; *Epipedobates pulchripectus*, Weygoldt 1983) in neotropical primary and secondary forests from Nicaragua in the north to Bolivia and the middle of Brazil in the south. Annual climate fluctuations in such an environment are low, consequently most dendrobatids may be found to reproduce during all months of the year (Luddecke 1974; Duellman 1978; Myers et al. 1978; Schluter 1984; Hodl 1990; Zimmermann, E. 1990).

The enormous growth rate of the human population during the last two decades with people searching for more and more land for settlements, requiring more and more food and energy and producing more and more garbage, has an enormous impact on non-human populations and ecosystems. The probably human-caused greenhouse effect leading to an increased heating of the world's climate, the ozone gap in the atmosphere with the correlated higher probability to get radiation-induced diseases like cancer, or acid rains changing forest structures and animal populations, are only the most well known effects. Topical ecosystems like tropical rainforests with their highest known biotic diversity of species formerly belonged to the least human-populated land masses on earth. Actually, however, human growth rate is most rapid in the tropics. Consequently, tropical ecosystems suffer most heavily from the human-caused alterations of the environment. They are being destroyed at a rate of 250,000 km^2/year, a size as large as the former Federal Republic of Germany (Myers 1984). This causes an alarming threat to the whole endemic wildlife, such as to the rain forest adapted poison-dart frogs.

Within this paper we will outline major topics which seem to be important when so-called "species-survival programmes" with "flagship" species, like dart-poison frogs, are evaluated. Special attention will be given thereby to the experience we have gained during the last two decades by studying the behavior and reproduction of 34 different dendrobatid taxa, partly in the field and partly in the laboratory (Zimmermann & Zimmermann 1988, Zimmermann, E. 1990; Zimmermann, H. 1989). First, we will review under which conditions the major groups of dendrobatids can be bred and with what success. Then we will demonstrate different reproductive strategies they have differentiated during evolution as an adaptation to their particular habitats to ensure offspring survival. A case study about the ephiphyte breeder *Dendrobates histrionicus* with its highly specialized larval food (nutritive eggs of mother) will show how vulnerable these species may be to habitat disturbances by humans. Finally, based on this background, we will provide suggestions for their conservation in the future.

MAINTENANCE AND BREEDING OF DART-POISON FROGS

According to their particular habitats, dendrobatids can be kept in moist and warm terrariums (Figure 1). If the interior walls are covered by cork, the terrariums can be made more structured.

Tropical plants like epiphytes, *Philodendron*, *Scindapsus* or *Ficus* are useful. (For details of terrarium construction and furniture see Zimmermann 1986). The size of the terrarium as well the composition of breeding groups depend on the behavior of the particular species (see Table 1). Due to a quite similar size and similar morphs of adult males and females, sexes are difficult to distinguish in most species. Sometimes males are a bit smaller than females, or they may have broader digits. However, these traits aren't reliable. The most obvious feature separating males and females is their calling behavior. Only males are able to produce calls; in females, calls are lacking.

With four representative species and species groups (species groups correspond to Zimmermann & Zimmermann 1988) we will describe the main terrarium conditions under which we have bred dendrobatids over several captive generations.

Phyllobates terribilis (and all the dendrobatid taxa of the species group VI and VII)

Species which are less active and in which neither males nor females are territorial, like in *Phyllobates terribilis*, need terrariums of sizes that vary according to the size of the frogs (e.g., in this species a size of 60 cm x 40 cm x 40 cm was sufficient to breed with a group of 2.3 adults). Reproductive males call antiphonally and make real call duels for attracting females. Gravid females in such situations show aggressive interactions by clasping another's body and pressing it down. When several captive females are living together, they synchronize breeding activity (Zimmermann & Zimmermann 1985). The eggs are laid at dark sites, often under oak leaves or on petri dishes under coconut halves turned upside down. Tadpoles hatch after about two weeks at temperatures between 20 and 25°C. They are transported by the male to a water side on the ground nearby. The nonaggressive tadpoles of a clutch can be raised together in water containers by feeding them with algae as well as commercially available fish food (Tabi Min®, Tetra Min®, etc.). After about two months, metamorphosis is complete and the 1.5 cm sized froglets with their juvenile pattern (two yellow stripes on black dorsum) should be transferred to terrariums. They take newly-hatched crickets or fruit flies as food.

Epipedobates tricolor (and all the dendrobatid species of species group I, II and III)

Males (in Colostethus also females) of these species are territorial and defend small areas with potential breeding sites. The size of the terrarium, therefore, has to take into account the number of males and their territory size. Territories shouldn't overcross and they should be visually separated from each other. A sex composition of 6.3 adults maintained in terrariums of a size of 1.3 x 1.1 x 0.6 m (see Figure 1) was appropriate to breed *Epipedobates tricolor* successfully in quite high numbers (Zimmermann 1983). Raising conditions of tadpoles and froglets correspond to those already described for *Phyllobates terribilis*.

Dendrobates imitator (and species of the species group VIII)

Relatively small terrariums of about 50x40x35 cm with at least one bromeliad are sufficient to maintain and breed these tiny dendrobatids. In most cases, both, males and females are aggressive towards individuals of the same sex. Thus, for *Dendrobates imitator* maintenance in pairs seems to be appropriate. The clutch comprises about two eggs and is laid on bromeliad leaves. Tadpoles are transported individually to water-filled bromeliad leaf axils where they are fed regularly by eggs of their mother. However, they may also feed on any other item. It is also possible to rear them up artificially in small water containers. Since they are aggressive, they should be kept singularly. Their artificial food corresponds to *Phyllobates terribilis* larvae. They complete metamorphosis in about three months and then need tiny arthropods like springtails, dwarf fruitflies or ground mites as a first food.

Dendrobates histrionicus (and species of the species group IX)

Males are highly territorial and need relatively large enclosures. Terrariums of a size of 70x60x50 cm shouldn't contain more than one male and one or two females. Females of this species show an extraordinary brood care behavior. They carry each tadpole of a clutch individually on their backs to a water-filled bromeliad leaf axil where they feed them at regular intervals with specially produced nutritive eggs (Zimmermann & Zimmermann 1981; Weygoldt 1980; Jungfer 1985). The highly specialized oophagous larvae can't feed on any additional food besides chicken egg yolk if reared artificially (1 drop of yolk/larvae every second day, after five hours completely change water). Mother-reared tadpoles complete metamorphosis after about three months and have a size of about 1.7 cm; artificially-reared ones need 1 to 2 months more and then have then a size of about 1.1 cm. Larvae don't show any sign of aggressiveness toward each other. However, if more than one is reared up in a water container only one will succeed to survive and grow. Raising conditions of froglets correspond to *D. quinquevittatus*.

Detailed information about main reproductive characteristics in 35 dendrobatid species belonging to one of the described groups is presented in Table 1.

DIVERSITY OF REPRODUCTIVE STRATEGIES IN DART-POISON FROGS

Compared to most other anurans, dendrobatids develop a highly elaborated form of courtship and brood care behavior. To synchronize breeding activity in mates they exchange various accoustic, tactile, and visual signals. Three main reproductive strategies were determined in the course of our comparative study of the behavior of 32 different dendrobatid species (see Figure 2-4).

Epipedobates pictus and *E. tricolor group* (species group II and III), Figure 2.

Courtship is relatively simple. Males defend breeding sites. No female-female aggressiveness is shown during courtship. Advertisement call is a trill or peep; courtship call, a buzz or peep; aggressive call, a trill or peep. Courtship ceremony ends with cephalic amplexus and oviposition. Brood care, conducted by a territorial male, consists of attendance, moistening and defending clutches. Tadpoles of whole clutches are transported to water side at the ground. Males may attend several clutches simultaneously. Conspecifics of both sexes may eat eggs of tadpoles of unattended clutches. Tadpoles are nonaggressive, herbivorous.

The *Colestethus* group (species group I) and the *Allobates femoralis* group (species group V) differ from the former group by always having peep calls as advertisement calls, buzz calls as courtship calls, and peep calls as aggressive calls. Courtship ceremony is finished and leads to oviposition when the male crouches on the back of the female. Cephalic amplexus is lacking. Brood care and tadpoles correspond to former groups.

Phyllobates terribilis group (species group VI) and Dendrobates leucomelas group (species group VII), Figure 3.

Courtship more elaborated. High female-female aggressiveness during courtship. Female has to stimulate male by stroking with hand over his back to show her potential spawning sites. No cephalic amplexus, but body-body or anal-anal contact before oviposition. Trill call or buzz as advertisement call. Trill call or buzz as courtship call. Trill call or buzz as aggressive call. Brood care simple. Moistening of clutch rare. Clutch attendence and defense lacking. Clutch feeding by conspecifics not observed. Male transports tadpoles in groups to water holes. Tadpoles aggressive towards non-siblings; herbivorous and carnivorous.

Dendrobates histrionicus group (species group IX) and *Dendrobates quinquevittatus* group (species group VIII), Figure 4.

Courtship highly elaborated. Male defends potential breeding as well as spawning sites, no female-female aggressiveness during courtship. Male has to show several potential oviposition sites before spawning, female may choose another male even after elongated courtship ceremonies. No cephalic amplexus, but anal-anal or body-body contact before oviposition. Brood care conducted by male and/or female (group VIII) or by female alone (group IX). Brood care extends to clutch moistening, tadpole transport and in some members of group VIII and all members of group IX, tadpole feeding by the mother (see next paragraph). Tadpoles in group IX show begging behavior. They are oophagous, not aggressive towards siblings or nonsiblings, however, they influence the development of each other by growth suppression if more than one occur at the same water site. Frogs of both sexes eat clutches. In *Dendrobates imitator* the male transports each tadpole individually to a water-filled leaf axil. He induces the female to follow him by producing advertisement calls. The female then deposits a feeding clutch at the water border of the leaf axil. Afterwards she feeds her tadpoles without being stimulated by the male. Tadpoles aggressive towards siblings and nonsiblings, omnivorous.

MAJOR THREATS TO THE SURVIVAL OF DART-POISON FROGS: A CASE STUDY ON DENDROBATES HISTRIONICUS

Dendrobates histrionicus is an egg-feeder whose reproduction is highly adapted to bromeliads. It is distributed in a fairly high variety of morphotypes (see Figure 5) in tropical lowland rain forests of the eastern slopes of the Andes, from Colombia to Ecuador. Primary rain forests with a high abundance of bromeliads characterize their habitats. Population density at our study sites were relatively high with 2 frogs/100 square meter. Males defend territories with potential spawning sites. Nearest neighbor distances between calling males varied between 2 and 8 m. Males try to attract females by producing advertisement calls sitting at exposed sites within their territories. Gravid females respond by phonotaxis. Then, a highly complex courtship ceremony starts, often extending for several days. The male then leads the female to several oviposition sites. The female inspects these sites which are often under fallen leaves or in the vicinity of bromeliads and then often leaves to search for another male and spawning site before depositing her clutch (for further details see Silverstone 1975, Zimmermann & Zimmermann 1981, Zimmermann, E. 1990; Zimmermann, H. 1989). Probably the female is so choosy because she has to take over a presumably highly energy-consuming brood care behavior which is unique for frogs but characteristic for this species of dendrobatids. After oviposition, the female, and not the male, returns to the clutch to moisten it by spraying water from the anal bladder over it. When the tadpoles emerge from their egg capsule, the female (and not the male as in the other dendrobatid groups) transports each tadpole individually on her back to a water-filled bromeliad leaf axil. She then returns to each larvae once a week to feed it with specially produced nutritive eggs, 3-7 eggs/tadpole. For this procedure, she climbs backwards into the bromeliad leaf axil. When the tadpole recognizes its mother, it starts to show a sort of begging behavior. It displays a trembling movement in a circle, showing heavy tail vibrations, then it wriggles upon its mother's back again and again. Probably these tactile stimulations induce oviposition. A female may have up to five reproductive clutches per year. On the average she cares for four tadpoles per clutch deposited in different axils of the same bromeliad. Thus, compared to most other anurans, fecundity per year appears to be very low. However, in an area where population density is high, the rising generation is protected during critical periods, enough for propagation of the next generation.

Unfortunately, due to the strong adaptation of reproduction to epiphytes (usually bromeliads) and the highly specialized larvae, such species are highly vulnerable to habitat disturbances by humans. Thus, we intended to study the ecology and behavior of *Dendrobates histrionicus* populations at the lowland tropical rain forest of the pacifian side of Ecuador in the same habitats over several years. We selected sites where intact breeding populations were found by Silverstone 1975 (see Figure 6). However, in 1984 when we started our field study, three populations disappeared totally. Two years later in 1986, five further populations were lost and another two years later, in 1988, four further populations were gone. Only one population with probably endangered self-sustaining capacity remained as isolate (see Zimmermann, H. 1989 for further information). As it is now characteristic for the whole Pacific tropical wet forest region of Ecuador, original rain forests are logged. Where in 1960 no roads and only few settlements existed in this region, in 1984 asphalt highways connecting the greater villages were constructed. Together with the roads, new settlers arrive, logging more and more of the pristine rain forest. Dodson, an American tropical biologist working in this area, emphasized that these Pacific lowland forests of Ecuador, representing one of the most species-rich endemic flora and fauna regions in South America, is currently the fastest disappearing habitat of the country (Dodson & Gentry 1978). In our cases, most of the extensive wet forest vegetation with the extraordinary fauna of frogs and other animals has been converted almost completely to pineapple, banana, or oil plantages.

SUGGESTIONS FOR THE EVALUATION OF CONSERVATION PROGRAMMES

Similar situations could be seen almost everywhere in the tropics. Dart-poison frogs, however, benefit from their contrast to the lesser attractive tropical anurans. Their fascinating colors and patterns, their extraordinary behavior as well as their unusual skin toxins, make them more interesting than any other neotropical anuran family for the public, as well as for scientists and frog hobbyists all over the world. All frogs of this family (except Colostethus) are included in the appendix II of the Washington Convention. Are populations or species really protected by a law? In our opinion, effective species protection requires more; it requires not only a detailed knowledge of the life history and the ecosystem of the concerning species, but also, and most important, habitat protection in accordance to the needs of the human population.

Thus, what may be done and what has been done for the protection of poison-dart frogs? For establishing self-sustaining populations in captivity, it was suggested to build up a gene pool large enough for retaining the greatest possible amount of variability of each species. Therefore, as many individuals as possible should be kept.

However, the available space for adequate maintenance will delimit this goal quite rapidly. Thus, priority species have to be selected. But, how to choose the right species? Will species endemic for a limited locality occurring in large population densities have a higher priority level than species whose members occur in only limited numbers over broad ranges? How many sibling species looking superficially very similar like the "*Dendrobates quinquevittatus*" group are presently treated as a single species because of lacking information about their biology? Do all the different morphotypes of a species like *Dendrobates histrionicus* really belong to one biological species? How to evaluate conservation programmes which don't include only one particular species but instead whole biomes and take into account the needs of the original human population? These are some major queries we have to respond to in the right way if conservation efforts should be successful.

As a first step to preserve poison-dart frogs in captivity, an anuran specialist group was founded in western Germany by members of the DGHT (German Society for Herpetology and Terraristics).

Anuran breeders and scientists cooperate in enlarging our present knowledge about the taxonomy, reproduction, ecology, behavior, physiology, genetics, keeping and breeding of frogs and in exchanging animals with known origin for the establishment of self-sustaining populations in captivity. Figure 7 gives an impression of the breeding results of members of this group. From 1981 and 1983 till 1989, more than 10,000 individuals of 35 different species of dendrobatids were bred successfully, in most cases over multiple captive generations (see also Table 1). Besides these captive breeding programmes, efforts have to be made for the protection of natural areas as biosphere reserves spacy enough to protect not only single species but as much of the biotic diversity as possible. Proposals are outlined by the IUCN 1987, Myers 1989 and other international conservation agencies as well as by the DGHT Anuran Specialist Group. To be successful, however, these programmes have to take into account programs for the improvement of education and life style of the indigenous human population and have to be accepted by both the concerned governments and the inhabitants of the respective areas. Promising efforts in this direction are about to be conducted now at Ecuador (e.g., the Tobar Donoso project, see R.I.C. Report 1988 for further information). Here, private individuals and the Awa-Indians, as well as the governments of Ecuador and Colombia, are collaborating to protect a 530,000 ha area of pristine rain forest with a species- rich flora and fauna, including a buffer zone. Only if these efforts are strengthened and financially supported will some parts of the flora and fauna of tropical rain forests survive.

ACKNOWLEDGEMENTS

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TABLE 1. Breeding Data on Dendrobatid Frogs

	LGTH. AD. (mm) m/f	AT SEX. MAT. (mos)	LONGE -VITY (yrs)	NO. EGGS/ CLUTCH	[1]FOOD OF LARVAE	[2]REF.	[3]GEN. BRED	[4]NO. FROGS BREED-ING
Colostethus								
palmatus	27/35			29	c,h	1	F2	
saulii	17/19			30	c,h	2	F?	
sp. (lit.)	23/26			43	c,h	p.o.	F1	
talamancae	22/28	12		33	c,h	p.o.	F1	69
trinitatis	23/31	7		35	c,h	3	F1	10
Allobates								
femoralis	28/33	10	6	20	c,h	4,p.o.	F3	14
Dendrobates								
arboreus	21/22			7	o	5	F1	
auratus	28/30	15	6	8	c,h	6,7,8	F4	323
azureus	33/37	10		5	c,h	6,9	F1	6
fantasticus	23/25	6		4	om	10	F1	
histrionicus	28/30	10	4	9	o	11	F2	103
imitator	17/19	8	3	2	om	12,13, 14	F2	81
lehmanni	28/30	10	4	9	o	11	F2	72
leucomelas	30/32	16	10	8	c,h	15	F4	161
pumilio	19/21	10	4	9	o	16,17	F3	43
quinquevittatus	15/16	8	3	9	om	18,19, 20	F1	17
reticulatus	14/16	7	3	2	om	19	F2	35
sp. (vir.)	20/22			8	o	5	F1	
speciosus	27/29			9	o	21,22	F1	
tinctorius	38/40		11	7	c,h	6,23, 24	F3	147
variabilis	16/17	8	3	6	om	13,14	F2	29
Epipedobates								
anthonyi	21/23	11	4	25	c,h	14	F4	426
azureiventris	24/27			14	c,h	25	F?	
"boulengeri"	21/23	12	4	20	c,h	14	F3	207
bilinguis	19/20			13	c,h	5	F1	
parvulus	23/25	12		16	h	26	F3	

	LGTH. AD. (mm) m/f	AT SEX. MAT. (mos)	LONGE -VITY (yrs)	NO. EGGS/ CLUTCH	[1]FOOD OF LARVAE	[2]REF.	[3]GEN. BRED	[4]NO. FROGS BREED-ING
pictus	19/21	10	3	30	h	14,26	F2	55
pulchripectus	23/25	12	5	20	h	14,26	F3	56
tricolor	22/26	9	5	30	c,h	27,28	F7	1696
Phobobates								
bassleri	34/40			35	c,h	29	F3	
silverstonei	38/40			30	c,h	30	F1	5
trivittatus	35/40			34	c,h	31		
Phyllobates								
bicolor	40/41	12		17	c,h	14	F2	285
lugubris	23/25	10	5	15	c,h	32,14	F4	270
terribilis	32/35	12	8	20	c,h	33,34, 35	F5	836
vittatus	26/29	10	5	15	c,h	14,32, 36	F6	624

[1] c = carnivorous, h = herbivorous, om = omnivorus, o = oophagous
[2] 35 authors, see Zimmermann 1986.
[3] Breeding to Fx generations by members of the DGHT-ANURAN SPECIALIST GROUP
[4] Record of the total number of frogs bred in the authors' own collection until Dec 1990.

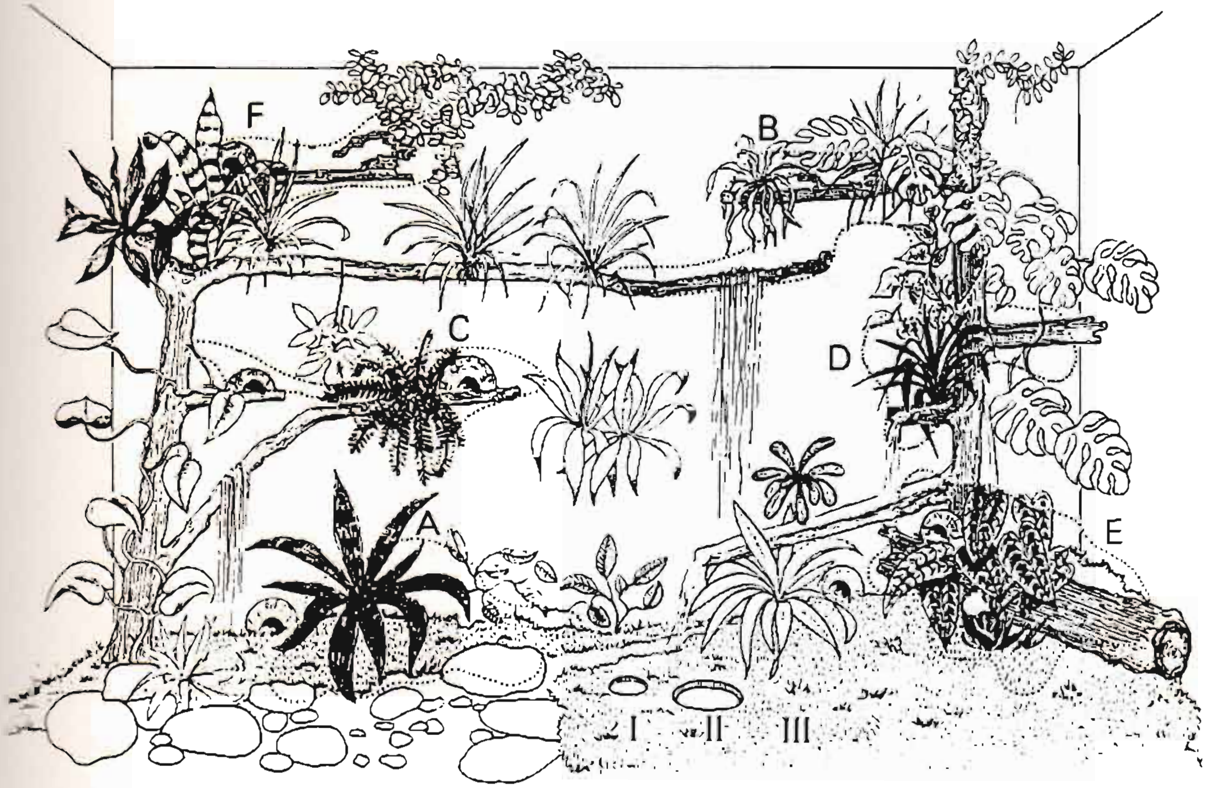

Figure 1. A terrarium for a breeding group of 6.3 *Epipedobates tricolor*, 130x110x60 cm (description see text).

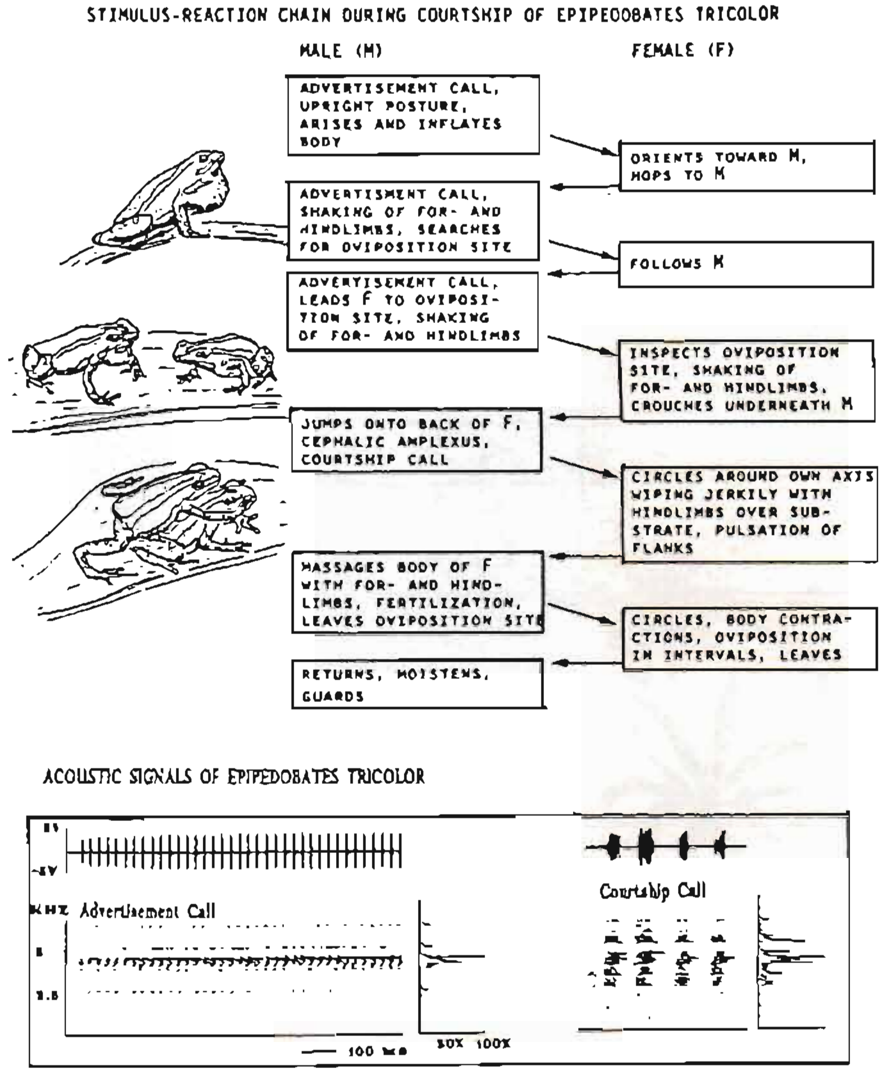

Figure 2. Schematic representation of stimulus-reaction chain during courtship of *Epipedobates tricolor* (top).
The advertisement call or long courtship call (bottom, left) and the short courtship call (bottom, right) are represented by oscillograms, sonograms and power spectra. Both calls are recorded at 24°C.

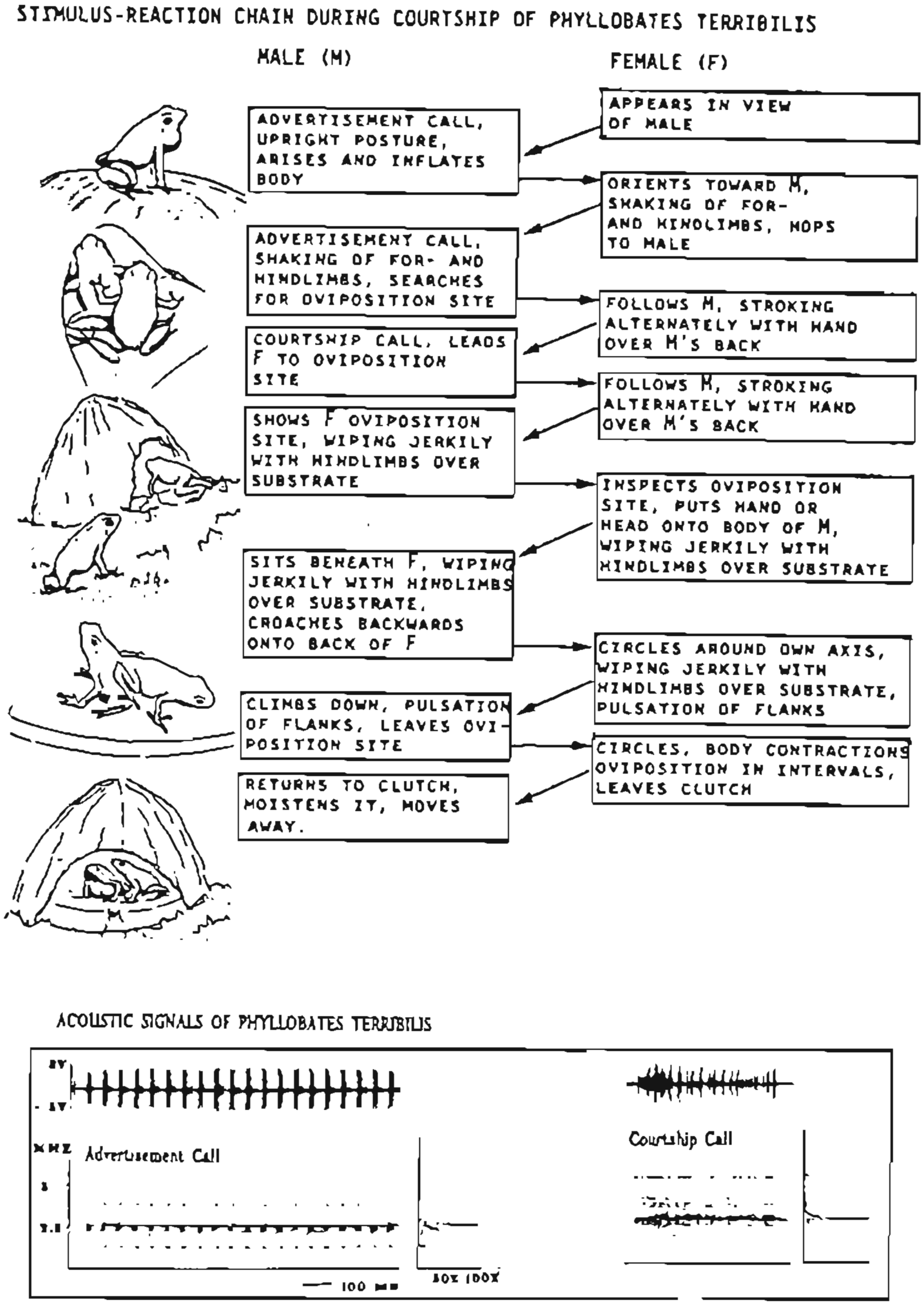

Figure 3. Schematic representation of stimulus-reaction chain during courtship of *Phyllobates terribilis* (top). The advertisement call or long courtship call (bottom, left) and the short courtship call (bottom, right) are represented by oscillograms, sonograms and power spectra. Both calls are recorded at 24°C.

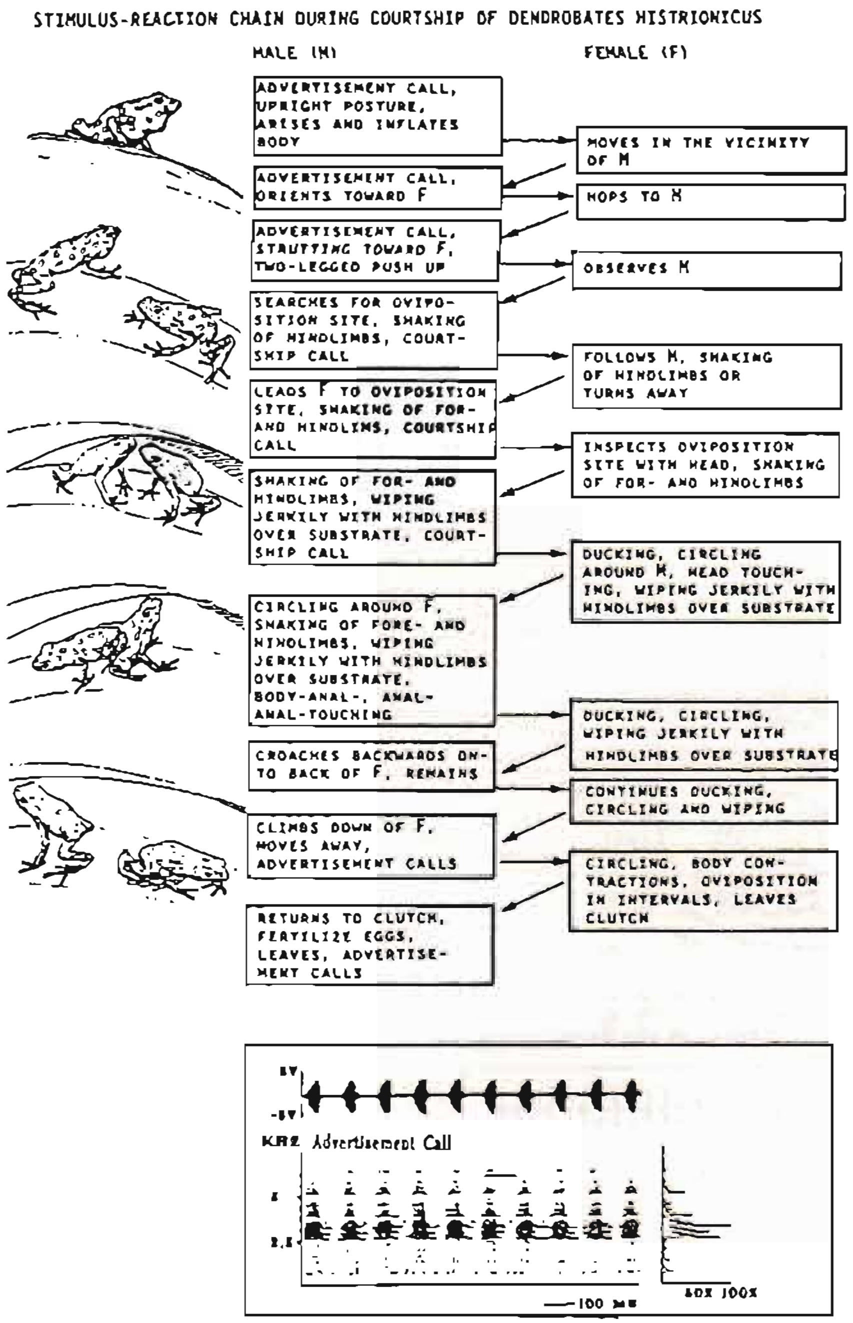

Figure 4. Schematic representation of stimulus-reaction chain during courtship of *Dendrobates histrionicus* (top). The advertisement call is represented by oscillogram, sonogram and power spectrum (bottom). Call recorded at 24°C.

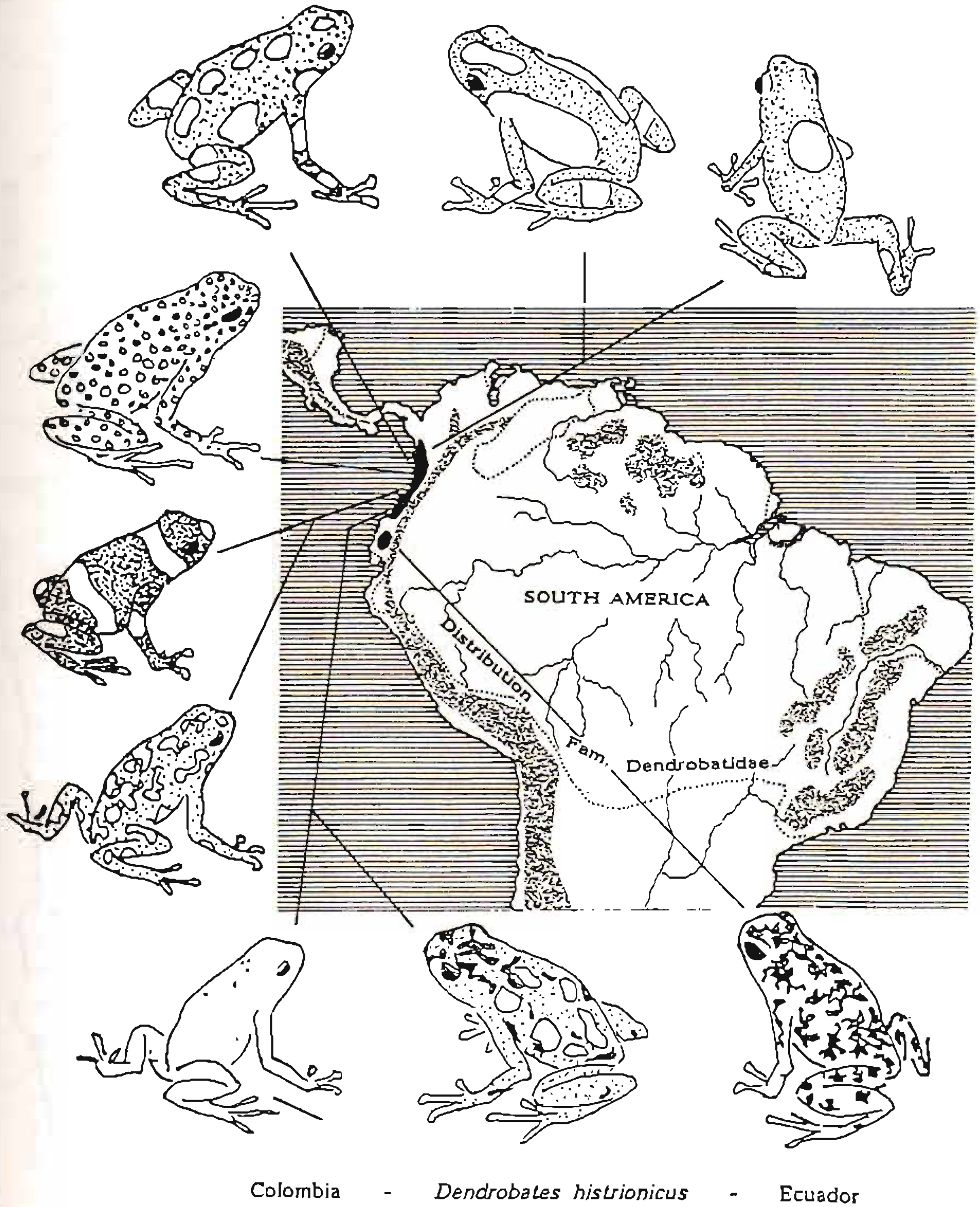

Figure 5. The family *Dendrobatidae* is distributed in Middle and South America (boundaries see pointed lines). *Dendrobates histrionicus* occurs in a variety of morphotypes in western Colombia and northwest Ecuador.

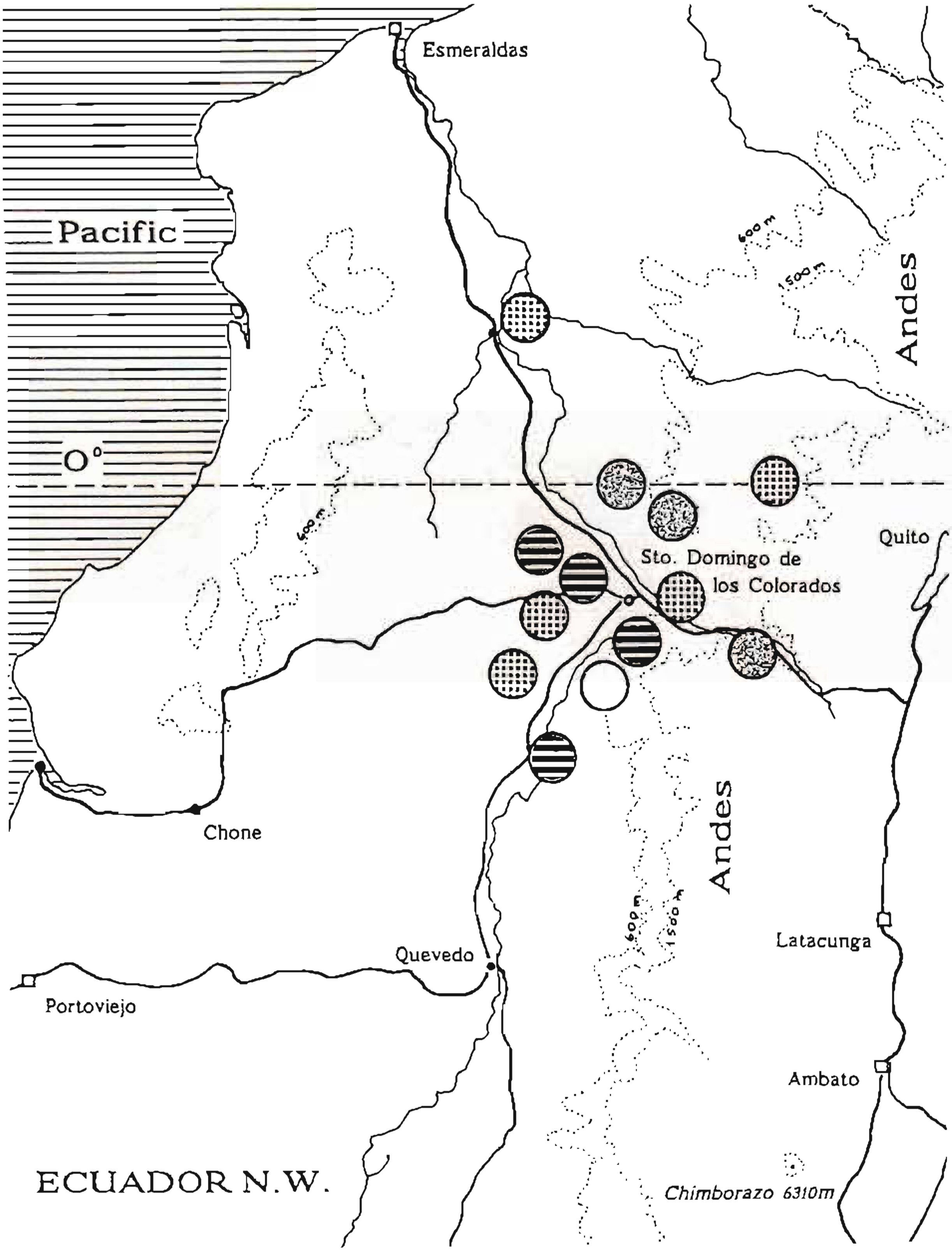

Figure 6. The most southern populations of *Dendrobates histrionicus* around the little town Santo Domingo de los Colorados in west Ecuador have almost completely disappeared. Decrease from 1975 to 1984 (points), from 1984 to 1986 (squares) and from 1986 to 1988 (lines). Only one self-sustaining population (circular area) remained at the Indian reserve of the Colorados in 1988.

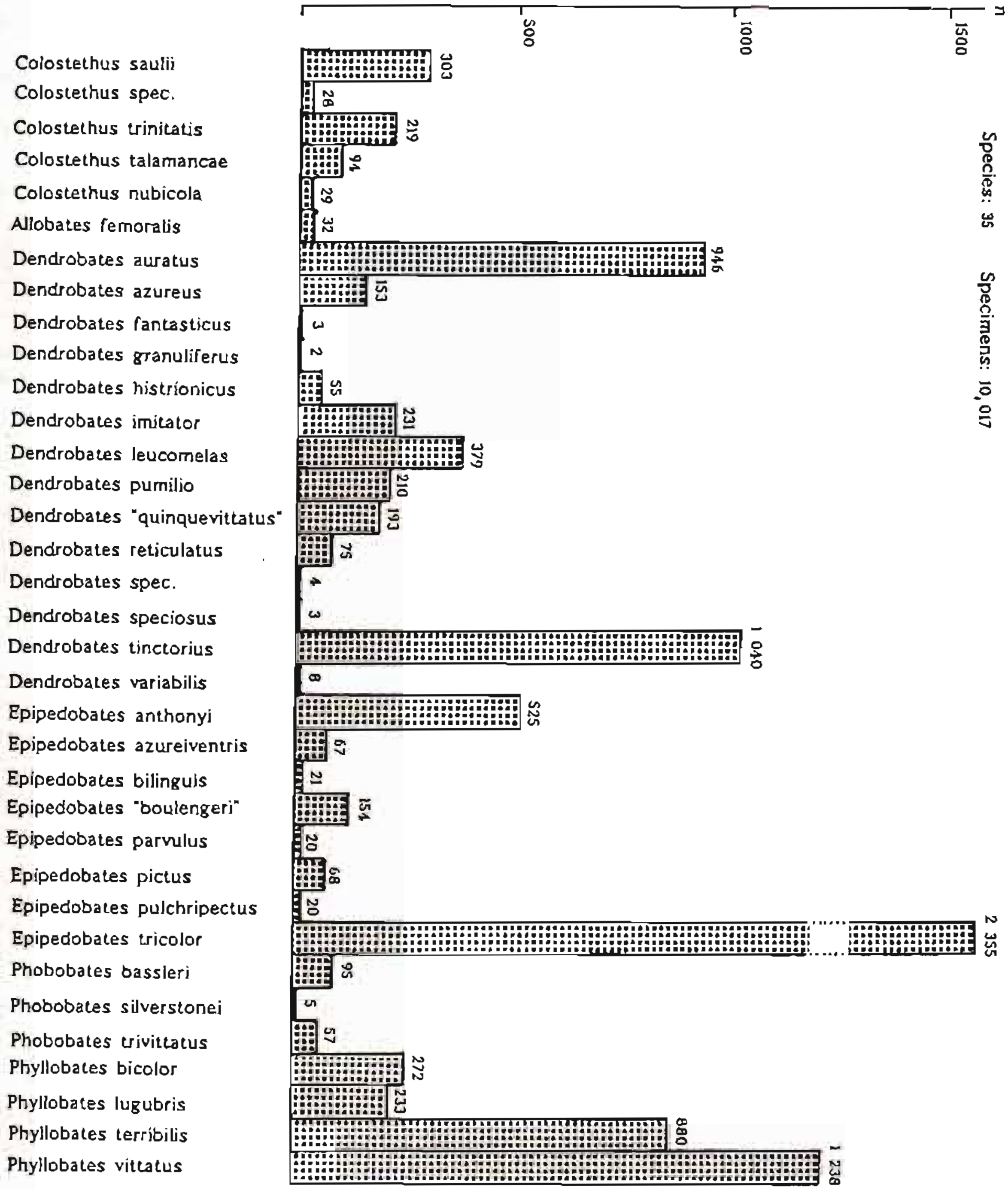

Figure 7. Synopsis of breeding records of DGHT members in 1981, 1983-1989 (1982 not recorded) shows 10,017 bred individuals of 35 species of dart-poison frogs.

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THE "JUNGLE PHASE" CARPET PYTHON, *MORELIA SPILOTA*, HUSBANDRY AND BREEDING

William B. Montgomery

ABSTRACT

The carpet python group, *Morelia spilota* (Gray, 1842), inhabits much of continental Australia, and parts of New Guinea, and includes three subspecies: *spilota*, *imbricata* and *variegata* (Cogger 1981). In the rainforests of Queensland occurs a form commonly referred to as the "Jungle Phase." It is quite distinct from other forms, having a highly contrasting pattern of black and yellow, and adults are generally much smaller than other carpet pythons. For three consecutive years, a pair of these snakes has been maintained and bred by the author. Husbandry, breeding incubation and neonatal care are discussed.

INTRODUCTION

The form of carpet python found in the rainforests of Queensland, which I will hereafter refer to as the "jungle phase," reaches a maximum adult length of about 2 meters, a much smaller size than the 4-meter maximum length (Cogger, 1983) attained by other *Morelia spilota*. The males are typically smaller than females. The ground color is usually bold blackish-brown to black, interspersed with irregular pale lemon-yellow to gold variegation, which may form bands or longitudinal stripes. The ventral surfaces are cream to yellow with black blotches. In older snakes, the yellow usually darkens dorsally and sometimes becomes infused with black pigment.

Although the jungle carpet phase python is usually regarded as being restricted to the Atherton Tablelands, John Weigel (pers., comm.) has stated that the Atherton Tablelands actually consist primarily of open woodlands, rather than rainforest, with "normal" looking carpet pythons which are typically dark brown to black, with paler olive or gray. According to Weigel, the yellow and black coloration occurs in *Morelia spilota* from the coast through the rainforest gullies that only marginally transect the tablelands. Similar looking snakes are also found in rainforest of the Lockerbie Scrub and Jardine River area, on the northern tip of the Cape York Peninsula.

Although usually placed in the subspecies *variegata*, many authors have remarked on the very unique characteristics of the jungle phase. Some have even suggested that it is sympatric with other forms without intergrades occurring (Worrell, 1963; Wilson & Knowles, 1988), but there doesn't seem to be any conclusive evidence of this. The subspecies *macropsila*, described by Werner in 1909 (Cogger, Cameron and Cogger, 1983) and still in use as late as 1964 (Kinghorn 1964), may have included this particular snake, but there is no locality data for the holotype. The divergent characteristics of the jungle carpet phase are not limited to appearance. A ongoing study by Gregory A. Mengden (with portions in collaboration with Hal Cogger and Richard Shine), electrophoretic data (unpublished) indicates that these snakes are very distinct from most of the *Morelia spilota* group; as distinct a form as *M. bredli*, and possibly as distinct as the Diamond python, *Morelia s. spilota* (G. Mengden, pers. comm.).

The carpet python is bred frequently in captivity, both in Australia and the U.S., and there is abundant literature pertaining to their reproductive biology (Charles, et al. 1985; Ross and Marzec, 1990). But, to my knowledge, the only published information which seems to deal specifically with the jungle phase carpet python is by Boos (1979), who described breeding a pair of carpet pythons from Queensland, the male being yellow and black, the female being dull black and grey.

HUSBANDRY

In June, 1986, a yearling female jungle phase carpet python was obtained, which was approximately 75 centimeters long at the time. In June, 1988 a three year old male, which was about 120 centimeters long, was obtained from a different source. Both snakes were captive-hatched, and apparently unrelated.

The snakes were housed separately, except when placed together for breeding purposes. The male was kept in a 31 x 122 x 49 cm. glass terrarium with a sliding pegboard lid. The female was kept in a 60 x 87 x 45 cm. wooden cage with hinged glass doors in front. These pythons, at least in captivity, are almost entirely arboreal, and both cages originally had tree branches placed diagonally for climbing. These were eventually replaced by elevated wooden bars in the form of horizontal ladders. This is where the snakes stayed most of the time. These props also make it much easier to clean the cages, because the snake can be left in while the cage is cleaned. If the snake needs to be moved, it can be lifted out on the wooden bars and will usually stay coiled there long enough to move it or clean the cage. This is less stressful for it, and easier for the keeper.

Newspaper was used for substrate. Water was available ad libitum. Hide-boxes were provided originally, but since they were seldom used, they were eventually removed. A heating pad (Valentine Equipment Co., #C95) was located directly under the floor of one end of each cage, and was regulated by a thermostat (Wrap-On general purpose). The room temperature ranged from 27° to 30°C in the summer and from 22° to 28°C in the winter. Temperature was controlled thermostatically by a wall heater and a window-unit air conditioner. Humidity was not controlled, but was generally high. A natural light cycle was provided to some degree by two windows, and an over head fixture with two Vita-lite (Duro-Test Corp.) bulbs was turned on every day from morning until night (timing variable).

Both snakes were offered food weekly or biweekly, except when opaque. If they were together, they were separated for feeding. The female was started on mice, and was offered rats and chicks once she reached an appropriate size. She consistently refused rats, even after many efforts were made to change her diet preference. Methods which have worked well for other snakes, such as washing and scenting the rats, and sewing rats onto mice, and dipping rats in chicken broth, were all unsuccessful. As an adult, this snake is fed a diet of quail or young chickens. Other people have reported similar rejection of rats by some of these snakes (D. Reed, pers. comm.). The male initially refused rats, then started taking them willingly and has fed on them ever since.

BREEDING

First Year:

On 11 October, 1988, the male was moved into a cooler room, the temperature ranging from 21° to 25°C. At 0830 h on October 18, the female, which had just shed, was placed in with the male. The temperature at this time was 26.5°C. Since the weather had warmed up this room to almost the same temperature as the heated room, the whole cage was moved back to the heated room. At 0800 h the next morning, the snakes were observed coiled together on the branch copulating. The male soon moved off of the branch and into the hide box.

They were separated and fed two days later. Then on 8 November, the female was placed with the male, and they were both moved to a cooler room where they remained for the next 13 days. Temperature ranged from 22° to 25°C. After this, they were returned to the warm room, separated and fed. They were not cooled again. On 17 January, at 0830 h the female was placed with the male, and at 1200 h they were observed copulating. The female was removed two days later.

The female began refusing food on 2 February. By early April, her girth was noticeably large, and she was spending most of her time on the floor of the cage over the heating pad. At this point, a plastic pan, 30 x 35 x 13 cm., half filled with slightly damp sphagnum moss, was placed in the cage adjacent to the heating pad. Over this, a large cardboard box with a hole in it was placed. She began staying alternately in the box, or on the heating pad. On 30 April, she was discovered wrapped around a clutch of 18 eggs. One slug was also present, but separate. Shivering thermogenesis was not observed, possibly because of the warmth of the room, which was about 30°C (Shine, 1988).

Second Year:

The male was placed with the female on 25 September because of an unexpected shortage of cage space. They were housed together almost continuously until 2 January, the female being removed for no more than two days at a time. The temperature fluctuated a great deal during this time, depending on the local Texas weather. On 18 December, the temperature was 23°C, and the heating pads were disconnected. On 27 December, the snakes were separated for one day, on the 28th, the female was placed back with the male, and on the 29th, at 0800 h copulation was observed, and continued for at least two hours. This was the only time that they were seen copulating this year. On 2 January, they were separated. The male refused food until the 24th. The female started refusing food on 13 February.

In early April, the female was determined to be gravid by her appearance and behavior as stated previously, but a laying box was not placed in the cage in time for the deposition of eggs. Late on the morning of 10 April, she was found coiled on the floor of the cage around a clutch of 18 eggs, including one slug. One egg was not adhered to the rest, and remained outside the coils of the snake.

Third Year:

The male was placed in the female's cage on 16 November and left for two days, and on 29 November, the female was placed with the male for two days. No breeding behavior was observed on either occasion. The male's cage was moved to a cooler room on 2 December, and the temperature was manipulated daily to range from a day-time high of 26°C to a night-time low of 22°C. The female was introduced 8 days later. From this point on, they were kept together almost all the time until 17 January, 1991 at 0800 h the snakes were observed copulating for at least 3 hours. As per the previous year, they were only seen copulating on one occasion.

On 6 February, the female began refusing food. At the end of May, the female was determined to be gravid and a laying box was placed in the cage. At 1130 hrs on the morning of 7 April, the female was observed laying eggs (three eggs were out). The eggs were laid in a spiral, emanating from the center. Oviposition was completed 3 hours, 20 minutes later; a total of 21 eggs were laid with no slugs (see Table 1).

INCUBATION

The eggs were removed from the female upon discovery, never longer than seven or eight hours after deposition. The third year they were removed immediately. The female was quite aggressive at this time, and rather difficult to separate from the eggs. The mass of adhered eggs were placed in a plastic food storage box, measuring 24x35x12 cm. A 1:1 (by weight) mixture of vermiculite and water (Tryon, 1975) was used as a substrate (about 4 cm. deep). They were then placed in the incubator.

The incubator used in 1989 and 1990 was comprised of the top of a styrofoam chicken incubator (Hova-Bator) which was placed on top of a wooden box built to fit it. This was successful in hatching the eggs, but the temperature fluctuated quite a bit. In 1991, a wooden and glass incubator was built, with a Brower Air-Flow heating unit on the bottom, and welded wire shelves above it. A Micro-Climate DL2 thermostat was wired to the heating unit, and this kept the temperature absolutely constant.

The incubator temperature was set each year at 31°C, slightly lower than the 90°F recommended by Ross an Marzec (1990). The first two years, the temperature reached an occasional high of 33°C and was as low as 29°C several times. The eggs were checked daily and if there was not a lot of condensation on the sides and top, they were misted lightly. Opening the box daily also increased the available oxygen, possibly an important factor especially just before hatching (Black, et al., 1984). Incubation time ranged from 51 to 54 days (see Table 2). The eggs always started to collapse about three weeks before hatching.

The eggs hatched over a period of three days and the egg box was removed from the incubator at this time. The percentage of eggs that successfully hatched was 94% for all three years. The 1991 hatchlings were measured and weighed 36 hours after hatching was complete. The measurements were made by photocopying them and then measuring the 1:1 copy (see Table 3). Neonates' average mass was 26.9 g, the average SVL was 340 mm., and the average TL was 70.2 mm. One neonate in 1991 had a severely kinked spine; all other were healthy and normal.

CARE OF NEONATES

When the eggs began to hatch, the box was removed from the incubator, opened, and placed in a 31x76x32 cm. all glass terrarium. The terrarium had several water bowls and several plastic boxes with damp sphagnum moss. The purpose of these was to increase the humidity, as well as provide hiding places. The humidity was also increased by occasionally misting the inside walls of the cage.

The neonates were left together in one cage for about two weeks, or until the first snakes began to shed. The time of the first shed varied a great deal among individuals, ranging from two to five weeks. After shedding began, they were sexed and placed in individual plastic boxes (18x31x8 cm.).

The juveniles were offered pink mice within two weeks of hatching and most of them fed aggressively right from the start. Live pink mice were offered first; if these were refused, feeding response was elicited by tapping the snake's body with the food item which is held with forceps (Peterson and Odum, 1985). There were invariably one or two snakes that repeatedly refused food. If this continued for over five or six weeks, they were force-fed, using a Pinky Pump (BJ Specialties). This usually had to be done only once or twice before the snake began taking food on its' own. Juvenile coloration was generally dull white and black; the yellow color developing at six to twelve months of age.

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TABLE 1. Breeding data for "jungle phase" *Morelia spilota*

Year	First Observed Copulation	Last Observed Copulation	Date of Oviposition	# of Days Since Last Observed Copulation
1	10/19/88	1/17/89	4/30/89	103
2	12/29/89	12/29/89	4/10/90	102
3	1/06/91	1/06/91	4/07/91	91

TABLE 2. Incuation data for "jungle phase" *Morelia spilota*

Clutch	Date Laid	Date of Hatching	Length of Incubation	# Laid	# Hatched	% Hatched
1	4/30/89	6/23/89	54 Days	18	15	83
2	4/10/90	5/31/90	51 Days	18	17	94
3	4/07/91	5/28/91	51 Days	21	21	100

TABLE 3. Length and mass of 1991 hatchling "jungle phase" *Morelia spilota*

Specimen	Mass (g)	SVL (mm)	TL (mm)
1	25.0	295	68
2	28.7	352	69
3	24.7	326	68
4	26.2	354	69
5	27.8	345	65
6	28.2	352	74
7	29.4	331	71
8	24.9	350	70
9	29.1	335	72
10	27.6	343	64
11	25.2	346	69
12	24.9	333	71
13	27.6	362	70
14	24.3	341	68
15	27.7	327	71
16	27.3	345	76
17	29.1	343	70
18	27.4	348	76
19	27.7	337	72
Mean (S.E.)	26.9(0.38)	340(3.3)	70.2(0.7)

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14 Watt Moisture Proof Heating Pad #C95
Hova-Bator Incubaro #1602N
Brower Ait-Flow Heating Unit #5003-S
Valentine Equipment Co.
P.O. Box 53
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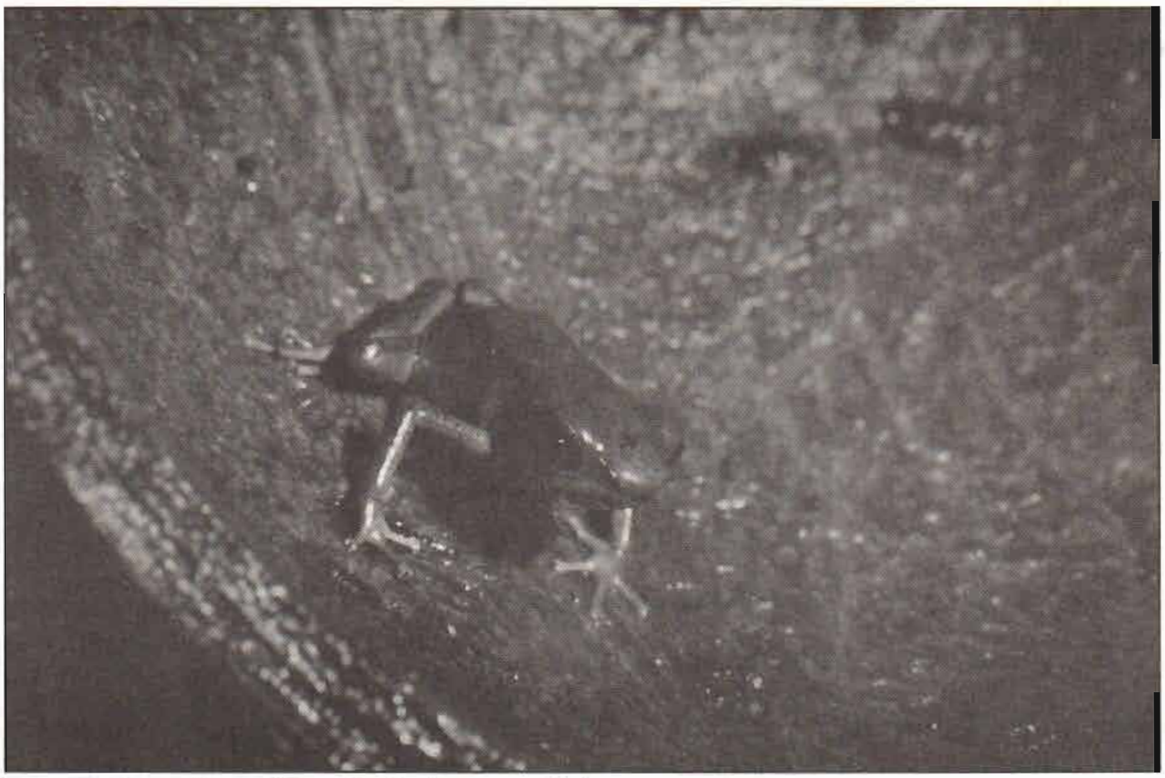

Dart-Poison Frog (*Dendrobates pumilio*)
Photo by David Hulmes

ECOLOGICAL STUDIES ON AUSTRALIAN PYTHONS

Richard Shine

ABSTRACT

Although considerable information is available on feeding and reproduction of captive boid snakes, the field biology of pythons is poorly known. This paper describes the results of three major studies from the University of Sydney over the last ten years. First, measurement and dissection of >1,000 preserved specimens in museum collections provided background data on the natural history of thirteen species of Australian pythons. Second, David Slip's radiotelemetric work on free-ranging diamond pythons *(Morelia s. spilota)* provided extensive information on movements, habitat use, reproductive biology and feeding habits of this species. Third, continuing mark-recapture and radiotelemetric studies by Thomas Madsen and myself are providing an insight into the life history and population ecology of one tropical species, the water python *(Liasis fuscus)*. In combination, the results of these three studies provide a considerable amount of information on the lives of pythons under natural conditions.

Until the last few years, we have known remarkably little about the biology of pythons in the wild. These beautiful, spectacular animals have long been popular choices as exhibition animals - both for zoos and for private reptile-keepers - but the ecology and behaviour of pythons under natural conditions have been virtually unstudied. There is an urgent need for information on these topics, because in many parts of the world pythons are heavily exploited for their hides and meat. Unless we know something about natural populations of pythons, we will be unable to plan effective conservation measures.

Fortunately, field studies on boid snakes are expanding, and work is currently underway on a variety of New World species from anacondas through to rubber boas. Pythons themselves have been relatively ignored, probably because the areas in which they are found - Australia, Africa and Asia - are far from most of the major Universities and Museums (which are concentrated in Europe and North America). Australia contains most of the world's python species and retains more relatively undisturbed wild habitats than do most other parts of the global distribution of the Pythoninae. Hence, it is the logical place to carry out detailed field-based ecological studies on pythons. Over the last few years, my group at the University of Sydney has commenced this kind of research. This paper will review our recent and current studies on the biology of Australian pythons.

EVOLUTION Of THE AUSTRALIAN PYTHONS

The first step in carrying out research on any group is to work out a satisfactory classification scheme and nomenclature, but this apparently simple goal has proved to be elusive in the case of the Australian pythons. There is little agreement among authorities on the evolutionary relationships among this group, or indeed whether the pythons deserve separate familial status in their own right, as the Pythonidae (e.g., McDowell 1987; Underwood and Stimson 1990). Controversy occurs at lower taxonomic levels as well - for example, in the definition of genera (e.g., does *Chondropython* warrant separate status from *Morelia*?) and species (e.g., are *Liasis childreni* and *L. stimsoni* really distinct?). Arnold Kluge has recently re-examined this topic, and his publications will be of great interest. In the interim, the consensus seems to be that the Australian pythons should be allocated to either three or four genera - *Morelia* (with *Chondropython*?), *Aspidites*, and *Liasis*, but that all of the Australian species are relatively closely related. This high degree of relatedness is evidenced by close biochemical similarities (Schwaner and Dessauer 1981) and the readiness of captive pythons to interbreed (Banks and Schwaner 1984).

It seems likely that the biogeographic history of the Australian pythons is similar to that of another large and diverse group of Australian snakes, the elapid. Although a now-extinct lineage of large constricting snakes (the Madtsoiidae) was found in Australia during its ancient northward drift after the breakup of Gonwanaland, the pythons almost certainly were not a Gondwanan group (but see Smith and Plane 1985 for a different interpretation). Instead, the pythons invaded Australia from the north, probably less than 25 million years ago, when Australia collided with the Asian plate. Thus, the present-day Asian pythons probably give us the best idea of what the early pythonine invaders of Australia may have looked like. Most are large, semiarboreal mammal-eaters of tropical forests, but the Australian forms have diverged considerably from this type.

NATURAL HISTORY OF THE AUSTRALIAN PYTHONS

Detailed field studies of single populations of pythons can tell us a great deal, as I'll argue later in this paper. However, they are no substitute for a broad overview. Several years ago, I decided that it would be worthwhile to document the basic biology of the entire Australian evolutionary radiation of these animals before I began delving into detailed studies of the ecology of any single python species. Published books and scientific papers either offered nothing reliable (often just repeating inaccurate statements by previous authors), or provided only anecdotal reports of particularly large snakes or a few prey items. There was no reliable source of information on such basic aspects as body size (e.g., How large are hatchling pythons? How large are adults? Do males and females differ in average size?), reproductive biology (How many eggs are produced? How large are they? When does breeding occur? Do larger females produce larger clutches?) or feeding habits (What types of prey are eaten? Do diets change with the snake's age and size?) and so forth. To try to answer some of these questions, I and one of my graduate students (Dave Slip) embarked on a program of examining preserved python specimens in the collections of all of the Australian museums.

Museum collections are generally regarded as being mainly for taxonomic purposes, but an immense amount of ecological information can be gained from them as well. Many museum personnel are well aware of this fact, and the reptile curators in every large natural history museum in Australia gave me permission to cut open their specimens to look for prey items in the stomach, determine gender, count eggs and so forth. There are obvious problems with studies of this sort, because the preserved specimens in museum collections may sometimes provide misleading information. For example, the snake may have been kept alive for a long time before being killed and preserved (in which case its stomach will be empty) or even worse, fed in captivity shortly before being killed (in which case a 'foreign' prey item will be found). In practice, the problems are minor. Obviously 'foreign' prey items (like white rats) are rarely found, and one can always restrict attention to the specimens killed by automobiles, firearms and the like. Presumably, these animals were killed when they were collected, and so their stomach contents will be legitimate records. Keeping snakes around for some time before killing and preserving them (perhaps for photography) is a more significant problem, and many preserved pythons have almost-empty guts. However, all it takes is one or two hairs from the lower intestine or rectum for identification of mammalian prey, because hairs can be accurately identified after microscopic examination. Some other kinds of biases are harder to overcome - for example, field-workers are understandably reluctant to preserve huge snakes (it takes too much formalin!) and so maximum sizes are undoubtedly underestimated. The great advantage of using museum specimens, however, is that very large sample sizes are often available, even for relatively rare species, and that there is no need to go out and kill additional animals.

The 1082 preserved pythons that Dave and I measured and dissected provided very useful information on the natural history of Australian pythons. Although the thirteen species examined spanned a wide range of adult body sizes, morphologies, and habits, several consistent ecological features emerged. Females generally grow larger than males, and mature at considerably larger sizes. Males are much more common in museum collections than are females, probably because many of the snakes collected for museums are males wandering around in search of a mate. Cloacal spurs tend to be larger in males, and to be relatively larger in larger species. All of the species we examined are egg-layers, with strongly seasonal reproductive cycles even in the tropics. However, the exact timing of the reproductive season varies considerably among species and among areas. Females probably do not reproduce every year in most species, judging from the low proportions of reproductive females in museum collections. Average clutch sizes range from five eggs in *Liasis perthensis* (the pygmy python) to sixteen eggs in *L. olivaceus* (the olive python). Larger species have larger hatchlings.

Our dissections showed that the Australian pythons eat a wide range of vertebrate prey, with a consistent shift from reptiles to mammals in larger species, and in larger individuals within a single species. The only real exceptions to this general pattern were *Liasis childreni* (which is unusual in eating many frogs) and *Aspidites melanocephalus* (which is unusual in eating mostly reptiles, despite its large body size). Overall, we concluded that the adaptive radiation of pythons in Australia had apparently favoured terrestrial rather than arboreal habits, a greater dependence on reptilian prey, and - perhaps as a consequence of feeding mostly on reptiles - a smaller average body size. We published this work in Herpetologica (Shine and Slip 1990).

This work was designed to give us an overview of the natural history of the Australian pythons. Fortunately, several types of data that we couldn't get from preserved specimens - like observations of egg-grooming behavior and incubation periods - were available from private reptile-keepers. Neil Charles was especially helpful in contributing information from his captive snakes, and of course there have been many papers published on food habits and reproductive biology of captive Australian pythons (e.g., Charles et al. 1985; Charles and Wilson 1985; Christian 1978; Fyfe and Harvey 1981; Grow et al. 1988; Harlow and Grigg 1984; Mackay 1973; Murphy et al. 1978, 1981; Ross 1973; Sheargold 1979). Nonetheless, there are a lot of things that simply cannot be determined without going out into the field. In order for effective conservation planning, we need to know about the processes occurring in natural populations of pythons, and the dynamics of movements, habitat and prey use, and reproduction. Thus, Dave embarked on an ambitious ecological study of a python species that was particularly well-suited for intensive study.

DIAMOND PYTHONS IN THE SUBURBS

The diamond python *(Morelia spilota spilota)* is a medium-sized (to 3 m body length) species of coastal New South Wales. It is regarded as subspecifically distinct from the carpet python *(M. s. variegata)*, a far more geographically widespread and variable species (or species complex). Electrophoresis of blood proteins suggests that the evolutionary radiation of *Morelia* (including the giant form, *M. oenpelliensis,* but excluding *Chondropython*) is very recent compared to that of the other Australian pythonine lineages (G. Mengden and H. Cogger, per. comm.). The close relatedness of *M. s. spilota* and *M. s variegata* is shown by an intergrade zone on the central coast of New South Wales, and by the production of fertile hybrids from cross breeding in captivity. The most obvious difference between the two subspecies is in colouration: most carpet pythons are blotched in shades of brown, whereas diamond pythons are black with yellow spots. However, hatchling diamond pythons are virtually indistinguishable from carpet pythons, and the bold black-and-yellow pattern develops gradually over the first few years of life.

Diamond pythons are unusual in several respects. Their bright colouration and 'mellow' temperament make them particularly popular with reptile-keepers, but they are also unusual in being the python species which penetrates furthest south (to the border region of Victoria and New South Wales). Dave Slip and I decided that diamond pythons should be feasible to study, because they were relatively large (and hence, could carry implanted radio transmitters without ill effect), and were found close to the University of Sydney - even in the suburbs of Sydney. Our decision to work on M. s. spilota was also prompted by reports that the numbers of this species had declined, and suggestions from the local National Parks and Wildlife Service that diamond pythons might require urgent conservation measures. Because of the perceived scarcity of this species, local wildlife regulations prohibited private reptile enthusiasts from keeping diamond pythons, but allowed them to keep carpet pythons.

The first problem in working on a 'rare' species is to find specimens to study, but with cooperation from local reptile-keepers (especially, Gerry Swan), we obtained two freshly-caught diamond pythons in Belrose, a northern suburb of Sydney. The snakes were fitted with temperature-sensitive radio transmitters (implanted surgically into the peritoneal cavity under halothane anaesthesia) and released at the site of capture, in a small gully surrounded by houses. Our initial thought was that these two snakes would be the only ones in the valley, but we were very wrong. One of the snakes, a large female, reproduced the next spring, and attracted a succession of males. We caught these snakes as they arrived, and implanted transmitters in them also. In following years these males led us to more females, which in turn attracted more males, and so forth. It soon became clear that this small fragment of bushland, surrounded by houses, contained a large and thriving population of diamond pythons. We found the same situation in a nearby nature reserve. Far from being rare or endangered, diamond pythons had adapted spectacularly well to urban encroachment. Indeed, most of their feeding was done in backyards rather than the bush itself, because prey items like rats and possums were found in much greater densities near human habitation.

Dave worked on the diamond pythons for four years (1982 to 1985), monitoring the ecology and behavior of eighteen adult pythons in the field for periods of from 4 to 34 months. This unique study - the first-ever detailed ecological study of any python - yielded extensive information on the day-to-day lives of free-ranging snakes, and provided many surprises. We found that the pythons were active mainly during daylight hours, although they also moved around on unusually hot midsummer nights. They were mostly terrestrial rather than arboreal. The snakes emerged from their overnight retreats to bask in the morning, raising their temperature to between 28 and 30°C. Active pythons generally had body temperatures around 25°C (on cloudy days) to 28°C (on sunny days). These large snakes did not 'shuttle' between sun and shade, as do many smaller reptiles, but instead showed only a single basking period per day. Because of their large body size, and their ability to form a tight coil, the snakes were able to slow down their rate of cooling sufficiently to maintain high and relatively constant temperatures long after they had finished basking (Slip and Shine 1988a).

Four radio-tracked female diamond pythons produced eggs during the study, and their temperature regulation was particularly interesting. Each of the females constructed 'nests', usually a few weeks before they actually laid eggs. The 'nests' were made in areas with sandy soil, heavy leaf litter (>5 cm), and 20 to 70 m from a creek. The female coiled under the leaf litter at the base of a tree or bush, burrowing slightly into the soil and pushing the leaf litter up to form a distinct mound just large enough to accommodate the coiled snake (25 to 30 cm diameter, 5 to 10 cm high). Females remained with their clutches for about eight to ten weeks, from laying until near the time of hatching. The females emerged to bask during sunny mornings, but did not rely on basking to maintain high and stable nest temperatures. Through frequent 'shivering' behavior (metabolic thermogenesis), the female pythons were able to maintain a body temperature about 9°C above ambient (occasionally up to 13°C), and their temperatures were also significantly less variable than were those of males or nonbrooding females (Fig. 1; Slip and Shine 1988b). Females lose up to half their pre-oviposition mass by the time of hatching (about 30% due to egg-laying, 15% due to the metabolic costs of 'shivering') and as a result, take two or three years to regain condition sufficiently to brood again (Slip and Shine 1988c).

The radio-tracked diamond pythons usually moved around very little, especially in summer, autumn and winter. In summer and autumn, the general pattern was of a prolonged (up to 80-day) stay at one spot, followed by a long (often, hundreds of metres) move to a new site, followed by another long wait. The snakes seemed to use this strategy because of their dependence on 'ambush' predation. However, during the mating season in spring, males moved long distances, and often moved every day. The relative use of different types of habitats changed seasonally. In summer and autumn, snakes were most frequently found in disturbed habitats (such as areas around houses), where prey are more common. In winter the snakes used rocky habitats, especially sandstone crevices. No winter aggregations were observed. The radio-tracked snakes had large (up to 124 ha) well-defined but overlapping home ranges. These were larger in males than females, and male home ranges were larger in spring than in other seasons (Slip and Shine 1988d). Comparisons of the proportion of time spent active by each sex in each season showed that males were active much more than females, especially in spring and summer. These relative activity levels correlated very highly with the sex ratios and seasonal biases of numbers of diamond pythons in museum collections (Fig. 2), suggesting that collectors almost always relied on finding active snakes - and hence, usually reproductive males.

In spring, two to six males would gather around each reproductive female, and stay with her for four to six weeks. No aggression between males was noted, and more than one male was seen to mate with the female, in the presence of other males (Slip and Shine 1988c). This behaviour is in striking contrast to the vigorous male combat seen in the other subspecies, *M. s. variegata* (e.g., Covacevich 1975; Wilson

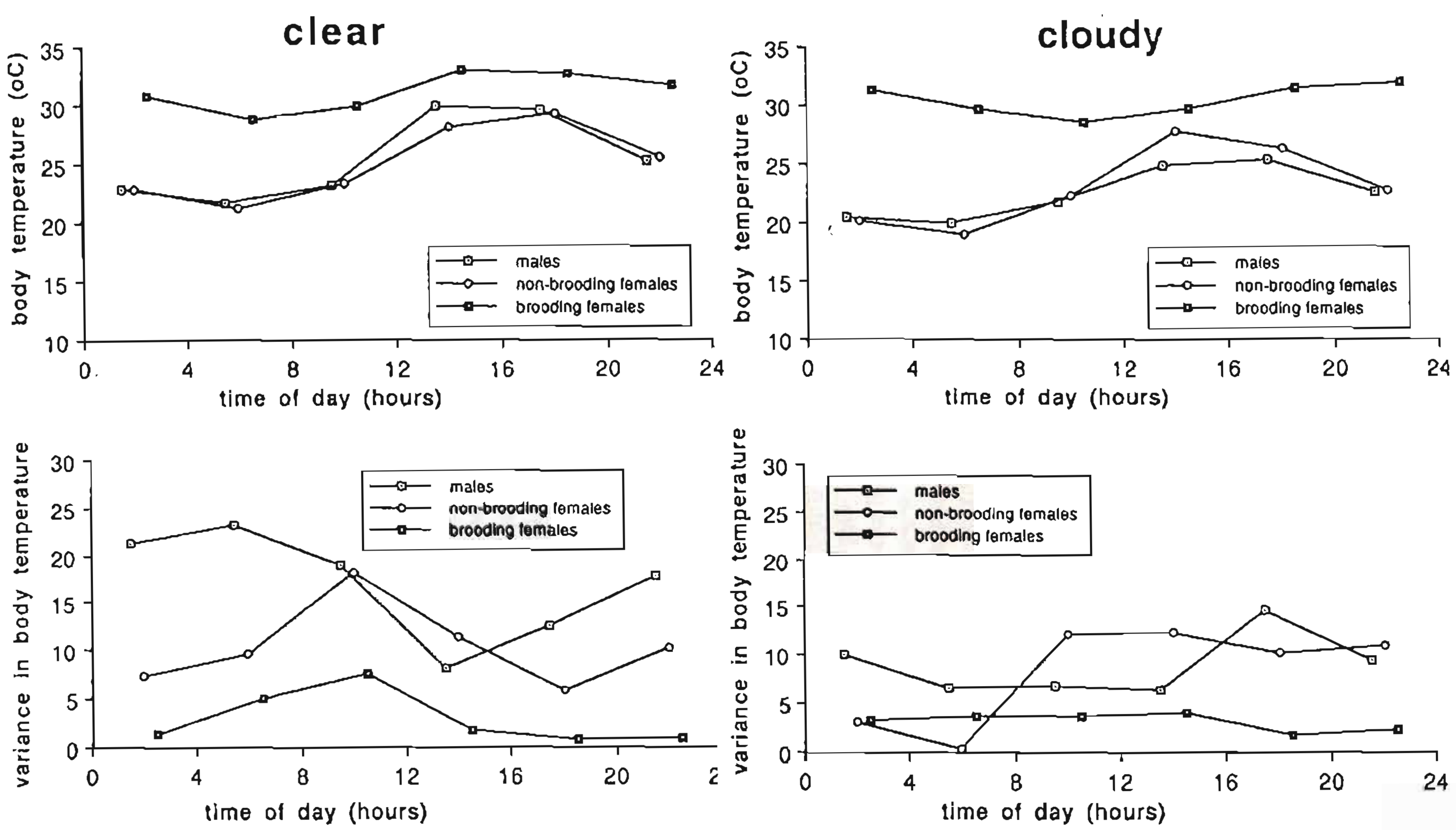

FIGURE 1. Body temperatures of free-ranging diamond pythons, as measured by radiotelemetry. Mean values are shown separately for adult male pythons, adult non-reproductive pythons, and females brooding their eggs. Data are given separately for clear sunny days (graphs on left side) and cloudy days (right side), and for both average temperatures upper graphs) and the pooled variability in body temperatures over each four-hour period (lower graphs). Note that brooding females maintain higher and more stable temperatures than do the other snakes, even on cloudy days when basking is not possible. Data from Slip and Shine 1988b.

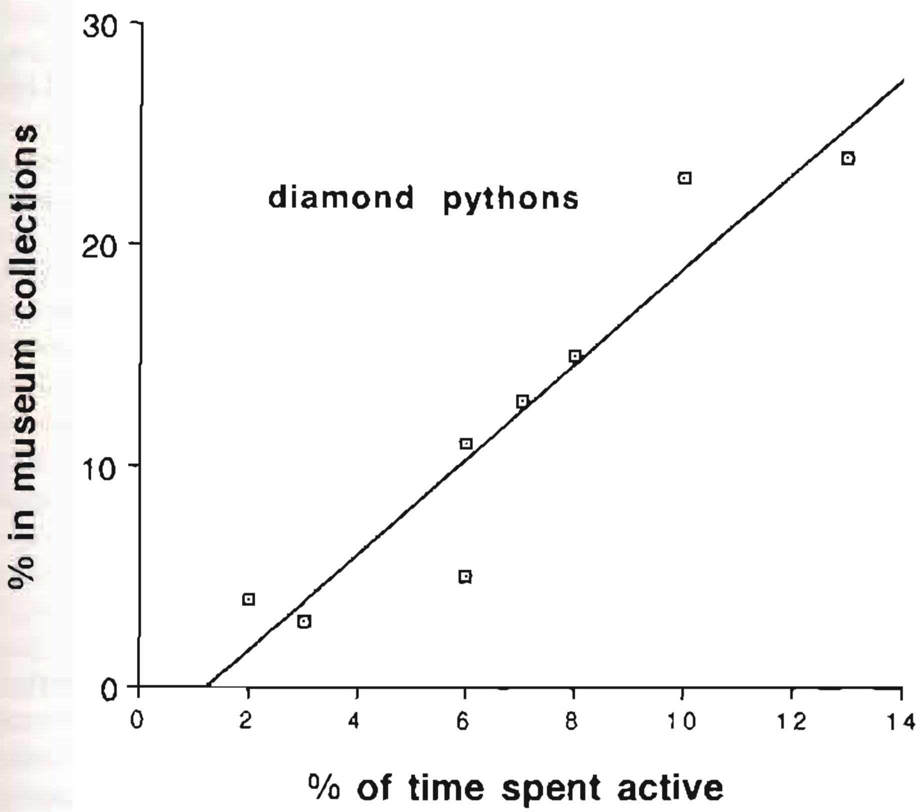

FIGURE 2. A comparison of relative activity levels (% of time active) in male and female diamond pythons in each season, relative to the numbers of each sex in each season collected and preserved in museum collections. The high correlation suggests that most specimens are collected while they are active, presumably because they are much easier to find at these times. Data from Slip 1986.

and Knowles 1988). I am currently planning an experimental study in which male diamond and carpet pythons will be placed with receptive females, to look at the causes and consequences of aggressive behaviour in males. I would be grateful for any reports of male-male behaviour in captive pythons (of any species), to help with this research project.

Our radio-tracked diamond pythons spent more than 80% of their time coiled, usually in a distinctive ambush posture near mammal trails. Adult diamond pythons feed almost entirely on mammals (91% of records), mainly introduced and native rats. Possums, bandicoots, mice and rabbits are also eaten, as are occasional birds. Juvenile diamond pythons feed on mammals (69%) and reptiles (23%). Larger snakes consume larger prey. In captivity, hatchling diamond pythons show a preference for coppertail skinks (*Ctenotus taeniolatus*) but will also eat newborn mice. In terms of feeding biology, diamond pythons may actually be more similar to viperid snakes of other continents than to the Australian elapids or colubrids (Slip and Shine 1988e).

We've also used diamond pythons in a series of laboratory-based studies, mostly with respect to feeding. We found that captive pythons select higher temperatures after feeding, presumably to speed digestion (Slip and Shine 1988f). Also, an extensive series of studies on preyhandling behavior (for example, the influence of relative prey mass on handling and swallowing times) suggested that some aspects of the diets of free-ranging pythons could be successfully predicted from optimal foraging theory (Shine 1991).

Although much remains to be learned, this pioneering study has provided the first real information on the ecology of free-ranging pythons. I am hoping to follow up the work with a more detailed look at the mating systems of diamond and carpet pythons, and have planned a major telemetric study on carpet pythons on the north coast of New South Wales to compare to the Sydney diamond pythons. My other detailed ecological work on pythons is a very different type of study, on a very different species, and in a very different habitat: population ecology of water pythons in the Wet-Dry tropics.

WATER PYTHONS ON THE FLOODPLAIN

Although diamond pythons are very convenient study animals in some ways, there are some kinds of investigations for which they are poorly suited. In particular, it is difficult to imagine a successful study of population ecology, growth rates, survivorship, density fluctuations and the like, simply because it's impossible to obtain the large numbers of animals needed for this kind of work. Indeed, good demographic studies of snakes are very rare, precisely for this reason. I know of only one place where pythons are so abundant, and so easy to capture and recapture, that a detailed population study is feasible. This is a site near Humpty Doo, in the Northern Territory, where water pythons (*Liasis fuscus*) occur at high densities in a dam built for agricultural purposes. I've been working on this system for the last five years, and it's beginning to give us some remarkable information about the population biology of these tropical pythons.

The northern part of Australia's Northern Territory has a 'Wet-Dry' climate: temperatures are high all year (daily maximum above 30°C) but most of the year's rainfall is concentrated in a short 'Wet-season' (January - March). Lowland floodplains are dry for most of the 'Dry-season', but monsoonal rains inundate them for a few months each year. The timing and intensity of 'Wet-season' rainfall varies considerably from year-to-year, and this climatic variation has an enormous impact on the plants and animals of the area - including the water pythons.

Water pythons are widely distributed over northern Australia, and common in many areas. They are about the same size as diamond pythons (up to 3 m long) but differ considerably in colour, being brown above and yellow beneath. The brown colouration appears drab at first sight, but the highly polished scales are iridescent and can flash all the colours of the rainbow in sunlight. Indeed, iridescent snakes like the water python and the olive python (*L. olivaceus*) may have stimulated the Aboriginal legends of the great 'Rainbow Serpent'. Some authorities suggest that the Australian water python (*L. fuscus*) should be placed in the same species as the new Guinea species *L. mackloti*, but morphological and electrophoretic studies indicate that the Australian form is distinctive, and warrants recognition as a separate species (G. Mengden, pers. comm.).

Despite their common name, water pythons are not aquatic. They are usually found very close to water, and use reedbeds as their usual daytime retreats. Like most tropical Australian snakes, water pythons are almost entirely nocturnal. The only diurnal activity seems to be in the middle of the 'Dry-season', when night-time temperatures are low and the snakes emerge to bask in the morning. However, they are secretive and rarely seen at these times. They become active soon after dark, leaving their reedbeds or burrows to wander in search of food (or, during the middle of the Dry-season, mates). The dry soil of the floodplains is honeycombed by deep cracks that often contain floodplain rats (*Rattus colletti*), the chief food of the water python. The snakes investigate these crevices, and enter them if they can fit. They are much more reliant on active searching for food, rather being specialist 'ambush predators' like the diamond pythons.

Although Tom Madsen and I have carried out extensive radio-tracking of water pythons in the Humpty Doo area over the last five years, it is the mark-recapture study which has provided the most spectacular results. First and foremost, the population densities of these animals are astonishing. The study area is quite small, and all of the pythons are caught at night along a 2-kilometre stretch of road. We have caught up to 50 pythons in a single night this way, and over the last five years have captured and marked almost 2,000 water pythons. The animals are quite large, averaging over a metre in length and a kilogram in mass, so this means that we have handled well over two kilometres, and two tons, of python during the study! Remarkably, we still capture many unmarked snakes, and our population statistics suggest that the area is home to several thousand water pythons. This works out to a density of around 300 pythons (i.e., 300 kg) per hectare, an enormous density for any predator population.

Because of this high feeding rate and this high population density, the water pythons play an important ecological role in the local ecosystem. Floodplain rats are the most important single prey species, but other types of prey are taken also. Young pythons eat other snakes, especially the slate-grey snake (*Stegonotus cucullatus*), a sympatric colubrid, and pythons of all sizes eat occasional water birds. The eggs of the magpie goose (*Anseranas semipalmata*) are an important food source late in the Wet-season for the larger snakes, but most water pythons find the eggs too large to swallow.

The mark-recapture study has also generated a considerable amount of information on growth rates of recaptured individuals. When rats are abundant, the feeding rates of the pythons are very high, and we have recorded pythons adding more than one kg of mass in periods as short as a few weeks. During such times of plentiful food, juvenile pythons grow rapidly - to around one metre in a year - and both sexes mature in about two years. However, very heavy rain early in the 'Wet-season' can have a catastrophic effect on rat numbers - the floodplain cracks fill with water and the rats are driven out or drowned. Thus, rat numbers can plummet dramatically in some years, and the water pythons then must switch to other, less abundant, sources of food. Under such conditions their diet becomes much broader, and feeding rates drop substantially. The pythons also lose condition rapidly - especially the larger snakes - and emaciated snakes are commonly seen. Growth rates decline almost to zero in the larger snakes, but the smaller pythons seem able to keep finding food - perhaps because they can search deeper within the floodplain crevices than can the larger snakes.

This climatically-induced annual variation in food supply can influence reproduction as well as growth rates. In years when rat numbers are low, very few pythons seem to reproduce - indeed, we have seen only one really good year of reproduction in the five years of the study to date. This kind of observation fits well with what we have found in diamond pythons, and what we have seen in our examination of museum specimens: adult female pythons may tend to reproduce only once every few years. The same phenomenon is common in 'ambush' foragers like many viperid snakes and in the Australian death adder, a highly modified elapid that relies on 'ambush' foraging (Shine 1980). Snakes that rely on lying in wait for their prey may often experience relatively low feeding rates, and hence females may be unable to accumulate enough energy to reproduce every year. Although water pythons are not classic 'ambush' foragers, they may similarly experience low feeding rates (because of low prey availability) in many years. It would be interesting to see to what extent these low reproductive frequencies are 'hard-wired' in female pythons, by gathering data on well-fed captive specimens.

In summary, research by my group at the University of Sydney over the last several years has begun to clarify some aspects of the basic biology of free-ranging pythons. All that we have been able to accomplish so far is a superficial look at a broad range of species using museum specimens, and detailed field studies of one temperate-zone (*Morelia s. spilota*) and one tropical (*Liasis fuscus*) species. Nonetheless, our results are the first ever obtained on these topics, and can usefully be integrated with the much larger body of information available from studies of captive specimens. Field-based research on both diamond pythons and water pythons is continuing, and work on carpet pythons (*M. s. variegata*), olive pythons (*Liasis olivaceus*) and Oenpelli pythons (*Morelia oenpelliensis*) is planned.

ACKNOWLEDGEMENTS

Pythons are not easy animals to study, and the work described in this paper would have been impossible without the help of many people. The data on diamond pythons are a tribute to Dave Slip's perseverance, and especially his ability to sit for hours watching radio-tracked pythons doing nothing. The water python work has involved many other helpers - notably Rob Lambeck, Peter harlow and Russell Hore - but special credit goes to Tom Madsen, whose singleminded enthusiasm for herpetological ecology has enabled him to carry on where lesser souls would have given up long ago. Finally, I thank the Australian Research council for funding much of this work.

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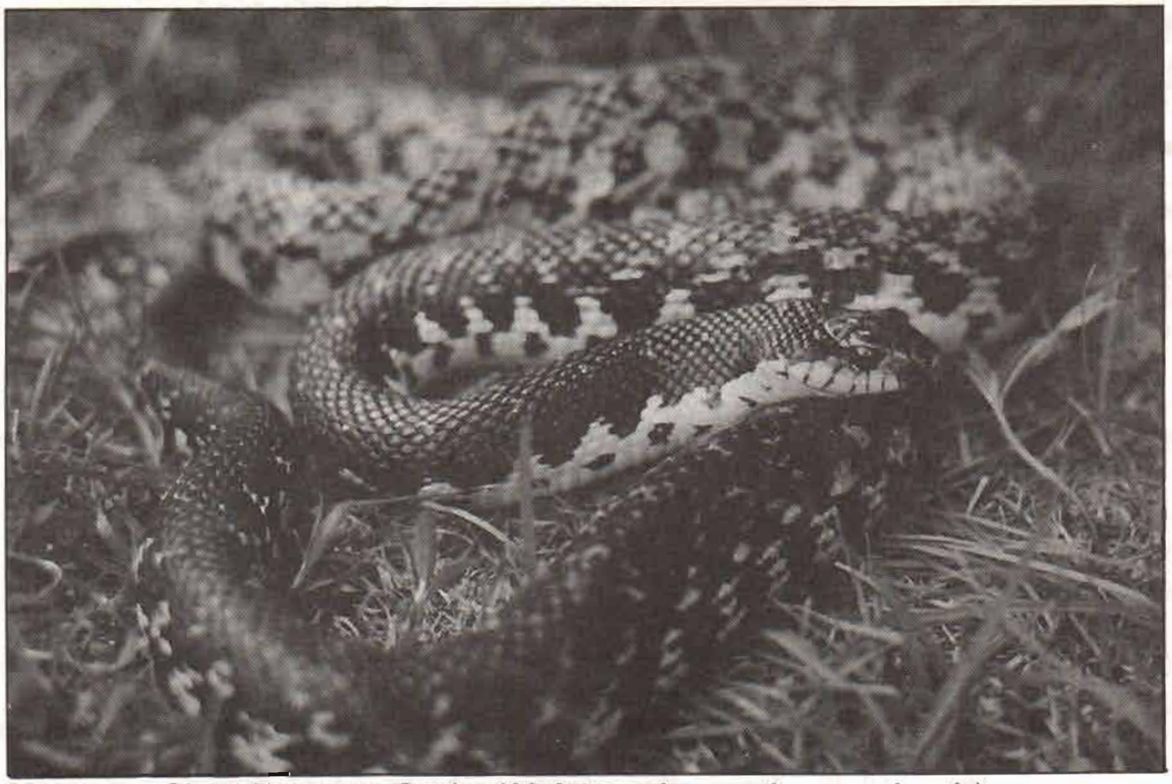

Malagasy Giant Hognose Snake (*Lioheterodon madagascariensis*)
Photo by Dr. Michael J. Uricheck

MAINTENANCE AND BREEDING OF AUSTRALIAN ELAPID SNAKES

John Weigel

ABSTRACT

Information on the captive biology of most of Australia's 80 species of elapid snakes (family Elapidae) remains limited, due at least in part to the statutory restrictions on the collection of reptiles for hobbyist and exhibition purposes, and the federal restraints on the exportation of native reptiles to overseas facilities. On the positive side, these constraints have created a strong impetus to breed whatever species are held. This paper attempts to identify the elapid species (and their numbers) currently held in Australia by hobbyists and zoological facilities, and to assess the incidence of captive breeding and some of the techniques invoked. The Australian Reptile Park maintains one of the largest collections of Australian elapid snakes, (primarily for the purpose of venom collection) and the caging facilities, husbandry and breeding procedures used at that facility are discussed.

The front-fanged venomous snake family Elapidae is well represented in Australia with approximately 80 species, accounting for nearly half of the world's total and some of the most dangerously venomous of all snakes.

There is little agreement on the origins of Australian Elapids, this being the subject of a large portion of current Australian herpetological research. Its been suggested that ancestral forms arrived from Asia and the relative isolation of Australia provided the opportunity for massive speciation. The ecological studies of Dr. Richard Shine and a few others have in recent years shed considerable light on the natural history and reproductive biology of Australian elapid snakes. However, information on the husbandry and captive breeding of these, Australia's most numerous snakes, remains fairly scant.

The shortage of published information on the care and propagation of the elapids, and for that matter, most Australian reptiles, is contrasted by a growing pool of knowledge internationally - possibly a reflection of the comparative difficulties that Australian hobbyists and zoological facilities experience in finding legal avenues through which to experiment with new species. The impact of the legislative prohibition on collecting reptiles for hobbyist or zoological display purposes in Australia is discussed at length in another study (Weigel, 1991). It should also be said however, that Australia is a very large country with a large and varied herpetofauna and only a relatively small population (17 million) from which to draw interest and funds for research. Due to export bans, few specimens, other than those smuggled out (and their progeny) are available for study overseas.

Interestingly, of the relatively few reptile collections that are legally held by Australian hobbyists, a large proportion include dangerously venomous elapids, due largely to the ease and regularity with which some species are bred and the resulting high availability of captive-bred specimens. While prohibiting the collection of specimens from the wild, about half of the States and Territories do allow the transfer of captive-bred reptiles to previously unregistered hobbyists giving them an opportunity to become 'legal'. By limiting the choice of available species to those for which captive breeding is achieved, the government authorities have inadvertently encouraged novice reptile keepers, regardless of age, to obtain highly venomous species such as the tiger snake *Notechis scutatus*, death adder *Acanthophis antarcticus* and taipan *Oxyuranus scutellatus*.

A survey was conducted to determine the numbers and species of elapid snakes being maintained and bred in Australia. A questionnaire was circulated to hobbyists through the newsletters of various amateur herpetological associations and by direct mail to many of the better known breeders (Table 1). Copies of the questionnaire went to all of the large municipal zoos and to most of the private ones maintaining substantial numbers of reptiles.

Representative keepers from 12 zoos participated in the survey, accounting for most facilities with large collections of reptiles, but only 15 hobbyists participated - and the survey can only be regarded as providing a limited view of the hobbyist situation.

The participants in the survey revealed that they collectively held 483 specimens, representing 18 Australian elapid species on March 31, 1991. Of these, 151 specimens representing 15 species were held by hobbyists, while 332 specimens representing 16 species were held by the publicly and privately-funded zoos participating in the survey. The participants reported 91 instances of captive breeding successes during the five year period ending on March 31, 1991 (39 for hobbyists, 52 for zoos). A captive breeding success is defined in the questionnaire as the production of a litter or clutch which results from captive matings in which at least one neonate survived for at least a month after egg-hatching or birth). From these 91 breeding successes spanning the past five years, 1183 specimens arose (656 for hobbyists and 527 for zoos), of which 338 specimens (99 produced by hobbyists, 239 by zoos) represented second generation captive breedings - involving parents which were themselves both produced from captive breedings.

During the 12 month period leading up to March 31, 1991, the survey participants collectively reported breedings for only 9 species (hobbyists 6 species, zoos 7 species) producing 352 specimens (hobbyists 219, zoos 169). Of these results, second generation breeding was reported for 6 species giving rise to 130 specimens (hobbyists 72, zoos 58).

In addition to requesting data on species held and captive breeding statistics, the survey questionnaire also asked elapid keepers to briefly describe any particular procedures/conditions that they considered useful for encouraging the well-being and/or breeding of their captive charges. About half of the surveyed keepers responded to this question and the following recommendations were made in order of the number of keepers that mentioned them:

a) the separation of the sexes except for brief mating interludes (8);
b) winter cooling or at least 'cooling before mating' (8);
c) use of outdoor facilities (6);
d) use of multiple males to encourage mating (5); and,
e) the provision of thermal gradients (4).

Due to the difficulty in obtaining permits to collect from the wild, it is no surprise that the majority of species that are currently held by the survey participants were represented in collections before the introduction of legislative protection of all reptiles, which occurred during the early to mid-1970's of most States and Territories. In some cases specimens held today represent numerous successive generations of breeding, but in a few cases, where permits have been obtained to collect from the wild, new species, which include the fierce snake *Oxyuranus microlepidotus*, and the Collett's snake *Pseudechis colletti*, have been added to the captive pool. Subsequent breeding of these species allowed sufficient dispersal of specimens to ensure their future accessibility to herpetoculturists. The Collett's snake is a spectacularly coloured and very large species (to 2m) that is very widely held throughout Australian collections but all of these specimens have a common lineage that can be traced, in some instances through five generations, to the original two males and two females that were collected under license in 1982. There has been no signs of fitness reduction due to inbreeding reported in captive Collett's snakes as yet. Other species, including Butler's black snake *Pseudechis butleri*, and the desert death adder *Acanthophis pyrrhus*, have entered the captive role in recent years, but although both species have been bred to a limited extent, neither species has as yet become widely distributed.

CAGING FACILITIES AND HUSBANDRY OF ELAPIDS AT THE ARP

A practical system for maintaining a large off-display collection of elapids used for venom production purposes has been devised at the Australian Reptile Park (ARP), incorporating many of the elements common in other Australian collections as well as a few new ideas.

The concept of one snake per cage (except during mating intervals) was regarded as extremely important in the design of the facility, not only for the welfare of each specimen due to reduction of stress, but for ease of handling, feeding and record keeping. Since the spatial requirements involved in housing the snakes individually in the traditional style of top-opening holding cages would have proven inhibitive, a logical solution was to construct caging in vertically oriented batteries of front-opening cages to achieve an efficient use of space, reduce the amount of materials required in construction and to minimize energy requirements.

The caging system includes 160 cages built into 12 separate banks which line the walls of the holding facility. Eight of the cage banks extend from floor to ceiling and are with front opening cages. These cage banks all measure 240cm high, 120cm wide and 60cm deep but vary in the numbers and sizes of cages that they contain, these being arranged in multiples of five cages (single cage across, five high), ten cages (two across, five high) and 21 cages (three across, seven high) cages. This variation in cage size accommodates the diversity of specimens from 60cm death adders, *Acanthophis antarcticus*, to two metre long king brown snakes, *Pseudechis australis*, and Collett's snakes, *Pseudechis colletti*. The hinged access doors are fitted with glass viewing windows and are cut out of the cage front in such a way as to leave a substantial lip, especially on the bottom, where the cage front extends a minimum of 12cm from the cage floor upwards, to discourage rapid departure by flighty snakes when their cage doors are opened.

Additional cage banks are comprised of fairly large cages 120cm wide, 60cm deep and 60cm high, which are built only two cages high. This allows servicing from above for the upper cages, which are used to house large taipans, *Oxyuranus scutelllatus*, and common brown snakes, *Pseudonaja testilis*, two particularly flighty and dangerous species.

A bank of 36 small modular 'nursery cages' is provided, fashioned after snake breeding systems popular amongst U.S. collections, consisting of rows of heated shelves between which are sandwiched the 'cages' - which are actually clear, hard plastic food storage containers. The plastic containers extend about 5cm out from the shelves allowing sufficient ventilation through their perforated lids.

Heating for all cages is provided in a manner intended to produce a thermal gradient across the floor providing adequate scope for the snakes to control their body temperature. In the case of the nursery cages, a long, metal heating element is incorporated along the back of each shelve to produce a gradient of warmth from the back to the front of each cage. All other cages are heated by the inclusion of a red incandescent light globe mounted on the ceiling in one of the back corners. Because the cages are oriented one above the other, each snake is able to absorb heat directly from the floor of its cage, which is heated considerably by the globe below. The floor material is of adequate thickness to ensure gradual reduction of warmth moving away from the 'hot spot' and creating the desired thermal gradient ranging from 'too warm' in one corner to 'too cool' in the opposite corner and allowing the snake sufficient scope to regulate its body temperature as desired. Electric heat pads are positioned beneath a corner of the bottom cages of each cage bank. Thermostats are doubled up to avoid the disasters of malfunction, and rheostats fine tune the level of heat produced to minimize the need for thermostatic control and to extend light globe life. The backs of the cages consist of strongly perforated 'peg-board' for ventilation.

Because the red coloured globes within the cages produce lighting conditions of dusk or darkness as perceived by the snakes, photoperiod is controlled by daylight balanced, fluorescent lights within the rooms containing the cage banks. This sufficiently illuminates the cages through their glass or clear plastic cage fronts, allowing the day/night interval for the snakes to be controlled by the turning on and off of the fluorescent ceiling lights by automatic timer. On occasions where keepers have visited the facility at night, the red lighting within the cages has allowed observation of a high degree of movement among the nocturnally active species.

The substrate used in all of the cages is unprinted 'news' paper, purchased in bulk packages as it has superior hygienic value to more commonly used substrates as pea-gravel wood shavings, leaf litter, etc, as these tend not to be changed often enough and faecal matter can remain unnoticed. Cage dimensions were initially influenced by the standard sizes of the paper.

A wooden 'hide box' is placed in each cage. Each hide box is bottomless, so that faeces deposited within can be easily removed with the cage paper upon which the hide box rests. A single half-circle access entry is cut from the bottom, so that the snakes cannot become jammed, as can happen in round access holes. The hide boxes are coated with polyester resin so that they can be submerged and disinfected from time to time, and as a consequence are heavy enough to resist flipping over, as often happens with plastic hide boxes. A metal 'o' ring screw extends from the top of each hide box allowing safe removal of the box with a snake hook.

Water is made available from plastic, domestic pet water bowls with widened basses to resist spillage. Two sets of water bowls are required; while one is being used, the other is cleaned and dried.

To clean a particular cage, the inhabiting snake is removed (with a snake hook), placed in a large rubbish trolly, 130cm high with a hinged top and two wheels for ease of movement. The trolly provides a safe means of temporarily holding large dangerous snakes and is highly recommended. On the bottom of the holding bin is placed a layer of wood shavings which is changed after each bank of cages is serviced to minimize cross-contamination.

All feeding at the Australian Reptile Park is done on a designated day of the week (at present, Tuesday). In this way, all snakes are offered food on a regular basis and the dangerous effect of having the smell of food present (which excites the snakes) when venomous snake cages are opened is eliminated. There are very few mature elapid snakes in the collection that will not readily accept either mice, rats or day-old chickens - all easily obtainable food sources. On the other hand, the young of many of these same species, and most small species, feed primarily upon lizards and/or frogs in the wild, and might refuse pink rats or mice. In captivity they may readily accept a pink rodent scented with skink blood or frog 'slime', becoming 'weaned' onto a diet of unscented rodents over a period of time. However, because all skinks and many frogs are legally unobtainable in New South Wales, considerable difficulties can arise.

The extraction of venom from the snakes is done on a scheduled basis once every two weeks; on the morning before every second designated feeding day. This allows a maximum amount of time to lapse between the last time the snake bit something (ie last week's meal), presumably dispensing venom in the process, and when the venom is collected. It also appears that in offering food to the snakes shortly after being 'milked', there is a reduction of any prolonged stress following the activity of biting and ostensibly 'killing' the thawed food item (live food is never provided).

The majority of Australian breeders incubate squamate eggs in a similar manner, placing the eggs into a moistened incubating medium which half-fills a plastic container (usually 1-5 litre volume) with a single layer of 'glad wrap' secured over the top, which presumably allows the movement of gasses into and out of the incubating container while retaining water molecules within. These plastic containers, once sealed, are placed into a darkened incubating chamber with a thermostatically controlled temperature of between 26-30°C. To date, the most popular incubating medium is 'vermiculite' an inorganic gardening material which is purchased in a dry condition and moistened. Most breeders mix the dry vermiculite with water in equal parts (by weight). At the ARP, it has been suspected for some time that this standard mix may be excessively wet, possibly accounting for poor hatching results widely reported in at least some reptile species. To test this suspicion, an experiment was conducted by randomly dividing the eggs from each of 7 clutches of elapid eggs (3 clutches of taipan eggs, 2 clutches of Asian cobra eggs, 1 clutch of king brown snake eggs and 1 clutch Collett's snake eggs), into five differing conditions if incubation, including dry (7:3 vermiculite/water by weight) slightly less dry (6:4), standard (5:5), moist (4:6) and wet (3:7). In all cases the eggs were buried or partially buried in the vermiculite mixture, which approximately half-filled the 15cm high, 5 litre plastic incubating containers. The temperature was maintained at 29°C in all five containers.

All of the eggs that were incubated in the three driest conditions hatched. All except one of two king brown snake eggs and two of three Collett's snake eggs maintained in the second wettest condition hatched, and only the taipan eggs (4 out of 6) maintained in the wettest conditions hatched. Hatching dates for the various clutches did not vary amongst the test conditions and upon later inspection all unhatched eggs were found to contain dead embryos. Although the full results of the experiment will not be presented in detail until further experimentation is conducted, an interesting finding of the preliminary study may be worth mentioning. The hatchlings produced in the 6:4 (vermiculite/water) container were consistently heavier and slightly longer shortly after hatching than those arising from the containers with the driest mixture (7:3) and the standard mix(5:5) - and these, the hatchlings produced in these two conditions were in turn larger than the hatchlings produced in the two wettest containers. All of the hatchlings were humanely sacrificed immediately after measurements and weights were recorded and it is not known if the smaller hatchlings would have suffered reduced fitness. One possible explanation for the variation in hatchling sizes might be that typical incubating techniques, especially where these involve regular spraying of the eggs with a water mister, can cause a buildup of moisture on the egg shell, thereby interfering with the transpiration of gasses through the shell and retarding embryonic development.

At the ARP, hatchlings and newborn elapid snakes are maintained in separate quarters for the same reasons underlying the individual housing of the mature snakes. Hatchlings are much more likely to feed voluntarily if kept separately, and for those that do feed in communal conditions, the risk of cannibalism exists for some species. A group of three one month old death adders *Acanthophis antarcticus* that were feeding voluntarily on pink mice were lost one evening when one of the three swallowed both cage-mates and died before being discovered the next morning. They hadn't been fed for several days prior to the accident and the smell of rodents was not present in the building. Hatchlings are typically fed twice a week for the first few months and thereafter on a weekly basis.

Breeding of most species is not encouraged at the ARP due to difficulties in placing the young in appropriate hands and an unwillingness to place some of the more dangerous species into inexperienced hands. Where undesired eggs are produced, these are disposed of by freezing. On the other hand, several species for which breeding is strongly desired are represented in the collection by a single sex only. Requests for permits to collect specimens of the desired sex of these species have to date been consistently denied.

Where breeding is desired, opportunities for mating are provided every one to two weeks during the early to late Spring, depending upon the species, or for some live bearing species, Autumn as well. The ovulated, receptive condition of female elapids is not always apparent, and it may even be that the activity of mating may play a role in stimulating ovulation. The procedure is to remove a male and female from their respective cages, then to put them both back into either one of the cages, one after the other. This is to avoid accidental bites occurring resulting from confused feeding responses. Although it is generally believed that the envenomation of snakes by other snakes of the same species is harmless, this is certainly not true for at least some elapid species. Adult specimens of two species, the spotted black snake, *Pseudechis guttatus*, and king brown snake, *Pseudechis australis*, have died following bites by conspecifics at the ARP - though death in both cases did not eventuate until approximately 10 days later. The oviparous elapid snakes are kept together for mating purposes for a day or so at a time, and are repeatedly introduced, perhaps once every two weeks until the female becomes substantially distended in the gravid condition.

Apart from the common death adder, commonly held live-bearing elapid species such as the copperhead, red-bellied black snake, common tiger snake and black tiger snake are only infrequently bred in indoor conditions, including the ARP facility. However, there is a high degree of success in breeding these species where the snakes were kept in open, outdoor circumstances, as evidenced by the results of the elapid breeding survey. It is likely that substantial winter cooling is required if these predominantly temperate species are to be induced to breed in indoor circumstances.

TABLE 1. Questionnaire.

SPECIES	A	B	C	D	E	F
Acanthophis antarcticus	79	23	9	142	23	2
Acanthophis pyrrhus	10	2	2	19	-	-
Austrelaps superbus	19	-	3	33	-	-
Demansia psammophis	1	-	-	-	-	-
Drysdalia coronoides	1	-	-	-	-	-
Hoplocephalus bitorquatus	2	-	-	-	-	-
Hoplocephalus bungaroides	2	-	-	-	-	-
Hoplocephalus stephensi	5	2	-	-	-	-
Notechis ater	29	30	13	243	55	-
Notechis scutatus	73	6	7	139	60	14
Oxyuranus microlepidota	23	10	2	12		
Oxyuranus scutellatus	51	44	20	145	38	-
Pseudechis australis	46	19	9	93	26	8
Pseudechis butleri	3	1	-	-	-	-
Pseudechis colletti	29	20	6	45	23	23
Pseudechis guttatus	12	6	6	57	23	23
Pseudechis porphyriacus	23	3	8	113	37	37
Pseudonaja affinis	5	-	-	-	-	-
Pseudonaja guttata	1	-	-	-	-	-
Pseudonaja nuchalis	60	14	12	117	67	-
Pseudonaja textilis	15	-	1	25	-	-
Totals * Number in zoos	483 *332	182 *110	91 *52	1185 *527	352 *169	130 *58

A. How many specimens were present in your collection on March 31, 1991?
B. Of these, how many are of captive bred origins?
C. How many clutches/broods produced during the past five years?
D. How many specimens produced during the past five years?
E. How many specimens produced this season (after July, 1990)?
F. Of these, how many were produced by parents which were both captive bred stock?

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A REGIONAL HERPETOFAUNA MANAGEMENT PLAN FOR AUSTRALASIA

Chris B. Banks and Jon Birkett

INTRODUCTION

We are all now well aware, or at least we ought to be, that the resources of our planet are finite and exhaustible. However, terms such as progress, development and economic growth continue to justify our exploitation of global resources. The immediate casualty of this worldwide concept is the growing number of plant and animal species that are threatened with extinction. As our global human populations increase and continue to demand more and more space, energy resources and a higher standard of life, biodiversity of our planet continues to be lost at an unprecedented rate.

These facts are not new to us, neither are they new to government agencies. They have been documented by experts, debated by conservationists, and endlessly covered by the media from every viewpoint. Many governments have responded by developing and enforcing conservation of wildlife acts, which are designed to protect wildlife and the environments on which they ultimately depend. There is, however, an urgent need for national zoo communities, worldwide, to co-operatively participate directly and indirectly with each other and with other conservation and research organizations with similar policy goals.

Until the last decade zoological institutions around the world have existed and operated more or less independent of one another. Breeding efforts were often insular and without any long-term objective, other than breeding to keep a species going at the zoo. From this naivety has evolved an awareness that a co-ordinated, co-operative effort is essential for our small captive populations of fauna to endure in time, without falling into the temptation of annexing new animals from wild populations. As a result, over the last decade, the worlds' zoo communities have fully realized their responsibility to wildlife conservation and research, and accepted the challenge and need to direct their resources toward active as well as passive conservation goals.

BACKGROUND

The idea of a regional co-ordinated approach for the management of reptiles and amphibians (herps) in Australasian zoos was first raised in June 1989. At that time, established regional plans existed for birds (Regional Avian Species Plan - REGASP) and, to a lesser degree, ungulates (Regional African Ruminants Stocking Program - RARSP). These were co-ordinated under the umbrella of the Australasian Species Management Plan (ASMP), operated by the Association of Zoo Directors of Australia and New Zealand (AZDANZ).

To date, three meetings have occurred that are of most interest to herpetologists. A herp workshop was convened in April, 1990 at the annual Australasian zoo conference in Auckland, New Zealand, where workshop participants established the Regional Herp Management Team (RHMT). The first meeting of the RHMT was held at Taronga Zoo, Sydney in October, 1990. The most recent meeting was held at Western Plains Zoo, Dubbo, where it was decided, among other specifics, to change the name of RHMT to the Australasian Herp Taxon Advisory Group (Herp

TAG). The objective of the name change, was simply to establish international uniformity between similar advisory groups in other regions.

AIM OF THE AUSTRALASIAN HERP TAXON ADVISORY GROUP

The aim of the Herp TAG is to encourage the development of a regional collection, comprising individual collections, for the effective and on-going co-operative management of herps in Australasia. This includes native and non-native forms. Where appropriate, particular attention should be given to the co-operative maintenance and breeding of rare, threatened, or poorly-known species. Where possible attention should also be given to taxa from the Australasian-Indomalayan-Oceanian realms.

Whilst this reflects a zoo approach now, it is intended to pursue the broad involvement of the private herpetological community in the longer-term. The expertise of many private herpetologists is significant and their involvement would greatly benefit captive breeding programs for native species. Indeed, such an approach has been clearly identified and recommended by the Captive Breeding Specialist Group (CBSG), Herpetology, of the World Conservation Union/Species Survival Commission (IUCN/SSC).

The Herp TAG also recognizes that:

i) many species will, and should, be maintained/displayed in our zoos that are not from the Australasian-Indomalayan-Oceanian realms.

ii) participating institutions may place different emphases on their collections.

INITIAL GOALS

Seven initial goals were set at the Auckland meeting, most of which were the determination of necessary base-line information:

i) Current composition of herp collections in Australasian zoos.

ii) List of taxa proposed for addition to, or deletion from, current collections.

iii) List of institutions willing to receive proposals from, or participate in, Herp TAG.

iv) Collation of lists of rare or threatened species in Australia and New Zealand, and of current/proposed management plans for any of these species.

v) The need for, and appropriateness of, zoo involvement in programs highlighted in (iv).

vi) Determination of areas of expertise within the private herpetological community (individuals and societies). The role of the private sector has already been noted, but to date only a register of private holdings in New South Wales is being pursued. In relation to links between zoo and private herpetologists, Lone Pine Sanctuary and Zoological Board of Victoria properties (Melbourne Zoo and Healesville Sanctuary) are able to trade approved species with private herpetologists in their respective areas. In New Zealand, private herpetologists are involved in captive-breeding programs with the Department of Conservation (DOC), and the New Zealand Herpetological Society (NZHS) feels that involvement of NZHS members in the Herp TAG could operate in a similar manner. It is pertinent to note that some of the U.S. Herp Taxon Advisory Groups have representatives from the private sector.

vii) Collation of herp management plans from other regions.

HERP TAG MEMBERSHIP

The herp TAG Convenor is Chris Banks, Curator of Herpetofauna at the Melbourne Zoological Gardens. Current membership to Herp TAG comprises nineteen representatives from:

Adelaide Zoo, South Australia
Auckland Zoo, New Zealand
Australian Arid Zone Reptile Display, Alice Springs, Northern Territory
Australian Reptile Park, Gosford, New South Wales
Ballarat Reptile & Fauna Park, Victoria
Bowman Park Trust, Crystal Brook, South Australia
Bredl's Wonderworld of Wildlife, Renmark, South Australia
Healesville Sanctuary, Victoria
Lone Pine Sanctuary, Brisbane, Queensland
Orana Park Wildlife Trust, Christchurch, New Zealand
Otorohanga Zoological Society Inc., New Zealand
Pearl Coast Zoological Park, Broome, Western Australia
Perth Zoo, Western Australia
Queensland Reptile & Fauna Park, Beerwah, Queensland
Royal Melbourne Zoo, Victoria
Taronga Zoo, Sydney, New South Wales
Territory Wildlife Park, Berry Springs, Northern Territory
Ti Point Zoological Park, Warkworth, New Zealand
Wellington Zoo, New Zealand

RELATIONSHIP OF HERP TAG TO AUSTRALASIAN ZOO AND HERP STRUCTURES

The Herp TAG is the group responsible for co-ordinating herp management and breeding programs in Australasian zoos. It reports to the Species Management Co-ordinating Council (SMCC) through the SMCC's Conservation Co-ordinator. The SMCC is new the body responsible for overseeing the ASMP and comprises members from the Australasian Regional Association of Zoological Parks & Aquaria (ARAZPA) and the Council of Governing Bodies of Australasian Zoos (COGBAZ - the restructured AZDANZ).

The relationship of Herp TAG to the Australasian Amphibian and Reptile Specialist Group and the Australian National Parks and Wildlife Service's (ANPWS) Reptile Action Plan is undefined at the present time, but it is to be hoped that all three groups/projects can co-operate to the benefit of our reptiles and amphibians. Clearly, this particularly applies to native species. The Herp TAG and CBSG (Herpetology) have a closer relationship, as the goals of each overlap and the Convenor of Herp TAG is also the Australasian Regional Co-ordinator for CBSG (Herpetology).

There is currently no particular relationship between the Herp TAG and the various private herpetological societies in Australia and New Zealand. However, the need to develop co-operative dialogue and involvement with the societies is acknowledged and a representative from the Australasian Affiliation of Herpetological Societies (AAHS) has recently joined the Herp TAG.

There is also a need to establish good communication with various regulatory authorities, e.g. Vertebrate Pests Committee (VPC) and Australian National Parks & Wildlife Service (ANPWS), so that both the goals of the Herp TAG and the concerns of the regulatory bodies can be met.

THE GLOBAL PERSPECTIVE

A number of herp-based groups, acting in management and/or advisory capacities, have been established in recent years in Europe and the United States. Efforts are now underway to co-ordinate the activities of all these groups, including the Herp TAG. It is proposed that, acknowledging the right of the individual institutions to use their own contacts and sources, these regional groups be utilized to both source and place stock.

CURRENT REGIONAL STOCK-LIST AND COLLECTION POLICIES

The current regional stock-list, as collated in October 1990, comprises 220 species and sub-species from 36 families. Of these, 41 species and subspecies (including 19 chelonians) are represented by single animals and efforts are being made to either pair these animals or delete them from the regional collection. However, some of these species require VPC reclassification before this can be achieved. In addition, 116 of the 220 taxa are currently held in single collections. These statistics highlight the need to develop a meaningful regional approach and, as an exercise to clarify difficulties in achieving stock rationalization within the region, the testudinids (land tortoises) are being used as a model.

At this point the proposed Future Stock-list includes 210 species from 44 families, providing greater taxonomic diversity. However, this list remains flexible and it will be some time before it is finalized. But even when this point is reached, we need to be able to respond quickly to changing circumstances (habitat degradation, etc.). Particular zoos are already emphasizing, or directing special attention to particular taxa or groups. The Herp TAG will encourage such an approach where appropriate, but agrees that these decisions should be based on sound criteria, e.g. thematic displays, high priority species or increase in diversity (fewer species from more families).

PRIORITY SPECIES

At its Sydney meeting, the Herp TAG designated 15 species or species groups as Priority Species that require immediate co-ordinated management or particular attention. These are those taxa which:

i) are rare or threatened in the wild, or
ii) are of high scientific, conservation or education value, or
iii) have poorly-known life histories;

and which are currently held in Australasian zoos in such numbers to warrant, or benefit from co-ordinated co-operative management. A Priority Species Data Collation Form has been distributed to participating institutions to provided the data for future management. The inclusion of these taxa and their future Herp TAG attention will be reviewed at the Group's next meeting in Adelaide in July, 1991.

A further 23 species or species groups have been designated for priority consideration in the long-term as the animals and facilities become available.

The Herp TAG would welcome proposals for additional Australasian species.

a) Short-term Priority Species

Alligator Snapping Tortoise (*Macrochelys temmincki*): management program for U.S. populations, in 4 Australian collections.

Galapogo Giant Tortiose (*Geochelone elephantopus*) and Aldabran Giant Tortiose (*G. gigantea*): high profile species, both are IUCN-listed, *G. elephantopus* in 4 collections, studbooks proposed for U.S. collections.

Spur-thighed Tortoise (*Testudo graeca*) and Hermann's Toroise (*T. hermanni*): both are IUCN-listed, *T. graeca* in 6 collections and *T. hermanni* in 3 collections, have been bred and need to register specimens.

Tuatara (*Sphenodon punctatus*): now held in 4 collections and being bred in N.Z., high scientific interest.

New Zealand geckos (*Heteropholis* spp., *Hoplodactylus* spp., *Naultinus* spp.): now receiving significant attention in N.Z., many life histories poorly-known.

Knob-tailed Geckos (*Nephrurus* spp.): much requested group but poorly-known.

Frilled Lizard (*Chlamydosaurus kingii*): high profile species, now in 4 collections.

Fijian iguanas (*Brachylophis* spp.): existing management plan, IUCN-listed.

New Zealand skinks (*Leiolopisma* spp.): stated commitment from Orana Park, important N.Z. species.

Gila Monster (*Heloderma suspectum*): high profile IUCN-listed, international studbook.

Australian monitors (*Varanus* spp.): very important Australian group, poor breeding record in captivity until very recently.

Woma (*Aspidites ramsayi*): high herpetological interest, rare overseas.

Green Python (*Chondroputhon viridis*): high profile species and now in 4 collections, also held in private collections.

Eastern Diamondback Rattlesnake (*Crotalus adamanteus*): represents a large crotalid, which will be kept by a number of collections.

All native frog species, with possible exception of larger hylids (e.g. *Litoria caerulea* and *L. infrafrenata*): global decline of many species, many Australian species poorly-known.

b) Long-term Priority Species

Asian freshwater tortoises, (e.g. *Batagur baska* and *Geoemyda spengleri*): group has been highlighted for attention in recent IUCN reports.

Pig-nosed Turtle (*Carettochelys insculpta*): important Australian species.

Western Swamp Tortoise (*Pseudemydura umbrina*): existing management plan, but currently held in only one collection.

Chinese Alligator (*Alligator sinensis*): considered as a replacement for *A. mississippiensis* in some collections, existing international management plan.

Philippines Crocodile (*Crocodylus mindorensis*): rarely held outside Philippines and in urgent need of international attention.

Philippines Sail-fin Lizard (*Hydrosaurus pustulatus*): IUCN-listed and currently in one collection.

Komodo Dragon (*Varanus komodoensis*): registered interest from number of Australasian zoos.

Australian pygopods: poorly-known group with number of vulnerable species.

West Indian iguanas, *Cyclura* spp. excluding *C. cornuta*: group highlighted for attention at recent U.S. meetings, replace *C. cornuta* with more threatened forms.

Chameleons: high profile group, recently imported by 1 zoo.

Chinese Crocodile Lizard (*Shinisaurus crocodilurus*) and Prehenesile-tailed Skink (*Corucia zebrata*): regional studbooks proposed at U.S. meeting, both within realms of RHMT preference.

Pedra Branca Skink (*Pseudemoia palfreymani*): plus other restricted native skinks.

Madagascan boids (*Acrantophis/Sanzinia* spp.): flagged by Australian collections, all species proposed for international attention.

Keeled Python (*Morelia carinata*): recently-described and poorly-known Australian species.

Oenpelli Python (*Morelia oenpelliensis*): restricted distribution and poorly-known Australian species.

Broad-headed Snake (*Hoplocephalus bungaroides*): IUCN-listed, high education potential.

Small Australian elapids (eg. *Neelaps*): many species poorly known.

Papuan Black Snake (*Demansia papuensis*): restricted distribution and concerns that it may be declining.

Asian rainforest vipers (mainly *Trimeresurus* spp.): status unknown, but important group in realm of RHMT preference.

Central Asian Cobra (*Naja oxiana*): IUCN-listed, possible replacement for more common Asian cobras.

Puerto Rican Crested Toad (*Peltophryne lemur*): existing successful SSP.

Blue Poison Arrow Frog (*Dendrobates azureus*): highlighted by U.S. Amphibian Advisory Group.

Japanese Giant Salamander (*Andrias japonicus*): IUCN-listed.

General interest is expressed in herpetofaunas of Papua New Guinea (e.g. *Tribolonotus novaeguinea* and *Pseudechis papuanus*), Vietnam, Philippines, Madagascar and Indonesia.

It is also appropriate that specimens of any species having management programs based in other countries should be part of those programs. This applies to specimens/species currently in Australasian collections and to those which we may obtain in the future.

CONTROLLED BREEDING

Uncontrolled breeding of any species can create potential housing problems, resulting in space being utilized that could be available for more important taxa, and is not a desirable practice for professional operations. Many zoos have already instituted voluntary controls on the breeding of a number of species.

As a general principle, breeding of any taxa should only occur if the progeny can be placed satisfactorily, either in another collection or as part of that institution's programs. However, the need to gain more knowledge of many poorly-known native species is noted and the value of breeding such species in public collections concentrating on these species, and in private collections, is stressed. Indeed the role of the private herpetologist in this regard is very important.

Herp TAG members agree that reproduction of the following species should be controlled:

Species		Control Category
Painted Terrapins	*Chrysemys picta sub. sp.*	1
Red-eared Slider	*C./Trachemys scripta elegans*	1
River Cooter	*Pseudemys concinna*	1
Carolina Box Tortoise	*Terrapene carolina major*	2
American Alligator	*Alligator mississippiensis*	1
Freshwater Crocodile	*Crocodylus johnstoni*	2
Estuarine Crocodile	*C. porosus*	2
Leopard Gecko	*Eublepharis macularius*	1
Madagascan Day Gecko	*Phelsuma madagascariensis*	2
Crested Basilisk	*Basiliscus plumifrons*	2
Rhinoceros Iguana	*Cyclura cornuta*	2
Green Iguana	*Iguana iguana*	2
Jewelled Lizard	*Lacerta lepida*	1
Boa Constrictor	*Constrictor constrictor*	2

Species		Control Category
Rainbow Boa	*Epicrates cenchria*	2
Yellow Anaconda	*E. notaeus*	2
Burmese Python	*Python molurus bivittatus*	2
Reticulated Python	*P. reticulatus*	2
African Python	*P. sebae*	2
Corn Snake	*Elaphe guttata*	1
Grey-banded Kingsnake	*Lampropeltis alterna*	2
Egyptian Cobra	*Naja haje*	2
Black & White-lipped Cobra	*N. melanoleuca*	2
Mozambique Spitting Cobra	*N. mozambique*	2
Indian Cobra	*N. naja*	2
Taipan	*Oxyuranus scutellatus*	2
Collett's Snake	*Pseudechis colletti*	2
Russell's Viper	*Vipera russelli*	2
Mexican Cantil	*Agkistrodon bilineatus*	1
Urutu	*Bothrops alternatus*	2
Western Massasauga	*Sistrurus catenatus tergeminus*	2
Cane Toad	*Bufo marinus*	1
Giant Tree Frog	*Litoria infrafrenata*	2

Category 1 = No Breeding.
Category 2 = Controlled breeding, i.e. breeding will only occur to ensure adequate stock levels for Australasian collections or where progeny can be satisfactorily placed.

OTHER ROLES FOR HERP TAG

These are seen as including:

1. Determination of skills currently lacking in the region, i.e. relating to herp management/reproduction.
2. Development of bibliographies and where herp journals are held.
3. Development of register of non-participating institutions that hold herps.
4. Determination of status of herps in the Pacific region.

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ADVANCED PROTOCOLS FOR THE MANAGEMENT AND PROPAGATION OF ENDANGERED AND THREATENED REPTILES

Howard E. Lawler

INTRODUCTION

Natural environments around the world are experiencing rapid change. Correspondingly, the biodiversity supported by and integral to these natural systems is increasingly threatened. Unique plants and animals, many of them highly specialized and limited in natural distribution, are vanishing at an unprecedented rate. Many will become extinct before we realize their existence. The priority conservation objective, to sustain wildlife and their vital habitats in a natural state, is becoming increasingly tenuous as human need and greed reaches even the most remote regions of the planet.

CAPTIVE PROPAGATION AND CONSERVATION

The premise that a few taxa of threatened wildlife can be preserved from extinction through propagation in captivity has long been debated. Many believe this is a viable alternative to extinction for as many species as possible, and worthy of intensive coordinated effort (Gray, 1985). Unfortunately, the percentage of biodiversity which might be preserved in this way is very small, and we must not delude ourselves in thinking that a great many species can be conserved in this way.

While biological extinction occurs when wild populations are no longer self-sustaining, absolute extinction is forestalled as long as sufficient numbers of genetically-diverse reproducing individuals are maintained in captivity. Establishment of genetically viable captive populations can provide opportunities for continued scientific study, perhaps eventually resulting in reintroduction to the wild. Obviously, factors which endangered the species must be mitigated and sufficient habitat must exist or be restored for reintroduction to be feasible.

Critics of captive propagation as a conservation tool correctly point out that few species have been successfully restored to the wild following ecological extinction. They believe conservation efforts in captivity are too-often anthropocentric and absorb funds which might otherwise be invested in habitat preservation to benefit entire ecological communities rather than a few target species (Varner and Monroe, 1990).

The holistic ecology philosophy championed by Aldo Leopold (1948) holds that actions which "tend to preserve the integrity, stability, and beauty of the biotic community" are the most morally correct. This view is a natural ally of scientifically developed and managed captive propagation efforts involving carefully prioritized threatened wildlife.

These diverse views can be mutually-supportive in holistic conservation strategies which incorporate participating resources from different quarters. There is little doubt that sequestered wildlife resources will become increasingly important to conservation and research in the 21st century.

DESIGN OF REPTILE CONSERVATION PROGRAMS

Management and propagation techniques for reptiles and amphibians have progressed notably in recent years. While much technical knowledge and skill is present in the private herpetoculture community, this resource has rarely integrated with programs designed primarily to conserve threatened reptile taxa.

Some good contemporary reptile conservation programs illustrate key parameters necessary for success. While biological specifics vary from species to species, these design categories are relatively consistent. The foundation of program planning is knowledge about the ecology, behavior, physiology, and natural history of the target species, often derived from associated field studies (Lawler, in press).

I will present a Ten Point Plan for design of captive breeding programs for threatened reptiles. The key criteria are:

1. **coordination and authorization**
2. **species selection**
3. **founder diversity**
4. **genetics**
5. **space**
6. **social biology**
7. **reproductive biology**
8. **diet and nutrition**
9. **pathology and health management**
10. **reintroduction to the wild**

AUTHORIZATION

Governmental wildlife agencies regulate all activities with Threatened or Endangered species. Permits are required for most field studies, including take and transportation of specimens or their parts. Regulations governing state-listed taxa vary considerably. Permits from the country of origin and the Office of Management Authority in the U. S. Fish and Wildlife Service are required to import exotic taxa (and parts thereof, including tissue and blood samples) listed under the Endangered Species Act or Appendix I of the Convention on International Trade in Endangered Species (CITES). CITES Appendix II species require only a permit from the country of origin.

Information derived from scientifically-designed programs can be very useful to domestic and foreign wildlife agencies. For example, information on genetic variability can be applied to demographic management in the wild as well as in captivity. Proposals to establish captive-breeding programs are increasingly tenable if the project design is biologically and administratively sound, and properly coordinated with management authorities.

COOPERATION

The unfortunate fact is that we will not be able to preserve a significant percentage of the threatened herpetofauna solely through captive management simply because be will never have enough collective space to do so (Soule et al. 1986). We can, however, expand opportunities to work more effectively with more taxa through increased collaboration among institutions and private individuals who commit to cooperative management of carefully selected species for which we can provide sufficient space, expertise, technical resources, and funding.

Zoological parks are working toward the collective management of selected threatened and endangered species. The Species Survival Plan (SSP) concept establishes formal working groups of specialists to devise plans for genetic management and distribution of founder specimens and their progeny. The fundamental objective is to maintain 90% of the natural genetic diversity over 200 years (Hudson, 1988).

The Species Survival Group of the International Union for the Conservation of Nature (IUCN) sponsors the Captive Breeding Specialist Group (CBSG). Specialist subcommittees make recommendations on conservation strategy. The CBSG coordinates captive breeding activities of over 200 active members representing 37 countries.

Conway (1987) estimates that all the zoos in the world can collectively support only 96 reptile and 32 amphibian taxa under SSP guidelines. Given these predicted limitations, it seems logical to increase the potential captive species carrying capacity by encouraging participation by the qualified private sector in captive breeding consortia.

SPECIES SELECTION

Historically, selection of wildlife for zoological exhibition and breeding projects has reflected the personal interests of management personnel or sponsoring organizations more often than not. The growing complexities of acquiring wild founder and exhibition specimens dictate changing priorities in institutional and private acquisition criteria.

The foundation of successful wildlife propagation programs is pragmatic planning and application of basic resource strengths, i.e. local climate, space, personal expertise, operational cost, inter-disciplinary opportunities, and cooperative potential. Species selection should be guided primarily by the quality of these management resources. Large crocodilian, turtle, tortoise, and lizard taxa are generally best managed in or near their historic range.

Taxon Advisory Groups have been set up to advise the Wildlife Conservation and Management committee of AAZPA on selection of reptiles and amphibians for coordinated zoological conservation programs (Behler, 1989; Hudson, 1989; McLain, 1989; Paine and Johnson, 1989; Stearns, 1989). these groups include zoo staff, field biologists, veterinarians, and private organizations and individuals.

FOUNDER DIVERSITY AND GENETICS

Probably the greatest liability in the development of longterm genetically-viable programs for threatened herpetofauna is the difficulty in assembling sufficient unrelated founder stock. While required founder diversity varies greatly from species to species, some population biologists believe as few as 10-15 unrelated founders can represent up to 95% of a species' genetic diversity. Thereafter, a stable population of 40 to 1000 individuals, depending on generation time, is required to retain 90% genetic variability for 200 years (Gray, 1985).

Complicating matters further, without knowledge of how a species' genetic diversity is divided within and between localized populations, large founding numbers do not guarantee that a species' genetic diversity will be preserved (Templeton, 1990).

Genetics data from the field are necessary to construct accurate profiles of genetic variability in species. These data are basic to evaluation of genetic representation in captivity and are important in predicting rates of inbreeding expression and genetic drift (Lacy, 1987).

Many captive wildlife managers now lament their lack of foresight in the not-too-distant past when specimens of many now-threatened and endangered reptiles were readily and legally available.

A Species Survival Plan (SSP) has been designed for the Aruba Island rattlesnake (*Crotalus unicolor*). This outstanding effort on behalf of a venomous snake is distinguished by its holistic approach to the conservation of an endangered reptile.

Odum (1991) reported 84 animals in captivity at 22 U. S. institutions and established the collective zoo carrying capacity at 250 animals. Four breedings involving wild founders are scheduled at four institutions. Ten (4.6) new founders will be imported under permit from Aruba. Electronic transponders will be used for specimen identification following recommendations by the IUCN Captive Breeding Specialist Group (anon., 1991). Research will be initiated on artificial insemination, sperm retention, and genetic variability in the species.

In 1983, Arizona-Sonora Desert Museum and Rio Grande Zoological Park developed a cooperative program for propagation of Arizona's protected mountain rattlesnakes based on a deme-specific founding principle. Captive breeding colonies of twin-spotted rattlesnake (*Crotalus p. pricei*), banded rock rattlesnake (*Crotalus lepidus klauberi*), and Arizona ridge-nosed rattlesnake (*C. w. willardi*) were established with founders collected from specific canyons and mountain ranges in southern Arizona where these taxa exist in discontinuous sub-populations where isolation has resulted in varying degrees of genetic variation. Progeny grow such projects benefit conservation by providing alternatives to continual scientific collecting from parental localities (Lawler and Belcher, 1983).

A colony of *S. varius* has been maintained at the Arizona-Sonora Desert Museum since 1977. In 1981, we developed a comprehensive plan to participate in the conservation of this unique insular desert lizard through propagation, scientific study, and education of the public (Lawler and Jarchow, 1986). This plan is frequently evaluated and adjusted according to new information and observation. Primary areas of continuing refinement are diet and nutrition, pathology and veterinary care, social organization and behavior, spatial requirements, and genetics.

Since 1981, 8.13 founders have produced 133 progeny representing 9 maternal blood lines (Lawler, in press). Some of the 1981 founders may be progeny of a smaller founder unit collected by Charles Sylber in 1977 and donated to ASDM in 1980 (Sylber, 1985). A second founder group consisting of 2.3 animals was established at the Centro Ecologico de Sonora in 1985.

We have initiated DNA fingerprinting (Jeffreys 1985, Jeffreys et all 1985, 1987; Burke and Bruford 1987) and mitochondrial DNA analysis to determine founder relaitonships and clarigy lineage when it is unknown. Molecular analyses of DNA from blood samples will determine genetic variability in wild and captive populations. This information will guide refinement of the long-range genetic management plan to meet SSP guidelines.

Collaboration with qualified genetics investigators is essential since most captive wildlife managers lack technical expertise and resources in this area. Llew Densmore of Texas Tech University is directing genetics analysis of the *S. varius* program.

SOCIAL BIOLOGY AND SPACE

In many reptiles, dominance hierarchies or territoriality involve intensive, often seasonal, agonistic behavior. Size is usually the principal factor affecting success in such encounters. Space to accommodate these natural behaviors is essential to reproductive success.

Seasonal manipulation of competition among males often achieves synchronous reproductive cycling with females. In species characterized by male dominance hierarchies, this can be accomplished by isolating the selected breeding male with one or more smaller males until observed chase-flee sequences indicate dominance by the desired male (Burchfield et al, 1980; Lawler and Jarchow, 1986, Burchfield et al, 1987).

Snakes can be effectively managed in more limited indoor space. Consequently, coordinated programs can involve a broad network of qualified cooperators. Programs for larger lizards, turtles, and crocodilians generally require adequate outdoor space for long-term success. Programs established in or near the natural range of the target species benefit from climatic advantages allowing extensive use of outdoor space (Behler, 1989).

The Arizona-Sonora Desert Museum employs outdoor enclosures in managing *Sauromalus varius*. Good reproductive success has been achieved due in part to space and near-natural climate for the species.

Features of the enclosures closely replicate natural microhabitat used by the species in the wild. The master enclosure encompasses 104 m^2 and is landscaped with natural Arizona Upland vegetation, i.e., saguaro (*Carnegiea gigantea*), paloverde (*Cercidium microphyllum*), jojoba (*Simmondsia chinensis*), creosotebush (*Larrea tridentata*), desert broom (*Baccharis sarothroides*), and native grasses, especially threeawn (*Aristida* sp.). Vegetation and numerous rock piles provide visual barriers and topographical diversity, thereby reducing seasonal agonistic behavior and increasing spatial carrying capacity.

An electrically-powered concrete-block refuge building 5 m^3 in space volume is buried to the roof in soil and rock. PVC pipe 12.7 cm diameter communicate from separate interior shelter boxes to the outdoor enclosure. These features provide separated primary retreats for the colony. The foam-insulated roof is removable for periodic cleaning (Lawler and Jarchow, 1986). The building is electrically heated to a constant 16°C from November through March to compensate for colder Arizona winters than occur in nature. Emergent winter activity is regulated entirely by prevailing climate conditions.

Three isolation enclosures ca 15 m^2 have been added to isolate designated founders for selective breeding. Two additional outdoor screened enclosures provide environmentally healthy space for rearing of progeny without risk of predation by birds.

Observations in these quasi-natural outdoor enclosures have enriched our knowledge of the social biology of *S. varius*. While observed behavior may be influenced to some degree by confinement, cyclic repetition and field observations support interpretation as ritualized natural behavior.

A long-term breeding program for the Endangered bolson tortoise (*Gopherus flavomarginatus*) has been conducted at The Research Ranch, Elgin, Arizona, since 1976. This program utilizes 1-5 acre enclosures in relatively flat grassland, providing sufficient space for burrow separation, space for a diversity of plant growth for forage, and space for the exercise intrinsic in foraging. Studies of captive growth, dietary plant selection, and microbial analysis of feces and soil have continually refined management techniques (Appleton, 1986).

Finca Cyclura in Key West, Florida,utilizes spacious outdoor enclosures in their successful breeding programs for several threatened species of West Indian land iguanas, *Cyclura* spp. (Ehrig, pers. comm.).

The conservation program for *Crocodylus moreletii* initiated by Alvarez del Toro at Instituto de Historia Natural de Chiapas in Mexico and funded by the World Wildlife Fund achieved notable captive breeding success in natural outdoor enclosures. Protected and manageable outdoor space, ideally within the species' historic range, is a primary requirement for successful long-term programs for larger crocodilians

(Behler, 1989).

Commercial ranching of reptiles in Third World countries may prove extremely pragmatic in perpetuating the species. Crocodile ranching has been particularly successful, not only in producing large numbers of animals, but also giving local people a justification for tolerating these large aquatic carnivores that may threaten humans and livestock, and an economic motive for maintaining wetlands. While purely conservation-oriented breeding programs differ greatly from commercial ranching in objectives, they often employ similar techniques benefiting wild populations (King, 1990).

Large iguanids have been eaten by indigenous peoples in Central America for centuries. Burgeoning human population and rapid reduction of habitat is beginning to threaten some of them. Food ranching programs for the green iguana (*Iguana iguana*) in Panama and spiny-tailed iguana (*Ctenosaura similis*) in Nicaragua are being developed as a pragmatic approach to meet both natural resource and human protein needs.

REPRODUCTIVE BIOLOGY

Studies of species' reproductive biology must accrue but not be limited to captive studies. In many cases, basic studies of reproductive and social biology in the field are necessary to refine captive breeding strategies. Species-specific analysis of embryonic physiology is sometimes necessary to refine incubation techniques.

Collaboration with Howard Snell at The University of New Mexico produced data on the effects of varying water potential on embryonic and neonatal development of *S. varius* based on similar studies of *Iguana iguana* by Werner (1988). Experimental incubation of fertile eggs in various water treatments defined optimal moisture levels for successful hatching and revealed a developmental effect of varying incubation water levels on tail and limb length.

Although soil substrates suitable for nesting and incubation result in nearly 100% hatching success at ASDM, this information is especially useful to program cooperators who lack suitable climate or space for outdoor nesting.

Finca Cyclura has established a fine record of success through their work with the West Indian land iguanas *Cyclura lewisi*, *C. nubila*, and *C. cornuta*.

DIET AND NUTRITION

Captive dietary regimens for herbivorous reptiles have often been formulated arbitrarily, often with more attention given to palatability than to nutritional content (Lawler and Jarchow, 1986). The assumption has been that captive diets with a wide range of essential nutrients must provide everything required by the species. As we learn more about the often species-specific adapted nutritional physiology of many herbivorous reptiles, this "shotgun" approach to diet becomes less acceptable and even harmful in terms of optimal longevity and reproductive potential.

Our approach to dietary formulation for *Sauromalus varius* has been to analyze the diet in the wild and determine the nutritional values of the most frequently consumed plants. The captive diet consists of some of those plants or suitable nutritional analogs according to availability.

Sylber (1988) identified 22 plant species consumed by *S. varius* in nature and determined relative frequencies of consumption. He also documented seasonal variations in food preferences. This may be explained, in part, by seasonal availability. This dietary flux may also reflect changing nutritional requirements associated with variations in hydration, growth, activity, and reproductive cycles.

We conducted a similar analysis of S. varius food preference during a reproductive year in 1985. In addition, fresh cuttings of primary plant foods were analyzed for crude protein, ether extract, neutral fiber, acid fiber, hemicellulose, cellulose, lignin, calcium and phosphorus.

Data from six major plants consumed during a reproductive year reflects an extraordinarily high calcium/phosphorus ratio (x = 31.79:1) and relatively modest protein intake (x = 10.27%) (Lawler, in press).

Similarly, Burchfield et al (1987) considered the effect of overly rich produce diet on captive Galapogos tortoises (*Geochelone elephantopus*) at Gladys Porter Zoo. Based on normal dietary flux in the wild, they reduced the fruit and vegetable diet to once weekly and introduced alfalfa as the dietary staple, thus increasing fiber intake to maintain proper gut mobility.

Dietary guidelines for captive populations of herbivorous reptiles should be refined through understanding of naturally-evolved feeding strategies and nutrient intake in the wild. Special consideration should be given to seasonal and annual variation in nutrition, particular in insular and desert species.

PATHOLOGY AND HEALTH MANAGEMENT

Health management programs for captive reptiles generally have four major objectives:

1. To prevent disease and promote general health through proper diet, social grouping, sanitation, and stress management.
2. To identify and effectively treat disease through regular evaluation and veterinary diagnosis of observed health problems.
3. To continually refine dietary and nutritional guidelines.
4. To gather information about normal physiologic processes through study and observation.

The early detection of pathologic change is an important part of the health management program. Each animal should be regularly examined for physical or behavioral abnormalities. Swellings, weight loss, abnormal ambulation or posture, inappropriate behavior, inanition, prolonged lethargy or sustained escape-type behavior are often early indications of stress or disease and require immediate referral for veterinary evaluation.

Examination consists of visualizing eyes, tympana, the buccal cavity, vent and integument. Each animal is palpated, and reflexes and ambulation are observed. If signs of pathology are found, ancillary diagnostic procedures including hematology, bacterial culture and sensitivities, fecal flotation and cloacal smears for endoparasitism analysis, radiography, and/or surgical exploration are utilized to aid in making a definitive diagnosis. At ASDM, we maintain computerized records for each animal.

Cowan (1980) provides a good discussion of the effects of environmental stress on reptiles and its role in the pathogenesis of disease. He states that opportunistic infections and generalized debilitation are often associated with environmental stress. Spacious outdoor enclosures with microhabitat diversity and numerous refuges are essential in the management of large lizards and serve to reduce stress and accompanying disease problems. The frequency of intraspecific interaction is also an important consideration in stress reduction as well as reproduction (Crews, 1980). Population densities and sex ratios should be regularly evaluated to promote good health and optimize reproductive output (Lawler and Jarchow, 1986).

Epidemiology of infectious diseases must be considered in the captive management of threatened reptiles. Small captive populations are particularly vulnerable to such catastrophic impact.

For example, The Aruba Island rattlesnake program suffered serious setbacks from outbreaks of paromyxovirus infection in the past decade. *C. unicolor* appears to be particularly vulnerable to this aerosol-transmitted pathogen. A quarantine and testing procedure has been developed to control this disease. Blood samples reveal paromyxovirus antibodies and strict long-term quarantine and veterinary evaluation precedes and follows all transportation of specimens. An experimental vaccine is in development.

REINTRODUCTION PROGRAMS

Although an attractive notion, release to the wild is in fact a complicated proposal. It is rarely desirable where viable wild populations already exist. Captive animals may harbor opportunistic pathogens capable of epidemic outbreak in wild populations lacking acquired immune response. The sudden infusion of additional individuals into a wild population may result in increased competition or social instability with devastating effect on the existing population.

Release of captive wildlife must observe rules of biological common sense as well as the regulations and prerogatives of governing wildlife management agencies. Direct collaboration with such agencies is the first essential step toward participation.

Kleiman (1990) provides an excellent outline of elements essential to successful reintroduction programs. She emphasizes assessment of captive and wild populations through broad interdisciplinary studies, habitat protection and management, conservation education for long-term support, and preparation and reintroduction of animals.

Conservation of herpetofauna is inexorably linked to the fate of other wildlife throughout the world. Conservation of the charismatic megafauna attracts far more public attention and support than do our efforts to preserve West Indian boas and iguanas, Aruba Island rattlesnakes, tortoises, or insular chuckwallas. The common denominator is, of course, habitat. If we preserve ecosystems which support tigers, jaguars, and gorillas, we also preserve many reptile and amphibian populations. Virtually all habitat refuges directly benefit herpetofauna diversity.

Reptiles and amphibians generally require less preparation for release and adjustment to the wild than do birds and mammals (Wemmer and Derrickson, 1987).

A successful captive breeding program for the Endangered Virgin Islands boa (*Epicarates monensis granti*) was initiated in 1985 at the Toledo Zoological park (Tolson, 1989). Ten founders have produced 48 offspring of which 40 have survived. Two distinctive demes of this subspecies are now maintained in captivity as each exhibits distinctive coloration. TZP maintains a regional studbook and has petitioned AAZPA to establish a SSP for this snake. A reintroduction plan has been developed based on extensive field studies (Tolson and Tuebner, 1987; Tolson, 1988). Rat and cat control programs on offshore cays near Puerto Rico and the Virgin Islands is considered essential to reintroduction success (Tolson, 1990).

In cases where nest predation is a threat, eggs can be gathered, incubated, and progeny released under more favorable conditions than might prevail through natural circumstance. This method has been successfully employed in recovery projects for marsh crocodile (*Crocodylus palustris*), gharial (*Gavialis gangeticus*) (Behler, 1989), and Kemp's Ridley sea turtle (*Lepidochelys kempi*) Burchfield, 1989).

Zoo Atlanta's successful captive breeding program for Morelet's crocodile (*Crocodylus moreletii*) has produced 357 progeny (Behler, 1989). Staff provided 60 captive progeny for release in Mexico in 1975 (Lawler, 1976), and 33 more in 1978

Hunt, 1987). For reasons unknown, all 93 animals were retained in captivity in Mexico.

Hunt (1987) reported unsuccessful efforts to develop an experimental release project on private property in Belize. Permission was denied by the government on the grounds that Belize "had enough crocodiles" and because of concern about introduction of disease from captivity.

SUMMARY

The development of viable captive refuges for threatened and endangered reptiles requires synthesis of conservation biology and progressive captive management methods. Primary development areas are authorization, cooperation, founder diversity, genetics, space, social biology, reproductive biology, pathology, diet and nutrition, and most tenuously, reintroduction to the wild.

The future success of captive reptile conservation programs can be enhanced by synergistic programs involving wildlife management agencies, natural history institutions, and the private sector.

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CONSERVATION, CONSENSUS AND COOPERATION: HOW HERPETOLOGICAL ORGANIZATIONS CAN WORK TOGETHER

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ABSTRACT

Herpetological organizations, composed of amateurs and professionals, representing many occupations and interests, can utilize the potential of their diversity by cooperating to promote conservation programs for amphibians and reptiles.

All members of the herpetotogical community agree world wide destruction of habitat, and illegal and unwise traffic in the skin and pet trades, make conservation of habitats and species imperative.

Herpetological organizations, by planning coordinated, cooperative initiatives, can:

(1) Develop conseration objectives through identification and coordination of lead individuals and groups;
(2) Build a consensus among groups and polities (including other conservation organizations) in advocating conseration programs for amphibians and reptiles.
(3) Cooperate to achieve objectives, utilizing strategies by which all members of the herpetological community communicate with individual consituencies: The amateur; the professional; the naturalist; the captive breeder; those who simply like amphibians and reptiles; the environmental community; and the general public.

Herpetological organizations, cooperating through consensus on conservation issues, can achieve significant objectives toward preservation of habitats and species of amphibians and reptiles worldwide.

INTRODUCTION

This paper will offer suggestions for appling our herpetological interests to community and political organization. We will look at how our shared concern for conservation and preservation of habitats can be a catalyst for leadership and cooperation with other individuals and groups. United through consensus we can cooperate to secure the future of the animals we love so much.

All of us, as amateur and professional herpetologists, encounter daily, ecological dilemmas, not just in the world, but in our own back yards. How can we preserve the environment and yet sustain the economic growth necessary to provide the resources to preserve that same environment? How can we influence far away actions by far away governments? How can our concerns be noticed amid a world of competing ideas?

Our ecological dilemmas divide us worldwide between pro-development and pro-environmental groups. Often we find ourselves in a "having to burn the village to save it" quandry. Despite rhetoric to the contrary, our national environmental agenda does not begin to meet our national needs. We are still in a "we" versus "they" mode of thinking. For any real improvement in our environmental agenda to occur, we must realize that the issue is not "we" versus "they" but rather, the issue is how can we all work together to insure the survival of our world. To achieve that goal we must find common ground among the diversity of individuals and organizations interested in herpetology and conservation.

The examples we set by working together can be a catalyst for other groups and organizations to conserve resoures and preserve habitat. Many of the ideas for this paper came from experience resolving conflict by improving communication among diverse groups pertaining to grazing, forestry, and wildlife issues. Similar techniques for improving communication, will be applied in the coming months in a project for generating financial and community support for the Idaho Fish and Game Department and its Nongame Wildlife Management Program.

We can break down barriers to communication concerning environmental issues by employing three strategies: Conservation, Consensus, and Cooperation.

CONSERVATION - THE FIRST STRATEGY

The first strategy involves understanding our mutual commitment to conservation. More than simply being neglected, or, tragically, even destroyed, the herpetofauna of the world have been ignored. Though the cycle of public concern for conservation of natural resources is again reaching a high point, the attitude concerning reptiles and amphibians remains generally neutral, and in many instances, negative. As we are only too aware, this attitude prevails largely because of an historic indifference to non-mammalian species and "Western Civilization's" historic misunderstanding of reptiles in general, and inparticular, snakes.

This fact affects the conservation of herpetofauna in that very few people seem to care about it. Many of those who do profess to care for the conservation of herpetofauna still are visibly nervous when snakes are mentioned. We are troubled that, as such a small minority, we seem powerless to do anything at all. Yet as we talk to each other, we discover common concerns including conservation of natural resources; prevention of species becoming endangered; loss of habitat; and the need to promote captive breeding for reintroduction of species into the wild, and for the live animal/pet trade. We know there is a need to educate not only the public at large, but also other conservation groups about amphibians and reptiles.

In 1989, in his opening remarks to the First World Congress of Hepetology in Canterbury, Dr. Kaig Adler observed, "Amphibian and reptilian species, proportionate to their numbers, are the most threatened and endangered of all vertebrate animals, and they are particulary sensitive to environmental change...We are on the brink of losing forever a significant fraction of the diversity that we are only beginning to comprehend." (Adler, 1989).

Loss of habitat is the foremost threat to amphibibans and reptiles. We are as frightened as we are familiar with the dramatic statistics, and though events, from time to time, seem to warrant some optimism in some places, the problem persists. Consider this recent report on the Brazilian rainforest: "During the first half of the 1989 dry season, 59,000 human-set fires destroyed 13,000 square miles of rainforest in Brazil's Amazon region. This area...is far smaller than the areas burned during the four-month dry seasons of 1988 (50,000 square miles) and 1987 (80,000 square miles). Slowing deforestation by fire this year (1989) are heavy rains, fines for illegal burnings, and suspension of tax incentives offered to large landowners for clearing land for cattle ranches." (National Institute of Space Research, Brazil, 1989). To put this into another perspective, in 1987, an area the size of Idaho, the 13th largest state in the United States was burned. A year later, an area approximately the size of the state of Florida was burned. In 1989, an area equivalent to New Jersey and

Connecticut combined was destroyed.

But loss of habitat is not a far-away rain forest problem. The Pine/Bull/Gopher Snakes (*Pituophis melanoleucus/Pituophis catenifer*) so common throughout the United States are on the watch/threatened/or endangered lists in at least eight states (Allen, 1987). We need only to look at population growth patterns throughout the nation to discover that habitat loss is a problem right in our own backyards - even in sparsely populated states like Idaho. Each year housing and commercial developments creep further into the foothills, desert or forest, and each year citizens complain of snakes in their backyards or garages. Clearly, there is work to be done at home.

The second threat to amphibians and reptiles, is collection for the skin and pet trades. For example, in 1989, of 50,597 Burmese python items (*Python molurus bivittatus*) imported into the United States, 3,306 entered the country live, the remaining 47,291 items entered the country as skin products. Although, it might be possible to conclude from these figures that the pet trade is insignificant, by comparison to the skin trade, a check with Royal pythons (*Python regius*) entering the U.S. in 1989 causes concerns. Of 32,037 *Python regius* items, 26,253 were imported live (CITES, 1989). Considering the high mortality rate of imported *Python regius*, giving them "U.S. citizenship" is hardly doing the species a favor. Even more sobering is that fact that, "From 1987 to 1988, the Port of Miami processed 1.26 million imported reptiles, including a total of 18,150 ball pythons." (Vivarium Magazine, May, 1991).

Certainly all of us feel horror about these statistics and feel frustration at how little we appear to be able to change things. Yet, our shared horror and frustration constitute the beginnings of the consensus needed to reach out to others. Certainly, we all agree on the need to preserve habitat and prevent the unwarrented taking of animals from the wild. What we need to do is to mold this shared concern into a consensus which can influence others. As we shall see, herpetologists and herpetological organizations are uniquely suited as catalysts for influence.

CONSENSUS - THE SECOND STRATEGY

The second strategy is using our concern for conservation to build consensus. The first step for a consensus strategy is our process of responding to the comments of others. The second step is to seek out others who share our concerns for these animals. In increasing our numbers, we can influence key people, decision makers, and other conservation groups and citizen lobbies.

Our first step is our individual response to the comments of others. We have all encountered many times, situations like the following: A regional representative of a large and wealthy environmental organization told me he would have a very difficult time supporting programs which would protect snakes. He felt guilty about his views but he said someone else would have to protect snakes. In my presentations to schools and service groups in which I use my Burmese python, people continually ask if I'm married. When I tell them "no", they reply, "well, I can see why". Others ask, "how can you have snakes in your house?" or "what would happen if it got out?". We are constantly called upon to be diplomats and spokespersons for our animals.

First, we must analyze the various negative and neutral comments. What qualities of amphibians and reptiles will lesson people's fears. We pick those qualities with which others can identify - snakes kill rodents which cause diseases, or few snakes are venomous, for example. Then we choose the most effective ways to communicate these positive qualities.

Secondly, we try to seek out others who share our concerns for these animals. The first place we look is to herpetological organizations. Indeed, the growth of herpetological organizations in the past few years is indicative of our desire to communicate and share ideas.

Why can herpetological organizations be effective in building consensus among different individuals and groups? What are the qualities which uniquely qualify us for such a task?

Herpetology attracts people from all segments of societies; Scientists from different academic disciplines; Zoo personnel; Animal welfare groups; Children; Hobbyists; Breeders; Ecologists; Elements of the pet trade; and people who just "like the outdoors," or "just like animals". It is that diversity transcending professional, age, socio-economic strata, geographic distribution, just to name a few characteristics, which makes us unique. It is that diversity which gives our organizations effectiveness and strength.

Within our diversity is the potential for unity on several key issues which transcend the entire conservation community. Our members are also members of other conservation groups. And as members of other groups, our interests in amphibians and reptiles can educate and inform those groups and add support to those groups' efforts in trying to preserve habitat.

But to effectively influence outside groups, we must first define those areas in which we agree. A perusal of the herpetological society newsletters exchange throughout the world tells us that this will not be difficult to achieve. They all outline our common concerns of the need for captive breeding, conservation and preservation of habitat. By captalizing on this agreement we can advocate issues which are shared by all environmental groups. Through our membership in other conservation groups, we can promote unity within the environmental community, and at the same time, fill the gap in those organizations for concern for amphibians and reptiles.

With such a diverse makeup, members of herpetological organizations can provide a wealth of information and talent to the comunity at large about conservation and amphibians and reptiles.

Just as our concern for amphibians and reptiles has led to finding others who think as we do, our concern for conservation can build consensus among other people and groups. All we need to do is agree upon some common issues and make a conscious effort to work together.

What, then, are some common issues we share, which could be the basis for a consensus on conservation?

1. A concern about stopping the destruction of the natural environment world wide, and the need for conservation of resources.
2. A concern for preservation of habitat whether in the Amazon, the Columbia River Basin, or the Persian Gulf.
3. Ceasing the destruction of tropical rain forests and the desecration of the resources of the land and water through unnecessary and unplanned development.
4. Concern about the need for preservation of species in the wild, in captivity, and through research.
5. Concern about the need for ethical behavior in dealing with animals in the wild, in research, and in captivity.
6. Extending the attention of the conservation community, through educational and political activity, to amphibians and reptiles.
7. Creating, supporting, and utilizing political and economic resources in

persuading the world's leaders to understand the need for preservation of wildlife. The world's political leadership includes elected and appointed officials, in individual towns, cities, counties, states, provinces, territories and nations. The world's leadership begins right where people live, not in some far away place!

Once we discover our mutual concern and agreement on the importance of these and other issues, how can we work together to bring about change? What can we do to initiate cooperation?

COOPERATION - THE THIRD STRATEGY

The third strategy is using our consensus to find means for cooperation with others. Cooperation is, in effect, increasing our numbers and influencing different groups. We can do this through a variety of means of communication. We talk to others - we write - we ask questions. It is a slow steady process. As we expand our network, we continually refine our positions on conservation, captive breeding, keeping animals in captivity and a whole range of other issues.

What are some specific actions we can take through our network to bring obout cooperative actions among different groups both collectively, and individually?

1. Identify a lead group and/or person within the herpetological community to research and assemble data supporting conservation goals.
2. Communicate with groups to identify areas of agreement.
3. Identify key people within organizations to carry the "message" to respective group members.
4. Identify shared areas of interest among the environmental community - Conservation, - Preservation of habitat, Helping endangered species, etc.
5. Identify shared areas of interest among members of our local communities. We can support improvement of parks and zoos and planned development, to name a few issues.

Remember that the central issue is not one group vs. another group, or how we differ, but rather, the responsible promotion of shared goals. These shared goals should recognize the following principles:

1. There should be roles in the process for individuals of all backgrounds and similarly roles for different groups and organizations.
2. Interests which appear to be incompatible, may not necessarily be. Shared concerns can be identified. For example, many people who don't like snakes, like "animals". People who are afraid of snakes may want to preserve habitat for birds of prey without actually realizing that snakes also benefit.
3. It is possible for sound policies to come about if all parties to a problem are able to recognize what they have in common and are able to negotiate their differences.

Specifically, how can we as individuals, in our own communities, put these principles to use to foster cooperation among groups? We can:

1. Find out who our allies are in our individual communities - those who share our concern for preservation of habitat.
2. Initiate ad-hoc citizens committees to publicize concerns. In so doing we must always build from strength. Build on existing strength and the growth will occur as members of the core group expand their circle.

3. Write articles and encourage others to do so. Remember, because of the diversity of herpetology, we have the capacity to reach members of all professions and all age levels.
4. Talk to people - not in an adversarial way, but just in conversation. Always look for areas of agreement and emphasize those areas.
5. Recognize the difference between giving support and giving advice, as appropriate. Most folks know what needs to be done. They simply need active reassurance and encourgement.
6. Don't ever assume something won't work without at least thinking about it, or talking about it with others.
7. Don't overlook the obvious or assume something has already been done. An example is identifying our allies. It was surprising to find there is no single source of names and addresses of conservation groups in Idaho, in fact there is no single source in the Northwest. Finding those names and addresses may be our first step. We must proceed one step at a time in building coalitions. Remember to not move from point "A" to point "C" without first going to point "B".
8. Identify causes of problems and not symptoms. People's opposition to conservation programs is sometimes symptomatic of deeper fears. Our solution must address those deeper causes.
9. Link our groups together. Many herpetological societies have a conservation committee. Let's identify, through the newsletter exchange and other contacts, who those committee members are, and compile a conservation directory. Let's identify ourselves within our communities as resources for information on conservation and preservation of habitat. In so doing, we can assist other groups in achieving their goals, and further educate the public about amphibians and reptiles.
10. Above all, we must lead by our examples. The professionalism we display in caring for our animals, in the business of buying and selling, in the business of breeding, in the busines of education, is the foundation upon which we build our reputations, and in turn, increase compassion and understanding for our animals.

In taking these, and other actions, we must remember that all our efforts in caring for amphibians and reptiles and in preserving habitat, no matter how seemingly small, can have an impact. Many small efforts will eventually add up. Who knows what accomplishments those small efforts can bring about?

CONCLUSION

If the animals we love so much are to survive, we must do something. If the earth is to survive, we must do something. We all agree conservation and preservation of habitat are the greatest needs of the animals. We all agree we must fo something about it. We know others who agree with us. Our commitment to conservation can lead to a concensus which will bring about cooperation among diverse interests.

Herpetological organizations, composed of amateurs and professionals, representing a wide variety of occupations and interests, can cooperate to promote conservation programs for amphibians and reptiles and programs for preservation of habitat.

We can, with coordinated, cooperative initiatives, promote conservation and preservation of habitat, by identifying, and working with, lead individuals and groups. Those efforts in building a consensus can become a catalyst for cooperation with many diverse individuals and groups.

Most of us have used these techniques at various times. What we are talking about is really just common sense approaches to dealing with people and issues. In fact, you might even have been saying, "but we already know all of this. Why tell us something we already know?" While it is entirely possible we already know what to do, the fact is, we are not doing as much as we can to promote conservation and preserve habitat, and we are not realizing our leadership potential.

All of us, acting together, in our own communities, to preserve a local habitat, can be much more effective than each of us working seperately. All we need to do is use common sense to build consensus and bring about cooperation. It is not always an easy process, and, much of the time it is a slow process. And, it is a never-ending process. But, the result will be a brighter future for amphibians and reptiles. Indeed, the result will be a brighter future for our world.

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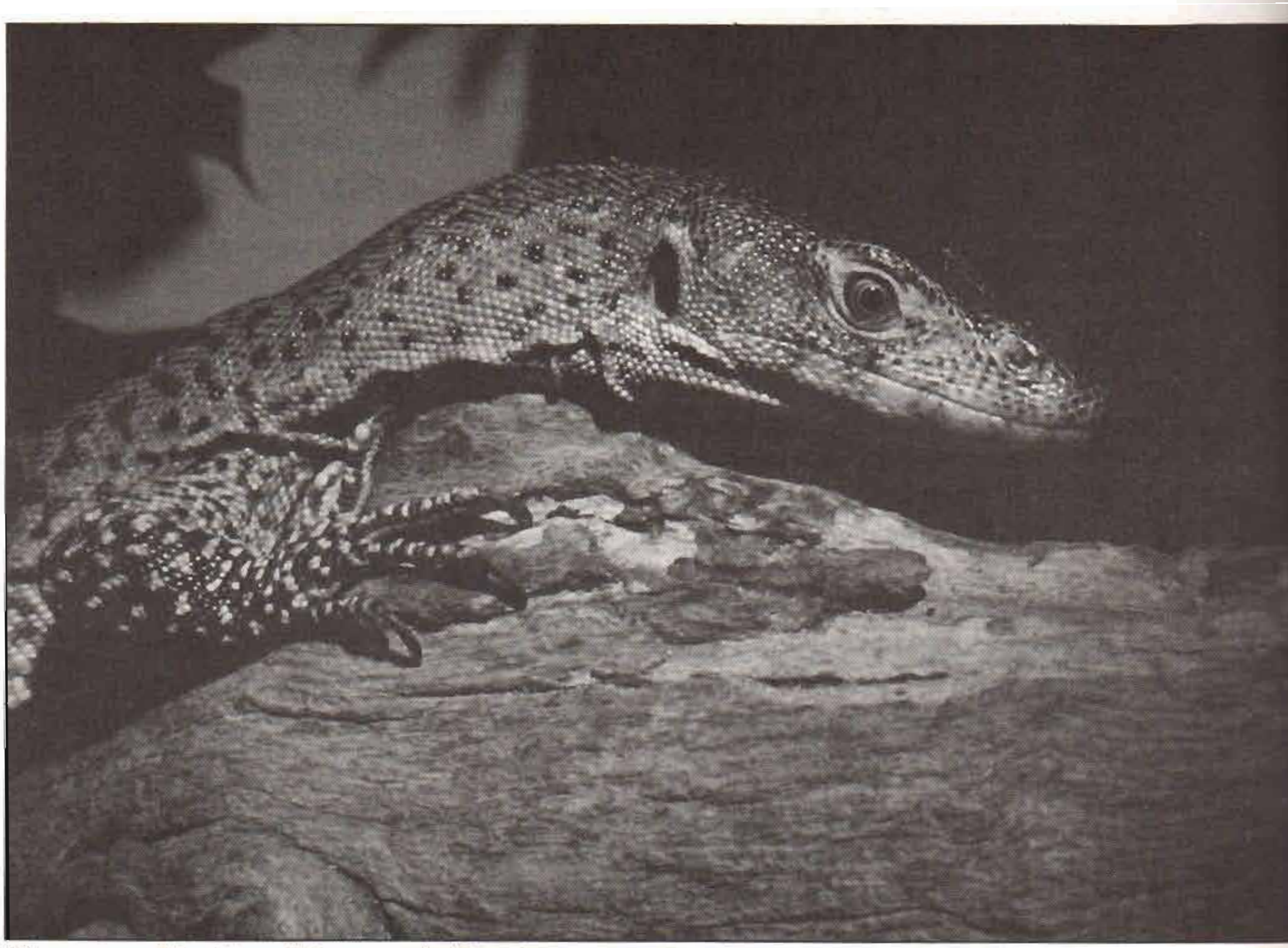

Mangrove Monitor (*Varanus indicus*)
Photo by Bill Love, Glades Herp, Inc.

REPTILES AND THE LAW IN AUSTRALIA: HOW PROTECTIVE WILDLIFE LEGISLATION CAN IMPEDE HERPETOLOGY

John Weigel

ABSTRACT

This paper evaluates the effects of Australia's highly restrictive conservation legislation on amateur and professional herpetology, the public exhibition of reptiles and the conservation of Australian herpetofauna. A survey of amateur and professional herpetologists underscored very divided assessments of the value of the legislative restrictions on amateur study. Although the amateurs were almost unanimously critical of the legislative constraints imposed upon their activities, about half of professional herpetologists surveyed supported these constraints and overwhelmingly expressed the view that their own herpetological activities are not significantly impeded by the legislation. Zoo keepers viewed the constraints placed on amateurs unfavourably and indicated that their own activities are also substantially impeded by the legislation.

Australian wildlife conservation efforts are largely focused on the legislative protection of individual vertebrate specimens and particular 'high profile' species. A network of state and federal wildlife protection legislation controls the activities of Australian herpetology. In less than 20 years all States and Territories have gone from having no protection for their herpetofauna to adopting blanket protection of all reptiles (and frogs in some States and Territories). Tasmania was the last State (1991) to draw up protective legislation for its reptiles. The legislation in all States and Territories generally allows the collection of most reptile species for bonafide scientific projects undertaken by professional herpetologists, but have more or less banned the collection of specimens by amateur herpetologists*. In New South Wales, Australia's most populous State, hobbyists in that State have been generally critical of the makeup of that list and the restriction to keeping only two specimens.

The trend to protect fauna on valid conservation grounds has been international, but in most other western countries, the collection of common reptile species for hobbyist purposes is generally tolerated, possibly because the keeping of reptiles in those countries was a fairly entrenched activity when legislative changes were contemplated. In Australia, where the hobby was neither well established nor organized when the legislative push of the early 1970's began, the establishment of a prohibition against the collection of reptiles was implemented virtually unopposed. Amateur aviculture, on the other hand was very well established and organized and is presently much more widely tolerated by the legislation, as is the maintenance of native fish.

In more recent years there has been an increasing adoption of 'animal rights' ideals by Australian legislators, and the collection of specimens from the wild for hobbyist purposes or zoological exhibition is now viewed in most States and Territories as 'exploitative' and prohibited on an 'animal welfare' basis as well as the original 'conservation' basis.

To varying extents, most of the States and Territories allow the keeping of certain reptiles by hobbyists where these are legally acquired from other captive sources. However, permits and licenses for such transactions are generally only reluctantly issued, and in some cases, only when it can be shown that the action or transaction fulfills some 'bona fide' scientific study as endorsed by a professional herpetologist. In order to restrict the distribution of specimens amongst hobbyists in some States it is illegal for the few licensed hobbyists to breed their captive reptiles. Several States and Territories ban the importation of legally acquired specimens across State boundaries though this may well contravene provisions of free trade outlined in the Australian Constitution. The authorities in all States and Territories appear to go to great lengths to police the restrictions placed upon amateur herpetologists. Hobbyists who maintain illegal collections of herpetofauna risk heavy-handed raids of their homes, complete with search warrants and confiscation orders - not unlike the operations of 'drug busts'. The last few years have seen an increase in the number of such raids and resulting criminal convictions.

In New South Wales, the Reptile Keepers Association (RKA) was formed in 1984 as a lobby group of over 200 hobbyists in an attempt to negotiate a loosening of legislative constraints imposed upon its membership. The author was a founding, office bearing member during the six years that the group existed. Correspondence and expensive legal submissions from the RKA directed to the New South Wales National Parks and Wildlife Service over that period, when stacked into a pile, stands over 20 cm high. After six years of largely unsuccessful dealings with this government body, and after many unsuccessful requests to meet with the Director of the Service, the RKA eventually slipped into quiescence in 1990.

Zoos are affected by the stringent legislation in that they are rarely able to obtain specimens from the wild and as a result only a very small number of native species are currently displayed in Australia. Zoos are also finding it more and more difficult to obtain non-indigenous species from overseas due to their 'pest potential' as perceived by government authorities, should the imported animals escape and colonize. At first the difficulties were experienced primarily by privately-funded institutions, but the effects of tighter legislative controls are creeping into government-owned zoos. The recently formed Australasian Regional Herpetofauna Management Team (RHMT), an Australasian equivalent to the highly successful international Captive Breeding Specialist Group includes both privately and publicly funded zoological parks and aquaria. The RHMT has expressed the view that the federal legislation presently imposes unreasonable restrictions on the ability of zoos to move animals, including those species which are not under threat. The Wildlife Protection Act of 1982 impairs the interaction of Australian zoos with overseas zoos, because few exportations from Australia are allowed, and due to the amount (and detail) of information required before a transaction can be undertaken. The movement of reptiles into and out of Australia is only very rarely permitted, and privately-funded facilities may not export live native specimens under any circumstances.

To cite an example of the degree of bureaucratic impediment to the activities of zoological facilities, consider the Australian Reptile Park (ARP), a privately-funded facility which displays reptiles and other fauna, and where the author is employed. The ARP also produces snake venoms for use in the production of Australian antivenoms by the Commonwealth Serum Laboratories and supplies researchers internationally. The activities of the ARP are subject to licensing provisions (and fees) imposed by the following bureaucratic bodies:

- New South Wales Zoological Parks Board - implements the Exhibited Animals Protection Act (1986), which controls most activities relating to the running of the ARP, including the manner in which reptiles are maintained. Permits are required prior to the commencement of any construction activities or the acquisition or disposal of specimens.

- New South Wales National Parks and Wildlife Service - Implements the National Parks and Wildlife Act (1974). Permits are required for all interstate transactions involving native reptiles and to take specimens from the wild in New South Wales.
- New South Wales Department of Agriculture - implements the Non-indigenous Animal Protection Act (1987). This government department duplicates the role of the Zoological Parks Board in that it further controls the acquisition, transfer and maintenance of non-indigenous reptiles and amphibians. It also assigns pest potential categories for non-natives, though this process is effectively duplicated by the Vertebrate Pests Committee.
- Vertebrate Pests Committee - a Commonwealth (Federal) body that overshadows the role of the New South Wales Department of Agriculture in that it coordinates the activities of all State and Territory vertebrate pest control bodies, making final decisions and policies regarding the importation and maintenance of non-indigenous reptiles.
- New South Wales Animal Welfare Branch (Department of Local Government) Animal Research Act (1985) - Under the Animal Research Act, the venom production activities of the Park are defined as research, and this activity, as well as the caging and husbandry circumstances for the venomous snakes must be overseen by an 'ethics committee'. An Animal Research License is required, as is an Experimental Animal Supply License to allow the disposal of the venom. This Act, as it applies to the ARP amounts to a duplication of the Exhibited Animals Protection Act.
- Australian National Parks and Wildlife Service - implements the Federal Wildlife Protection Act (1982). This body regulates the import and export of reptiles (including snake venoms) and amphibians. This body prohibits the export of any live native reptiles or amphibians (including captive-bred specimens) from privately-funded facilities such as the ARP. A permit must be obtained for each exportation of venom.
- Two government bodies (Australian Department of Customs; Australian Department of Primary Industry and Energy) oversee the importation of antivenoms for non-indigenous snakes, and a third (Department of Community Services and Health - the Federal body administering the Therapeutic Goods Act [1989]) controls the use of the antivenom. If a bite from one of the ARP's cobras or rattlesnakes occurs, a permit must be obtained by the physician handling the case before antivenom can be administered to that patient. This is an extremely dangerous requirement considering the urgency associated with snake-bite accidents, particularly in view of the fact that the Department of Community Services and Health does not have an office in New South Wales.
- The Royal Society for the Prevention of Cruelty to Animals (RSPCA) is a non-government animal welfare authority that, although funded primarily by public donations, its 20 inspectors police the New South Wales Prevention of Cruelty to Animals Act, primarily responding to complaints from members of the public.
- Local Shire Government - must approve any planned structural changes to the facility.

In addition to the requirement to obtain relevant permits for the various types of transactions, most of these government departments also require a written confirmation when the transactions are completed.

Those professional herpetological researchers who have criticized the Australian statutory approach to wildlife conservation (Tyler 1979; Rawlinson 1981; Ehmann and Cogger 1985) have claimed that while providing government bodies with a politically convenient and relatively inexpensive means of 'doing something' for the environment, this process has tended to divert public attention (and consequently government funding) from more important activities such as the identification and preservation of disappearing habitats, control of feral pests, fundamental research programs and public education. Criticisms of the prohibition approach against the taking of specimens for amateur study or hobbyist purposes were summarized by Ehmann & Cogger (1985): "We cannot conceive of any non-commercial harvesting activity which would cause concern for any more than a small minority of Australia's 850-plus species of frogs and reptiles". Peter Mirtschin (1991) assessed the value of the 'blanket ban' approach to conservation somewhat more rigorously with his assessment that "the second greatest threat to herpetofauna conservation in Australia is the very legislation supposedly established to address the greatest threat to herpetofauna conservation - habitat degradation".

It would seem fairly universally accepted (Tyler 1979; Rawlinson 1981; Buridge and Jenkins 1984; Ehmann and Cogger 1985) that the significant threats to Australian herpetofauna are:

1. physical degradation of habitats brought on directly or indirectly through the activities of man,
2. feral pests, and
3. commercial exploitation; the only Australian examples of this threat to date have been the uncontrolled crocodile skin trade between 1940-70, and the current legal harvesting of sea snakes.

Quite apart from man-induced causal agents, it is often overlooked that many wild populations of reptilian and non-reptilian vertebrates are subject to massive fluctuations in response to variable environmental factors, especially rainfall patterns. To a much lesser extent, road mortalities and the Australian tradition of killing snakes may contribute localized declines in particular species, but there is no biological evidence nor serious scientific opinion indicating that herpetological activities (professional or amateur) in Australia have led or could lead to declines in reptile or amphibian populations (except for a few highly threatened taxa). Neither is there evidence that the restrictions which have been imposed have led to an increase in herpetofauna populations. However, the evertightening wildlife regulations have certainly had the unfortunate effect of discouraging amateur herpetological activities, thereby alienating many of those who would otherwise have become strong supporters of genuine conservation measures. The legislative emphasis on protecting specimens rather than ecosystems has resulted in a negative effect on reptile conservation, not only because it has steered interest away from the subject, but because it has given the appearance of conservation action where none really exists (Ehmann and Cogger 1985).

For nearly 20 years, herpetofauna protection in Australia has used the law enforcement approach as a conservation priority despite condemnation from various quarters around the world. The First World Congress of Herpetology held in Kent in Cantebury, U.K. (Sept. 1989) established the "Committee on the Preservation of Reptiles and Amphibians through Captive Husbandry and Propagation" (CPRACHP) to promote the recognition of amateur herpetology worldwide. The draft objectives produced at the Congress were as follows:

1. To establish that the live animal trade, as used by pet keepers, zoo keepers, and professional herpetologists, is a negligible factor in population depletion;
2. To admit that most herpetologists got their interest and much of their training with 'pet' reptiles and amphibians;
3. To acknowledge that the subsequent contributions to herpetology by amateurs has been considerable. It includes entry into the profession by some, serious husbandry and breeding efforts by others, and serious conservation efforts by others.
4. To demonstrate that the current conservation laws are contrary to the needs of species preservation, in that they
    a. are written for ease of enforcement, which severely limits access to specimens by qualified students;
    b. provide protection to animals but not their habitats, which effectively renders them useless;
    c. makes serious amateurs and many professionals criminals in the eyes of the law, or near enough to criminal to elicit ill-will from many colleagues.
5. To move herpetological societies with large or predominantly professional memberships to acknowledge as matter of policy that:
    a. contributions made by amateurs are of importance;
    b. such serious amateur efforts should be encouraged by cooperation from professionals, and;
    c. laws restricting access to animals need serious revision that will allow greater access to live specimens by all interested persons.

There have been a few influential Australian herpetologists who have publicly recognized that the international problem outlined by the World Congress is present in Australia, but by and large there has been very little public expression of support for the amateurs. One of the more influential herpetologists to publicly acknowledge the problem in recent years was Allen Greer (1989) "Amateurs have contributed substantially to the development of Australian herpetology, as will be evident from references to their work in this book. Their importance derives primarily from their observation of live animals: captive specimens, a species seen during a field trip, or a local fauna. They publish with out the inhibitions of having to preserve a professional image, and if they fail to understand the full ramifications of what they have seen, at least they have put into the literature an observation that can be taken up and developed by someone else.... Unfortunately the role of amateurs in Australian herpetology is now under threat from certain State authorities. Rules and regulations make it increasingly difficult to collect, keep, or even disturb in order to observe or photograph native fauna. For many amateurs who are often either too young to fight or have no affiliation with another, protective bureaucracy like a museum or university, this means giving up or going "underground". As a result, much opportunity for knowledge and personal development through investigation, discovery and discussion is lost."

In order to test the views of amateurs and professionals alike as to the impact of the proliferation of Australian wildlife protection legislation upon the herpetological activities of hobbyists, zoological exhibitors and professional herpetologists, a survey was undertaken. A questionnaire was devised with the assistance of the Australian Herpetological Society - a predominantly amateur group of approximately 200 members, with a view to collect the considered views of the herpetological community.

Copies of the questionnaire were distributed through the newsletters of several amateur herpetological associations. Others were mailed to members of the Australian Society of Herpetologists - an association comprised primarily of professional herpetologists. Copies were also mailed to all Australian museums employing herpetologists, and to most Australian zoological facilities holding substantial reptile or amphibian collections. All recipients of the questionnaire were invited to make copies of the form and distribute them to other herpetologists. (See Table 2).

Participants in the survey were asked to provide their name and describe their level of involvement/interest in herpetology (professional herpetological researcher; university graduate student; employed as reptile keeper at a zoo, reptile park, etc; or amateur herpetologist and/or hobbyist reptile keeper). They were then provided with a list of six questions - though participants identifying themselves as professional researchers, graduate students or zoo keepers were asked to skip question number 1 and those identifying themselves as amateur herpetologists and/or hobbyist reptile keepers were asked to answer all questions except questions number 2 and 3. Following are the questions asked in the survey:

1. Do you presently maintain reptiles in a hobbyist capacity? (yes or no). If not, why not? a. disinterested in doing so; b. the difficulty/impossibility of obtaining approval from relevant statutory authority to hold or obtain (by collection from wild or from other keepers) the species of reptiles which would be of interest; c. other - please explain.
2. Did you maintain reptiles at any time before pursuing your career in herpetology or zoo keeping?
3. Would you say that the collecting and/or keeping of reptiles by ourself or someone you knew acted as a catalyst leading to your present interest and involvement in herpetology or zoo keeping?
4. Insofar as it controls the activities of amateur herpetologists, do you think that fauna protection legislation and its associated regulations and policies in your state or territory is: a. not restrictive enough tot adequately conserve native reptile populations; b. fairly balanced and justified - playing a positive role in the conservation off native reptile populations; c. too restrictive - having a limited role to play in the conservation of native reptile populations and therefore unfairly curtailing the activities of amateur herpetologists; or d. other - please explain.
5. Do you feel that existing state and or federal fauna protection laws are discouraging the cultivation of the professional herpetologists of tomorrow?
6. Which of the following best describes the overall effect that state and/or federal fauna protection laws/regulations/policies have upon your herpetological activities? a. they substantially restrict or impede your herpetological activities; b. they are at worst somewhat annoying, but do not restrict your herpetological activities to any significant degree; c. they make your herpetological activities easier to achieve; d. other - please explain.

DISCUSSION

Of the 85 survey participants, 35 described themselves as professional researchers (17 being employed by universities or the CSIRO, 9 being employed by museums, 6 being employed by wildlife protection agencies, and 3 who did not specify where they worked). Of the remaining participants in the survey, 7 described themselves as university graduate students, 13 as zoo keepers, and 30 as amateur herpetologists and/or hobbyist reptile keepers.

The findings of the survey demonstrate that although the professional herpetologists and graduate students were largely (81%) of the view that their own activities were not impeded to any significant extent by the legislation, they were fairly evenly divided on the issue of present restrictions on the activities of amateurs (45% approving, or indicating a need for tighter constraints; 40% not approving of current constraints). The 6 participating professional herpetologists employed by wildlife protection agencies were highly supportive of the present restrictions upon amateurs (5 in support of status quo vs 1 not in support), and in the absence of these data a slightly more sympathetic view is expressed by the professional herpetologists, with 34% supporting the need for current (or tighter - one participant) restrictions upon the activities of amateurs, 48% not approving of the current restraints, and 18% registering their tick marks in the 'other' category.

The majority of amateurs (80%) indicated that their activities were substantially restricted by the legislation. The zoo keepers also indicated the opinion that their activities, as well as those of the amateurs were adversely restricted by the legislation.

The majority of the professional herpetologists (71%) indicated that they maintained reptiles at a hobbyist level before pursuing their careers and (66%) claimed that hobbyist reptile keeping led to a herpetological career decision. Interestingly however, only 43% of the professional herpetologists expressed the view that the legal constraints presently imposed upon amateur activities are discouraging the cultivation of the professional herpetologists of tomorrow, although of the 6 professionals employed by wildlife protection authorities (who unanimously indicated 'no' to this question) are removed from the data, 52% of the remaining professionals answered 'yes', 41% indicated 'no', and 7% abstained.

Although the promise of confidentiality prevents a close analysis, it is interesting to note that there was a strong tendency in the survey for the more widely known and published herpetologists to share the view of the amateurs - that present legislative controls relating to amateur activities are too strict and without conservation justification and that they are discouraging the cultivation of the professional herpetologists of tomorrow.

Most of the results of the survey were fairly predictable, though the views of approximately half of the professional herpetologists and graduate students that the legislation as it pertains to the amateur herpetologists is 'fairly balanced and justified - playing a positive role in the conservation of native reptile populations' may come as a surprise to many amateurs and professionals alike. A number of different factors may contribute to the unsympathetic view held by many professionals concerning the problems that amateurs claim to be confronted with, these factors possibly including:

1. To date there has been very little dialogue between the amateur and professional herpetological communities. Perhaps some professionals are unaware of the stringency of the legislative restrictions presently imposed upon amateurs.
2. Possibly the fact that the most professional herpetologists in Australia are entirely funded by the State or Federal government has led to a tendency not to be critical of 'the hand that feeds'.
3. An underlying distrust of amateurs may exist due to the perception that illegal activities relating to the collecting and keeping of reptiles are prevalent among amateurs. For some professionals, negative attitudes to amateurs were reinforced by the controversial taxonomic reclassification undertaken by two

amateur herpetologists in the mid-1980's.

4. Perhaps after nearly 20 years of suppressed activities faced by amateur herpetology, some of the younger professionals have little interest in amateur herpetology simply because they were legally circumvented from that stage of career development. This would not necessarily be a healthy thing for the profession, considering that most of the truly prolific contributors to Australian herpetology (and indeed, 71% of those sampled in the present study) have had careers which could be dated back to an early hobbyist-level interest in herpetofauna - activities that are now largely illegal. Due to the prohibition against the collecting of reptiles in most States and Territories, responsible parents have learned to discourage their children from early interest in the subject.

5. Perhaps some professionals simply do not recognize the existence of a link between public education and conservation in the same sense as Rick Shine (1991), who argued that "for every pet diamond python in a Canberra living room, there will be literally hundreds of friends, schoolmates, relatives and general acquaintances whose attitudes to snakes will be changed for the better." Alternatively, perhaps there is a view that the removal of specimens for hobbyist purposes, while educationally valuable, does not sufficiently compensate for the potential of over collecting from the wild; or perhaps a concern is held that unsatisfactory conditions of husbandry may adversely effect the welfare of captive reptiles.

6. Perhaps the reason that many professionals surveyed failed to support the amateur cause is simply that they are too focused on their own short term aims to see the big picture. This would be to ignore the current legislative trend, which is to forbid the taking of specimens. Although their work may not be outwardly hindered by the growing conservation/animal rights blend of wildlife management philosophy as yet, the future could see increased onus placed onto scientists to prove, possibly to an ethics committee comprised of laymen, tangible and possibly short-term ecological justification for their activities when these require the taking of specimens. This is not inconceivable - the government-owned zoos were very non-committal when constraints related to animal welfare began to creep into the governmental control of privately funded zoos, but it now appears that they too are becoming affected by the restrictions in ways that they see are unjustifiable from a conservation viewpoint.

CONCLUSION

Fauna protection laws and regulations are undoubtedly necessary, but as implemented at present are often irrational and needlessly restrictive. The laws and policies of the various States and Territories direct surprisingly little attention towards the preservation of habitats, population monitoring, research activities or public education. They presently impede the activities of amateurs and provide professional herpetological researchers with a lot of paperwork, but appear to do nothing much to ensure reptile conservation. The Australian public would no doubt expect that herpetologists who draw their salaries from public funds are obliged to play an active role in influencing the formation of the conservation priorities and directives of statutory authorities where these relate to native herpetofauna. However, to date there has been little visible effort from researchers to steer wildlife bodies away from their current preoccupation with law-enforcement-oriented goals and onto proper conservation missions. One very important exception is the recently launched National Action Plan for reptile conservation being undertaken by Dr. H. G. Cogger of the Australian Museum on behalf of the Australian National Parks and Wildlife Service. Dr. Cogger has widely invited public submissions relating to the nomination of reptile species requiring conservation action. This project will be Australia's first ever conservation action plan relating to endangered reptiles and amphibians.

Without support, the amateur herpetologists appear to be ineffective in their negotiations with relevant statutory authorities. The cause of the amateurs is a justifiable one and worthy of the support of herpetological profession for the following reasons:

1. If the conservation of reptiles and amphibians is desired, then our knowledge of them must be improved. Public appreciation should be fostered for these little known and in some cases, much maligned animals. Increased public awareness and appreciation of the ecological role of reptiles and amphibians is fostered by simple contact with them.
2. Ironically, from an animal welfare point of view, governmental regulations designed to protect the welfare of reptiles and amphibians have forced many hobbyists to pursue their interests 'underground' and have discouraged rather than encouraged responsible private keeping.
3. One of the more unfortunate consequences arising from the limitation of amateur activities is that the traditional pathway leading from hobbyist reptile keeper to keen amateur researcher to a professional career in herpetology is lost. The earliest herpetological activities of many world renowned researchers such as Harold Cogger and Richard Shine would, if conducted today, be regarded as illegal. The responsible action of parents today is to not allow their children to pursue their natural interests in herpetology.
4. Australia is a large country with a large, relatively poorly understood herpetofauna. Amateurs have in the past been able to contribute to a better knowledge of reptile and amphibian distributions, reproductive patterns, dietary requirements, etc. Through their publications in reptile club newsletters and popular science journals they have until recently been able to contribute substantial worthwhile scientific information. Unfortunately, these publications (including Herpetofauna), have indicated an in creasing shortage of articles submitted from amateurs while at the same time, in other western countries there have been an explosion of publications by amateurs.
5. Because the activities of professional herpetologists in Australia are almost entirely funded by the government, their activities have always been financially constrained. The amateur herpetologists require no government funding, dedicating their own resources - both financial and time to their study.
6. Whether or not reptiles and amphibians have statutory protection has no bearing on their true conservation status. By focusing on a law enforcement style of conservation program, the very limited funds available for conservation of herpetofauna are largely squandered on the costs of upholding the policy.

It may be that the professional herpetological community is the appropriate group, and the Australian Society of Herpetologists the appropriate forum, to approach relevant government bodies with a view of discussing the cause of the amateur herpetologist not only because it is a fair and just one, but because the future of professional herpetology may be more directly linked with that of the amateurs than is widely recognized.

In view of the perception of statutory wildlife protection authorities that insufficient conservation/education benefits arise from the activities of amateur herpetologists to justify the taking of reptiles from the wild, professional researchers would do well to wonder how much longer they will be able to rely on the potency of the *'professional scientific investigation = conservation'* argument to justify their activities where these require the collection and captive maintenance of specimens.

It would be a logical first step to addressing the problems perceived by the amateur herpetologists and by a substantial proportion of the professionals surveyed if communication between the two groups could be undertaken. Once such a dialogue is established, it may prove that in at least some cases, the research projects *undertaken by professional herpetologists and statutory wildlife protection bodies (ie: the National Action Plan) could benefit by the involvement (and subsequent nurturing* of skills) of amateurs into particular worthwhile directions. This, for some hobbyists, might eventually lead to a contributing role in the maintenance and breeding of captive populations of threatened species.

Table 1. Bureaucratic bodies imposing licensing provisions (and fees) upon the activities of the Australian Reptile Park.

New South Wales Zoological Parks Board	Implements the Exhibited Animals Protection Act (1986)
New South Wales National Parks and Wildlife Service	Implements the National Parks and Wildlife Act (1974)
New South Wales Department of Agriculture	Implements the Non-indigenous Animal Protection Act (1987).
Vertebrate Pests Committee	a Commonwealth (Federal) body.
New South Wales Animal Welfare Branch	(Department of Local Government) Animal Research Act (1985).
Australian National Parks and Wildlife Service	Implements the federal Wildlife Protection Act (1982).
Australian Department of Customs	Oversees the importation of antivenoms of non-indigenous snakes.
Australian Department of Primary Industry and Energy	Oversees the importation of antivenoms for non-indigenous *snakes.*
Department of Community Services and Health	The Federal body administering the Therapeutic Goods Act (1989).
The Royal Society for the Prevention of Cruelty to Animals (RSPCA)	
Local Shire Government	

Table 2. Results of Questionnaire

1. Did you maintain reptiles at any time before pursuing your career in herpetology or zoo keeping?

	Yes	No
Professional Researchers	25 (71%)	10 (29%)
Graduate Students	7 (100%)	0 (0%)
Professional Reptile Keepers	12% (92%)	1 (8%)

2. Would you say that the collecting and/or keeping of reptiles by yourself or someone you knew acted as a catalyst leading to your present interest and involvement in herpetology or zoo keeping?

	Yes	No
Professional Researchers	23 (66%)	12 (34%)
Graduates Students	7 (100%)	0 (0%)
Professional Reptile Keepers	12 (92%)	1 (8%)

3. Insofar as it controls the activities of amateur herpetologists, do you think that fauna protection legislation and its associated regulations and policies in your state or territory is:

a. not restrictive enough to adequately conserve native reptile populations.

b. fairly balanced and justified - playing a positive role in the conservation of native reptile populations.

c. too restrictive - having a limited role to play in the conservation of native reptile populations and therefore unfairly curtailing the activities of amateur herpetologists

d. other - please explain.

	N	a.	b.	c.	d.
Professional Researchers	35	1 (3%)	14 (40%)	15 (43%)	5 (14%)
Graduate Students	7	1 (14%)	3 (43%)	2 (29%)	1 (14%)
Professional Reptile Keepers	13	0 (0%)	2 (15%)	11 (85%)	0 (0%)
Amateur Herpetologists	30	0 (0%)	3 (10%)	22 (73%)	5 (17%)

4. Do you feel that existing state and federal fauna protection laws are discouraging the cultivation of the professional herpetologists of tomorrow?

	Yes	No
Professional Researchers	15 (43%)	18 (51%)
Graduate Students	2 (29%)	5 (71%)

	Yes	No
Professional Reptile Keepers	11 (85%)	2 (15%)
Amateur Herpetologists	26 (87%)	4 (13%)

5. Which of the following best describes the overall effect that state and/or federal fauna protection laws/regulations/policies have upon your herpetological activities?

a. they substantially restrict or impede your herpetological activities.

b. they are at worst somewhat annoying, but do not restrict your herpetological activities to any significant degree.

c. they make your herpetological activities easier to achieve.

d. other - please explain.

	a.	b.	c.	d.
Professional Researchers	5 (14%)	28 (80%)	0 (0%)	2 (6%)
Graduate Students	1 (14%)	6 (86%)	0 (0%)	0 (0%)
Professional Reptile Keepers	9 (69%)	3 (23%)	0 (0%)	1 (8%)
Amateur Herpetologists	24 (80%)	4 (13%)	0 (0%)	2 (6%)

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CAPTIVE TREATMENT OF A JOHNSTONE'S CROCODILE *CROCODYLUS JOHNSTONI*, UNDER TREATMENT FOR BILATERAL MANDIBULAR FRACTURES

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INTRODUCTION

In 1979, a geographically isolated population of Johnstone's Crocodile *Crocodylus johnstoni*, often referred to as the 'Stone Country Form', was discovered inhabiting the upper reaches of the Liverpool River, upstream of Cuthbertson Falls, Arnhem Land, Australia (Webb, 1979). The populations of *C. johnstoni* Crocodile occurring in this uninhabited region of the Northern Territory are probably as close to pristine as those anywhere in Australia. The major finding of the survey expedition that found the isolated population was that these crocodiles were stunted and much smaller in size at maturity than *C. johnstoni* found downstream from the falls and in other areas of the species' range (Webb, 1979).

A group of two male and two female crocodiles were caught upstream of Cuthbertson Falls in July, 1979, during the survey expedition and were donated to Melbourne Zoo a year later (July, 1980). They were housed together in an exhibit featuring a heated pool (6m long x 3m wide x 0.5m deep), a land area (4 x 3m), and landscaped with large tropical plants to reflect the crocodiles' tropical riverine habitat in the Northern Territory.

In late May, 1990, the subordinate male, #3 (SVL. 67cm, TL. 127cm), was incidentally found to have bilateral mandibular fractures during the capture and tail tagging of the group. It is presumed that its injuries were sustained at an earlier date during fights with the dominant male, #1 (SVL. 77cm, TL. 144cm), as territorial breeding behaviour is observed at this time each year. The fractures were estimated to be less than seven days old.

FRACTURE MANAGEMENT

The injured crocodile was removed from its display enclosure and transported to our veterinary facilities for immediate surgery.

Anaesthesia was induced with 5% isoflurane delivered by a home-made elongated plastic face mask. Induction was prolonged (15-20 minutes) due to frequent breath-holding. When the pinch withdrawal reflex had been eliminated, the crocodile was intubated with a 4.5mm cuffed endotracheal tube. Anaesthesia was maintained with 1-2%isoflurane delivered by intermittent positive pressure ventilation (IPPV) mimicking the crocodile's observed respiratory pattern (four full inflations in immediate succession every two minutes). Optimal ambient temperature was maintained during anaesthesia using a thermostatically-controlled heat pad under the crocodile and a forced air heater in the room.

Examination of the animal, following aseptic preparation of the injury sites, revealed an open, contaminated, transverse and moderately displaced fracture of midshaft left mandible; and an open, oblique, comminuted and mildly displaced fracture of the right mandible, just posterior to the mandibular symphysis. There were skin lacerations and soft tissue damage at both fracture sites.

Both fracture sites were thoroughly cleansed and debrided back to healthy bone and soft tissue, and irrigated with aqueous antibiotics (gentamicin and ampicillin). The left mandibular fracture was reduced and stabilized using an external fixateur apparatus (Kirschner splint) with two stainless steel pins on each side of the fracture site. The right mandibular fracture was fixed using a stainless steel lagscrew and interdental wiring (see Fig. 1A). This achieved only moderate stabilization.

Intra-operatively, the crocodile was commenced on a parenteral course of gentamicin in an attempt to prevent the soft tissue contamination progressing to osteomyelitis. It was also given the corticosteroid dexamethasone, 10% dextrose and multi-vitamins subcutaneously in an attempt to prevent the occurrence of post capture shock which has been reported in crocodiles (Cermak, 1988). On this occasion, all drugs were given subcutaneously as intramuscular injections have been reported to cause fatal hypoglycemic shock in crocodiles. During the subsequent 10 months of treatment, however, we changed to intramuscular administration of antibiotics in an attempt to improve drug uptake, and no adverse effects were observed.

The post surgical management of the crocodile was aimed principally at prevention of the development of osteomyelitis at the fracture an pin insertion sites. It was perceived from the outset that this would be a difficult task given the animal's aquatic needs. Submersion in water would permit contamination of the wounds with micro organisms from the environment and from the animal's skin and gastro-intestinal tract, but it was believed that regular immersions were necessary to enable the crocodile to eat and drink and hence meet hydration and energy requirements. A management plan was devised to strike a balance between the needs of the crocodile and the needs of the fractures, using the concept of the "Golden Period" of wound contamination. In mammals, it is known that there is a period of 6-8 hours before bacterial contaminants of a wound begin to invade and establish as infection. This is known as the "Golden Period". The crocodile's management plan involved being kept in a dry, disinfected fiberglass tank. Every 72 hours, the tank was filled with warm water and the crocodile allowed to submerge, and on most occasions feed. After two to three hours, within the "Golden Period", the tank was drained and the crocodile captured for treatment. The fractures and pin insertion sites were all thoroughly cleansed using a dilute povidone iodine solution in sterile saline delivered under pressure through a fine flushing needle, and then irrigated with aqueous gentamicin. Gentamicin was also given parenterally. The aim of the local wound treatment was to eliminate contaminants acquired from the water before they established as an infection. The crocodile was then returned to the dry tank.

Two weeks after the initial surgery, the crocodile was anaesthetized again as stabilization of the right mandibular fracture was inadequate. The lagscrew and wire were replaced with a Kirschner splint with two pins either side of the fracture site (see Fig. 1B).

Six weeks later it became evident that, despite all efforts, osteomyelitis had occurred at both fracture sites. The original Kirschner splints were removed, the infected bone ends debrided back to healthy tissue, and new Kirschner splints applied to both mandibles. The most anterior and posterior pins of the splints passed through both mandibles (see Fig. 1C) effecting much better stabilization of the fracture sites than was the case with the previous arrangement.

Post-surgically the crocodile was managed as previously described for local wound treatment and parenteral antibiotic administration. It was anaesthetized every 3-6 weeks in order to assess progress, debride infected bone and collect material for bacterial culture and antibiotic sensitivity testing. Over the ensuing seven months of treatment, a range of antibiotics were used, as indicated by culture and sensitivity results. *These included amikacin, ceftazidime, piperacillin and chloramphenicol, each* given at prescribed reptilian dose rates every 48 or 72 hours.

Sixteen weeks after the new Kirschner splint had been applied, extensive bone loss at all pin insertion sites necessitated its removal. Osteomyelitis was still present at the fracture sites and all pin insertion sites. The prognosis of the jaws at this stage looked very poor as the bones had become weakened by the multiple sites of bone infection and destruction. Nevertheless, as the crocodile appeared to be handling this intensive, prolonged treatment regime very well, it was decided to persist with attempts to repair the fractures. The mandibles were tied to the upper jaw using strips of soft cloth, to achieve non-invasive fracture immobilization. Treatment of the osteomyelitis continued for 16 weeks as previously described and by March, 1991, 40 weeks after discovery of the fractures, the infections had completely resolved. The unhealed fractures at this stage were classed as "non-unions", a result of the prolonged infection. The fracture sites, however, were quite stable as the gaps were bridged with fibrous tissue. The pin insertion sites had also filled with fibrous tissue. From this point, therefore, the crocodile has been maintained in the same enclosure with constant contact to water and without jaw bandages. It is being fed to allow it to regain body condition before a new attempt is made at fixation of the unhealed fractures.

HOUSING

Johnstone's crocodile is a shy, nervous species. Because of the need for frequent handling for treatment, it was vital to house the crocodile optimally in a small, heated and easily serviceable, covered fibreglass tank (floor dimensions: 1700 (L) x 1000 (W) 500mm (H). In addition, it was essential to develop passive capture and restraint techniques to ensure that the crocodile was not unduly stressed, and did not continually destablize the healing fractures or sustain additional injuries. The normally applied 'snout noosing' or 'snatch and grab' techniques for capturing small crocodiles could not be considered due to the severity of the animal's lesions. A method of stealthfully covering the animal's eyes to prevent it seeing its captors approaching was obviously required. After careful deliberation of the crocodile's normal behaviours, potential reaction responses and the physical aspects and parameters of its enclosure, a capture and restrain technique was developed and implemented.

A timber frame construction covering the fibreglass tank was equipped at either end with a hinged service door (1200 x 870mm). Ventilation panels (750 x 380mm) in each door provided adequate air flow and the opportunity to provide an artificial ultraviolet light source (Blacklight, BL type) and radiant heat source. A cotton sheet (1700 x 1000mm) was attached at its corners by flexible electrical wire cables. Two short cable lengths (600mm) were permanently secured to the near side corners of the enclosure's timber frame, ensuring that the sheet could be retrieved after treatments. Two long cables (2500mm) travelled under the service doors from end to end, enabling the sheet to be tautly and slowly drawn under the raised doors (50mm) for the full length of the enclosure (see Fig.2). The cloth curtain was then dropped over the crocodile, which was submerged in the water of the half-filled tank. The typical natural response of a crocodile hauled out on land, when threatened with danger, is to take to the water, and if already in water, it will sink to the bottom. This known behaviour was used to our advantage in passively capturing and handling the injured crocodile. The tank would then be drained of water and the floating curtain would neatly envelope the crocodile, defining its outline. The covered, unaware animal was then gently restrained by two keepers and, after removing the curtain, it was presented for treatment with only a small cloth covering its eyes. Following each treatment, with the exception of refilling the tank, the process was reversed as follows (i) covering the crocodile with the curtain; (ii) closing the service doors; and (iii) vertically raising the curtain off the crocodile and slowly withdrawing it out of the tank. The crocodile accepted the procedure well, which minimized the risk of further injury to its jaws.

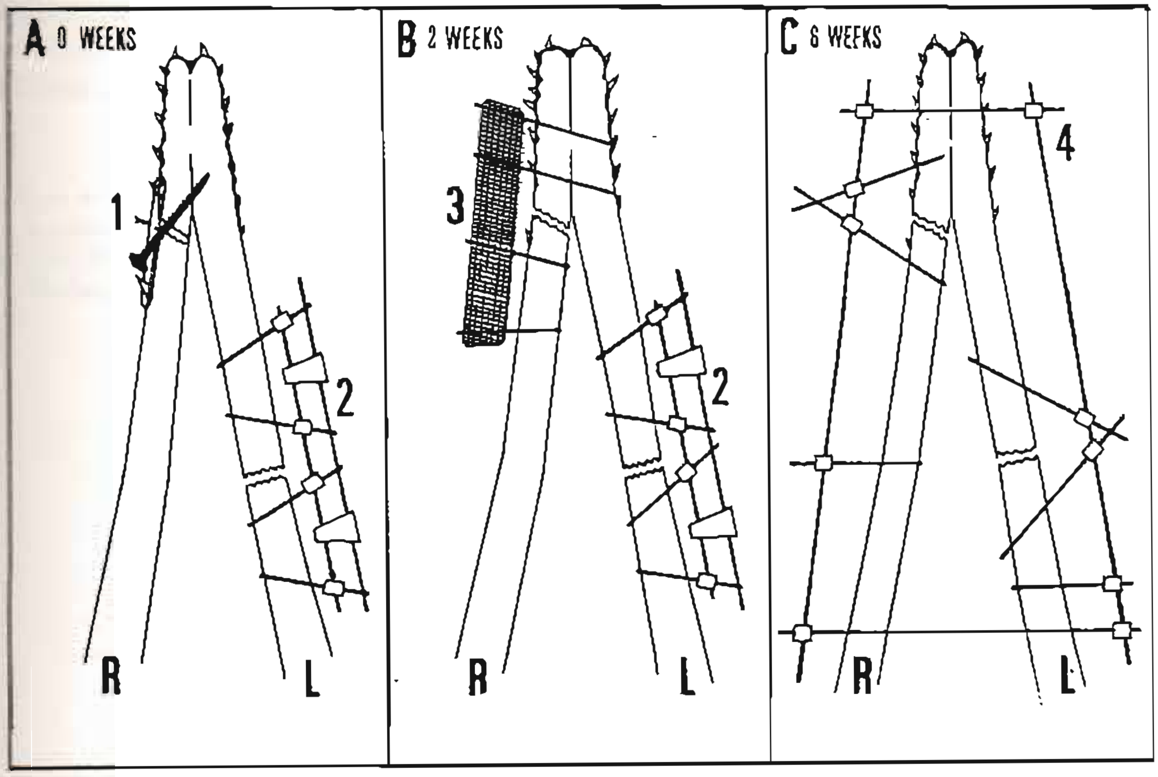
DISCUSSION

The lack of success to date in the management of this crocodile's injuries was due to the inadequate initial stabilization of the fractures and the osteomyelitis which occurred. There is always a high probability of osteomyelitis occurring in open, contaminated bite wound fractures. The chances were further increased in this case by the apparent delay between the occurrence and recognition of the fractures, and the necessity for frequent immersion of the animal in water. The attempts at prevention of osteomyelitis described in this report were obviously unsuccessful. This was presumably because complete decontamination of the fracture and pin insertion sites was not possible using the local flushing technique.

A bone graft and plating procedure is planned for the near future, as aa further attempt to effect fracture stabilization and repair. Hydration techniques, methods for lesion cleansing, and antibiotic therapy will receive cautious review before we enter this next phase of treatment.

The passive capture and restraint techniques developed for this crocodile were very successful. The animal displayed no signs of post capture shock following the more than 70 restraint and handling procedures endured during its treatment. We therefore feel confident that it will adequately handle the final phase of treatment.

Figure 1. Fixation Devices Used on Mandibular Fractures.



LEGEND

R	right
L	left
1	lag screw and interdental wiring on R mandible
2	original Kirschner splint on L mandible
3	original Kirschner splint on R mandible (bars fixed in position using Hexcelite bandage)
4	final Kirschner splint fixing both mandibles

Figure 2A. Cross Section of Johnstone's Crocodile Enclosure.

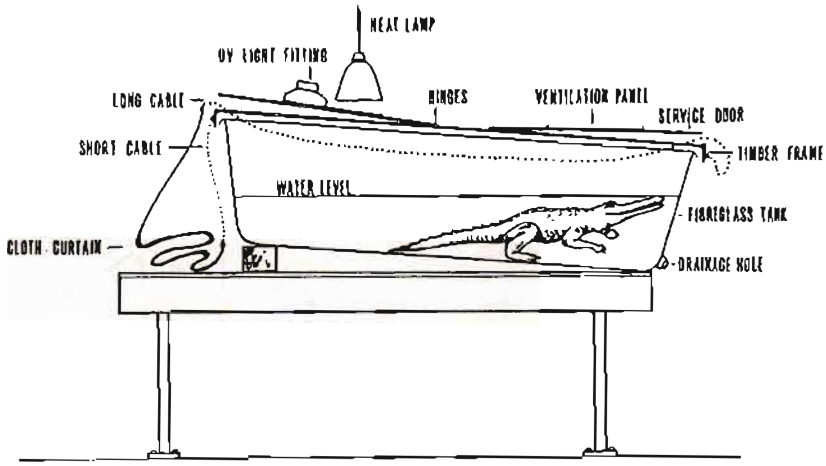
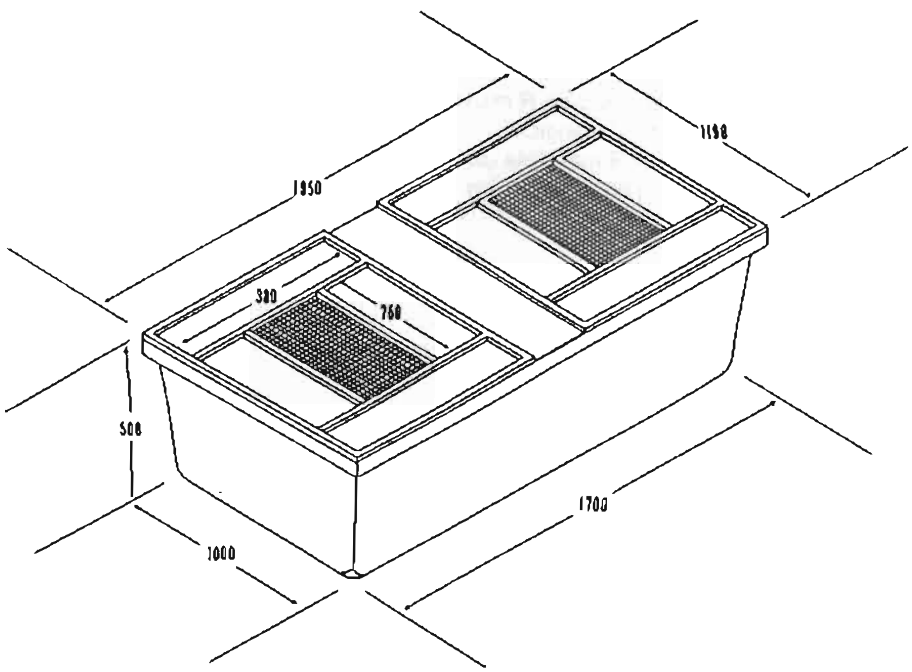


Figure 2B. Top View of Crocodile Enclosure



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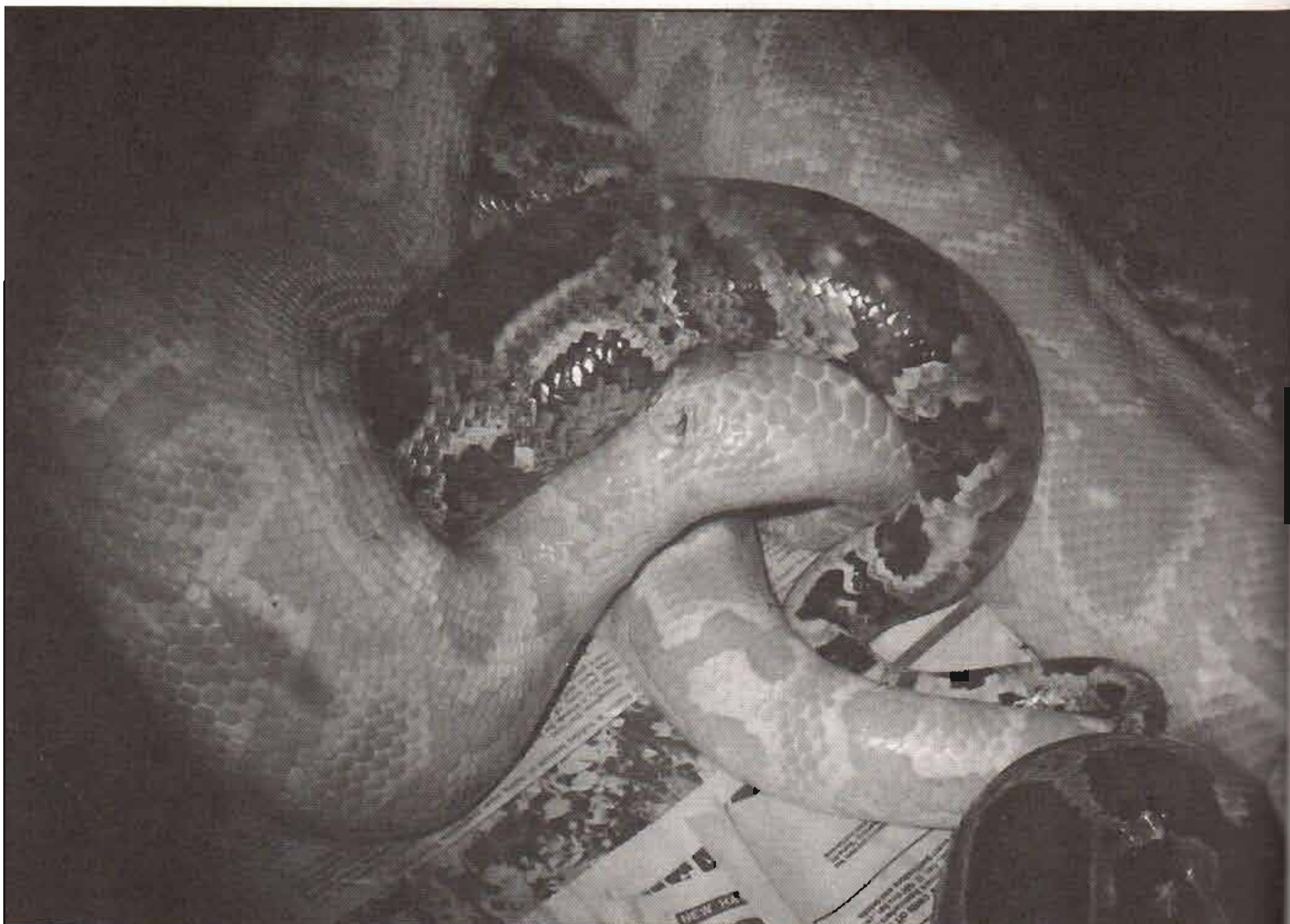

Burmese Pythons Mating (Albino x Heterozygous)
Photo by Dr. Michael J. Uricheck

EXCITATION AND INHIBITION OF REPRODUCTIVE EVENTS IN CAPTIVE REPTILES

David Chiszar[1], James B. Murphy[2], Hobart M. Smith[3]

INTRODUCTION

There appears to be a strong tendency on the part of researchers and reptile breeders to interpret successful propagation efforts as implying the presence of necessary excitatory stimuli. Indeed, the words "stimulus" and "excitation" are frequently used interchangeably. While we certainly do not deny the existence or the importance of excitatory stimulation, we want to point out that some (perhaps many) stimuli act by removing inhibition rather than by generating excitation. We shall return to this distinction shortly. For the moment, consider the following brief passage (from Huff, 1980) to understand what we call the "excitatory interpretation of stimulus effects."

> "Most important of all, the species to be bred must be given proper stimulus. The determination of proper stimulus for a given species is the key to successful propagation. Stimulus in the wild is environmental and, while it may not be necessary (or feasible) to duplicate the natural environment in captivity, it is necessary to duplicate the natural mating stimulus or create an artificial stimulus acceptable to the snakes. As mentioned in other papers (Huff, 1979a, 1979b), the stimulus may be temperature fluctuation, introduction of one snake to another, a shortening or lengthening of the diurnal cycle, a rise in humidity, increased rainfall, manual probing, or some other physical or environmental change." (Huff, 1980, p. 182)

We selected this passage because it is impeccably worded. Notice that Dr. Huff speaks of the "proper stimulus" and that he carefully refrains from interpreting the effect of the proper stimulus as being excitatory or as removing inhibition. On the other hand, the passage could easily lend itself to an "excitatory interpretation". We suspect that many readers will assume that the proper stimulus always generates excitation or arousal by somehow imparting energy or by promoting gonadal development. This appears to be the underlying assumption when the words "stimulus" and "excitation" are used interchangeably. But, consider the effect of modest amounts of alcohol on human sexuality and related behaviors (Abrams & Wilson, 1983; Hull & Bond, 1986; Mosher & Anderson, 1986; Steele et al., 1985; Steele & Southwick, 1985). The effect appears to be one of disinhibition rather than one of excitation. None of the energy or intensity that may eventually be manifested comes out of the bottle, so to speak, but is permitted to flow from internal sources by the removal of blocking processes. Although we do not advocate the procedure of plying reptiles with alcohol, it may be worthwhile to consider whether some procedures in common use might be successful for analogous reasons. More important, it may be worthwhile to analyze captive environments and potential new interventions from this point of view.

Dr. Huff's excellent paper provides an example. He introduced the term "captive stagnancy":

> ..."This condition is characterized by the snake becoming so accustomed to routine that it becomes lazy, lethargic, and generally inactive. Snakes which exhibit this condition will seldom breed, and a change in captive conditions

should be effected in order to create a recrudescence in the animal. Changes in general routine of husbandry, feeding schedule, type or quantity of food offered, and other interruptions or alterations in the maintenance of he reptile will often eliminate captive stagnancy." (Huff, 1980).

The late Joe Laszlo (personal communication) took much the same view by recommending that we must arrange captive conditions which force snakes to move about, to change positions, and to alter the lethargic habits acquired in cages. Joe was thinking about the exercise value of locomotion, but we can recognize that exercise and disinhibition are probably two sides of the same coin. There is an enormous literature dealing with "learned laziness" and "learned helplessness" (Maier & Seligman, 1976; Maier, 1989; Engberg et al., 1972), and there is little doubt that standard conditions of captivity can give rise to these phenomena. The result is essentially what Huff called captive stagnation. In essence, animals come to inhibit foraging, exploration, and other types of behaviors which normally cope with environmental events. Such animals also experience profound physiological and immunological alterations. These sequelae can interfere with numerous behaviors, including reproduction (Steven Maier, personal communication). Most important in the present context, the phenomena clearly involve complex inhibitory processes and treatment must involve removing the inhibition (Maier et al., 1990; Willner, 1984).

WHY WILD ANIMALS ARE VULNERABLE

Relatively long-lived animals must face certain major reproductive decisions, particularly early in life and during "bad" years (low food availability, intense intraspecific competition from more dominant individuals, etc.). Under such circumstances, the best decision might be to refrain from investing energy in reproduction when there is little chance of success, and to wait for a better year. Of course, there are intermediate courses of action such as adopting alternative mating tactics (satellites, sneakers, pseudofemales, etc.). In either case, we can conceptualize the animal as inhibiting one course of action based on assessments of environmental, social or other cues. Further, we are conceptualizing such inhibitory processes as being of value, and consequently, as being subject to natural selection. Species with relatively long life spans and with numerous potential breeding years might, therefore, be expected to exhibit refined sensitivity to cues signalling low reproductive success, and to possess corresponding inhibitory process to respond appropriately to this information.

This argument leads to the conclusion that long-lived reptiles ought to be particularly vulnerable to reproductive inhibition. If captive conditions inadvertently incorporate stimuli that simulate those natural cues mitigating against reproductive investment, reptiles should be specially sensitive to them. Captive stagnation is precisely what we would expect because the animals are shutting down while they wait, interminably, for a better year.

DOMESTICATION

Few of us want to think of ourselves as being in the business of breeding domesticated strains of reptiles. Yet, this is a potential consequence of our propagation efforts, and it is worthwhile to reflect on the process. Bronson (1989) conceptualizes domesticated mammals as having become insensitive to cues that normally inhibit reproduction in nature. Of course, many other differences exist between domesticated mammals and wild counterparts, but this is one of them. Now, consider the remarks of Fitch (1980):

"As an outcome of the great interest that has developed in recent years in the keeping and breeding of reptiles, it can be predicted that domesticated stocks will be developed. ... Along with transformations in appearance, will come a variety of other changes including those of temperament, and reproductive physiology. Even without conscious selection on the part of the keepers, the original traits of a species will tend to be altered in the following ways: 1) generation time will be shortened, for instance from two years to one, or from three or four years to two; 2) captives will become less exacting in their requirements for mating; 3) fertility will be increased, with more eggs per clutch or young per litter; and 4) interval between clutches or litters will be shortened. These are trends that are well known in most domesticated animals (Darwin, 1868). Thus captivity will result in intensive selection, molding the animal in a manner quite different from that followed in its natural environment. The final product will be an animal much better adapted to live in close association with humans, in the home or laboratory, but less well adapted for life under natural conditions"(p. 30).

It is clear that Fitch agrees with Bronson, and that he goes further to consider domestication to be a virtually inevitable result of captive propagation efforts. We think the changes described by Fitch can be avoided, but only with concerted effort. Also, we think it is possible (indeed necessary) to monitor the competence of offspring and to detect changes in their abilities to face the demands of life under natural conditions. We have argued elsewhere (Chiszar et al., 1990, Murphy & Chiszar, 1989) that this work must come to be seen as being of equal importance to producing offspring, and that it promises to reveal a great deal about reptile developmental psychobiology.

On the other hand, should domesticated stocks of reptiles come into existence, it is quite possible that research comparing them with wild counterparts will be extremely informative regarding the mechanisms that mediate generation time, mate selection, sexual inhibition, fertility, and so forth. Data on these issues can make important contributions not only to our knowledge of reproductive physiology but also to behavioral ecology and to related subdisciplines concerned with the evolution and modification of sexual behavior. More to the present point, such data can give rise to increasingly enlightened captive propagation programs designed to avoid domestication.

GENERATING HYPOTHESES REGARDING INTERVENTION

Putting aside the complex issues attending domestication, the ideas developed in previous sections might prove useful in thinking about how to manipulate captive environments to encourage breeding. As Huff (198)) and others (see other chapters in Murphy & Collins, 1980) have shown, reptiles respond to a number of peculiar interventions, such as slapping, poking, prodding and cloacal probing. In such cases we may reasonably assume that the individuals were in reproductive condition prior to the intervention, and that the effect was disinhibitory. Otherwise we would not expect to see courtship and copulation within minutes or hours of the treatment. The same comments could be made in cases where hiding boxes or blinds proved effective in short order.

These observations cause us to recall a series of investigations in which sexual behavior in male laboratory rats was measured after administration of various arousing treatments, such as amphetamine and electric shock. Provided that the dosages were not too great, these treatments enhanced sexual performance. Shocks were delivered through electrodes (common safety pins) places in the skin toward the rear of the back, dorsal to the flanks. Upon receiving shocks, male rats approached females immediately, mounted them and usually began thrusting. The median latency between shock and mount was four seconds (Barfield & Sachs, 1968), indicating that chock brought about a dramatic sexual response. The investigators hypothesized that excitation produced by shock summated with endogenous sexual excitation to generate supernormal sexual vigor. While this "excitatory interpretation" appears quite appropriate for the rat data, we wonder how things would work for male snakes that are not initially responsive to females. If mild electric shock brings about courtship behavior in such males, it seems entirely possible that the effect would be based upon disinhibition. One particular aspect of the rat data suggests that this possibility ought to be entertained. Male rats normally experience a refractory period of five to eight minutes following an ejaculation. Inhibitory processes probably play some role in the suspension of sexual behavior during this period. Shocks reduced the postejaculatory interval by 25 percent, strongly implying that inhibition was removed.

It is not necessarily our intention to recommend the application of electric shocks to captive snakes. Instead, we wish only to point out that our collective thinking and creativity in solving the problems of captive stagnation and ophidian libido are likely to be limited by the theoretical assumptions we make about their causation. We need to externalize our assumptions and we need to understand the logical alternatives. If we think only in terms of providing the correct, natural excitatory stimuli, then we may neglect the other possibilities that arise from alternative interpretations of causation. This will have two unfortunate consequences. First, we will miss opportunities for successful breeding. Second, we will retard the accumulation of knowledge by constraining our vision.

ANOTHER ITEM OF INTERPRETATION

The effects of stress were much discussed in the 1980 volume edited by Murphy & Collins, and these effects continue to be of great concern. A recent review can be found in Bronson (1989). Here we want to focus on one particular aspect of this immense literature, namely, the effects of social domination upon the sexual behavior of males. The data are fairly clear-cut for birds and mammals. Being dominated results in changes in appearance, behavior and physiology. Subordinate animals have fewer mating opportunities than do dominant ones, and this reduction sometimes occurs even if the subordinant individuals are temporarily removed from the dominant one. This has led investigators to study the effects of social interaction on various endocrine events:

> ... "there is no doubt that the kinds of emotional stresses that can be generated in the laboratory can exert potent suppressive effects on gonadotropin secretion and hence on the reproduction of domestic rodents. Indeed, in some cases emotional stressors seem to exert more potent effects than what appear to be exceptionally powerful physical stressors. ...
>
> "There is also no doubt that a reciprocal relation between circulating levels of LH and adrenocortical activity can be demonstrated in carefully controlled agonistic interactions in the laboratory. ... even a short aggressive encounter between two male laboratory mice results in a dramatic elevation of circulation corticosterone and an equally dramatic drop in circulating LH. At least the corticosterone dimension of this response is conditionable in the classic sense. That is, exposure of a naive male mouse to a trained fighter for

a few bouts conditions the nonfighting male to react (secrete corticosterone at a high level) *just when placed in the presence of the trained fighter, without* any physical contact (Bronson and Eleftheriou, 1965)."

(quote taken from Bronson, 1989, pp. 143-144; interested readers should see also Bronson, 1973, 9179).

There is ample reason to believe that similar effects of stress and aggression occur in reptiles (Callard & Callard, 1978; Greenberg, 1985, 1990; Lance & Elsey, 1984; Tokarz, 1987). Although we are aware of no studies that demonstrate for reptiles the classical conditioning phenomenon described by Bronson & Eleftheriou, it seems reasonable to expect that future research will find it. Accordingly, subordinate reptiles, especially males, probably suffer consequences that are quite analogous to those known to occur in birds and mammals; and this point has obvious husbandry implications.

Now we would like to bring up an admittedly speculative ramification that occurred to us during conversations about a paper by Grace Wiley (1930). She described the procedures used to tame down several neotropical rattlesnakes so that they could be carried about by hand.

"Every time the door of their cage was opened, they were stroked, first with a padded stick and then with my hand." (Wiley, 1930, p. 100)

Having seen numerous instances of combat between snakes, and knowing the significance of the behavioral element called "topping", we wonder if Wiley was actually simulating a one-sided dominance contest with her snakes. Although she spoke of "winning their confidence", it seems possible that she was actually enforcing their subordination.

Pushing this line of thought further, we wonder if handling snakes, even with hooks or tongs in course of routine cage maintenance, can be seen as a dominating behavior. Many snakes appear to exhibit submissive behaviors such as head hiding after being manipulated in this manner. Also, many breeders caution against handling snakes, especially males (Ross, 1980, p. 136). Such bits and pieces of experience converge on the hypotheses that captive maintenance can incorporate dominance-subordination relationships between keeper and kept. If the snakes see it this way, then it might follow that we are inadvertently inhibiting sexual expression in the very creatures we are attempting to propagate.

CONCLUSION

Reptiles certainly require specific combinations of temperature, photoperiod, humidity and food availability in order to stimulate gonadal growth. It has never been our intention to deny the importance of such factors. On the other hand, we have observed captive snakes fail to breed even though histological examination confirmed that gonads were ripe. This has caused us to think about additional mechanisms, namely those that block the occurrence of courtship and copulation in animals otherwise capable of exhibiting these behaviors. In the absence of systematic data, it is easy to carry speculation too far, and we have probably done so. Nevertheless, we hope that our thoughts about inhibitory processes might give rise to alternative and testable hypotheses in situations where propagation attempts have failed even though healthy animals have been maintained under ecologically appropriate climatic conditions. Further, we hope that some of the references cited here, though unusual in a herpetological context, might trigger interdisciplinary investigations aimed at generating both practical and theoretical advances in herpetoculture.

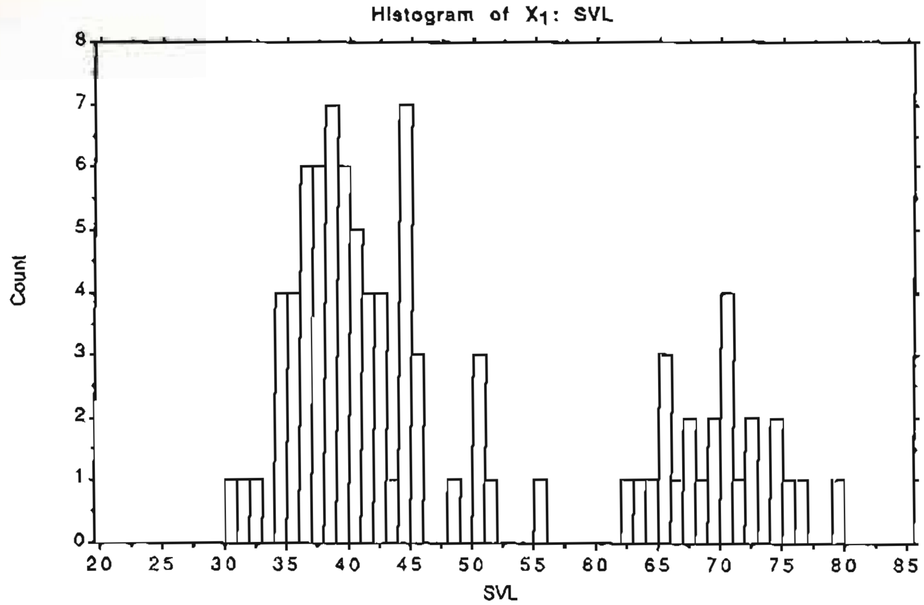

Figure 1. Histogram of x1: SVL

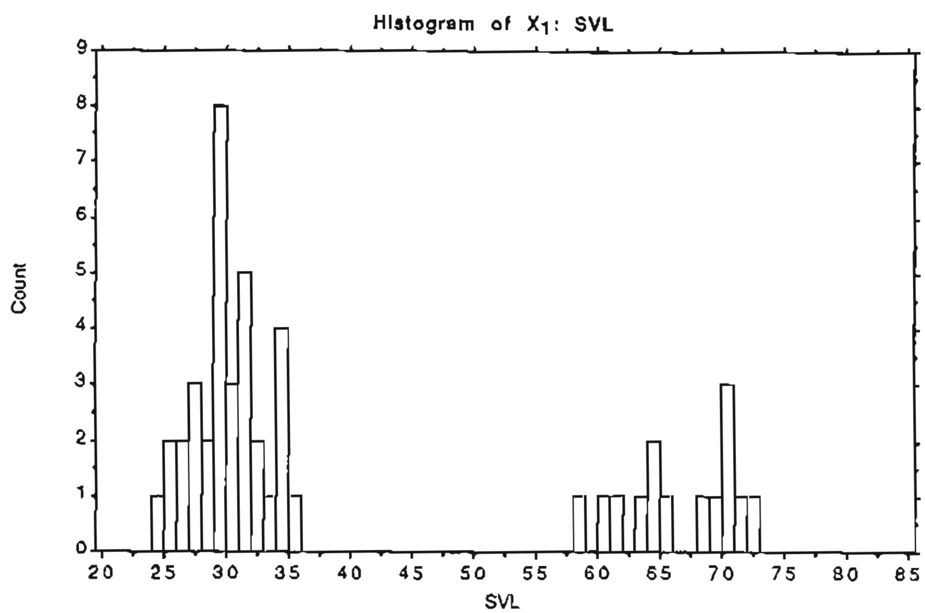

Figure 2. Histogram of X1: SVL

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NEW CONCEPTS IN COLUBRID EGG INCUBATION - A PRELIMINARY REPORT

Stephen H. Hammack

ABSTRACT

Over the past two breeding seasons, 1989 and 1990, six clutches of colubrid eggs have been incubated at a temperature of 29°C in a constant temperature chamber at Texas Christian University. These clutches were split up into three treatments with varying water potentials. Treatment #1 had a water to vermiculite ratio of 1.1/1 by weight; Treatment #2 a ratio of .4/1; and Treatment #3 a ratio of .1/1. Eggs were set up in gallon jars with a semipermeable "Gator Bag" sandwich bag as a top. This bag would allow gaseous exchange and oxygen transfer to occur to and from the jar. Eggs were weighed and measured at oviposition, day 2, and at weekly intervals, until pipping. The complete incubation set up (jar, sandwich bag top, water, vermiculite and eggs) were weighed prior to incubation and also at weekly intervals. Each jar was reset at day 30 or when a 10% weight loss occurred, whichever came first. Upon hatching, incubation time, sex, weight, snout-vent length (SVL) and total length (TL) were recorded for each hatchling. Nearly all eggs hatched, with the most prominent death of eggs occurring in Treatment#1, with a 1.1/1 water to vermiculite ratio by weight. In addition, those hatchlings with the most variety in size hatched from eggs incubated in Treatment #1. Though these results represent small data sets and are only meant as a preliminary report, they do suggest that we may think of altering our original thoughts of incubating colubrid eggs at a 1/1 water to vermiculite ratio by weight.

INTRODUCTION

There are 3 types of reptilian eggs in terms of texture and flexibility of the shell: (1) flexible, parchment shelled eggs; (2) pliant, parchment shelled eggs; and (3) hard shelled eggs. Each type responds in its own way to environmental moisture. Their water relations have been reviewed by Packard, Tracy and Roth (1977), Tracy, Packard and Packard (1978), Ewert (1979), Lillywhite and Ackerman (1984), Black, Birchard, Schuett and Black (1984) and Packard, Packard and Boardman (1982).

Most lizards and all snakes have eggs with a flexible, thin, parchment like shell lacking a well defined calcareous layer (Sexton, Veith and Phillips 1979). Some species, however, do have a small amount of calcium deposits in the shell layer (Lillywhite and Ackerman 1984). Such shells are permeable to water, both to and from the egg. Under dry, and excessively wet, conditions, eggs of this type may desiccate and die (Fitch and Fitch 1967) or swell and burst, if too much water is taken in, or at the very least, they may have a reduced hatching success.

Most of the studies done to date on reptilian eggs have been done in the lab. However, one recent study by Burger and Zappalorti (1991) showed that Northern Pine Snakes (*Pituophis m. melanoleucus*) tend to lay their eggs in nest chambers with moist environments. They also showed that females of this subspecies tend to dig several test holes, prior to selecting a site for oviposition. Thus, maintenance of a moist environment may be a critical factor in the selection of nest sites for snakes.

Eggs incubated on the surface of wet substrates increase in weight during the first half of incubation but lose weight thereafter, whereas those that are half buried continue to gain weight throughout incubation (Packard, Packard and Boardman 1980). Eggs incubated under favorable conditions have longer incubation times and produce larger hatchlings (Gutzke and Packard 1987). Gutzke and Packard showed that this was true with hatchlings of the Bull Snake (*Pituophis melanoleucus sayi*) and their results showed that the larger hatchlings came from the wetter incubation environments.

This preliminary report is based on a single clutch of Texas Ratsnake eggs that were incubated in a manner similar to that used by Gutzke and Packard in their 1987 Bull Snake work. Our results, however, are different from those of Gutzke and *Packard (1987)*.

MATERIALS & METHODS

Eggs from 5 clutches of various *Lampropeltis* species in 1989, and 1 clutch of Texas Ratsnake (*Elaphe obsoleta lindheimeri*) in 1990 were incubated at a constant temperature of 29°C at Texas Christian University. These clutches were split up into three treatments with varying water potentials. Treatment #1 had a water to vermiculite ratio of 1.1/1 by weight and a water potential of ca. -300 kPa; Treatment #2 a ratio of .4/1 and a water potential of ca. -700 kPa; and Treatment #3 a ratio of .1/1 and a water potential of ca. -1500kPa.

Snakes were checked carefully when the time of oviposition was near. When oviposition took place, eggs were set up in the following manner: Treatment #1 was composed of 165 g of distilled water to 150 g of vermiculite; Treatment #2 was composed of 60 g of distilled water to 150 g of vermiculite; and Treatment #3 was composed of 15 g of distilled water to 150 g of vermiculite. All eggs were set up in gallon jars with a semipermeable "Gator Bag" sandwich bag as a top, held on with a rubber band. This sandwich bag top would allow for gaseous exchange and oxygen transfer to occur to and from the jar. All weight data was taken using an Ohaus digital balance and all measurements were taken using a vernier caliper. Once the various treatments were ready, then the eggs were individually numbered, weighed, and width and length measurements taken. This data was recorded on a data sheet (see Table 1). Eggs were split up as equally as possible among the three treatments.

Weights and measurements of the eggs were taken at oviposition, day two, and then at weekly intervals until pipping. In addition, the complete set-ups (jar, vermiculite, water, eggs, top) were weighed at the same interval to determine the amount of water loss. The complete setup was reset at day 30 or when a 10% weight loss occurred, whichever came first. This weight loss would be evident when the following weights were lost: Treatment #1, 16 g; Treatment #2, 6 g; and Treatment #3, 1.5 g. One egg from each clutch was frozen after the initial data was taken. At a later date, these eggs will be freeze dried and their wet weight, less their dry weight, will give us the amount of moisture in a given egg from a given clutch for a given species.

Eggs were checked daily near hatching time, and upon hatching, incubation time, sex, weight, snout-vent length (SVL) and total length (TL) were recorded. This data was also recorded on the same datasheet as the egg data. In 1989, 1 clutch of New Mexico Milksnake (*Lampropeltis triangulum celaenops*) of 7 eggs; 1 clutch of Mexican Milksnake (*L. t. annulata*) of 6 eggs; 1 clutch of Durango Mountain Kingsnake (*L. mexacana greeri*) of 4 eggs; and 2 clutches of Pueblan Milksnake (*L. t. campbelli*) of 5 and 7 eggs respectively, were incubated as described above. Since these clutches were the first attempt at this experimental design and due to the relatively small clutch sizes, only one clutch, that of the *L. t. annulata* was able to be split into all three treatment groups. The other clutches were only distributed between treatments #1 and #2.

In 1990, 1 large clutch of 20 eggs of the Texas Ratsnake (*Elaphe obsoleta lindheimeri*) were set up and incubated as described above. This clutch was able to be split up between all three treatment groups, and most of the data presented here is a reflection of this one large clutch.

RESULTS

As previously stated, eggs from one clutch of Texas Ratsnake eggs were the main basis for the following results. Table 2 shows the results of the data for this one clutch of eggs for 1990. At the beginning of this preliminary trial, the beginning egg mass was relatively equal between all three treatment groups. At 29°C, the incubation period was approximately 6-7 weeks.

Graph #1 and graph #2 both show the relative intake of water, by weight, of this clutch of eggs throughout the incubation period. Graph #1 is a scatter plot of the complete clutch of 19 eggs, which shows the rather constant, beginning egg mass. As time passes, the three groups show a definite divergence in the amount of water that they are taking in. At the end of incubation, Graph #1 shows a definite clustering, of relative weights, of the three treatment groups. Graph #2 shows the same data in a linear regression graph.

Going back to Table #2, you can see, in the center column, that the egg mass near hatching time has a definite and significant difference among all 3 groups. The significant differences here were tested using analyses of variation (ANOVA) and Tukey's Test. It should be noted at this time that Treatment #1 had 7 eggs, treatment #2 had 6 eggs and treatment #3 had 6 eggs.

Two thirds of the way through incubation, eggs in treatment #3 had already started to dimple, while eggs in the other treatments had not. Also, one of the eggs in treatment #1 was starting to look bad, and in fact died, near full term in the egg. at approximately 5 days prior to hatching, eggs in treatment #3 were basically collapsed, not dimpled, while the other eggs had not started to dimple.

Incubation time was only slightly different between treatments, with treatment #3 hatching 1-2 days earlier than those in the other treatments. Sex ratios showed no significant differences, with treatment #1 having the most skewed sex ratio of 1.5. Treatment #2 had a sex ratio of 3.3, as well as treatment #3.

Hatchling mass did show a statistically significant difference between treatment #1 and treatment #2, but treatment #2 and treatment #3 showed no significant difference in hatchling mass. Treatment #1 had the smallest hatchling mass, consequently, the hatchling SVL between treatment #1 and the other 2 treatments also showed a difference, again with treatment #1 having he smallest SVL.

There were two other points of interest that are worthy of discussion here. The first of these was the weight of the discarded eggshells. Those of treatment #1 ranged anywhere from 1.3 g to 9.1 g in total weight. Three of the six eggshells in treatment #1 were left with significant amounts of unabsorbed yolk material, which gave them the higher shell weight. Treatment #2 had shell weights of 1.0 g to 3.6 g, and treatment #3 had shell weights of 0.8g to 1.4 g. The average shell weights for the 3 treatments were as follows: treatment #1, 5.07g; treatment #2, 1.68g; and treatment #3, 0.97 g. What this actually shows is unknown at this time, but as more data is accumulated, perhaps the cause and effect will become apparent. The other interesting point that happened deals with the color of the hatchlings.

One pair of hatchlings from each of the three treatment groups were held back and are being raised for future breeders for the continuation of this project. All hatchlings were of the same color and pattern, with only subtle differences, as would be expected within any clutch of hatchlings. As they started to go through their ontogenetic color change there were some apparent and obvious difference in the color between the pair that were incubated in treatment #1 and the other four hatchlings from the other two treatments. The pair from treatment #1 are of a much more lighter background color than their siblings from the other treatments. Whether this change will remain into adulthood is unknown at this time, nor is the cause and effect of this color difference apparent at this time. Offspring from future experiments of this type will also be held back, at least until the ontogenetic color change is apparent.

DISCUSSION

Though this report is meant as a preliminary report and nothing more, it does bring up some interesting, hard data and some other interesting points for consideration. This report is based solely on a single clutch of Texas ratsnake eggs from 1990, but it is the beginning of a long term study of eggs of the Ratsnake, *Elaphe obsoleta*. The project is continuing for 1991, with, to date, one clutch of Texas ratsnake eggs currently being incubated in the exact same manner, and one clutch of Black ratsnake eggs on the way from a population of ratsnakes in southern Ohio. In addition, specimens of the Everglades ratsnake (*E. o. rossalleni*) and members of the Black ratsnake (*E. o. obsoleta*), from two populations, one in southern Ohio and one in Ontario, Canada are also being raised in the lab at Texas Christian University for comparative work on the species throughout a good portion of the species' range. Texas ratsnakes will always be available from the Fort Worth, Texas area to give us a baseline of information to work from.

Some of the more interesting things to arise from this project are the differences in color of the juvenile Texas ratsnakes. it will be interesting to see if this trait is a result of the moisture content of the incubation setup or if it is simply a random, chance happening that has just cropped up. It is also interesting to note that, unlike the paper by Gutzke and Packard (1987), my results showed that the wetter environment did not produce the larger hatchlings. Based on my results, I have changed my thoughts of incubating colubrid eggs at a 1/1 water to vermiculite ratio by weight and now tend to lean more towards a .4/1 water to vermiculite ratio by weight.

ACKNOWLEDGEMENTS

I would like to thank Dr. Gary Ferguson for assisting me with this project, for analyzing the data and for allowing me to use his facilities at Texas Christian University to house the snakes. I would also like to thank Scott Moody of Ohio University for supplying me with Black ratsnakes from the southern Ohio area, as well as Gordon Schuett for supplying me with some hard to find reference material. And last but not least, I would like to thank my son, Kevin, for allowing me to travel to Seattle to present this paper.

TABLE 1. Water Potential Study Data Sheets

Common Name:__________ I.D.#:__________
Scientific Name:__________
Number of Eggs:__________ Initial Clutch Weight:__________
Date Laid:__________ Egg Number Frozen:__________

Egg #'s Treatment 1:__________ Set up Weight:__________
Egg #'s Treatment 2:__________ Set up Weight:__________
Egg #'s Treatment 3:__________ Set up Weight:__________
NOTES:__________

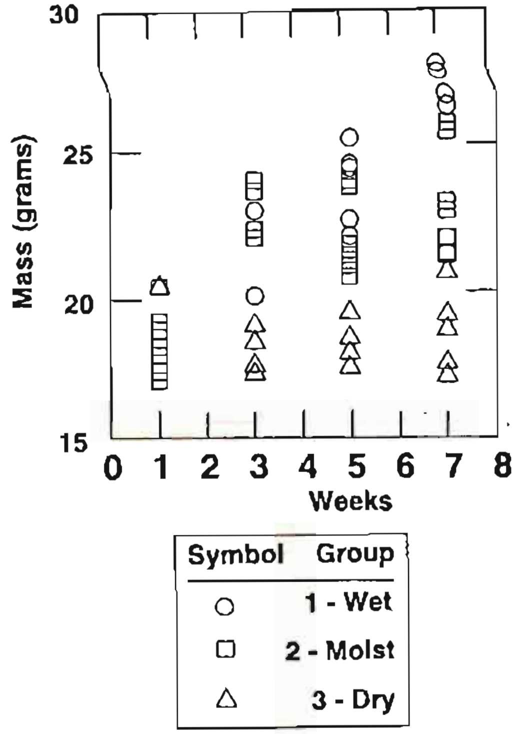
Date	Egg #	Egg wt.	Egg L	Egg W

TABLE 2. Egg and Hatchling Data for *Elaphe obsoleta lindheimeri* Eggs Incubated at a Constant 29°c at Different Water Potentials.

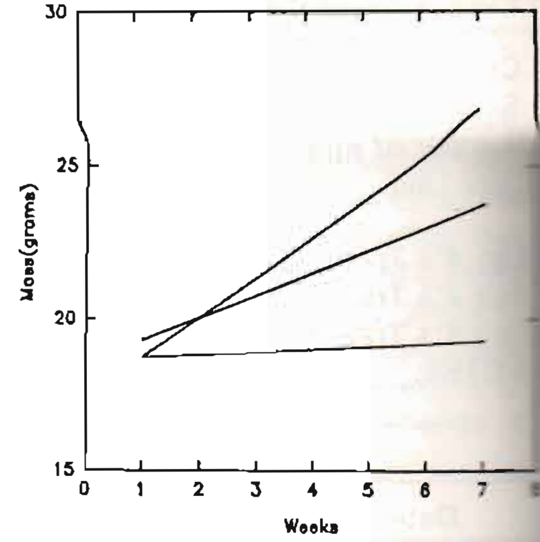
Group	Treat-ment	Beginning Egg Mass (g,mean ± s.d.)	6-Week Egg Mass[1] (g,mean ± s.d.)	Hatchling Mass[2] (g,mean ± s.d.)	Hatchling SVL (cm,mean ± s.d.)
1	wet -300 kPa	18.9 ± 0.6	26.8 ± 1.0	12.7 ± 2.9	27.7 ± 0.8
2	moist -700 kPa	19.1 ± 1.0	23.6 ± 1.6	15.7 ± 1.2	28.6 ± 1.0
3	dry -1500 kPa	18.6 ± 1.0	19.2 ± 1.3	14.6 ± 1.0	28.2 ± 1.0

[1] Differences amoung groups highly significant ($p < 0.01$) ANOVA and Tukey's Test
[2] Differences between groups 1 and 2 significant ($p < 0.05$).

Graph 1.



Graph 2.



REGRESSIONS	
STEEPEST GROUP 1 WET	$y = 17.4 + 1.33x$ $r^2 = 0.96$
NEXT GROUP 2 MOIST	$y = 18.6 + 0.75x$ $r^2 = 0.83$
FLATEST GROUP 3 DRY	$y = 18.6 + 0.09x$ $r^2 = 0.18$

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REPRODUCTIVE BIOLOGY OF THE RUBBER BOA (*CHARINA BOTTAE*)

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INTRODUCTION

This report is based on a partial compilation of data accumulated since 1962 from captive and wild-ranging rubber boas. Most of what is presently known concerning reproduction in this species is summarized in Wright & Wright (1957).

STUDY AREA AND SOURCES OF DATA

All information pertains to *Charina* collected in western Oregon with about 95% of the sample being collected near the communities of Corvallis and Salem, slightly south of 45° latitude. Some snakes were collected in temperate forest and grassland ecosystems; however, most were collected at edges between these plant communities.

In the mid-Willamette Valley, rainfall ranges from 40-43 inches (102-108 cm) per year, most precipitation occurring from late fall through spring (November-May). The valley floor lies 200-300 feet (60-100m) above sea level. Temperatures in this region are coldest during January (mean high and low of 45° F and 33° F) and warmest in July and August (mean high and low of 82° F and 50° F).

Information in this report came from the following sources:

1) Initial capture of specimens later released.
2) Specimens retained indefinitely in captivity.
3) Recapture of released specimens.
4) Release of newborn specimens with subsequent recaptures.

MATERIALS AND METHODS

The method used to capture *Charina* involves the distribution of placements, roofing tins and plywood boards at suitable locations. Dubbed 'multiple recapture placements' (MRP) by a colleague (Mike Lais), these tins and boards range in size from .25 m^2 to 3 m^2 and are distributed either on a random basis or in distinct patterns.

Upon initial capture, an information sheet is completed for each snake recording the date and capture location, sex, weight, length, coloration, tail tip scarring, presence or absence of female spurs, and scalation patterns. A combination of head scale configuration and presence of ventral and/or caudal anomalies serves as a natural tagging method used to identify recaptured specimens. All snakes are brought back home for this process and usually released from 1-14 days after capture. Gravid females retained to obtain data on litters are released soon after parturition. Similar information is recorded on newborn boas except that a single 'brood' sheet is used to identify all members of a litter along with the identity of the parent female.

Determining the minimum age at which male and female rubber boas reach sexual maturity in the wild involved the release of newborn boas into areas largely devoid of reptilian competitors (including adult boas) then monitoring recaptured specimens in subsequent years. The criteria used to establish adult vs. nonadult boas was based on recording the smallest sexually active males and smallest gravid females.

Three methods were used to estimate the mean frequency of litters produced by this species. The first involved establishing the ratio between gravid (G) and nongravid (N) females when first captured. The second method also included 'G' and 'N' years for females recaptured in later years. The third method incorporated the knowledge of the maximum litter frequency (biennial) and included only those females captured in three or more years. An 'N' was inserted (extrapolated) in years where these females were not recaptured but where it was known they could not have been gravid. The ratio of 'G' to 'N' was then calculated for this sample.

Snakes not designated for immediate release are housed in two 90 cm x 60 cm x 30 cm wood frame cages with two sides and lid covered with 1/8 inch (3 mm) wire hardware cloth. Each cage can be partitioned in half in order to provide 4 compartments. Substrate consists of medium fine Douglas fir sawdust. Large inverted shallow, metal pans, serve as thermoregulatory/incubation sites within each compartment. Either a 40 or 60 watt incandescent light bulb is suspended 1-5 cm above each pan during the reproductive season and at a somewhat greater height at other times. These light bulbs are controlled by an automatic timer and in most years set to coincide with the natural dark/light cycle.

Water is made available at all times. However, once every week to 10 days during the active season, all boas are routinely placed in gallon jars filled with three to six cm of lukewarm tape water for from 10-30 minutes in order to insure adequate water intake. Food, in the form of nestling young of lab mice and native small mammals is offered to all boas regularly during the active time of year. An exception to this procedure involves gravid female boas which seldom accept food during gestation.

Total weight loss during the reproductive process was obtained by subtracting a female's post partum weight from the weight at time of capture. Statistical treatment of the newborn sex ratios was provided by Mr. Ken Currens, Fisheries and Wildlife, Oregon State University, who used the log likelihood ratio test (G-test) for this analysis.

RESULTS

<u>Sample Characteristics and Sexual Maturity</u>: A total of 1167 rubber boas were captured from 1962-1990. The overall ratio of males to females was 624:543. Adult males outnumbered adult females 526 to 414, whereas the ratio of nonadult males to nonadult females was 98 to 129 (Table 1).

Based on the criteria mentioned in the 'Methods' section, males and females reach sexual maturity at 45.7 cm (18 inches) and 55.9 cm (22 inches) respectively. Four males of known age (released as newborn) reached the size of sexual maturity near their third birthday (in late summer). Theoretically, these males could have been active in the mating process the following spring at a little more than 3 1/2 years of age. Two females of known age reached the size of sexual maturity by their fourth birthday and produced litters near their fifth birthday.

Treatment of the available data has not been undertaken to provide an estimate of the mean ages at which each sex reaches maturity. With respect to the presently know maximums, reasonably complete data on two males show they took 6 years, possibly longer, in order to reach the minimum size for sexual maturity. One female, approaching her 11th birthday, is still 4-5 cm (1 1/2 - 2 inches) from the minimum size for mature females.

<u>Courtship & Mating</u>: Field observations of courtship, though observed more often, were recorded only 11 times with the earliest and latest dates being April 13 and June 2. Instances of actual couplings were recorded 10 times with the earliest

and latest dates being April 16 and May 28.

Females in reproduction condition are usually found alone or with one to two males. Only three instances of small mating aggregations have been recorded in which two to three females in reproductive condition were observed with from four to seven males.

Courtship and coupling are similar to that reported in other boids except that the rate of spur stroking by male Charina is in the order of one to two per second and often much slower. In this species, the spurs are frequently inserted beneath the free edges of the female scales which are picked-up in the stroking process. From observations of retained boas, most couplings have lasted from one to two and a half hours. They are known to have lasted longer but such measurements have not been taken.

Gestation, Parturition, & Female Weight Loss: Direct evidence of ovulation, the onset of gestation and the duration of gestation is lacking at this time. Estimates of the time of these events is made from indirect evidence. Working backward from the variation of observed parturition dates, palpation of ova which increase in size during the spring, altered behavior of female boas and a shift posteriorly in body proportions suggest that ovulation and onset of gestation occur from early May through June depending on the individual female and variations in weather. Similar imprecise clues suggest that gestation normally lasts between 90-100 days. These values are similar to those estimated for the rattlesnake *Crotalus viridis* in British Columbia, Canada, by Macartney and Gregory, (1988).

To reduce the influence of artificial incubation conditions, only females captured after the onset of gestation were used to provide an indication of the normal dates of parturition. Figure 1 portrays information on parturition of 82 females collected June 20th or later. The majority of births occurred during the last week of August through the first three weeks of September with a peak period during the first two weeks of September. The earliest date of birth was August 10 from a female collected on June 24, whereas the latest date was October 17 for a female collected on October 15.

The mean weight loss for 72 females was 45.25% from the time of capture to the time just after the birth of young. The components of this weight loss were 26.93% biomass (young & ova passed), 3.75% embryonic sacs and fluids, and 14.57% loss in female fat reserves.

Source of Litters and Litter Characteristics: A total of 378 pregnancies were examined, from 243 females, in which young, ova, or both were produced. This total includes 62 pregnancies from 15 retained females after their initial year of capture, (Table II). Because there was virtually no difference in mean litter size between retained and field captured females, the data from all litters were pooled. The number of young per litter ranged from 1-8 with a mean of 4.36. Females producing only one young always passed ova as well. Of 20 litters containing two offspring, ova were passed as well in 17 of these cases. One retained female produced a litter of nine but all young appeared premature (some scalation weakly developed), were undersized, and six were stillborn.

The ratio of newborn male and female rubber boas for each of the 23 years are shown in Table III. Newborn females outnumbered males in 17 of 23 years. The departure from a one to one ratio in favor of female births was significant at the 3% level.

Mean weights and lengths of newborn males and females were virtually identical, but there was a discernible difference between progeny from retained females versus wild females, so only data from the field collected group is presented here. Mean weights of newborn males and females were 8.13 g (N=576) and 8.18 g (N=685). Mean lengths of newborn males and females were 255.98 mm (N=576) and 256.79 mm (N=687).

Reproductive Frequency: The mean frequency of litters produced by female *Charina*, calculated by recording gravid (G) versus nongravid (N) females their initial year of capture, yields a ratio of 1:1.35, (176G:238N). When all data on adult female recaptures is also included, the ratio is 1:2.15, (363G:781N). In using females captured three or more years, when 'N' years are inserted (extrapolated) where these females had not been captured (before and/or after a known 'G' year) a ratio of 1:3.06 occurs, (196G:599N). Figure II is part of one data sheet which provides an example from which each of the three methods were calculated.

DISCUSSION

A number of observations have been made in which quantitative data is lacking. Fasting by gravid females of certain species is well known and is typical for females of this species during gestation. In addition, some males of this species fast during the time they are active in courtship and mating, refusing all offerings of food. Since some of these males emerge from hibernation in February and March, this fasting period may last from two to four months, equaling or exceeding the fasting period of females.

Not all adult males become active in courtship when in the presence of receptive females in reproduction condition. This was first noticed in retained males in which a male would ignore reproductive females one year but be actively involved the next. Some males brought in from the field behave similarly and on occasion, upon finding a male actively courting a female in the field, another male may be nearby but otherwise inactive.

What reasons have been offered for the use of male spurs during courtship??? Female arousal? The fact that the spurs of male Charina frequently pickup the back edge of female scales suggests that an alignment mechanism for proper vent apposition is involved.

Some females collected in late summer or early fall in robust condition seem to have follicles within, discernible by palping. This observation suggests that some degree of secondary vitellogenesis takes place at this time of the year, as is the case with *Crotalus viridis* (Aldridge, R.D., 1979; Macartney, J.V. & Gregory, P.T., 1988). Supporting this contention is that palpation of such robust (reproductive) females newly emerged from hibernation in April often reveals discernible ova.

Two sets of circumstances that seem to signal ovulation and the onset of gestation are currently being monitored and are as follows: Ova gradually enlarge from less than 1 cm to greater than 3 cm as detected by palpation until the point where they are no longer firm and are difficult to discern one from another; a slight shift of ova postiorly occurs coupled with a more noticeable distention of the lower abdomen. Along with these conditions, females generally refuse all food offerings, settle permanently under the heat source, and become restless if the heat source is removed.

In some reptile species, the temperature during embryonic development influences sex ratios. Female rubber boas collected well after the onset of gestation would be less likely to have the sex of their offspring influenced by the artificial incubation conditions. The sex ratio of newborn boas from females collected from July through October (N=58) showed virtually no difference (104 males : 136 females) from the ratio obtained from the overall sample.

Though statistically significant, the observed altered sex ratio should be subjected to further research. However, three ideas have emerged that could explain a selective advantage of greater numbers of females at birth in this species.

1) The energetics involved with adult females being considerably larger than adult males (25 5/8 inches to 21 inches, Hoyer, 1974) and having to gain considerable fat reserves in order to sustain a reproductive effort while fasting require a higher frequency of foraging. This would translate in a greater exposure to hazards thus leading to a greater attrition of adult females. Evidence supporting this contention is that in this species, adult females possess a greater incidence of tail-tip scarring (69% to 54%) than adult males, (Hoyer, 1974). Also in support are the data on field captured specimens in which adult males considerably outnumber adult females, (526:414). The fact that subadult females have outnumbered subadult males 129:98 also lends support to this reasoning.

2) With males reaching sexual maturity sooner than females, less males are needed at birth in order to still maintain suitable numbers for mating purposes.

3) With females reproducing on the average of once every 3-4 years, again less males are needed to still insure yearly coverage of the reproductive females. (This last point is courtesy of my 17 year old son Ryan).

The age at which both sexes reach sexual maturity has been manipulated with retained snakes. By altering temperatures so as to extend feeding and growth periods, two males and two females reached the size of sexual maturity one year ahead of what has been observed in field specimens of known age. One of these males mated at approximately 2 years, 9 months and both females produced litters at about four years of age.

The control of reproductive cycles in reptiles, genetic or environmental, has been a matter of debate. The rubber boa exhibits a variety of both repeating and random reproductive cycles. This alone suggests that environmental influences (e.g., food availability, foraging success, and length of the active season) is the major controlling mechanism in this species. As further support of their contention, six females have produced litters in consecutive years. This was accomplished by again purposefully altering confinement conditions so as to advance the entire reproductive process. By advancing parturition to July, (earliest date was June 28th), post partum females had sufficient time to regain the necessary fat reserves by late summer/early fall to initiate the reproductive processes before hibernation time, (late October).

The method(s) used to determine the mean frequency of litters requires additional thought and scrutiny. Recapture data for certain females strongly suggested a behavior component making gravid females more accessible than nongravid females, (see Figure II, females #51, #54, and #67). It is for this reason that I used the third method whereby I extrapolated 'N' years where females had not been captured but when it was known they would not have been gravid. This resulted in a considerable difference in mean litter frequency in comparison to the other two methods. Brown (1991) also used an alternative approach in dealing with reproductive cycles in the timber rattlesnake (*Crotalus horridus*) in northeastern New York. By taking the proportion of gravid vs. nongravid females collected over an eight year period, a biennial cycle was produced (219G:208N). However, by using data only from recaptured females, triennial and longer cycles were indicated.

Also noteworthy is a noticeable difference in mean litter frequency between the various capture sites but the data has yet to be analyzed.

Table I. Sex ratio of adult and nonadult rubber boa (*Charina bottae*) collected in western Oregon from 1962 through 1990.

	Males	Females
Adult[1]	526	414
Nonadult[2]	98	129
Totals	624	543

[1]Adult males: 45.7 cm or longer
Adult females: 55.9 cm or longer
[2]Nonadult males: < 45.7 cm
Nonadult females: < 55.9 cm

Table II. Sources of litters examined from 243 western Oregon female rubber boas in which young, ova or both were produced.

	Number of litters per female									
	1	2	3	4	5	6	7	8	9	10
Number of retained females (N = 15)	4	1	1	2	1	2	2	1	0	1
Number of wild females (N = 228)	176	32	13	3	3	1	0	0	0	0
Total Number of Litters Examined (N = 378)	180	66	42	20	20	18	14	8	0	10

Table III. Total number of newborn male and female rubber boas produced from 1968 through 1990.

Year	Males	Females
1968	3	0
1969	23	32
1970	16	26
1971	35	41
1972	22	32
1973	34	35
1974	38	46
1975	27	31
1976	32	21

Year	Males	Females
1977	35	56
1978	18	14
1979	53	43
1980	26	31
1981	21	17
1982	51	68
1983	41	55
1984	20	27
1985	16	31
1986	30	35
1987	38	46
1988	27	41
1989	30	44
1990	27	27
	663*	799*

*Significant departure from 1:1 at the 3% level.

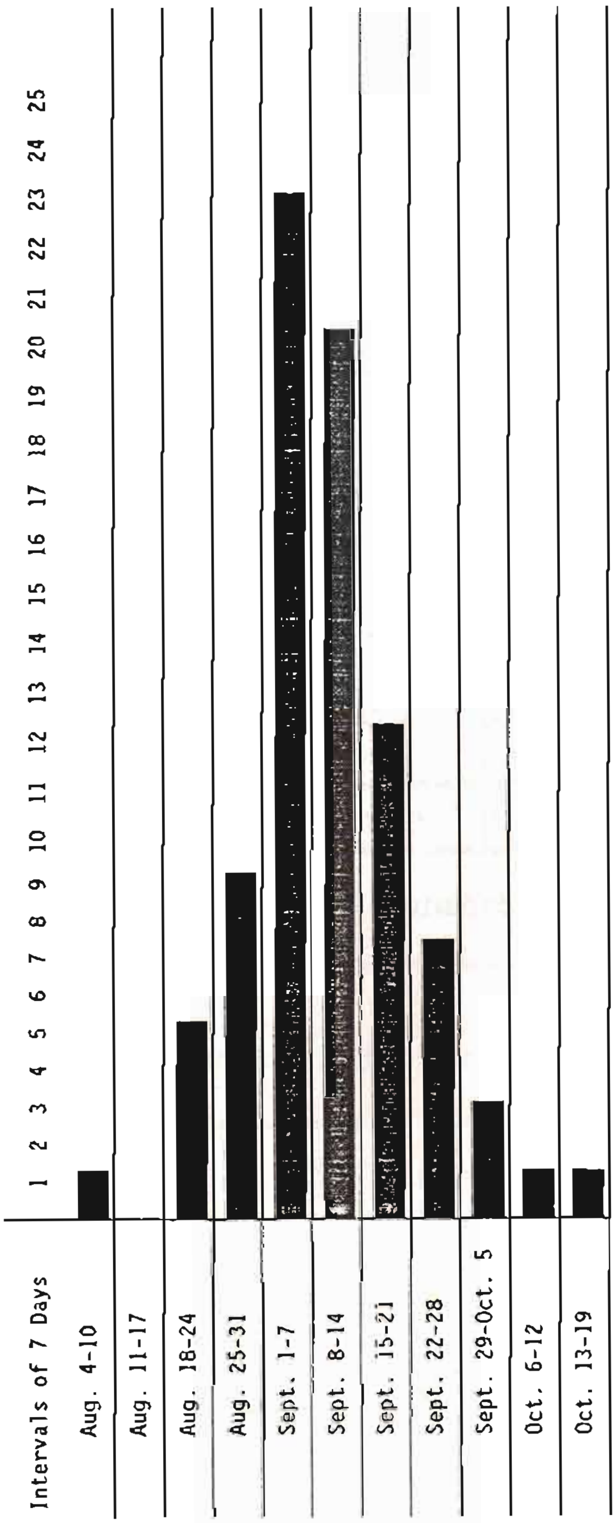

Figure I. Dates of parturition for 82 litters produced from females captured June 20 or later.

Figure II. Part of a data sheet from which the three methods for determining litter frequency were calculated.

Year/ Female	79	80	81	82	83	84	85	86	87	88	89	90	91	92
#49[2]	S	S	N	G	N	N	G	N	N	G	N	N		
#50	N													
#51[2]		G	n --	G	n --	G								
#52[2]		N	G	N	N	N	N	G	N	--	N	G		
#53		N												
#54[2]		N	n -	G										
#55			G	N										
	(females #56 - #62 omitted)													
#63				N										
#64[2]				G	n --	N	G	n --	--	N				
#65				N										
#66					G	--	--	--	--	N				
#67[2]					G	n --	n --	G	N	G	N	N		
#68					J	S								
#69[2]					N	N	N	N	G					
#70[2]					S	S	--	N	--	--	n --	G		

J = juvenile
S = subadult
G = gravid adult
N = nongravid adult
- = year boa was not captured between first and last capture years
n = extrapolated nongravid year

[2]These females used for method #3

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PROBLEMS ENCOUNTERED WITH THE HUSBANDRY OF THE EMERALD TREE BOA, *CORALLUS CANINA*

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INTRODUCTION

Its unusual coloration and relatively small adult size have made the Emerald Tree Boa (ETB; *Coralus canina*) highly sought-after by herpetoculturists. The popularity of this species, combined with an increased availability of wild-caught specimens over the last ten years, has served to increase significantly the number of ETBs that are being maintained in captivity. In contrast to the relative ease with which one may acquire wild-caught ETBs, their maintenance in captivity has proved to be difficult. Typical problems with captive ETBs include regurgitation syndrome (Wagner, 1985; Funk, 1987; Ross, 1989), moth rot (Wagner, 1985) and respiratory illnesses. Some of these illnesses manifest themselves shortly after a freshly imported specimen is acquired, and may be caused by specific pathogenic (i.e. disease-producing) microorganisms. In other cases, however, we have observed that the onset of an illness was sometimes spontaneous, following a long period of successful maintenance. These observaitons have led us to suggest that inappropriate captive conditions may sometimes be responsible for problems that are commonly encountered with the husbandry of ETBs. Indeed, a correction of captive conditions has in some cases resulted in the disappearance of symptoms seen in unhealthy captive ETBs. This paper will discuss illnesses, specifically those which are respiratory and gastrointestinal in nature, that we have encountered while maintaining ETBs in captivity. To put this subject into perspective we will begin by describing techniques that we have used for the successful husbandry and propagation of ETBs.

GENERAL CARE AND BREEDING

<u>General Maintenance</u>

The ETB is an arboreal species that is confined to some of the tropical rainforest habitats of equatorial South America. This information is crucial to the herpetoculturist who wishes to maintain the ETB in captivity; this species requires 1) high relative humidity (relative humidity >80%) and a readily accessible source of drinking water, 2) a branch that is raised above the floor of the cage[1] and 3) a relatively constant ambient temperature, between about 25° and 30° C. One of us (M.M.) successfully maintained a group of wild-caught ETBs over a period of four years in cages that addressed these requirements. Specimens were kept individually in glass cages that measured about 80 cm high, 50 cm wide and 30 cm deep. A single piece of untreated driftwood that varied in thickness along its length was fastened to the cage wall at a height of about 40 cm. Ventilation was achieved by approximately fifty 1/4 inch diameter holes set in the side of the cage. Humidity was attained by forced mist from an ultrasonic humidifier that was operated for twenty minutes, at the same time each day. Fresh high-quality water (reverse-osmosis

[1]The thickness and shape of the branch may be an important factor. Specimens given branches of non-uniform thickness and shape often utilized exclusively a particular part of the branch. Some keepers have suggested that branch thickness may affect physiological function, such as digestion.

purified) was always used in the humidifier.[2] The ETBs were never sprayed, but water was always available in a 20 cm diameter porcelain dish. Specimens were often observed drinking from a water dish while remaining partially coiled on the branch. The substratum was bark chips (redwood or pine). No direct hot spots were used, and the room was maintained between 25° and 30° C, with a slight nocturnal cooling. Lighting was indirect, being supplied by other lights in the room. A 12 hour photoperiod was maintained year-round.

Specimens were fed when "prowling" behavior was observed. Typical prowling posture consisted of the head being pointed toward the ground and up to a quarter of the anterior body being unravelled from the main coil. When exhibiting this behavior the ETB is very alert and responds to movement. Prowling is easily distinguishable from the normal resting behavior, where the animal is tightly coiled and usually refractory to movement outside the cage. Prowling behavior was almost always observed immediately after defecation, during the nocturnal period. Food consisted of live or dead items, depending on the preference of the individual specimen. Dead food had to be warmed to body temperature (i.e. 35°-40° C) in order to induce interest from most specimens. Food items were rats and mice, again depending on the preference of the individual specimen, with large ETBs (120 cm and larger) taking up to half or three quarter grown rats, while smaller specimens (75-100 cm) took young adult mice. ETBs typically have a slow digestive cycle; the process from feeding to defecation usually takes from two to three weeks. Specimens were usually fed following defecation, after digestion of their previous meal was completed.

BREEDING

Between 1988 and 1990, reproduction of the ETB was observed on two occasions by one of us (M.M.). In the first instance, breeding occurred during September and October, 1988. Two females (about 140 to 180 cm in length) that were housed individually copulated on numerous occasions with a single male that was cycled between them. All of these specimens had been in captivity since September, 1984. Actual copulation lasted several hours and was always observed during the nocturnal period. During copulation, which occurred while both specimens were positioned on the branch, the posterior portions of the animals were coiled together and hung from the branch while the anterior portions remained coiled tightly on the branch. No changes in temperature, humidity, or photoperiod were effected either before or during the breeding period. During this time females were fed once a week when they were not with the male. About four to six weeks after breeding had initiated it was noticed that both females had significant midbody swelling (MBS). Particularly characteristic of this phenomenon was what appeared to be numerous small masses that protruded ventrally within the swollen region of the body. The swelling remained fairly localized for several months, but near parturition it had elongated and spread posteriorly. Some days the swelling presented as a discrete mass while on other days a swollen area was difficult to localize but rather the entire posterior part of the body seemed enlarged. A thermal gradient was effected by placing a 30W heating pad at low power setting (i.e. ~ 10W) several centimeters

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[2]We have encountered strong allergic reactions (human) when tap water was used in an ultrasonic humidifier. Ultrasonic humidifiers differ from evaporative units in that the former atomize water, along with any impurities that water may contain (i.e. salts, bacteria, fungi) while the latter emit essentially pure water; impurities are left in the humidifier. It is not known if the airborne impurities that we have experienced with ultrasonic humidifiers have deleterious effects on captive specimens.

from the branch and directly against the front glass of the cage. Approximately 4 months after MBS was first observed in one of the females, the enlarged mass had disappeared and the specimen had resumed feeding.[3] The second female remained heavy from mid-body to the posterior part of its body. In May, 1989, about seven months after MBS was first noticed in the female ETBs, all specimens were moved from Canada to new facilities in California. In the new facilities the single female that still appeared gravid was provided with a screen-top wood cage, along with a thermal gradient using a 50W red spot bulb. This ETB was housed in a cage (50 cm high X 80 cm long X 50 cm wide) with much better ventilation than those used in the old facilities. The gravid female utilized extensively a branch positioned directly under the bulb, where the temperature was about 32-34° c. About four weeks after arriving at the new facilities, the female gave birth to six neonates; five living and one stillborn. The young were green and patterned similar to the mother. All of the young had extensively deformed vertebrae and incompletely reabsorbed umbilical. Despite topical treatment of exposed tissue with polysporin™ ointment, all of these specimens died within a week of birth. The cause of the deformities in the baby ETBs is not known, but it is possible that the basking spot provided during the first seven months of pregnancy was not warm enough for proper embryonic development.[4] Similar skeletal deformities have been observed in Burmese python embryos when eggs were incubated at a lower than optimal temperature (Vinegar, 1974).

A second breeding of this species occurred almost exactly one year after the breeding described above. The female that had appeared to be gravid in 1988 but then resumed feeding again exhibited MBS in October, 1989. This female was maintained in a well-ventilated cage that was similar to the unit that housed the gravid ETB the previous year for the last four weeks of its pregnancy. A basking spot was provided by placing a 30W heating pad (at full power setting) directly on the screen top of the cage, about 15 cm from the branch. Room temperature was maintained at about 28° C and the temperature directly under the heating pad was about 32-34° C, but varied by one or two degrees (C) with the temperature of the room. The female fasted from October, 1989, when the MBS was initially noticed, until parturition. The ETB gave birth to ten healthy young and one living deformed neonate on June 1, 1990. The latter specimen did not have the vertebral deformities seen in the previous litter, but instead one of its eyes was grossly undersized. This neonate died within two days of birth. As was the case with the other female's offspring, these neonates were green and patterned like the adults.

CARE OF NEONATES

The young ETBs were housed individually in Rubbermaid™ plastic containers that measured 41 X 28 X 15 cm. A 1/2 inch polyurethane-treated dowel was affixed 6 cm from he floor of the container. The substrate was a double thickness of paper towel, and a plastic water dish (23 X 15 cm) was positioned on the floor of the container near the dowel. The cages were placed on a 30W heating pad that was set at low power; in addition to maintaining a suitable temperature this provided humidity by heating the water container. Additional humidity was effected by spraying the

[3]Gravid ETBs generally refused food from the time that MBS was first observed until after parturition.

[4]A warmer thermal gradient was not used as it was feared that this may cause overheating in those poorly ventilated cages.

containers with water, once daily. A container of dampened sphagnum moss was placed in the cage to maintain a constant high level of humidity. Ventilation was provided by several large, screen-covered holes in the removable top of the container. The cages were kept in the same room that the adult ETBs were kept, so ambient temperature and photoperiod are as described above. Beginning after their first shed, all young were offered mouse "fuzzies" once a week during the nocturnal period. During the feeding period, the animals were disturbed as little as possible; uneaten mice were left in the cage overnight and no attempt was made to assist- or force-feed the specimens. In the first feeding trial, only three of the ten young accepted food, but two months after birth all young were feeding on a regular basis.

While raising the young captive-born ETBs was relatively simple compared to the problems associated with wild-caught specimens, it was not without some difficulties.After the first few months of regular feeding at one week intervals, it was noticed that some of the young ETBs were becoming abdominally distended to an alarming degree. Furthermore, regurgitation was observed on two occasions with two individuals. Since the ETBs were defecating at two to three week intervals, a decision was made to offer food only after defecation. This practice has resulted in young with more reasonably proportioned girths and further instances of regurgitation have not occurred.

Fighting may occur among ETBs, especially during feeding. A shortage of containers necessitated housing two young ETBs in a single container for several months; this container was outfitted with two dowels at opposite ends of the cage. One morning following a feeding session, one of the young ETBs in this cage was found dead with a dead mouse in its mouth. The snake was presumably in the process of regurgitating the food item since the mouse was completely covered with dried saliva. The dead ETB had no tooth marks on its body, but it is probable that the two specimens were coiled together and during the excitement of feeding one constricted the other. As a rule, ETBs are now always housed individually.

Another problem that has arisen with the young ETBs has been mild dehydration characterized by shedding difficulties. In one instance, the skin has taken on a glossy, "baggy" appearance. A further possible manifestation of dehydration in the young ETBs are urate plugs that appear to block the cloaca. On three occasions, specimens presented with distended lower abdomens with swelling that extended posteriorly to the cloaca. Specimens were sometimes observed with the posterior portion of their body hanging vertically off the branch. Cloacal blockages were removed by gently supporting the posterior part of the body under warm running water until the plug was expelled. Dehydration was remedied by increasing the frequency and length of time that animals were sprayed with water.

ILLNESSES

Respiratory

Several cases of a respiratory disorder were observed in ETBs by one of us (M.M.) beginning about nine months after setting up the new facility in California. We refer to this disorder as dyspnea syndrome because affected specimens appear to have difficulty breathing. Specimens initially present with a puffing of the throat upon exhalation that is sometimes accompanied by a wheezing that seems to originate in the mouth, around the lips or in the nares. Small quantities of clear, non-viscous fluid is often present around the nares and in some cases the nares are blocked by dried matter. The affected animal often appears dehydrated, characterized by skin that is duller and less elastic than that observed with healthy specimens. At this initial stage most specimens continue to feed, although some specimens become anorexic. Dyspnea syndrome at this stage can be considered chronic; it is often stable for several months. Furthermore, in some cases symptoms were reversed if the animal was promptly given conditions of high humidity (relative humidity >80%) and fresh circulating air. Affected specimens were also rehydrated orally. Three specimens with chronic dyspnea syndrome have progressed to a more acute stage. This stage is characterized by increased breathing difficulty, rales, resting with the mouth partly opened and drooling. The oral or nasal discharge is much more viscous and opaque than that observed during the initial stage of this illness. In its acute stage dyspnea syndrome may be equivalent to a pneumonia-like lung infection and does not appear to be reversible. Three specimens died within several weeks of the onset of the acute stage, even after oral rehydration and conditions of increased humidity were effected. The acute stage of dyspnea syndrome always seems to progress from the chronic state; specimens have never initially presented with symptoms characteristic of the later stage dyspnea syndrome.

All of the specimens that became affected with dyspnea syndrome had been previously housed for nine to twelve months in small, polyurethane-treated wood cages (80 cm high by 50 cm wide and 50 cm deep). These cages had glass fronts and a small screen opening (10 X 15 cm) in the top, effectively decreasing ventilation but keeping the humidity in the cage higher than that in the room. For logistical reasons, humidity was provided at the new facilities by spraying the cage with water once a day,instead of using an ultrasonic humidifier. Because of the lower ambient humidity experienced in California as compared to eastern Canada, it was difficult to maintain constant humidity within the cage above 60%, except during the period immediately following spraying.

It was thought that dry and/or stale air within the cages directly to poor ventilation may be causing the respiratory disorder observed in the ETBs, as others have observed a requirement by this species for freshly circulating air (Meyer-Holzapfel, 1969). We believe that dyspnea syndrome may reflect an inflammatory process in tissue that lines the airway. It is possible that dust particles, spores or other pollutants along with dry air irritate the cells that line the upper airway. Irritated cells would release excessive fluid into the airway leading to systemic dehydration. As the inflammation progresses it may move into the lower airway and possibly effect the lungs; more widespread inflammation may account for the later acute stage of dyspnea syndrome. Regions of inflamed tissue may also present a focus for opportunistic pathogens, further exacerbating symptoms. For two reasons, it is likely that the dyspnea syndrome observed in ETBs is caused by an inflammatory process due to inappropriate environmental conditions and not by a specific pathogen. First, animals with dyspnea syndrome did not respond to gentamicin, a powerful broad-spectrum antibiotic. Bacteria that are sensitive to gentamicin have been implicated as a causative agent of respiratory illness in boids (Ross, 1982). Second, dyspnea syndrome does not appear to be contagious. Healthy specimens failed to show any unusual symptoms when housed for several months with specimens that did show signs of the disorder.

To improve ventilation and internal air circulation while maintaining high humidity, some of the ETBs were moved to larger wood cages (80 X 50 X 50 cm or 200 X 100 X 60 cm) with screen tops and/or fronts. Plastic covering was positioned on the screen to maintain a balance between humidity and air flow. Humidity was maintained at about 80% spraying the walls of these cages once daily and by humidifying the entire room (room humidity was 50-60%). An air cleaner in the room maintained air quality and circulation. In the new cages no healthy specimens became ill. Moreover, symptoms disappeared in two specimens that were initially showing signs of the respiratory syndrome upon transfer to these cages. That dyspnea syndrome occurred after prolonged enclosure in small, poorly ventilated cages while symptoms disappeared when specimens were transferred to more ventilated cages (but with a relative humidity of >80%) strongly suggests that stale or polluted air is a significant factor in this disorder.

ETBs that had apparently recovered from dyspnea syndrome in the more ventilated cages reacquired symptoms of this disorder when they were allowed to remain at ambient room humidity (50-60%) for several days without additional spraying. In contrast, specimens that had never shown signs of dyspnea syndrome did not become sick under parallel conditions. This suggests that ETBs recovering from dyspnea syndrome have a reduced resistance to adverse environmental conditions. Moreover, it is likely that the hypothesized inflammation of airway tissue may be chronic in nature and thus damage done to this tissue may be irreversible or reversible only over a long period of time.

Gastrointestinal

A second major problem that we and others have encountered with newly-imported ETBs is regurgitation syndrome - the repeated regurgitation of freshly consumed meals (Ross, 1989). In our experience, ETBs usually feed readily[5] but after an indefinite period of regular feeding recently imported specimens will sometimes regurgitate a meal. Regurgitation was seen to occur three to ten days after consumption of the food item, and the regurgitated mass was often poorly digested. Specimens usually accepted food soon after regurgitation, but regurgitation was almost invariably repeated, often within a day or two after consumption in the second instance. What follows is a regular pattern of feeding and regurgitation resulting in weight loss, wasting and eventual death.

We have associated regurgitation syndrome with several additional symptoms including dullness and inelasticity of the skin, runny stools and severe weight loss. Actual regurgitation was often preceded by irregular coiling, with the part of the body that contains the food mass being looped loosely over the branch while the posterior portion remains tightly coiled over the branch in a characteristic manner. Although we have associated this behavior with regurgitation, it should be noted that we have observed similar loose coiling after a particularly large food item has been consumed by healthy specimens, and although this behavior may continue for seven days or more regurgitation has not followed in these cases.

The causes of regurgitation syndrome are not known, but inadequate hydration, Salmonella/Arizona-type infections, cryptosporidiosis, over-feeding and amebiasis have previously been suggested as possible etiological agents (Ross, 1989). Although regurgitation syndrome in other species, such as Redtail Boas from northeastern South America and Brazilian Rainbow Boas, could be treated by remedying one of the above situations, we are not aware of a single remedy that eliminates regurgitation syndrome permanently with ETBs. In a study conducted by the Institute for Herpetological Research, it was determined that husbandry practices and environmental conditions

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[5] *In one case where a recently imported ETB refused to feed a fecal examination revealed the presence of coccidial organisms. This specimen did feed regularly and without incident after treatment with the anti-coccidial agent Tribrisin™. Others (Wagner, 1987) have reported that specimens with mouth rot may also refuse to feed.*

may play a significant role in the etiology of regurgitation syndrome in ETBs. It was found that the survival of individual ETBs seemed to be dependent on their final destination. For example, out of a single shipment of imported ETBs, one group of specimens that was sent to Texas soon began regurgitating while another group that was shipped to the midwest all thrived. Consistent with these findings, there are several possible environmental factors which could play a role in the etiology of regurgitation syndrome. These include the quality of water, air and food. To test the effect of these factors on the husbandry of ETBs, one of us (R.A.R.) used purified (and softened) water, purified air and rodents purchased from a scientific laboratory supplier. Preliminary results suggest that while purified air seems to have no effect on the incidence of regurgitation syndrome in ETBs, poor food and water quality may be causative agents of regurgitation syndrome.

Regurgitation syndrome may result from chronic inflammation of the cells that line the gastrointestinal tract (Ross, 1989). An initial lesion in the gut tissue could result from a pathogenic agent, but as discussed above, specific pathogens that are known to cause gastrointestinal disturbances in other species have not as yet been linked to regurgitation syndrome in ETBs. Alternatively, rodents that are offered in a captive situation may be sufficiently different from the natural diet of the ETB to elicit an adverse gastrointestinal response. For example, perhaps the skin and fur or the fat content of certain food items makes them difficult for the ETB to digest. Indeed, one ETB that was maintained in captivity without incidence for about two years promptly regurgitated when fed for the first time an obese "retired breeder" mouse. Subsequent feeding with lean adult mice resulted in complete digestion but when another obese mouse was consumed several months later, regurgitation again occurred. In other cases, we have observed captive-born Red-tail Boas to regurgitate skin and fur when adult frozen rats were consumed, but an equal mass of 100 g rats in a single feeding was digested normally. Along these lines, we have been somewhat successful in breaking a steady pattern of regurgitation with several ETBs by allowing a specimen two or three weeks of undisturbed recovery following regurgitation, and then offering a very small food item (eg. a pre-weaning rat for a four or five foot specimen). If the food was accepted and properly digested, then the ETB was allowed to consume a slightly larger item. The size of the food item was gradually increased until weight loss by the specimen was halted. Unfortunately we have found that consumption of the quantity of food required by post-regurgitation ETBs for net weight gain often results in a relapse. It is thus imperative to take measures to prevent captive ETBs from falling into the wasting cycle of regurgitation syndrome. In this respect it is necessary to avoid overfeeding by either feeding too often or feeding inappropriately large or obese food items.

Treatment of Illnesses

We have found the treatment of respiratory and gastrointestinal illnesses in captive ETBs with drugs to be largely ineffective. Broad-spectrum antibiotics have not relieved symptoms in either dyspnea or regurgitation syndrome, and a host of other pharmaceuticals have proven ineffective in the latter illness (Ross,1989). We have suggested the involvement of inflammatory processes in both disease states described here; it remains to be determined whether anti-inflammatory agents might have beneficial effects in these instances. Given the deleterious nature of these illnesses, the difficulty in treating them and the likelihood that they only occur under incorrect captive conditions, it is advisable to provide ETBs with proper housing and feeding as outlined in the preceding text.

SUMMARY OF RECOMMENDED HUSBANDRY REQUIREMENTS OF ETBs

1. Housing

-vertically oriented enclosure with sturdy branches, of appropriate thickness, preferably placed at multiple levels.

-water in large container available at all times.

-high relative humidity (>80%); may be attained by frequent spraying with water, warming of water container or mechanical humidification (evaporative or ultrasonic).

-good air quality; cages and water must be kept very clean. Some ventilation is necessary. Plants may help maintain a suitable atmosphere with respect to humidity and air quality.

-temperature should be relatively constant, 25-30° C (cooling is probably unnecessary for breeding).

-12 hour photoperiod year round.

-specimens should be maintained individually.

2. Feeding

-avoid overfeeding; this species does not seem to tolerate obese or large food items. Food should be offered only after previous meal has been digested.

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THE USE OF CIPROFLOXACIN, A NEW ANTIBIOTIC, IN SNAKES

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INTRODUCTION

Ciprofloxacin is a member of the relatively new and rapidly developing class of synthetic antibiotics collectively known as the fluoroquinolones. Ciprofloxacin has been used by the authors for the treatment of various bacterial infections in snakes with great success over the last three years. Until 1990, our experience with this drug had been on a strictly empirical basis; however, in reviewing the good clinical results that the drug was able to achieve, it was decided to undertake more formal serum level and pharmacokinetic analyses to determine optimal dosage and frequency for commonly encountered bacterial pathogens.

The parent class of antibiotics, the quinolones, were first developed in the late 1950's and early 1960's. Nalidixic acid, introduced for human use in 1962, was the prototypical drug for this class. Unfortunately problems with toxicity, poor antibacterial spectrum, and rapid development of bacterial resistance prevented this antibiotic from reaching wide-spread usage. Though still available today, it is seldom used.

The quinolones, being wholly synthetic, were easily amenable to structural manipulation and it was only some 15 years before the first fluoroquinolone, ciprofloxacin, was entered into human clinical trials. These clinical trials revealed the drug to have a wide spectrum of antibacterial activity against many common gram negative bacteria -- the class of bacteria that causes many of the more notable infectious syndromes in snakes (necrotizing stomatitis, necrotizing dermatitis, and pneumonia). It was during these clinical trials that one of the authors (BPB) first became acquainted with the drug. However, ciprofloxacin was classed as "experimental" until 1989, and initial enthusiam for the drug had to await its approval by the FDA for general use.

CHEMISTRY AND MODE OF ACTION

Chemical modifications to the basic quinolone ring (see Fig. 1) from nalidixic acid to the modern class of fluoroquinolones served to both enhance the bactericidal action and antibacterial spectrum of the class. For all quinolones, the carboxyl group at position 3 and the keto group at position 4 are thought to be necessary for the inhibition of DNA gyrase. This enzyme is responsible for the supercoiling of bacterial DNA by a nicking, pass-through, and resealing process. Its inhibition, therefore, is thought to result in cleavage of the DNA backbone, accounting for its bactericidal (as opposed to bacteriostatic) mode of action. There is also some speculation that the fluoroquinolone molecule may actually bind to the DNA backbone and not to DNA gyrase, thereby inhibiting both the action of DNA gyrase and the series of enzymes responsible for DNA repair.

Addition of a fluorine atom at position 6 was the major change from the parent class of the quinolones. This modification resulted in two major enhancements; 1) markedly enhanced DNA gyrase inhibition, and 2) improved cellular penetration. This change was also felt to be responsible for the decreased toxicity seen with the fluoroquinolones. The further addition of a piperazine ring moiety at position 7 was found to impart anti-*Pseudomonas* activity to the molecule.

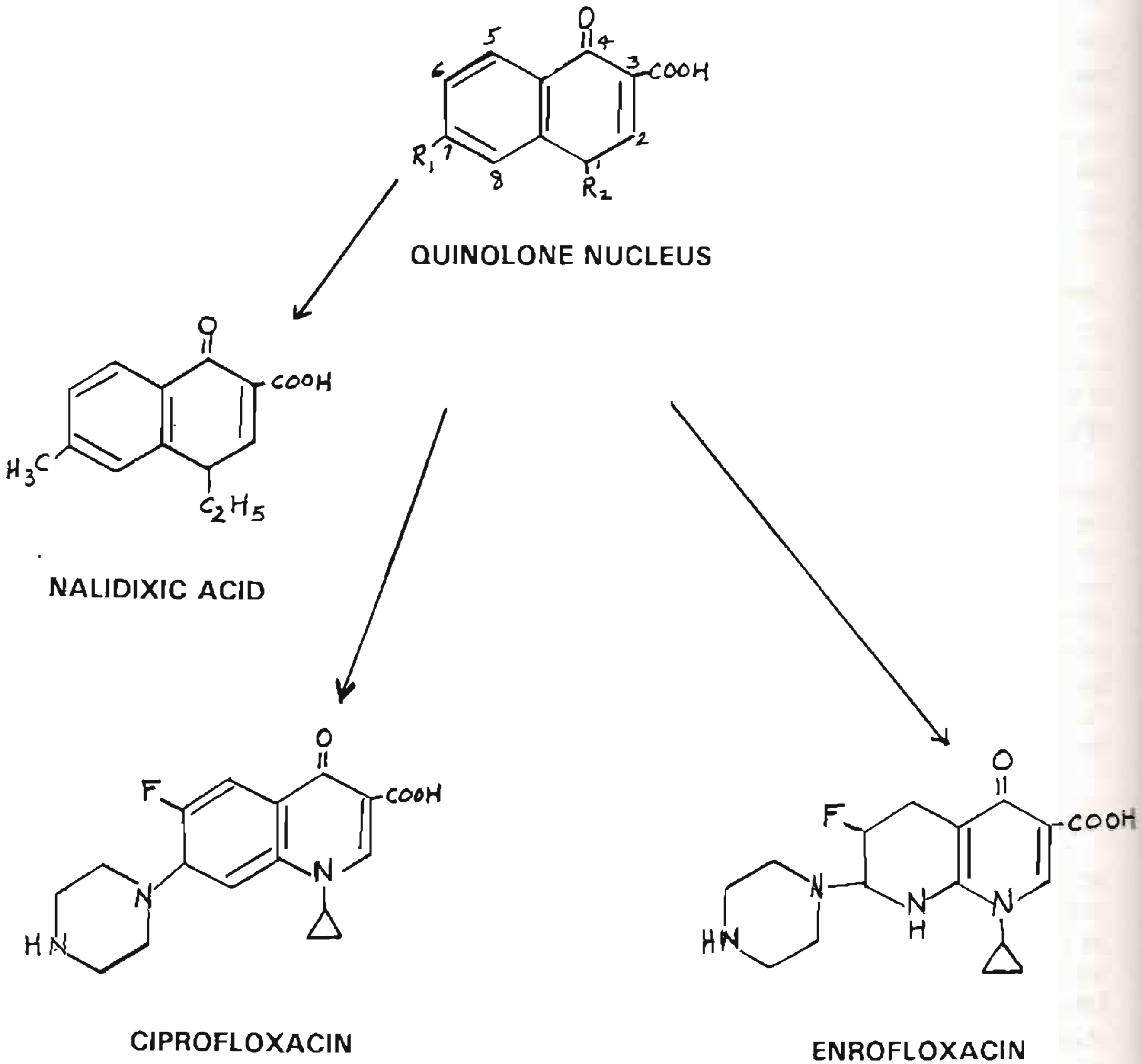


FIGURE 1. The basic quinolone ring.

The fluoroquinolones, as a class, are lipophilic and therefore dissolve poorly in water, making administration of the oral form of the drug rather difficult. Ciprofloxacin exhibits this same lipophilicity making it difficult to form a suspension from powdered tablets, (an intravenous form is now available; however, it is highly necrotizing if given by intramuscular injection and it is too unstable to be given orally). Orally administered, the drug has a bioavailability of 50-60 % in humans, and the lipophilicity ensures that the drug is widely dispersed throughout all the tissues of the body.

ANTIMICROCIAL ACTIVITY

The fluoroquinolones have a broad specturm of in vitro antibacterial activity (See Table 1). The gram negative rod bacteria, or Enterobacteriaceae, responsible for many of the infectious syndromes in snakes, in particular are susceptible to this class of antibiotics, suggesting that ciprofloxacin and its relatives could be highly effective for therapy in these situations. Ciprofloxacin has been shown to the most potent of the currently available fluoroquinolones against the Enterobacteriaceae, including *Pseudomonas aeruginosa*, as evidenced by the lower MIC_{90} (Minimum Inhibitory Concentration for 90% of bacteria isolated) values shown in Table 1. Ciprofloxacin has also been shown to be effective against several gram positive bacteria, most notably *Staphlococcus aureus*, which has recently been shown to be responsible for some cases of pneumonia and necrotizing dermatitis in snakes. Additionally, ciprofloxacin has been shown to have activity against several of the Mycobacteria, most notably *Mycobacteria tuberculosis*, *M. fortuitum*, and *M. kansasii*. Though most noted for causing the disease tuberculosis in humans, *M. tuberculosis* and its relatives have been known to cuase infectious syndromes in reptiles.

In limited studies, the quinolones have been shown to exert either indifferent, additive, or occasionally synergistic effects with other antibiotics. It has never been shown to impart an antagonistic effect on any antibiotic used in conjunction with it.

Bacterial resistance to ciprofloxacin has already been demonstrated and apparently results from DNA point mutations that result in conformational changes in either of the two subunits of the DNA gyrase complex that preserve its function. This has not yet been demonstrated to be plasmid mediated, but rather a case by case spontaneous mutation that occurs infrequently in most bacterial strains (estimated at less than 1 in 10^{11} bacteria). However, such mutations have been noted to be up to 1000 fold more frequent in *P. aeruginosa* and mycobacteria, raising concerns for the drug's continued use in reptilian medicine. Cross resistance generally does occur between closely related members of the fluoroquinolones, but not between the fluoroquinolones and other antibiotic classes. However, rare strains of *P. aeruginosa* have been shown to be cross resistant to ciprofloxacin, aminoglycosides, beta-lactams, chloramphenicol, trimethoprim, and/or tetracyclines. Resistance in these particular strains appears to be due to altered permeability of the bacterial cell membrane to the drugs, and not to any alteration of internal chemistry or structure.

TABLE 1. In Vitro Antimicrobial Activity of Enrofloxacin and Ciprofloxacin

	Minimum Inhibitory Concentration (MIC) Range (μg/ml)	
Organism	Enrofloxacin	Ciprofloxacin
Gram Negatives		
Escherecia coli	<0.01-0.5	0.003-1.0
Enterobacter ssp.	--	0.003-8.0
Enterobacter ssp.	<0.03-0.5	0.004-2.0
Klebsiella ssp.	0.003-0.5	0.002-0.5
Salmonella ssp.	0.03-0.5	0.002-2.0
Citrobacter ssp.	0.25-0.5	0.002-8.0
Pseudomonas aeruginosa	0.25-2.0	0.015-8.0
Serratia ssp.	0.01-1.0	0.015-4.0
Gram Positives		
Staphlococcus aureus	0.03-1.0	0.1-2.0
Staphlococcus epidermidis	--	0.15-1.0
Streptococcus ssp.	0.06-4.0	0.006-4.0

PHARMACOKINETICS

All the pharmacokinetic data available on ciprofloxacin are from human studies and therefore probably do not have relevance. In genreral the drug is well absorbed when given orally, with 50-85% of the drug being absorbed from the GI tract. The presence of food in the GI tract decreases the rate, but not the extent of the absorption. Peak serum concentrations are reached in 0.5 to 2.3 hours.

Following oral administration, the drug is widely dispersed throughout the tissues of the body, including lungs, bile and gallbladder, liver, kidney, uterus and fallopian tubes. Concentration of the drug in these tissues usually substantially exceeds serum levels. Ciprofloxacin is also distributed to bone, skin, muscle, fat, cartilage and pleural, peritoneal, and lymphatic fluid. Only low concentration occurs within the central nervous system, however.

Elimination of ciprofloxacin occurs by both renal and hepatic mechanisms, with an average serum half-life of 3-5 hours in normal adult humans. Impaired renal or hepatic function results in increased half-life and dosage much be adjusted downward in patients with severe kidney or liver dysfunction.

SIDE EFFECTS

In humans, side effects due to ciprofloxacin are relatively rare and involve primarily the GI tract (nausea and vomiting, diarrhea, and liver abnormalities) and central nervous system (headache, dizziness, and nervousness). One side effect of possible concern to herpetologists using this class of antibiotics, is the development of arthropathy, or arthritis, in developing, i.e. growing, animal models (rodents). For this reason, even though it has been reported in less than 1% of cases, the fluoroquinolones carry an absolute contraindication for humans under the age of 18. It has rightly been pointed out that as snakes continually grow and have thousands of joints, that they might also be susceptible to developing ciprofloxacin-induced arthritis. This would also be a concern, obviously, for gravid females. At present, there is no good evidence that ciprofloxacin is either safe or detrimental in this regard. In over three years of clinical usage, no signs of difficulty in adult animals has been noticed, and usage in gravid females has been avoided.

One side effect that has been noticeably absent with the use of the fluoroquinolones is renal impairment. Transient elevation in BUN and creatinine have been noted, but these resolve with cessation of therapy. More importantly, nephritis and acute renal failure, as may be seen with the aminoglycosides in reptiles, is exceedingly rare.

EXPERIENCE TO DATE

As stated earlier, all usage of ciprofloxacin clinically has been on an empiric basis, i.e., the dosage that got the job done. The dosage most commonly used has been in the range of 20 mg/kg given once daily of a suspension of the powdered pill form mixed in distilled water. With this regimen the authors have seen high success rates in treating necrotizing stomatitis (mouth rot), necrotizing dermatitis (scale rot), and pneumonia. Treatment has usually been begun empirically as well, i.e., prior to definitive culture and sensitivities testing on bacterial isolates when they are available. With its wide spectrum and low MIC values, changing to a second antibiotic based solely on culture results has been a rare occurrence. Occasional therapeutic failures, despite culture results that support ciprofloxacin as appropriate therapy, have been noted however, and has resulted in alteration of drug therapy - either changing to a different antibiotic, or prompting the addition of a second antibiotic.

The authors are aware that others have also used ciprofloxacin with apparently great success, but in dosages far exceeding that listed in the above paragraph. Dosages of upwards of 250 mg/kg per day have been reported with no apparent ill effects on the treated animal(s). The authors can make no comment about the safety or advisability of such high dosages.

Given such a disparate range of dosage, both with apparently equal clinical success, the authors determined to undertake a controlled study to determine optimum dosage and frequency based on serum levels of the drug compared to MIC values for bacterial isolates. The remainder of this paper deals with study design and results.

PURPOSE OF THE STUDY

This study was conducted to:

a) investigate Ciprofloxacin as a therapeutic agent in snakes
b) arrive at an appropriate dosage schedule
c) investigate potential renal impairment due to the usage of Cipro in snakes.

LIMITATIONS OF THE STUDY

This study was not designed as a comprehensive trial of all species of snakes. The obvious limitation is that it was done on only one species of snake and that the sample size is not great as it could be. However, the group is large enough to produce valid results which are representative of the drug's activity in snakes. It is hoped that such studies will stimulate further work to validate and modify the data produced.

SUBJECTS FOR THE STUDY

Eight wild caught reticulated pythons were obtained for the study group. These snakes ranged in size from 1.2 lbs. to .34 lbs. The subjects were isolated and a thorough physical examination performed. Fecals were obtained, and internal parasites treated with an appropriate agent. All signs of infection were treated with piperacillin at 40mg/lb every 48 hrs. as indicated by culture/sensitivity. The snakes were maintained individually in Sta-in-pet® cages for ease of cleaning/disinfection and for thermoregulation. The background temperature was 80° F with each cage provided with an under-cage heating pad for thermoregulation.

Two of the original eight animals died from *pseudomonas* abscesses of the lungs. Due to the fact that the intial isolation, treatment, and supportive care took over 6 weeks, it was impossible to obtain more subjects in time for the study.

Once healthy, subjects were caged as previously described and fed fuzzy rats. The Cipro study did not commence until each individual had been healthy for, and received no medications for three weeks. All participants were feeding prior to onset.

STUDY DESIGN

The study was broken into two phases. The first phase consisted of giving a certain mg dosage of Cipro and obtaining serum samples at set intervals. The mg dosages used were 2.5, 5.0, and 10.0 mg per lb. Serum was collectued for both Cipro level determination and uric acid evaluation. This phase was designed to answer the question of how much Cipro is required to produce effective yet safe blood levels.

The second phase consisted of administering a certain mg dosage every 24 or 48 hrs. and measuring both Cipro and uric acid levels. Phase two answers the question of how often Cipro should be administered.

Renal toxicity as measured by uric acid levels was also an important goal of the study.

COLLECTION OF SAMPLES

Each subject was x-rayed to determine the approximate location of the heart. The subject was then measured for this location and observed for a resting heart beat. Once located, a scale was tagged to mark the target. The blood was collected through an intra-cardiac puncture with a 25 gauge needle, and a 3cc syringe. Each sample consisted of 1.5 to 2ccs of blood, which was immediately centrifuged. The resulting serum was separated and placed in micro-serum tubes which in turn were frozen at -20° F pending processing by Miles labs.

No adverse effects were noted after the intracardiac punctures. I would postulate that a major part of the reason for this is the rapid clotting of the blood which would minimize leakage after puncture of the heart. If the serum is not immediately spun down and collected the clotting factors will gelatinize the serum rendering it useless. Using a heparinized needle facilitated collection while some samples collected without heparin clotted within the needle. I also feel that the primitive nature of scar tissue formation in reptiles helps prevent scar tissue and inflammation which could cause many complications in mammals.

DRUG ADMINISTRATION

Cipro is an extremely water insoluble drug, so a suspension is not available. An experimental injectible is being developed, but is not currently available for use.

A 250mg tablet was ground with a mortar and pestle into a fine powder. An entire tablet was used to provide uniformity of drug quantity which might be lacking in partial tablets. This powder was then mixed with distilled water as tap water inactivates the drug due to ion/cation reactions. The drug was mixed fresh and administered immediately to insure potency as the mixture has a shelf life of only 4 hrs.

The mixture was administered via stainless steel, round-tipped feeding needles.

DEFINITIONS REQUIRED TO BETTER UNDERSTAND THE STUDY

A measure of the in vitro antimicrobial activity of a drug is often represented by the minimum inhibitory concentration or MIC. The MIC of a particular drug is that concentration in the serum that must be obtained to eliminate a particular bacterial agent. For instance, the MIC for Cipro for *E. Coli* is 0.003-1.0 ug/ml, nad for pseudomonas is 0.015-8.0 ug/ml. In other words, Cipro would have to be at least five times the level in the serum to eliminate *Pseudomonas* vs. *E. Coli.*

A major portion of our study was to see what doses of Cipro produced what serum levels to make sure the MIC value of pathogenic bacteria is met or exceeded. It is important as well to see what frequency of administration is required to continue to the meet the MIC value.

RESULTS OF PHASE I

Six snakes were divided into three groups of two. Each of the three groups were given 2.5, 5.0, or 10.0 mg/lb. Blood tests for Cipro and uric acid levels were drawn at prescribed intervals, (see graphs nos. 1 & 2).

The snakes given 2.5 mg/lb produced much lower peak levels, but yet still exceeded the MIC 50 for many hours. If Cipro were excessively toxic, then this dose would be adequate. However, 5.0 mg/lb produced a quicker peak, and maintained a more stable peak; 10.0 mg/lb offered no real advantage over 5.0 mg/lb.

RESULTS OF PHASE II

A group of four snakes was divided into two groups. One group was given 2.5 mg/lb orally every 24 hrs. and serum samples collected at 24, 48, 72, and 96 hrs. The other group was given 2.5 mg/lb orally every 48 hrs. and serum collected at the same intervals, (see graphs nos. 3 & 4).

Once completed, the same regimen was followed, except giving 5.0 mg/lb at 24 and 48 hr. intervals instead of the 2.5 mg/lb.

The group given 2.5 mg/lb maintained levels just below the MIC 50 level, while the 5.0 mg.lb group maintained levels well above the MIC 50 level. The Cipro peaks within 2-3 hrs. of dosage and maintains a good level for 6-8 hrs. before dropping. Dosing at 24 or 48 hrs. didn't seem to make a large difference. In other words, Cipro doesn't accumulate such that a dose every 24 hrs. produces higher and higher levels. A dose given every 24 hrs. will peak within 2-3 hrs., level off for 6-8 hrs., and drop slowly over 48 hrs. Doses given every 48 hrs. produce only one peak, but levels will remain adequate for 48 hrs.

URIC ACID STUDY

Uric acid levels were not affected by any of the doses or schedules used. The highest uric acid level seen was 4.4 and this was a level before the study. This same snake had a uric acid of 1.9 after the Cipro! No reliable pattern was seen, and such random results indicate that there is no appreciable effect on the kidneys as measured by uric acid levels, (see Chart no. 5).

CONCLUSION

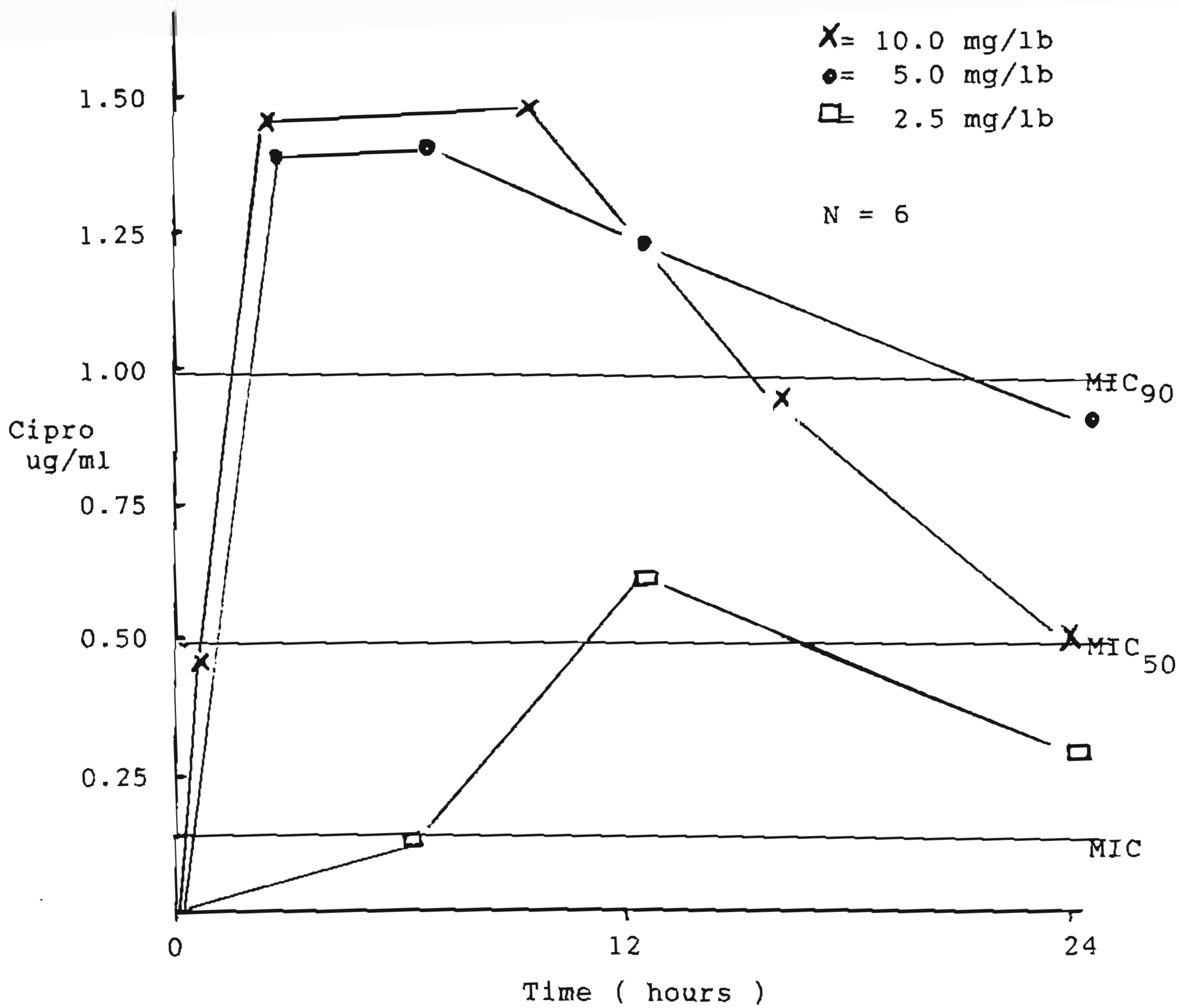
Ciprofloxacin appears to be a major new drug for use in reptiles. Oral doses of 5.0 mg/lb given once every 48 hrs. produces predictable and excellent levels, above the MIC 50 of the typical bacterial found in reptiles. The drug peaks within 2-3 hrs. and maintains this peak level for 4-12 hrs. before dropping off over a 48 to 72 hr. time period. The drug does not appear to accumulate in the body.

It is important to note that this is an oral drug, and must be mixed with distilled water. Once mixed the drug is good for only 4 hrs., so must be mixed fresh each administration.

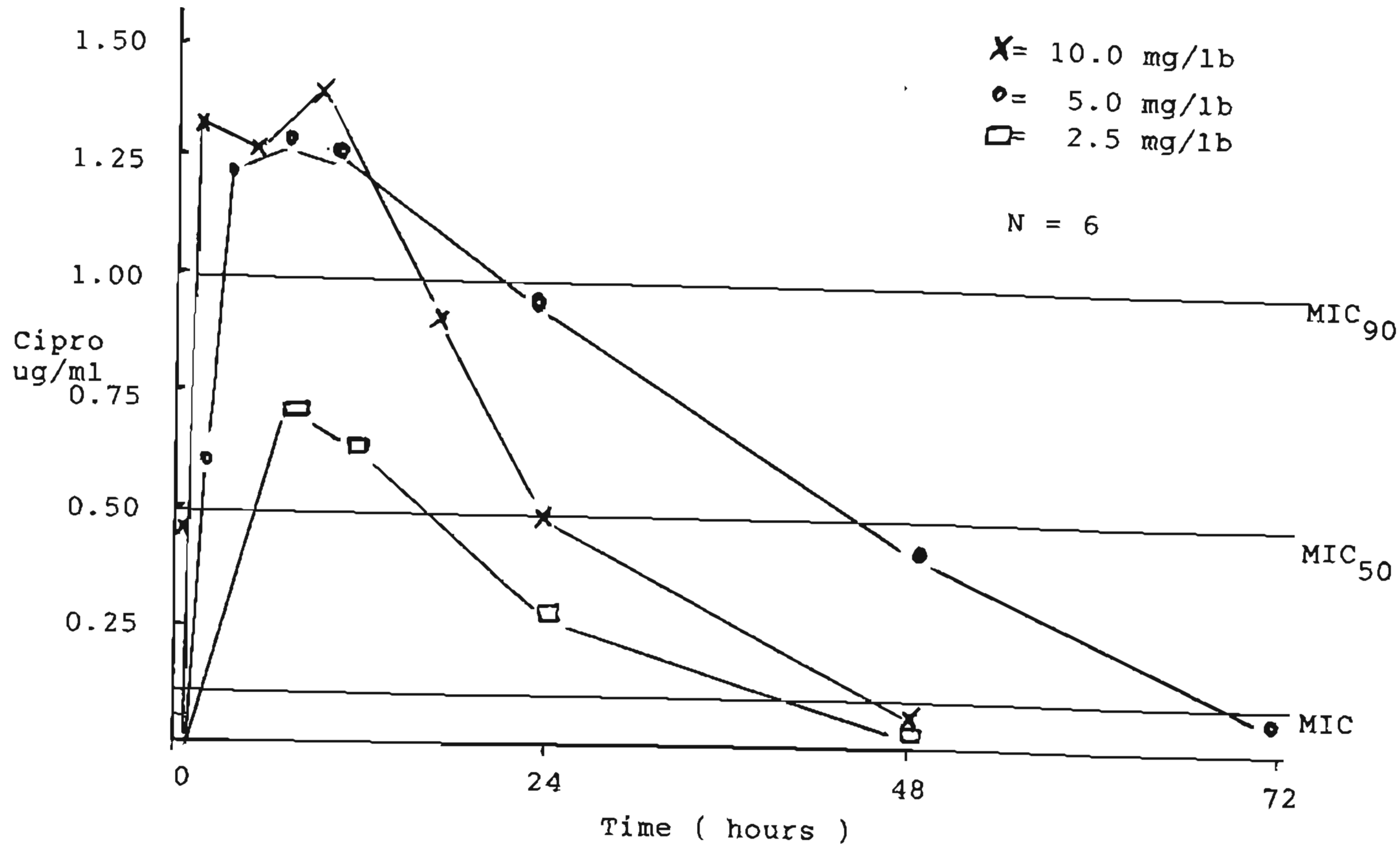
Despite these limitations, this drug appears to be a drug worth the trouble. As Cipro is synergistic with drugs such as the aminoglycosides, improved penicillins, etc. this makes it an extremely versatile drug.

CLINICAL TRIALS

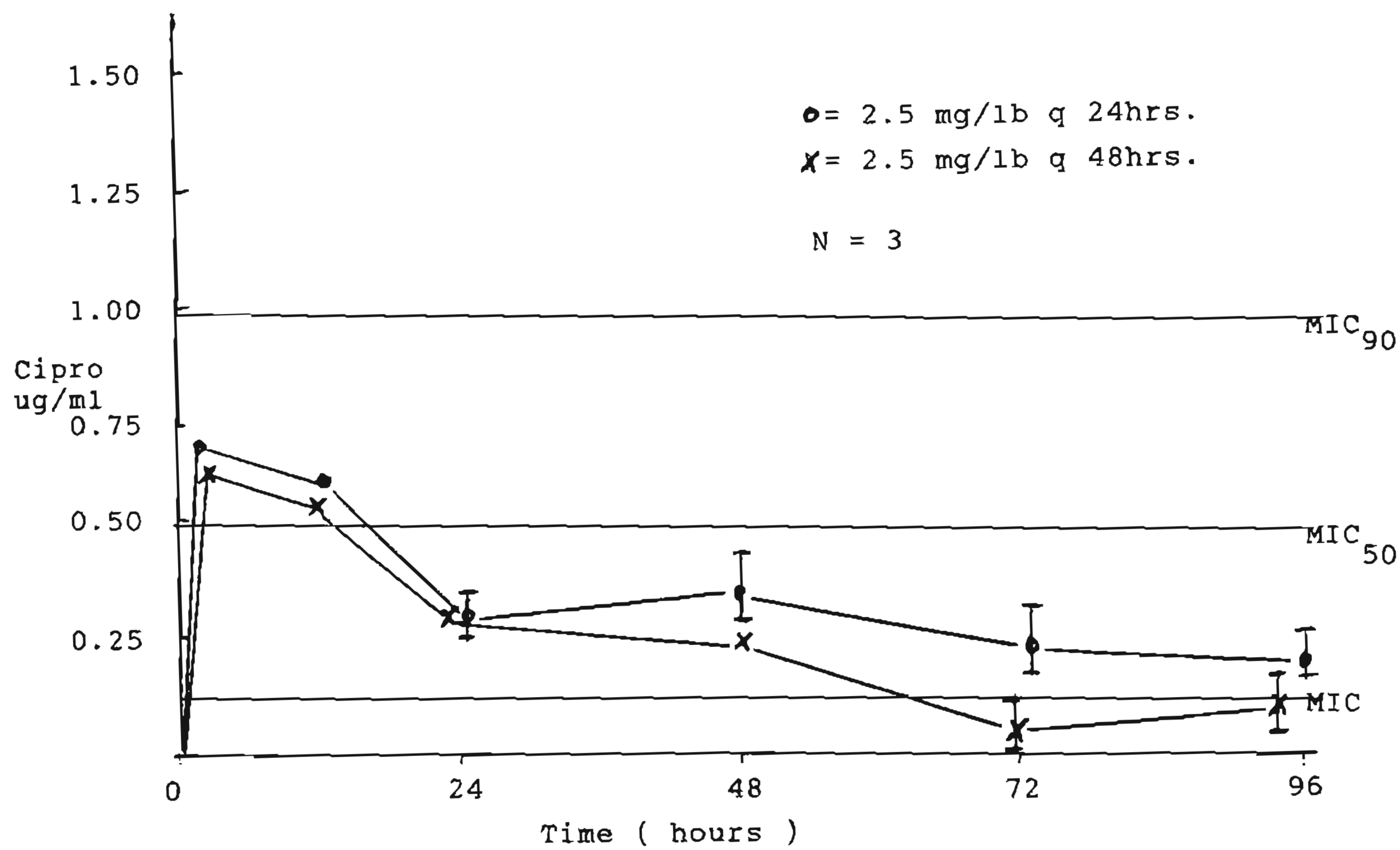
I have used Cipro for the last 18 months in over 100 reptiles with infectious conditions ranging from mouth rot, scale rot, abscesses, pneumonia, etc. with impressive results. No apparent toxicity has been seen, and better results have been seen than with Amikacin, piperacillin, etc. The fact that this drug is synergistic with these other antibiotics makes it nearly impossible to have bacteria resistant to treatment.



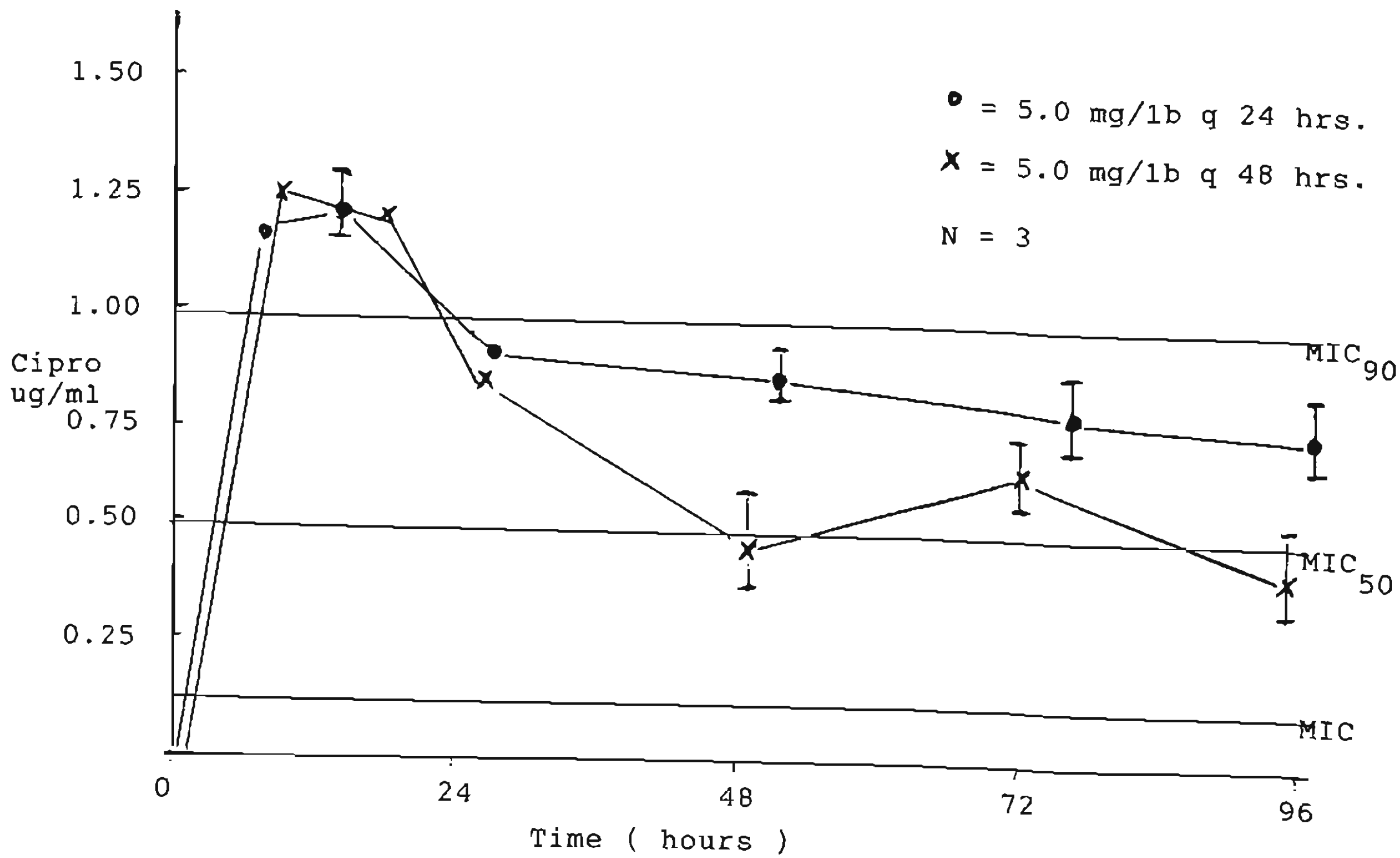
Graph 1. Cipro vs. Time



Graph 2. Cipro vs. Time



Graph 3. Cipro vs. Time



Graph 4. Cipro vs. Time

Chart 5. Uric acid levels.

The following uric acid levels are taken from a snake from each dosage protocol and are representative of values seen in the other snakes. N/A reflects an inability to produce adequate serum or other complication in the lab that prevented a level from being detected.

CIPRO (mg/lb)	HOURS						
	0	6	12	24	48	72	96
2.5	4.2	N/A	4.4	4.8	2.9	2.4	N/A
5.0	4.1	4.0	2.4	2.4	4.1	4.6	N/A
10.0	4.4	1.9	2.3	N/A	1.9	2.1	N/A
2.5 q 24 hrs.	4.4	4.6	N/A	4.4	2.8	2.4	3.7
5.0 q 48 hrs.	N/A	2.8	2.6	3.7	3.4	2.6	3.6

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BREEDING THE DESERT HORNED VIPER (*CERASTES CERASTES*) IN CAPTIVITY

Larry Moor

INTRODUCTION

The Genus *Cerastes* contains two species, *Cerastes cerastes* (Linneaus) and *Cerastes vipera* (Linnaeus). Both are desert species found in Northern Africa and the Middle East. Currently two subspecies of *C. cerastes* are recognized. *C. c. cerastes* (Linnaeus 1758) occurs from Egypt west to Morocco, Mauritania, Mali and Niger, and in the southern half of Israel. *C. c. gasparetti* is found throughout the Arabian peninsula and in Iraq east of the Euphrates (Joger 1984, Welch 1982). Taxonomy is by no means unanimous regarding these snakes, and some changes/additions can be expected.

Cerastes cerastes is a small (up to 850 mm) snake, with typical viper shape. The head is broad, flattened, and very distinct from the neck; the body is stout and ends in a short tail. Color varies regionally, but is a combination of reds, browns, yellows and greys. The pattern is indistinct blotches in four to six longitudinal series, with some specimens having faint blue spots interspersed. *Cerastes'* main characteristic is a large 'horn' above each eye, which is actually a single enlarged scale. The purpose of this horn can only ever be guessed at, but I have noticed that when a snake is basking directly under a light bulb, the horn casts a vertical shadow over the vertical eye pupil, so it may be a shading device. Both subspecies of *C. cerastes* occur in some areas without the horn present.

Although an attractive and undemanding species, *C. cerastes* is not a common display species. Slavens' 1990 Inventory lists only thirty-three specimens in captivity among fourteen institutions/private keepers. Successful breedings are a rarity and the same Inventory lists only one, in which a zoo produced one hatchling which did not survive. Most specimens offered for sale by U.S. dealers come from Egypt (Louis Porras, Zooherp Inc., pers. comm.)

CAPTIVE HUSBANDRY

HOUSING

Two male and one female *Cerastes cerastes cerastes* were obtained in October 1982 from a dealer in Victoria, B.C. All three were adult and originated with a German dealer who caught them in Tunisia a few years previously. They were housed together in a glass tank 900 X 600 X 300 mm high, and two still live in this cage. Substrate is 50 mm depth of swimming pool silica filter sand, which is natural-looking, dustless and does not have sharp edges. The cage lid is half transparent plastic and half plywood, the plywood part housing the light fitting and ventilation holes. Heat and light are supplied by two 40 Watt incandescent light bulbs situated 150 mm above a basking rock. This basking rock is a piece of rough slate approximately 380 X 300 X 20 mm thick which spans two small pieces of wood set in the sand. The dark color of the rock absorbs heat, and provides heat to the hiding place underneath it. Light come on noted below. Daytime temperature on the basking rock is 40° C, beneath the rock it is 33° C and in the cool end of the cage it is 24° C. At night the entire cage cools to 24° C. (See Figure 1 for cage setup).

FEEDING

My adult *Cerastes* are fed approximately every ten to fourteen days, and at this time each consumes two or three adult mice or a half-grown rat. Thawed or freshly-killed rodents are waved in front of the snakes until seized. Some caution is necessary here, as they strike lightning fast over an impressive distance, and long forceps must be used. There is also a risk of one snake biting the head of another. Once or twice a year I supplement the meal with cod liver oil to provide extra vitamins A and D_3.

WATER

When the snakes were first acquired, water was offered in a shallow glass dish. The snakes were never seen to drink, even after several days deprivation, and eventually it was removed. In Namibia I have seen *Bitis peringueyi* lick night-time condensation from their back, so I tried misting the snakes at night. This did not induce them to drink, and seemed to cause great agitation as all three snakes would writhe around on their back as if trying to rub off the water. Since then no water has been given.

CAPTIVE BEHAVIOR

My *Cerastes* are usually seen early in the morning lying on the basking rock, waiting for the lights to come on. When this happens they bask for a few hours, then crawl under the rock. In mid summer they often move to the cool end of the cage where, using a sideways 'shuffle', they bury themselves in the sand with only the top of the head, eyes and horns sticking out. They will also hide like this when hungry, presumably to conserve energy. Recently-fed snakes, and the gravid female, spend correspondingly more time basking. My snakes shed once or twice per year.

BREEDING

Early after I acquired the three snakes it was apparent that some mating/territorial behavior was happening. The larger male (male A) would chase the smaller male (male B) from the shelter of the rock and banish him to the cool end of the cage, often lying on top of him there. Just as often he would chase the female across the cage, and she seemed just as anxious to get away from him. Television shows usually depict sidewinding as a slow, laborious process, but these snakes speed across the sand at a furious rate, covering the 900 mm in less than a second. I observed nothing at the time that could be called mating behavior, but by April of 1983 male A had established dominance over male B (who more or less now lived at the cool end of the cage) and paid more attention to the female. She would flee from him, then stop and waver her tail in a vertical plan, with her cloaca wet and partially open.

FIRST CLUTCH

At 1325 hrs on May 20th 1983 the female and male A were found basking on the rock and copulating. They continued throughout the day, and were still coupled the evening of the next day. On July 27th fourteen eggs were laid under the basking rock. These were removed and incubated in a mixture of Vermiculite and water (1:1 by weight) at 30°C. Most of the eggs started to go bad after a few weeks, and they were opened up one by one. All had been fertile, and the fetuses had died in various stages along development. The last egg was opened on September 29th and contained a live snake which survived.

SECOND CLUTCH

The 1984 breeding followed the same pattern as the previous year, except that the snakes were cooled during February by leaving the lights off for the whole month. No food was offered at this time. Normal feeding and lighting resumed in March. Male A was observed copulating at 0900 hrs on April 14th, and was still coupled at 2330 hrs. He was seen copulating at 1100 hrs on April 30th, still coupled at 2330. Thirteen eggs were laid on July 14th, and these were incubated as described above. Once again they started to rot, and each, when opened, revealed a partially developed fetus. Seven babies were saved, but they were in poor shape, were unable to shed, and only two survived.

THIRD CLUTCH

In January 1985 I sold male B. He had never attempted to mate, was showing signs of stress, and was completely ignored by the other two snakes. His removal was a mistake, as no mating took place during 1985, and no eggs were laid that year. In fact nothing happened until 1989, although I continued to cool the snakes for one month each year, but for the month of March. Since I had only seen copulation in April, I decided that March would be a better month for cooling. In April 1989, when normal feeding and lighting had resumed, I introduced into the cage the snake born in 1983, which was a male (male C). Combat was seen immediately, and on April 30th copulation between male A and the female was seen. Male C was removed in May, and a 40 Watt red incandescent light bulb was installed at the cool end of the cage, and left burning continuously. This was on the advice of Tom Mason of Metro Toronto Zoo, who thought that the female might be too cool at night. Eighteen eggs were laid on July 5th, and these were incubated in freshly gathered, wet sphagnum moss at 33° C. Two eggs collapsed and rotted, but the remaining sixteen hatched on August 18th. The neonates were left in the incubator until all had shed.

CURRENT BREEDING

In 1990 I followed the order of events as for 1989, but instead of using male C to stimulate combat and breeding, I introduced a larger male obtained from a U.S. dealer. Although male A showed some dominant behavior, no mating took place and no eggs were laid. I subsequently discovered that the new male originated in Egypt. In 1991 male C was again introduced, as well as a pair of Egyptian *Cerastes*. Male A chased and lay on male C, but ignored the Egyptian snakes. He was seen mating with the Tunisian female at 1200 hrs on May 13th. To date no mating activity has been seen involving the Egyptian snakes.

The gravid female sheds about a month after copulation, and lays eggs shortly thereafter. She refuses food and basks continually. After the shed I remove the basking rock and substitute a plastic box 400 X 400 X 100 mm high full of wet sphagnum moss, with a hole cut in the lid. After the eggs are laid I substitute a complete lid, and since 1989 I remove the box and place it in he incubator. This way I do not have to handle the eggs. All the eggs produced by my *Cerastes* have been very soft and thin skinned - about 30 mm long and the consistency of overripe grapes - and the mere act of picking them up can rupture the skin.

CARE OF NEONATES

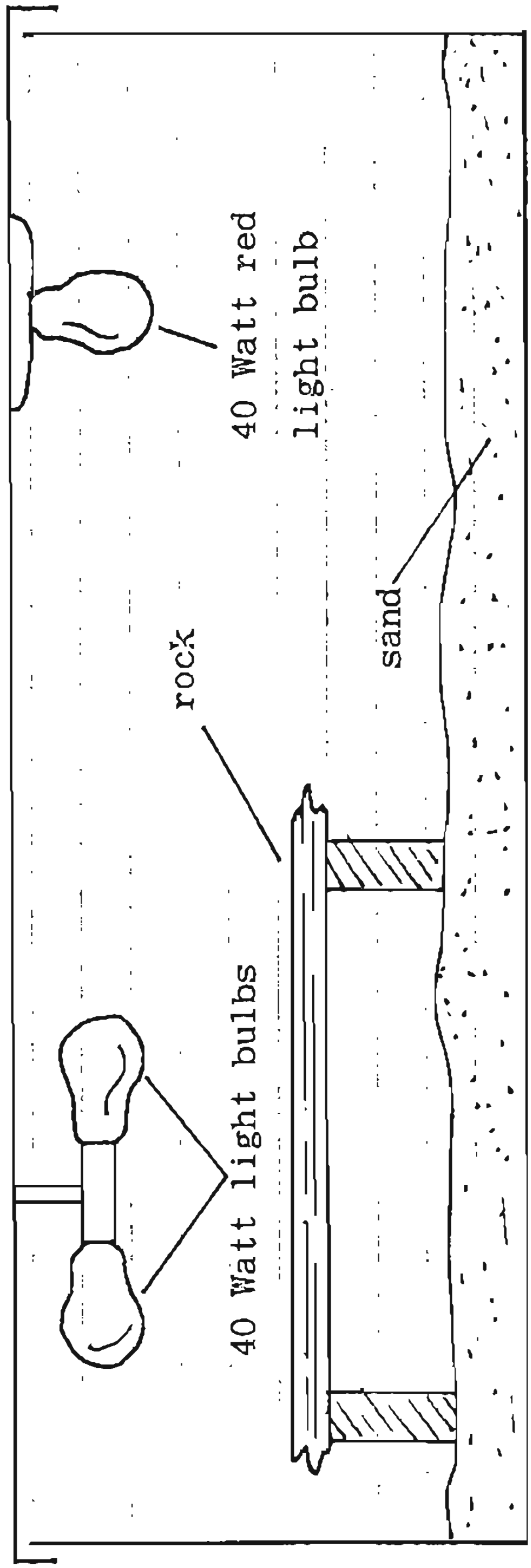
Hatchling *C. cerastes* are approximately 120 mm long. I house them in sandwich-type plastic boxes, which are laid over a heat tape. No overhead lighting is used. The babies from 1983 and 1984 never ate voluntarily at first, and were force-fed pink mice three or four times before they would accept these on their own, after which they thrived. The 1983 hatchling is still in my possession and currently weighs 400 g. The two hatchlings from 1984 were housed together, and after three months one killed and attempted to eat the other, dying in the process. Of the sixteen babies born in 1989, one died a few days after birth,but the rest are still thriving. They were housed together on 10 mm of sand in a plastic box 150 X 300mm laid over a heat tape. I would drop a live pink mouse in every morning, then check to see which snake had a lump in its body later on. As each snake ate, it was removed and placed in a plastic 900g size margarine container. Four neonates consistently refused pink mice, and rather than force-feed them I gave them newborn and juvenile Leopard Geckos (*Eublepharis macularius*). I had started breeding these geckos the previous year for just such an occasion. After three or four geckos, each snake readily took pink mice. Unlike adults, neonate *C. cerastes* drink water readily, and I keep a dish with them at all times.

CONCLUSION

Cerastes cerastes is an easy species to keep. A roomy cage, 50 mm or so of sand, and a basking spot with sufficient heat is all that is needed. Suitably sized mice form the total diet. Breeding *C. cerastes* is a more complex process: I attribute my success to the following four factors:

1. Male combat. Chasing a rival male stimulates the dominant male to begin courtship. Whenever I have introduced an extra male from the same geographical location, I have induced a successful breeding. Genetic isolation seems to prevent *C. cerastes* from Tunisia recognizing specimens from Egypt (the two countries are 1300 km apart at the closest point);
2. Large cage size. Only when the dominant male has banished the subordinate one to the farthest point possible will he pay attention to the female.
3. A continuous heat source for the gravid female. She is pregnant during the two hottest months in North Africa, and will bask at 32° C continually;
4. High heat (33° C) for egg incubation. This I believe to be the main factor in the increased egg hatch and survival rate.

FIGURE 1. Diagram of Cage Setup.



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METABOLISM OF EMBRYONIC REPTILES

Michael B. Thompson

INTRODUCTION

Eggs are arguably the most vulnerable stage of reptilian life cycles. For most species, eggs are deposited in a nest and abandoned by the mother. Some species spend considerable time building a special nest (e.g., *Alligator*), constructing the nest chamber (e.g., *Sphenodon*), and/or guarding the nest after oviposition (e.g., *Alligator, Sphenodon*, pythons). However, for the most part, reptilian eggs must sustain fluctuations in the physical conditions within the nest and are vulnerable to predation.

The physical conditions most likely to influence embryonic development and which may fluctuate within a nest or vary among nests are water potential, temperature, and concentrations of oxygen and carbon dioxide. There has been a plethora of research that shows the importance of the hydric condition of incubation for successful development and hatchling fitness, especially for soft-shelled eggs of turtles and squamates (G.C. Packard & Packard, 1988). However, the influences of temperature and gases are not so well known but have potential influences as profound as those of water availability.

The influences of temperature and concentrations of respiratory gases are linked. As temperature increases, the rate of oxygen consumption and carbon dioxide production increases, potentially modifying the gaseous environment of the nest. There are few measures of gas tensions in natural nests (Ackerman, 1977; Thompson, 1981; Booth & Thompson, 1991), but ease of measurement means that there are more data on rates of respiration in individual eggs throughout the incubation.

Incubating eggs at different temperatures and measuring the rates of oxygen consumption throughout allows estimation of the length of incubation, maximum rate of oxygen consumption, total amount of oxygen consumed for embryonic development and the pattern of change of rate of oxygen consumption during incubation.

Lower temperature of incubation results in longer development in embryonic reptiles. With longer incubation, one may expect that the total cost (measured as total oxygen consumption) of incubation may be higher. The first estimate of cost of incubation in reptilian eggs, a sea turtle (Ackerman, 1981), measured at 30° C was half to two-thirds that of an avian egg of equivalent size. The hypothesis suggested to explain the lower than expected cost of incubation was the low incubation temperature (30° C compared to about 38° C in avian eggs)c (Ackerman, 1981).

I tested that hypothesis by incubating and measuring the rate of oxygen consumption in eggs of the Australian chelid turtle, *Emydura macquarii*, at 25° C and 30° C (Thompson, 1983). Following that, I repeated the measurements on eggs of tuatara, *Sphenodon punctatus*, at 18° C, 20° C, and 22° C (Thompson, 1990), *Alligator mississippiensis* (Thompson, 1989), leatherback turtle (*Dermochelys coriacea*) (Thompson, in press), taipan (*Oxyuranus scutelatus*) and bearded dragon (*Pogona barbatus*) at 30° C (Thompson, unpubl. data).

METHODS

Eggs in these studies were collected in natural nests (*E. macquarii, A. mississippiensis, D. coriacea*), taken from females after induction using oxytocin (*E.*

macquarii, S. punctatus) (Ewert & Legler, 1978; Thompson et al., 1991) or bred in captivity by the Australian Reptile Park (*O. scutelatus, P. barbatus*). All measures of oxygen consumption were made using closed-system respirometry: Gilson (*E. macquarri*), Warburg (*S. punctatus*) or single chamber (all other species) using the method of Vleck (1987) and an Ametek oxygen analyzer. Temperatures at which measurements of oxygen consumption were made were the same as the temperatures of incubation.

Eggs used for measurements of rates of oxygen consumption were incubated at constant water potential, either in sand (*E. macquarii*) or vermiculite (all other species). Except for *E. macquarii* where eggs were completely buried, all eggs were approximately half buried in the substratum. Eggs and substratum were weighed periodically and water added to adjust for absorption by eggs or losses from the incubation chamber through evaporation.

All measures of rates of oxygen consumption were transformed to STPD and curves generated throughout incubation for each egg were integrated to give an estimate the total quantity of oxygen consumed during incubation. These values were compared among species and temperatures of incubation within species.

RESULTS

Length of incubation. For the species that I incubated at more than one temperature, higher incubation temperatures resulted in shorter incubation (Table 1). I used the time to pipping, in days, as the measure of incubation time (Gutzke et al., 1984).

Cost of incubation and maximum rate of oxygen consumption. Larger eggs consume more oxygen and have a higher maximum rate of oxygen consumption than smaller eggs. The cost of incubation across temperature profiles has been reviewed by Booth and Thompson (1991) for four species of reptiles (two turtles, *Sphenodon* and a crocodilian) and shown to be largely independent of incubation temperature. However, with so few species studied, evolutionary patters remain elusive, especially since the result of *Crocodylus johnstoni* may be different from the other species.

Rather than compare the cost of development among species as a ratio of total amount of oxygen consumed to fresh egg mass as has classically been the case, I have made my calculations on the basis of cost per gram of fresh hatchling mass. This does not change the patterns or any of the conclusions, but I consider it to be more biologically relevant. Ideally, the comparisons should be done per gram of dry hatchling, but there are too few data on hatchling dry masses to enable such comparisons at present. The pattern of cost of development that emerges (Table 2) is not easy to explain. The following tentative generalization can be made, however. The cost of development of turtles and snakes is considerably lower than that of birds, the cost in alligators is lower again. Surprisingly, the cost of development in *Sphenodon* and bearded dragons falls within the range for birds and is close to the mean for the birds selected for this comparison (they comprise a size range and include precocial and altricial species).

Ontogeny in rate of oxygen consumption. Three patterns of development of rate of oxygen consumption occur in reptiles. The pattern exhibited by snakes is very like that in altricial birds, that in Sphenodon and leatherback sea turtles is like a classic precocial avian pattern, and that of small turtles, bearded dragons and crocodilians is peaked, like ratites. The pattern in other sea turtles is like that of semiprecocial birds verging on altricial.

DISCUSSION

Length of incubation and cost of development. It is generally assumed that cost of development in avian eggs is comprised of two main parts - development and maintenance, with longer incubation resulting in a higher maintenance cost and therefore, a higher total cost of incubation (Vleck et al. 1980; Hoyt, 1987). This is partly borne out by studies of individual species of birds incubated at slightly different temperatures and incubation periods, but by no means proven (Booth & Thompson, 1991). However, unlike birds, the length of incubation of reptilian eggs is easily manipulated in single species with substantial changes in incubation temperature. The prediction of higher cost with longer incubation generally is not supported for reptiles (Booth & Thompson, 1991).

With few species studied, it is difficult to draw general conclusions, but some preliminary trends are emerging. For non-crocodilians, the cost of development is largely independent of incubation temperature. This means that no more energy is used during incubation, regardless of the incubation temperature, and hatchlings should emerge with the same energy reserve over a range of incubation temperatures (provided water potential is the same in each condition). Thus, for artificial incubation of eggs, temperature can be ignored as a potential variable in energetic fitness of hatchlings in selecting the best incubation protocol. Consequently, rapid development may be selected to reduce the time of incubation with its inherent disaster possibilities (e.g., incubator failure). Additionally, it means that species with temperature-dependent sex determination will produce males and females that are energetically as fit as each other.

The situation with crocodilians is not as clear and relies on data from just one study where the temperature difference during incubation was only 1 ° C (Whitehead, 1987). More data are needed form incubations over a wider temperature range to justify making generalizations about crocodilians. However, given the close phylogenetic relationship between birds and crocodilians, perhaps a similar pattern might be expected. If so, it indicates that cost of development has some basic biological difference in different lineages.

Comparative costs of development. Obviously, the different cost of development in many reptiles and birds does not result from different temperatures of incubation, so what does cause the difference? So far, no conclusive explanation exits, although tentative speculations have been made (Booth & Thompson, 1991; Vleck & Hoyt, 1991). The fruitful place to search for differences may lie in the chemical make up of avian and reptilian yolks, but no such detailed data are available. If there is a difference, then it may reflect some basic difference in development of birds and crocodilians on one hand, and non-crocodilians on the other, and this may translate to a difference in efficiency of development.

Generally, the increase in rate of oxygen consumption during incubation in avian eggs reflects increase in embryonic mass. Species of birds with altricial young have accelerating growth when they hatch and this results in a pattern of development of embryonic rate of oxygen consumption that shows an increasing rate up to hatching. This is called the "altricial" pattern. In contrast, the rate of growth of precocial species of birds has fallen by the time of hatching and the pattern of oxygen consumption reaches a plateau towards the end of incubation (C. Vleck et al., 1980). This is called the precocial pattern. The only exception to these patterns in birds is that of the ratites where rate of oxygen consumption reaches a peak and then falls prior to hatching (D. Vleck et al., 1980). The peaked pattern is accepted as providing a catch-up period that allows less advanced embryos to hatch synchronously with more advanced clutch mates (D. Vleck et al., 1980; Cannon et al., 1986).

The same patterns are observed in reptiles. Snakes show the altricial pattern (Black et al., 1984; Dmi'el, 1970, Thompson, unpubl. data). Sea turtles of the family Cheloniidae verge on the altricial pattern, with just a small fall in the rate of increase of the rate of oxygen consumption prior to hatching (Ackerman, 1981) while *Dermochelys* and *Sphenodon* show a normal precocial pattern (Thompson 1989, in press). However, many species (*Alligator*, freshwater turtles) show a distinctly peaked pattern.

The altricial pattern in snakes is difficult to explain. By avian standards, all reptiles are precocial. Until someone studies the relative rates of development of embryos of different groups of reptiles and relates it to the time of hatching, no firm conclusions can be drawn. However, from the pattern of development of rate of oxygen consumption, one can predict that growth of snake embryos is still rapid right up to the time of hatching. As this phase of development often is associated with development of neuro-muscular coordination, ensuring that embryos remain in the eggs as long as possible may result in "fitter" (i.e, more coordinated) hatchlings. However, this idea remains to be tested.

The peaked pattern is easier to explain. I suggested that it serves the same function as in the ratites, that of allowing a "catch-up" period for synchrony of hatching. Unlike most reptiles, birds are able to communicate vocally, and use this as a means of communication between eggs to aid in hatching synchrony.

Because alligator hatchlings do communicate vocally, I used them as a model to test the synchrony of hatching hypothesis to explain the peaked pattern of oxygen consumption.

I obtained eggs from two clutches that were 7-10 days apart in age. Using the usual incubation methods, I incubated some of the young eggs in chambers with the older eggs while in a separate incubator I incubated some of the young eggs in isolation. Throughout incubation I measured rates of oxygen consumption of all eggs. As predicted by the synchrony of hatching hypothesis, the isolated young eggs hatched after the same amount of incubation and with the same period of time from the peak of respiration to pipping (10-12 days) as the older eggs that were incubated with young eggs. However, that group of young eggs hatched much earlier and with a much shorter peak to pip period than either the older eggs or the isolated controls. There are a couple of problems with the results, though. Firstly, the young eggs did not hatch at the same time as the older eggs, although their incubation was accelerated and secondly, they showed a peak of oxygen consumption earlier than the control group. The latter result may have been caused by elevated carbon dioxide levels in the chambers with the older eggs because of their greater rate of respiration. This is something that I will be testing in the future.

However, this result indicates that for some species (i.e., those with peaked patterns of oxygen consumption: crocodilians, many turtles and at least some lizards, but not snakes) one should take care not to incubate eggs of different age within the same incubation chamber. Doing so is likely to result in some eggs being stimulated to hatch earlier than they might if incubated in isolation, possibly resulting in an increase in the number of smaller hatchlings, hatchlings with external yolks and more poorly coordinated hatchlings.

Table 1. Incubation period in days from oviposition to first eggshell pipping for the species incubated in this study. Time is estimated for *A. mississippiensis* because eggs were not collected on day of incubation.

Species	Temp (°C)	Pipping (Days)	Ref
E. macquarii	25	57-58	1
	30	46-49	1
D. coriacea	30	57-58	2
A mississippiensis	30	66-69	3
S. punctatus	18	305-366	4
	20	221-275	3
	22	162-175	4
O. scutelatus	30	70-76	5
P. barbatus	30	67-69	5

1. Thompson, 1983; 2. Thompson, in press; 3. Thompson, 1989; 4. Thompson, 1990; 5. Thompson, unpubl.

Table 2. Cost of incubation as estimated by total oxygen consumed during incubation per gram of fresh hatchling mass (ml.g-1) in major groups of reptiles and five species of birds.

Species	Cost		n	Range	Temp °C
	mean	S.D.			
Sphenodon	161	-	1	161	20
Lizard	175	-	1	175	30
Snake	97	33	6	54-135	30
Turtle	114	26	5	89-158	30
Alligator	76	-	1	76	30
Bird	161	28	5	135-202	36-38

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ANALYSIS OF BODY SIZE AND GROWTH IN AN INTRODUCED POPULATION OF THE WESTERN FENCE LIZARD (*SCELOPORUS OCCIDENTALIS OCCIDENTALIS*) IN NORTHERN PUGET SOUND

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INTRODUCTION

The western fence lizard is common and widespread in the western United States but there are no published studies on populations living in northwestern Washington (Nussbaum at al., 1983; Mathies and Aubry, 1988). Fitch (1940) studied the growth and behavior of *S. o. occidentalis* in southern Oregon and central California, and Davis (1967) made a detailed study of growth and size in central California. There are several recent experimental studies on the comparative growth rate of *S. occidentalis* from southern Washington, Oregon and California (Sinervo and Adoph, 1989; Sinervo, 1990).

Studies of introduced or colonizing populations of lizards (Kwait and Gist, 1987; Selcer, 1986) provide some understanding of the dynamics of successful colonization by a species, and other studies of birds an mammals suggest important factors to consider in the translocation of a species (Conant, 1988). Adolph (1990) reports the successful transplantation of *S. occidentalis* to a site where they do not occur naturally in mountains of southern California.

The purpose of this study is to report on an experimental transplantation of the fence lizard to northern Puget Sound where this species does not occur naturally, and it is part of an ongoing study of population dynamics (reproduction, growth, and behavior) of the western fence lizard in northern Puget Sound (H. Brown, unpubl. observ.).

STUDY AREA

The study was conducted during 1990 and 1991 at three sites: Clayton Beach and Oyster Creek Beach in Skagit County (6 and 8 miles, respectively, south of Bellingham, WA) and Cherry Point in Whatcom County (18 miles north of Bellingham). The first two sites are characterized by a mixed forest of douglas fir and big-leaf maple interspersed with ocean spray, madrone, and snowberry and steep, sandstone outcroppings. Cherry Point is a cobble stone beach with numerous small log debris and a steep, brushy dirt bank characterized by willow, alder, birch, cottonwood and grass.

The origin of the transplanted lizards comes from a natural population inhabiting beach sites at Tulalip Shores, Spee-bi-dah, Tulare Beach, and McKee Beach (about 15 miles north of Everett, WA.); the main study site at Spee-bi-dah was surveyed from May of 1986 to June of 1991 by mark and recapture techniques, and data on population structure, reproduction, growth, and behavior were collected. In September of 1986 I transplanted adults (N = 10), subadults (N = 15) and hatchlings (N = 25) to Clayton Beach, but I did not find the lizards here again until May of 1990. With this discovery I made further experimental transplants of juvenile lizards to the three study sites in early summer of 1990.

METHODS

Lizards were captured by hand or noose, sexed, and measured total length and snout to vent length (svl) to the nearest mm and weighed with an electronic balance to 0.01 g. Individuals were marked permanently by toe clip and for field identification, by painting various colors on the dorsum and/or limbs. Growth rates were estimated from lizards measured two or more times.

RESULTS

Clayton Beach

The experimental population at Clayton Beach is the oldest, most diverse in population structure and is best known. I collected a total of 138 new (resident) lizards from May to September 1990 and February to June 1991. I introduced 34 juvenile lizards (14 females and 20 males) to this site in late May and early June of 1990.

The period of lizard activity extends from late February to middle October. Females lay eggs in middle to late June, and hatchlings first appear in middle to late August. Three age groups can be found in the spring and early summer (Table 1): hatchlings, juveniles (entering first full year), and adults (entering second full year and older). Fence lizards of all age classes may have a conspicuous infestation of ticks on the neck and ear during May to July, but this is greatly reduced by September; lizards with ticks at the Tulalip site are rare. The adult lizards are extremely wary and very difficult to collect in September and October. There are three age groups in the late summer and early fall: hatchlings, juveniles, and adults (two years and older). Table 1 provides a summary of the snout-vent length and body weight of lizards: hatchlings (August and September), juveniles (April to June) and adults (February to October). The largest lizards (length and weight) are females, and this is true of the parent population (H. Brown, unpubl observ.).

The growth rate of adult and juvenile lizards is summarized in Tables 2 and 3. The growth rate of adult males and females was 0.03 mm/day. Juvenile males (N = 22) in May and June had a svl = 39.3 mm and body weight of 2.29 g and they grew to 62 mm and 9.80 g (N = 10) by middle September; this is a growth rate of 0.22 mm/day. One juvenile male grew from 44 mm and 3.38 g to 67 mm and body weight of 12.38 g. Juvenile females (N = 22) had a svl = 38 mm and body weight of 2.23 g and they grew to 60.8 mm and 9.95 g (N = 9); this is a growth rate of 0.24 mm/day. One juvenile female grew from 36 mm and 1.58 g to 64 mm and 11.98 g.

Oyster Creek Beach

The population at Oyster Creek was established in late May of 1990 by transplanting 64 juvenile lizards (32 males and 32 females). Table 4 is a summary of growth rate in this population. I recaptured five males in early October and they grew from 37.8 mm and 1.83 g to 65 mm and 11.22 g. Three of these males were recaptured in February/March and they did not grow in svl since the last capture in October. Females and other males were recaptured during February to June of 1991. Two females recaptured in early June reached a svl of 67 and 68 mm and body weight of 12.35 and 11.83 g, and they appeared to be carrying large eggs. The average growth rate at this site is 0.21 mm/day.

Cherry Point

The population at Cherry Point was established in early June of 1990 by the introduction of 64 juvenile lizards (28 females and 36 males). I recaptured 17 lizards in late August and early September, and Table 5 shows a summary of growth rate at this site. Females (N = 5) grew from 39.2 mm and 2.25 g to 60 mm and 8.81 g; this is a growth rate of 0.26 mm/day. One female juvenile grew from 41 mm and 2.62 g to 63 mm and 10.61 g. Males (N = 12) grew from 38.3 mm and 1.99 g to 61.4 mm and 9.37 g; this is a growth rate of 0.27 mm/day. One male grew from 35 mm and 1.47 g to 68 mm and 11.97 g.

DISCUSSION

The western fence lizard has been successfully introduced to northern Puget Sound beaches along Chuckanut Drive in Skagit County and Cherry Point in Whatcom County. It is likely that large nearby rivers and their estuaries, like the Stillaguamish and Skagit, may serve as formidable barriers to the historical dispersal of this species northward (see Pounds and Jackson, 1981). While Northern Alligator lizards (*Elgaria coerulea*) inhabit the San Juan Islands, there is no record of occurrence of fence lizards in this archipelago (see Nussbaum et al., 1983).

There are three major periods of growth in this species (Fitch, 1940): rapid growth between hatching and the first hibernation; the second, where most growth occurs, between first and second hibernation; and the third, where adult size is reached, after the second hibernation. The results of the present study show considerable variation of individual growth rate of juvenile lizards, and this has been found in many other species of lizards, including *S. occidentalis* (Fitch, 1940; Davis, 1967; Bradshaw, 1971; Sinervo and Adolph, 1989). The value for juvenile growth rate (0.22 mm/day) is similar to the rate (0.25 mm/day) reported by Tanner and Hopkin (1972) for juveniles in a Nevada population of *S. occidentalis*. At the end of one year some of the fence lizards transplanted to northern beaches of Puget Sound have reached a svl of 55 mm and are certainly subadult and nonbreeding. Many others have a svl of 60 mm and are probably still sexually immature, and a few lizards, less than one year old, have a svl of 67 or 68 mm in early June, and females of this category appear to carry mature eggs and may be successful egg layers. While these experimental populations show growth rates similar to the parental population studied at Tulalip (H, Brown, unpubl. observ.), the growth data in these experimental populations may also include slightly higher values generated because of small sample size in numbers of lizards transplanted and, perhaps, even restricted genetic sampling of the parental population from Tulalip. This can only be known after a thorough comparative analysis of population structure and individual body growth between the parental and derivative (transplanted) populations. There are also many environmental factors contributing to this variability like food availability, competition and time allocated to foraging activity that interact with the genetic constraints.

Table 1. Snout-vent Length and Body Weight of Various Age Classes of Western Fence Lizards at Clayton Beach, 1990 and 1991.

Age	Sex	Year	N	SVL mm	se	range	Weight g	se	range
Hatchlings		1990	34	29.6	0.49	24-35	1.04	0.06	0.44-1.76
Juveniles		1990	45	39.7	0.58	30-48	2.47	0.11	1.13-4.16
Juveniles		1991	16	36.8	0.71	32-42	1.94	0.17	1.00-2.87
Adult	F	1990	31	66.3	0.92	58-73	12.85	0.53	8.60-18.2
Adult	F	1991	14	69.4	4.87	63-79	14.01	1.00	10.60-19.2
Adult	M	1990	37	.66.4	0.68	60-73	11.79	0.32	8.20-15.9
Adult	M	1991	34	65.2	0.67	60-74	10.42	0.40	8.10-15.1

Table 2. Growth Rate of Adults and Juveniles at Clayton Beach: Males.

CLASS	ORIGINAL DATE	SVL	FINAL DATE	SVL	DURATION days	GROWTH RATE mm/day
Adults	May 12	66	Aug 28	70	108	0.04
	May 12	72	Aug 23	73	103	0.01
	May 17	67	Sep 16	68	124	0.01
	May 18	68	Sep 2	72	107	0.04
Juveniles	May 12	41	Mar 10	67	126	0.21
	May 17	35	Sep 10	60	118	0.22
	May 17	36	Aug 19	60	94	0.26
	May 17	36	Aug 23	60	98	0.26
	May 17	38	Aug 19	56	94	0.19
	May 17	38	Aug 23	65	98	0.28
	May 17	39	Sep 6	60	125	0.19
	May 18	39	Aug 24	65	98	0.27
	May 22	44	Sep 2	65	103	0.20
	May 30	43	Apr 17	65	108	0.20
	June 4	44	Sep 10	67	98	0.24
	June 13	44	Sep 2	61	81	0.21
	June 28	50	Mar 16	67	79	0.22

Table 3. Growth Rate of Adults and Juveniles at Clayton Beach: Females

CLASS	ORIGINAL DATE	SVL	FINAL DATE	SVL	DURATION days	GROWTH RATE mm/day
Adults	May 12	67	Sep 30	69	129	0.02
	May 15	74	Aug 23	75	101	0.03
	June 7	65	Aug 19	69	73	0.05
Juveniles	May 12	35	Aug 19	59	99	0.24
	May 12	38	Aug 24	64	104	0.25
	May 12	40	Sep 9	64	115	0.21
	May 15	41	Apr 15	65	123	0.20
	May 17	36	Aug 20	64	95	0.30
	May 17	36	Aug 23	60	98	0.25
	May 17	36	Apr 15	63	121	0.22
	May 17	39	Apr 25	63	131	0.18
	May 17	35	Sep 6	61	114	0.23
	May 30	30	Aug 23	50	85	0.24
	June 28	42	Sep 6	60	72	0.25
	June 30	50	Sep 7	65	69	0.22

Table 4. Growth Rate of Male and Female Juveniles at Oyster Beach.

CLASS	ORIGINAL DATE	SVL	FINAL DATE	SVL	DURATION days	GROWTH RATE mm/day
Males	May 26	37	Oct 5 Feb 22*	62 62	132	0.19
	May 26	36	Oct 10 Feb 23*	63 63	137	0.20
	May 26	36	Jun 8*	63	165	0.16
	May 26	38	Oct 3	65	137	0.20
	May 26	36	Feb 23*	63	112	0.24
	May 26	35	Feb 22*	59	112	0.21
	May 26	33	Feb 22*	59	112	0.23
	May 26	38	Feb 23*	61	112	0.21
	May 26	39	Feb 23*	62	112	0.21
	May 26	35	Mar 16*	59	112	0.21
	Jun 13	39	Oct 10	63	119	0.20
	Jun 13	40	Feb 23* Jun 3*	62 62	94	0.23
	Jun 17	39	Oct 5 Mar 16*	61 61	114	0.22
	Jun 17	42	Feb 23*	65	94	0.24
	Jul 29	45	Feb 28*	57	78	0.25
	Jul 29	52	Mar 16*	60	78	0.17
Females	May 26	32	Mar 16* Jun 8*	59 65	112 84	0.24 0.07
	May 26	39	Jun 9*	67	166	0.17
	May 26	35	Jun 8*	68	165	0.20
	Jun 13	39	Feb 28* Jun 3*	55 60	94 95	0.17 0.05
	Jul 29	54	Feb 28*	60	78	0.13

*Lizards collected during 1991.

Table 5. Growth Rate of Male and Female Juveniles at Cherry Point.

CLASS	ORIGINAL DATE	SVL	FINAL DATE	SVL	DURATION days	GROWTH RATE mm/day
Males	Jun 4	40	Aug 25	62	82	0.27
	Jun 4	38	Aug 25	61	82	0.28
	Jun 4	40	Aug 25	62	82	0.27
	Jun 4	38	Aug 25 Apr 29*	64 65	82	0.32
	Jun 4	40	Aug 25	62	82	0.27
	Jun 4	39	Sep 12 Apr 29*	60 60	100	0.21
	Jun 7	35	Aug 27	61	81	0.32
	Jun 7	39	Aug 27	59	81	0.25
	Jun 7	35	Aug 27	56	81	0.26
	Jun 7	37	Sep 10	68	98	0.32
	Jun 7	40	Sep 11	61	96	0.22
	Jun 7	38	Sep 12	61	97	0.24
Females	Jun 4	37	Aug 25 Apr 29*	57 62	82	0.27
	Jun 4	39	Aug 25 Apr 29*	61 62	82	0.27
	Jun 4	41	Aug 25 Apr 29*	63 66	82	0.24
	Jun 7	39	Aug 25	60	79	0.27
	Jun 7	40	Aug 25	59	79	0.24

*Lizards collected in 1991.

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LIZARD MANAGEMENT AT THE OKLAHOMA CITY ZOOLOGICAL PARK WITH SPECIAL REFERENCE TO *UROMASTYX, CHAMAELEO* AND *HELODERMA*

David Grow

The Oklahoma City Zoological Park typically exhibits between 35 and 40 species of lizards represented by 125 to 150 specimens. Approximately 30% of the exhibits in the herpetarium display lizards, including the three largest exhibits in the building. Seventeen species of lizards have reproduced since 1985 resulting in nearly 350 offspring. Many of these species continue to reproduce regularly. Notable genera to have reproduced during this period are *Hydrosaurus*; *Uromastyx*; *Chamaeleo*; *Ailuronyx*; *Rhacodacylus* and *Heloderma*. Formal and informal planning with careful attention to the simulation of natural environments and their climatic cycles, enclosure design, social management, nutrition and health facilitated this success. This paper presents the general management of the three problematic genera, *Uromastyx*, *Chamaeleo* and *Heloderma*, and is representative of the overall lizard management program.

Some brief comments on how we arrive at many of our husbandry decisions and program designs will be helpful in understanding our overall program.

The physical environment of the herpetarium itself has a profound effect on how we approach problems. While the zoo continues to fund improvements such as new public hallway paneling and back lighted graphics, the building obviously has serious limitations. It was built in 1925 and is the oldest active animal exhibit at the zoo. Its span of function has ranged from winter housing for birds and mammals to concession stand. There are only two peripherally located floor drains and exhibits are for the most part wall mounted plywood boxes. The building can be very cantankerous. We must negotiate with our facility. We must continually adapt. The unavoidable challenge of the building itself has had a positive effect on problem solving and has proven to be a useful tool in eliciting creativity. We are all proud of our facility.

Program planning occurs at several levels of formality and is generally based on a system of goals and objectives. Most planning time is spent in regular informal discussions between the animal technician and department supervisor including, only occasionally, the curator. There are, however, several formal meetings throughout the year where breeding priorities and strategies are discussed between the animal technician, supervisor, curator and, if appropriate, other interested parties. A plan evolves reflecting both consensus and specific commitments on the parts of all participants. Notes are recorded and serve as a road map.

A critical feature of all breeding program planning and execution is the creativity of the animal technician responsible for the program. The technician is expected to bring to planning meetings reasonably well-considered outlines of how they wish to proceed. Ideally, every effort is made to evaluate our own ability to recreate a species' natural environment including its climatic cycles within the constraints of our facility and budget prior to accepting existing dogma as a justification for program design. It is here, in the simulation of an environment and its cycles, that creativity and innovation is most often expressed. The animal technician is provided broad latitude in design development and execution to facilitate and encourage creativity. Breadth of latitude and independence of action increase proportionally with success.

The following management programs, while continuing to evolve, were developed in this environment and the success of each is, in the greatest measure, attributable to the creativity of the technician responsible for the program.

UROMASTYX

The Oklahoma City Zoological Park committed to work with *Uromastyx* in 1982 with the acquisition of five unsexed juveniles of the dabb spiny-tailed lizard, *Uromastyx acanthinurus*. The Egyptian spiny-tailed lizard, *Uromastyx aegyptius*, was added to the collection in 1986. Initially husbandry programs were based on accounts of the lizards in their natural habitats and climatological data for the region (Bons, 1959; Goets and Alberg, 1974; Grenot, 1967; Kevor and AL-Uthman, 1972; U.S. Dept. of Commerce, 1977). Helpful information on the dabb spiny-tailed lizard in captivity was provided by Brendel (1959), Fisher (1885), Kraalinger (1980) and Watson (1969). More recently, Grim (1985), and Wheeler (1988) have provided detailed accounts of husbandry and reproduction in artificial environments. Comparatively, there is little information on the Egyptian spiny-tailed lizard in captivity (Henke and Henke, 1977; Kevork and Al-Uthman, 1972). A detailed report on husbandry techniques employed at the Oklahoma City Zoo is provided by Wheeler (1990).

Both species are managed in a similar manner but with a few differences.

Enclosures must be large enough to accommodate their diurnal activity, adequate social spacing including multiple basking sites and refugia, and appropriate thermoclines. The Egyptian spiny-tailed lizard exhibit is one of the largest in the building and is approximately 2 meters x 2.5 meters with a top that angles from 1.5 meters in the front to 2 meters in the rear.

The dabb spiny-tailed lizard exhibit is smaller being 122 cm x 182 cm x 92 cm tall.

Annual temperature cycles are based on those reported for various sites in their natural habitat. Both species are strongly heliophilic requiring high basking temperatures. The exhibits for these species contain a variety of basking opportunities and broad thermoclines. Diurnal substrate temperatures of 58° C to 25° C are generated in the Egyptian spiny-tail lizard exhibit May through November. A slightly cooler but still hot environment exists in the dabb lizard exhibit during the same months with substrate temperatures ranging from 54° C to 25° . The maximum range between day and night air temperatures can be as much as 27° C.

A variety of lighting and strategically placed heat plates provide illumination and heat. Forty and eighty watt Durotest Powertwist Vitalites® and Sylvania 40 watt BL40 black lights provide florescent light. Incandescent illumination and radiant heat is provided by 250 watt clear reflector heat lamps, 275 watt sunlamps and three 400 watt metal halide lamps in the Egyptian spiny-tailed lizard exhibit. The photo period from March through November is 14 hours and 10 hours December through February.

A three month hibernation period is provided from December through February for both species but there are some differences. The temperature is gradually decreased for both species to 14° C over 30 days. The dabb spiny-tail lizards are housed individually during hibernation. The adult pair of Egyptian spiny-tailed lizards is housed together in a 379 liter (100 gallon) aquarium with a 43 cm deep sand substrate. Egyptian spiny-tailed lizards have proven delicate in hibernation causing us to provide a 22° C hotspot at one end of the aquarium during the temperature reduction period. When the temperature reaches 14° C the light is turned off. Care is taken to observe the animals for an increase in activity in February. This species tells us when they are ready to come out of hibernation.

The diet for both species is similar. Chopped greens consisting primarily of endive but also including spinach, mustard, turnip and kale leaves are provided daily before 10 a.m. Commercially prepared mixed vegetables made up of green beans, lima beans, peas, corn, and carrots are thawed and sprinkled over the greens. Adult crickets, *Acheta domestica* and wax moth larvae, *Galleria mellonella*, are offered three times a week. The dabb spiny-tailed lizard has proven more carnivorous than the Egyptian spiny-tailed lizard. Nekton-Rep® multi-vitamin powder and Osteoform® calcium supplement containing vitamin D_3 are sprinkled on the salad four times a week. Dried alfalfa leaves and occasionally dried split peas are offered the Egyptian spiny-tailed lizards. Water is provided by lightly misting the lizards at least once a week.

Differences in social behavior causes us to manage each species breeding group composition in slightly different ways. Male dabb spiny-tailed lizards are highly aggressive toward one another. Males will establish a dominance hierarchy through ritualistic combat. The subordinate males often remain hidden to avoid combat resulting in poor appetite. Additional males are introduced to the exhibit containing a pair to stimulate breeding but subordinates are, after a short period, removed to reserve enclosures.

No direct combat in Egyptian spiny-tailed lizards has been observed at this zoo but there does appear to be a hierarchy. During periods where two pairs of adults were housed in the exhibit, typically one of the animals for no obvious reason had chronic health problems characterized by an inability to maintain proper weight. During this period individuals died in hibernation with nothing remarkable being reported upon necropsy. This problem seems to have been controlled by reducing the exhibit population to a single pair of adults. Introduction of additional males has not been necessary to stimulate reproduction.

Post anal bulges on either side of the ventral surface of the tail are present in the males of both species. They appear however to be seasonal in the dabb-spiny tailed lizard being present only March through June.

Copulations in the dabb spiny-tailed lizards typically have occurred in April and May with oviposition occurring as early as April 20 and as late as June 13. Incubation temperatures range around 28° - 30° C and has taken from 83 to 93 days. Two clutches of eggs have been obtained from the Egyptian spiny-tailed lizards only one of which hatched. Breeding activity in this species comes later in the year than dabb spiny-tailed lizards.

Neonates of both species have similarly high temperature requirements and eat essentially the same diet as the adults but with a higher percentage of insects being eaten. The composition of the vitamin supplementation is the same as the adults but is provided more often. While they are fed daily before 10 a.m. a quantity is provided to ensure that some diet is available throughout the day. Water is provided in shallow bowls or by lightly spraying the individuals with water.

Neonate housing requirements differ markedly between the species. It has been necessary to maintain juvenile dabb spiny-tailed lizards in groups of two or individually. It appears juveniles establish some kind of hierarchy as ritualistic displays and even biting has been observed between individuals. Like the adults subordinates will remain hidden and will not eat. The one group of Egyptian spiny-tailed lizards hatched at this zoo contrastingly has required no separation. All eleven individuals, for a period of three months, did well in a space 76 cm x 35 cm. In late February, 1991, five juveniles were placed in the exhibit with the adults. There have been no problems in the group.

CHAMAELEO

Chamaeleo has proven by far to be the most problematic of the three genera discussed in this paper. The zoo has developed a wide variety of husbandry techniques to accommodate specific needs of the nine species with which it has worked however only a general review of our management practices is permitted by the scope of this presentation. Castle (1990; in press) provides detailed accounts of the husbandry techniques employed at the Oklahoma City Zoo.

In 1985, chameleons were being considered for exhibition at the Oklahoma City Zoo but their reputation for ephemeral health reinforced by previous failures caused us to carefully evaluate the feasibility of exhibiting chameleons. Chameleons had proven notoriously delicate in captivity (Wagner, 1958; Bustard, 1959; Bustard 1963; Mattison, 1982). Many zoos have worked with chameleons, however only a few have reported any success with them and were limited to a very few species (Bustard, 1989; Castle, 1990; ISIS, 1990; Slavens, 1990). The staff after some deliberation was challenged to teach themselves chameleon husbandry.

The formal goal of the program that evolved out of these deliberations was to solve problems with husbandry and reproduction so that captive management becomes a realistic option in the conservation of chameleons. Knowing that some losses were inevitable, an objective-oriented program was implemented in late 1985 addressing increasingly difficult species only after specific measures of success were achieved with each. The goal has been to learn from each species selected so that we would be more successful with the next and not to breed as many species of chameleon as possible.

The initial environmental parameters provided chameleons at the zoo were greatly influenced by the literature. Busack (1969) provides a bibliography of the Chamaeleontidae of over 500 citations between 1864 and 1964. Brygoo (1971), while in French, has been an important source of information on Malagasy chameleons. Parcher (1974) provides some behavioral data on Parson's and Wills' chameleons in the wild. DeWitt (1988) describes husbandry requirements of the Jackson's chameleon. An excellent review of the needs of oviparous chameleons in captivity is presented by Bustard (1989). De Vosjoli (1990a; 1990b) provides a very helpful account of general husbandry for chameleons. Fitzsimons (1943) and Branch (1988) provide helpful accounts of the dwarf chameleons (*Bradypodion*). Recent personal communication with other workers has been extremely helpful, most notably Dr. Gary Furgeson, Todd Risley and Ron Tremper.

Climatic data for broad areas is available but specific data for local climates is less common. The Department of Commerce's publication Climates of the World has provided some information but Annuare Statistique de Madagascar (1953) and Atlas de Madagascar (1969) has been much more helpful with data on specific localities.

During this period the zoo has worked with nine species of chameleon: *Bradypodion damaranum*; *B. gutturale*; *Chamaeleo dilepis*; *C. jacksoni*; *C. melleri*; *C. montium*; *C. oustaleti*; *C. parsoni*; and *C. willsii*. Three of these species have reproduced and five have been raised from hatchling or birth.

Two species were initially employed to establish basic husbandry parameters. The flap-necked chameleon was the initial teaching species because they were very common, inexpensive and appeared to inhabit a broad range of environments. Much was learned from this species which reproduced in 1987. Progeny was raised which reproduced in 1988. Flap-necked chameleons were replaced by Jackson's chameleons in early 1987. Over 150 offspring were produced over the next two years, including F_3 young.

These successes encouraged us to address the next objectives by adding to the collection over the next three years, beginning in 1987, three species of Malagasy chameleons: Oustalet's, Parson's, and most recently Wills' chameleon. Oustaket's chameleon reproduced in 1989 with only four hatches occurring in August in spite of several apparently fertile clutches being laid. Four more were manually hatched in 1990 but did not survive. A clutch of 54 eggs sired by one of the 1989 offspring is currently incubating under three separate thermal regimes. Castle (in press) presents a more detail account of reproduction in this species. Wills' chameleon copulated shortly after arrival and laid 9 eggs on 12 December, 1990, which appear fertile. A second Wills chameleon laid an additional clutch of nine eggs on February 20, 1991, also appearing fertile.

Three basic types of enclosures are employed: exhibits within the building varying widely in size and environment, aluminum framed screen walled enclosures which because of heir size are very mobile and wood or steel framed wire walled enclosures that because of their size are not very mobile. Individual enclosures are made as large as possible with due regard to space constraints, adequate prey density and providing the zoo visitor with some hope of seeing what we are trying to exhibit.

Four species of chameleons are on exhibit: Knysna dwarf chameleon, sail-fin, Oustalet's and Parson's chameleons. The Parson's chameleon exhibit is the largest exhibit in the building being 5m x 1.8m x 3m tall. This exhibit contains a tempered water stream and sprinkler system. It is the only sky lighted exhibit and is thickly planted. The sail-fin chameleon exhibit is 1.2 m in each dimension and is likewise thickly planted. The Oustalet's chameleon exhibit is also large, 2.5m x 2m x 2.5m tall but the propping is more open than the previously mentioned exhibits. The dwarf chameleon exhibit is being expanded to 2m long x 1m x 1.5m tall. It will also contain the South African areolated tortoise, *Homopus areolatus*, and tent tortoise, *Psamobates tentorius*.

There are three basic types of reserve enclosures. The aluminum framed screen walled enclosures are of three sizes: 60 cm in each dimension; 45 cm in each dimension and 30 cm x 30 cm x 60 cm long. They are inexpensive and easy to construct. In Oklahoma these very light enclosures are advantageous as they are easily moved outside and in as weather permits. The wood framed wire enclosures are of two sizes: 122cm x 60cm x 100cm tall and 122cm x 122cm x 213cm tall. The most recent design involves angle steel framed panels of vinyl coated wire which can be bolted together to form a single independent enclosure or configured to form a bank of enclosures. These enclosures are 122cm x 122cm x 182cm tall.

Lighting is provided in a variety of ways. Natural sunlight is provided whenever we can. Sky lights are the next best thing however we do supplement florescent and incandescent lighting even in the greenhouse and in the sky lighted enclosure. The artificial lighting includes 40 and 80 watt fluorescent Durotest Powertwist Vitalite® lamps often augmented by Sylvania® BL40 black lights. Incandescent bulbs used include 75 and 150 watt reflector growlites with 250 watt infrared heat lamps when necessary during the cold weather of winter. An attempt is made at this zoo to provide illumination as bright as possible of broad spectral composition.

The wide ranging climate of Oklahoma and our limited ability to control its effects have shown the chameleons species with which we have worked to be somewhat more thermally tolerant than we expected. Cooling has proved more difficult than heating but one technique has allowed even Jackson's chameleons to be kept outside during the hot Oklahoma summer. A garden soaker hose is draped or coiled over one half of the outdoor enclosure providing a localized spray or drip of water significantly cooler than the air temperature. The water is turned on when the temperature rises above 28°C. The chameleons typically use this opportunity to moderate their body temperature. It was found however, during the extended period of 38°C+ temperatures during the summer of 1990, it was necessary to install a programmable garden water timing system as the chameleons reacted poorly to constant rain during the extended periods of heat. The system provided several periods of rainless reprieve. Black plastic 40% shade cloth stretched over the outdoor reserve area aided in reducing the rate of heating during the rainless periods, and kept temperatures down in general.

The design of our enclosures and the special efforts made to keep the chameleons outside are results of our desire to provide an atmosphere around the chameleon as fresh and buoyant as possible. Electric fans in strategic locations help maintain air circulation. The two largest chameleon exhibits are capable of ducting outside air directly into the exhibit using thermostatically controlled fans.

Watering is gauged to the needs of species or individuals. A special concern is to provide adequate drinking water while allowing the enclosure to dry between watering. A pneumatic pressure water sprayer has proved an important tool, allowing a spectrum of both spray intensity as well as configuration ranging from a fine mist to a steady stream. Our experience shows that small chameleons like *Bradypodion* prefer a mist of water accumulating on surfaces in the exhibit so drinking is facilitated over a period of time while larger chameleons will readily drink from a gentle stream of water. Water temperature also influences a chameleon's inclination to drink. Water near 28-30° C has proven most commonly acceptable but may vary with species or individuals. Techniques of this nature require individual attention.

The composition of the diet for chameleons at this zoo is comparatively simple. Gray crickets, of various sizes with "giant" mealworms (*Zoophobias*) and waxmoth larvae make up the basic diet. The chameleons are fed daily using four techniques: hand broadcasting prey throughout the enclosure; placing prey in smooth round bottom bowls hung at appropriate heights in enclosures; release of prey and individual hand feeding. Again, the technique is gauged to the species, characteristics of the enclosure or particular individual. Nekton-Rep® and Osteform® are sprinkled on prey items three to five times per week with Nekton-Rep® occasionally being provided in drinking water.

Typically on male and one to three females are maintained in an exhibit. It is important to prop the enclosure so that all of the inhabitants have proper cover and adequate thermoregularity opportunities. We have yet to work with a specie of chameleon where males will tolerate one another's presence. Similarly, females sharing a single enclosure must be monitored as a dominant female can force the other females to the lower reaches of the enclosure, often depressing the displaced females' appetite. A critical aspect of the management plan is being able to identify subtle social stress and removal of individuals to less stressful environments.

It has been our experience, however, with the possible exception of Parson's chameleons that chameleons will reproduce of they are maintained in a supportive artificial environment. It is not always necessary to observe copulation to determine if a female has been bred. The females of he three species which have reproduced at the Oklahoma City Zoo have all displayed a change in body color once they became gravid.

As parturition or oviposition approaches changes in behavior occur. Changes in basking behavior, feeding and drinking habits and intolerance of enclosure mates will become more readily apparent. Adequate thermoregulatory opportunities and proper hydration are extremely important during this time.

Birth in Jackson's chameleons and Knysna dwarf chameleons have been similar to that described for Jackson's by DeWitt (1988) and Zimmerman (1986). No special modification of propping has been necessary to support parturition.

Accommodating oviposition has been a much more problematic effort. Six females representing three species have died that either contained near or full term eggs or died shortly after oviposition. While the specific etiology of this syndrome may be diverse and complex our experience suggest two general causes.

The production of viable eggs requires a tremendous investment of energy on the part of the female. If she becomes gravid while she is underweight, disinclined to eat, parasitized or unhealthy in any way her chances of survival are severely compromised.

Lack of adequate nesting opportunity may cause a female to postpone oviposition because she continues searching for an acceptable site. Females that do not find an acceptable site die. There are several considerations that should be addressed when providing a site for oviposition:

1. The substrate should be deep enough and wide enough to allow the female to dig a completely subterranean burrow at least as long as she is.
2. The substrate should be of a consistency that it does not collapse during the nesting process. it should be only moist enough to facilitate burrowing.
3. The substrate should not contain any hard obstructions like pots, rocks or sticks. We have, however, found that some females often dig a burrow up to the root ball of a plant and oviposit next to it.
4. The female should have time to become familiar with the substrate and enclosure where oviposition is to occur. We try to provide adequate nesting opportunity as early as possible.

Incubation of the eggs has also proven problematic. The hatch rate of the species that have reproduced at this zoo has been very low. Flap-necked chameleon eggs were incubated in plastic wrap covered gallon jars set in a water bath to maintain 22°-23°C. Incubation substrate was vermiculite 5cm deep moistened with water at a ratio of 1:1 by weight. Hatching occurred in seven clutches of eggs with an incubation period of 220-230 days.

The initial incubation parameters for Oustalet's chameleon eggs were the same as for flap-neck chameleons. Only four young hatched from one of four clutches after they were warmed to room temperature, 26°-28° C. Incubation was 245-248 days. Only after an accidental four-day cooling to 22°C was any development observed in the remaining clutches of eggs. None of these eggs hatched. Several eggs of one clutch were observed to be slit at approximately 483 days of incubation. After a period they were opened and were found to contain full term dead embryos. Currently the most recent clutch is being incubated in three separate thermal regimes to hopefully further identify incubation parameters in this species.

Neonates are housed in a variety of containers, the two smaller sizes of aluminum framed screen enclosures being most satisfactory. They are housed individually or in groups of six to ten. Our experience indicates that it is more important for neonates to have adequate opportunity to space themselves on a horizontal plane rather than a vertical plane. When horizontal space is restricted individuals space themselves in a vertical orientation. The bottom individuals lose their health rapidly. Vestigial winged *Drosophila* and newly hatched gray crickets are provided at least once a day in the morning. A second feeding is often provided in the afternoon. Enclosures are sprayed with water two to three times a day. During weather above 32° C water is constantly available. Neonates, we have found, are much less thermally tolerant than the adults. Care is taken to observe feeding habits and interactions between individuals on a daily basis. Young are separated into additional enclosures when aggression and depressed appetites are observed.

Chameleons are wonderful animals providing an exciting challenge in captivity. There are several general factors that must be addressed if any chameleon management program is to be successful.

1. A buoyant and fresh atmosphere surrounding the chameleons is critical.
2. A wide variety of species specific thermal requirements must be accommodated.
3. Stress arising from a wide variety of sources must be promptly recognized in individuals and promptly reduced or eliminated.
4. Adequate space and enclosures must be available for the management of social behavior.
5. Chameleons need individual attention on a daily basis requiring serious dedication on the part of the keeper.

HELODERMA

Heloderma has been part of the zoo collection as far back as the animal records department can account. One reproducing female reticulated Gila monster, *Heloderma suspectum suspectum*, has been at the zoo for 21 years. The zoo has been working exclusively with this subspecies since 1978. Husbandry practices evolved based on past practices at the zoo until 1979 when it was decided to hibernate them. The first successful hatch occurred in 1980. This group has reproduced eight of the last ten years producing 43 offspring. A more formalized effort was implemented in 1983 to improve reproduction. Information in formulating this effort was provided primarily by Bogert and Martin del Campo (1956) and Carpenter and Furguson (1978) but some other works were considered (Gates, 1956 b; Peterson, 1982). Osborne (1984) summarized the zoo's Gila program and commented on behavioral sequences in a poster presented at the 1984 combined meeting of the SSAR, HL, and AIHS at the University of Oklahoma.

There are typically two males and three females on exhibit. The exhibit which is about 1.75 meters on each side, does not provide opportunity to dig burrows but stacked rocks provide refugia for each animal. A shallow pool at the top of the rock is filled once a week and allowed to very slowly overflow for a brief period. The seeping water wets an area under the rocks where the Gilas often hide. We try to insure this area dries out completely between watering. A 250 watt reflector heat lamp provides a basking spot of 35°-38° C which helps keep one end of the exhibit very dry. The substrate temperature under the rocks when it is dry is around 25° C. Exhibit illumination is provided by six 40 watt Durotest Powertwist Vitalites®.

The Gilas are hibernated on the same schedule as the spiny-tailed lizards and likewise are cooled to approximately 13° C. No supplemental radiant heat is provided during hibernation. They are housed individually in sturdy plastic boxes 60cm x 35cm x 15cm deep. The lids are clear and are clamped for security. Moist long fiber sphagnum moss 3-6 cm deep is the current hibernation substrate. Care is taken to see that it is not too wet. It is initially wetted thoroughly and as much water as possible to squeezed from it. It dries considerably during hibernation but it is prevented from drying completely by lightly misting it one or twice a week. This technique contributes to keeping the lizards hydrated during hibernation but a bowl of water is provided at least once a week.

The males are placed on exhibit in early March with the females following them in later March or early April. Characteristics employed to determine sex have been the same as those described for *Heloderm suspectu cinctum* by Detmeter (1986).

The females are removed from the exhibit for egg laying and housed individually. Their enclosures are approximately 1 1/2 times as long as they are. The substrate is pea gravel and a light provides a 35° C hot spot. The same type of box used in hibernation is filled with moist sphagnum moss and placed in the enclosure. A corner is cut off the plywood lid providing access. Eggs are usually laid in this box. The tails of the females will loose girth as oviposition nears. The bones of the pelvic girdle will be increasingly apparent as time for oviposition approaches. Most eggs are laid during the day. Egg laying occurs in late May or early June.

The eggs are half buried in vermiculite moistened with water at a ratio of 1:1 by weight. A covered plastic shoe box is used as the container which is placed in our incubator ranging from 27°-29°C.

In the past it was not uncommon to have several young die in the egg at full term. In 1989, a simple container was constructed in our incubator that allowed us to more carefully control humidity around the eggs. In the last six weeks of incubation the humidity was gradually reduced to about 80% and the substrate was allowed to become quite dry. All 18 fertile eggs have hatched in this environment.

It has not been necessary to simulate the annual rain cycle of their habitat. The photo-period is 14 hrs April through September and 10 hours October through March.

We <u>do not</u> feed eggs of any kind. Our females are offered mice twice a week from the end of hibernation to when they are removed from the exhibit for oviposition and for a period after egg laying. They typically eat four to six mice per week during this time. Other times they will eat two to four per week. The males do not eat as much and do not eat at all during the breeding season, generally April through June.

The young hatch October through December and are fed exclusively mice of appropriate size. Juveniles have attained 80-90% of adult size in one year. The average total length of neonates has been 180mm and average weight has been 45 gr.

CONCLUSION

Much of the success of the overall lizard management program at the Oklahoma City Zoo rests on the fact that each of us accepts the reality that lizards are not snakes. I have come to believe over the years that the dominating fascination with snakes has had a profound effect on lizard husbandry in general. First of all, this can be seen in the general composition and productivity of many reptile collections. Hudson (1989) stated that less than 25 taxa of lizards are represented in five or more North American zoo collections with very little reproduction occurring in this group. Secondly, it seems that husbandry requirements of lizards are often underestimated because of the application of inappropriately extrapolated or generalized husbandry needs of snakes. Typically exhibit size, frequency and timing of feeding, lack of attentive accommodation of social behavior and limited thermoregulatory opportunities are suggestive of this phenomenon. Its negative effects are sustained as a result of limited success causing people to believe that lizards are difficult or have unreasonable requirements in artificial environments.

At the Oklahoma City Zoo we have found lizards to be valuable and stimulating components of our exhibit and conservation program.

We accept that lizards have their own set of unique requirements and whenever feasible we make every attempt to provide as supportive an environment as possible based on what we can learn about the species' natural habitats. There are several general characteristics of our overall program that we feel have been helpful in realizing success:

1. Allocate adequate space to facilitate a full range of natural behaviors and social densities.
2. Take the time to be aware of the social status of individuals in a group and be prepared to take prompt action to remedy stress.
3. Make every effort to provide food when and as often as a species feeds in the wild.
4. Provide the full range of thermoregulatory opportunities a species experiences in the wild.
5. Simulate natural climatic cycles.

There is a need for a broader and more effective collaborative effort on behalf of lizards in artificial environments. It is hoped this paper makes a contribution but just as important stimulates a somewhat different point of view when considering the management of lizards in such environments.

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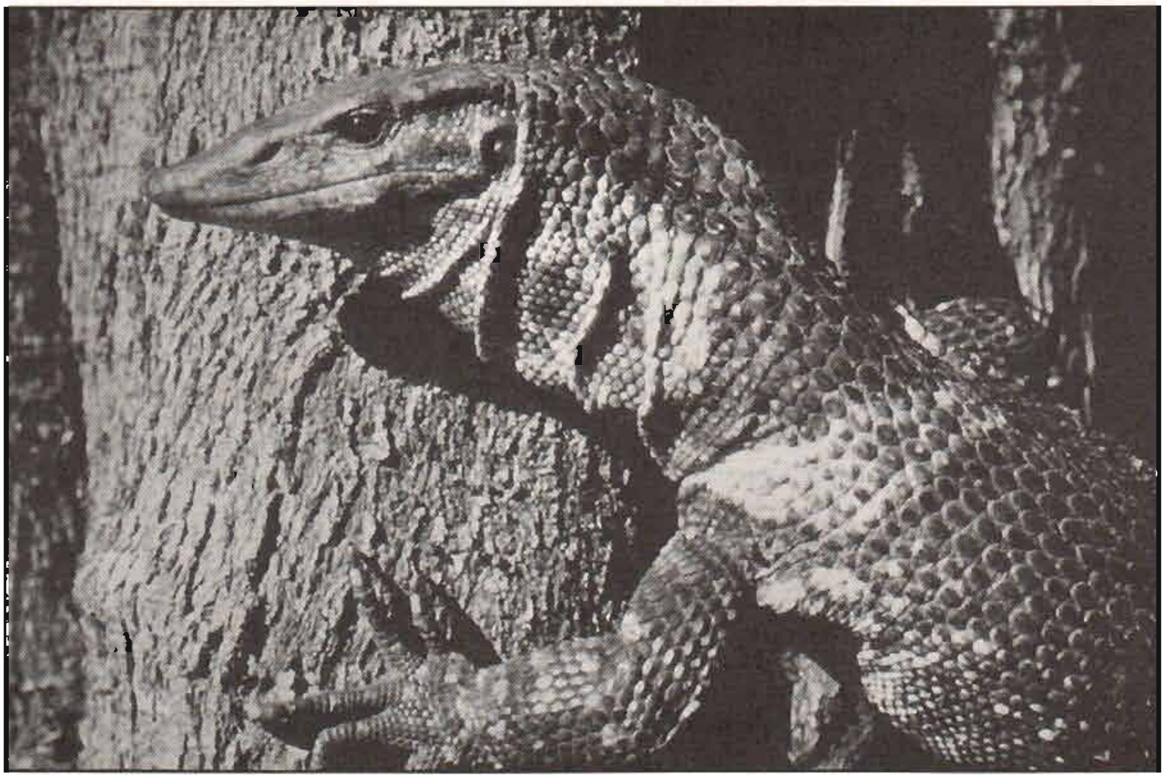

Dumeril's Monitor (*Varanus dumerilli*)
Photo by Bill Love, Glades Herp, Inc.

THE HUSBANDRY AND HEADACHES OF MAINTAINING LARGE LIZARDS IN CAPTIVITY: AN ANECDOTAL APPROACH

Tom Huff

The field of herpetoculture has seen numerous advances in the last ten years. The maintenance and, particularly, the propagation of certain species has increased dramatically. This is due in part to the greater number of individuals keeping reptiles, and the progressive attitudes of zoological institutions. Species which, only a few years ago, were considered to be extremely difficult to keep alive, are now being bred with some frequency. Among those groups of reptiles which have benefitted from this concentration of effort are the boids, the North American colubrids, the crotalids, the viperids, the gekkonids, the helodermids, and the Chelonia. Among the groups absent from this list are: some of the more obscure reptilia, species requiring specialized environments such as the sea snakes, and species of little or no interest (and therefore seldom maintained in captivity) such as the *Typhlopidae*.

Large lizards are the most blatant omission from this list. The larger species of varanids, iguanids, teids, agamids, and gerrhonotids are some of the groups that have only been maintained by small numbers of individuals. Although frequently kept by zoological facilities the number of successful breeding programs for these species is extremely small.

In a review of the records concerning the number of institutions and individuals maintaining large lizards and those successfully reproducing them, there is a major void in equalization. In Reptiles and Amphibians in Captivity, Breeding - Longevity and Inventory, Current January 1, 1990, by Frank and Kate Slavens, the records show this disparity: 23 institutions or individuals were listed as maintaining two species of *Hydrosaurus*, yet only three successful breedings were reported. 55 institutions or individuals were maintaining 10 species of *Cyclura*, but only seven reproductions of four species was reported. 28 respondents were maintaining 10 species of *Ctenosaura*, and 31 respondents were keeping two species of *Tupinambus*, yet none of either genera ere reproduced. 93 institutions or individuals reported keeping *Iguana* with only two successful breeding (not including those bred in semi-natural situations). The Case with *Varanus* is even more dismal and gives an indication of the overall situation: 195 institutions and individuals were maintaining 44 species, yet only four species were reproduced, with one success in each of the four. I could go on with this, but I will assume that you get the picture.

In Review of Reproduction of Monitor lizards, Varanus spp. in Captivity, Horn and Visser report similar disparity for this genus. Additionally, Sprackland reported in Mating and Waiting: A Status Report on Reproduction in Captive Monitor Lizards (*Sauria: Varanidae*), further evidence of this regrettable situation.

The greatest problem with breeding these species is our lack of knowledge. This was a problem with most reptiles maintained in captivity twenty years ago, but as we learned more, and more people became involved in this field, and as this data was disseminated, our knowledge increased and we were able to overcome our ignorance. Since there has still only been limited breeding of the large lizards, we have not yet emerged from the darkness of frustration with these animals. The problems in maintaining and breeding these larger lizards are varied, but generally fall into the following categories: Acquisition, Housing, Stress, and Medical/Nutritional Needs.

ACQUISITION

Because of the cost involved in shipping large animals, the space requirements, and the lower demand, dealers are hesitant to import many of these species. Also, because of their larger size, they are often more in demand for the skin trade, and are therefore frequently protected under the C.I.T.I.E.S. convention, and require extensive paper work and further headaches just to obtain. They are often rarer in the wild, as a result of being taken for their hides, and this makes them more difficult to capture.

Only the highly desirable species such as the rarer monitors are worth the time, effort, and expense to import. Some species such as the Green Iguana, are imported frequently as juveniles, but rarely as adults. They can ultimately make very desirable captives, when reared in an artificial environment, but most do not survive from importation to breeding size.

HOUSING

The obvious problem in this area is the size of the enclosure required for many of these species. You cannot maintain a monitor lizard in a shoe box. Space requirements are a problem for zoos and individuals. Since many of us enjoy keeping a variety of reptiles and amphibians, we have only limited space available, and are often unwilling or unable to provide large, adequate, enclosures for a pair or group of large lizards. There is often an economic consideration, since many herpetoculturists also rely on their captive reared offspring to help finance their collection. If there is a lesser demand for these species, there is less incentive to breed them, and therefore to devote valuable and necessary space to these species. It has further been my experience that many of these species are either social or require multiple numbers for courtship behavior to commence. Therefore, enclosure design must consider, with all its inherent problems, the requirements for a group rather than just a pair.

Economics also plays a role in maintain proper temperature control because of the large area requiring regulation. It is a lot cheaper to heat a number of small terraria than it is to provide the necessary temperature requirements in a huge enclosure. Further, the requirements for ultra-violet radiation, special lighting, and temperature gradients can be both costly, and difficult, from an engineering perspective.

Handling is yet another area of concern in the consideration of housing these larger reptiles. Handling can be both stressful to the animals and of potential physical danger to the herpetoculturist in working with these large animals in a confined area.

STRESS

If space were not enough of a problem, many of these larger species are arboreal, or extremely active, and require vast areas in which to climb or run. Just as a small antelope can be kept in a small fenced area, so will a water monitor "fit" in a small cage; but don't expect to maintain either animal for very long under such limited conditions. This touches on another area of difficulty - that of stress. Most of the problems relating to the husbandry of these or any reptiles can, and probably does, contain a very high degree of stress. Often, when an animal is doing proorly, yet all conditions appear appropriate, or even exemplary, stress is the unseen factor causing problems for the herpetoculturist and his charges. Stress encompasses many situations, from the animal's existence in the wild, to its capture and confinement in captivity, and then to its exposure to other factors (including mates).

MEDICAL/NUTRITIONAL NEEDS

We still don't know enough about the nutritional requirements and medical problems and treatment for these larger lizards. Although many facilities have maintained some of these species, the absense of successful reproduction may indicate a failure to properly provide for the nutritional requirements of these larger animals. Food can often be a problem. Species which feed on rats, mice, mealworms, and crickets, normally do not present a feeding problem, because these food items are readily available, and are cost effective. However, if you are dealing with species which require specialized herbivorous diets, large prey animals, or food species not readily at hand, obtaining food and providing a proper diet can be difficult.

A review of the literature indicates that with few exceptions there has been nothing innovative about the successful propagation which has occurred, and when weighed against the fact that most of these matings have been isolated occurrences, it would appear that the majority of these successes factored on luck. This does not include the success achieved in outdoor, semi-natural enclosures; these breeding have been routinely more fruitful than those occurring in smaller, totally artificial set-ups.

I would like to encourage more individuals and institutions to work with some of the larger lizard species, because:

- They are showy,
- They are, for the most part, threatened or endangered in the wild,
- They deserve our attention, and
- They are often beautiful and impressive relics from an earlier age.

But, don't keep them for the wrong reasons. Don't buy a water dragon just because it would be "neat" to have a giant lizard. Don't buy an iguana just to carry around on your shoulder in the hopes of scaring the heck out of people, or to inflate your own ego. And, don't buy a pair of monitors with the mistaken attitude that you can breed them (where others have failed), unless you are prepared to provide more than adequate captive conditions, and use some personal ingenuity in their herpetoculture.

INNOVATIVE HUSBANDRY

Don't simply put an animal in a cage, give it a dish of water, and throw in some food twice a week. Stop, and consider the needs of that animal. Think of innovative ideas in housing and maintaining your creatures, and don't be afraid to attempt them. However, don't hesitate to correct your mistakes when they prove themselves to be a dismal failure.

I make no pretense of knowing how best to care for or breed these species. I have always been a strong believer in adapting the captive environment to that of the captives (i.e. if your lizards display behaviors which indicate a particular requirement, don't overlook that and deny them that need). I am going to list a few suggestions based on observations which I have made and experiences which I have lived.

SUGGESTIONS

Change the captive environment periodically to stimulate your charges. I am not implying that you build a new cage every six months, but by occasionally rearranging the cage furniture (e.g., branches, rock piles, location of the water dish, feeding stations, etc.) you may stimulate these lizards to be more active, exercise more, and they in turn, may exhibit new behaviors which will lead to the successful propagation of the species.

With the varanids, the introduction of food, the hosing down of the enclosure, a dramatic change in temperature or in the diurnal cycle, or some other 'invasion' of the lizard's territory, will contribute to initiating courtship behavior with your charges. This indicates that manual human intervention can have successful results in reproducing this other genera.

A periodic change in the diet, or the offering of a varied menu will frequently create a positive change in reptiles. Just as your would most likely become bored with a constant diet of peanut butter sandwiches or tofu, a large foraging lizard will appreciate a 'new taste sensation' or stimulus on occasion. Although monitors will eat almost anything of animal (and often, plant) origin, a steady diet of mice and crickets can become tiresome. The provision of dog food and egg in a dish can become so mundane as to be of little more than survival interest to a lizard. But, give them a section of waxworm culture, and you will see even the largest of the monitors become extremely active and excited. In my experience in keeping Bengal Monitors, *Varanus bengalensis*, they were always hungry, and if we fed rodents, insects, fish, or dog food they would consume it immediately, and then become inactive. But if I tossed in a large chunk of waxworm culture, they would become extremely excited and curious. They would approach this mass, *en masse*, and prod, claw, and sniff it with great delight. They then would literally spend hours digging through it, and extracting even the tiniest of larvae, which they would devour with great relish. This frenzy of activity often culiminated in male/male combat and ultimate copulation. A very similar situation resulted when I offered a plate of giant land snails, *Achatina* ssp., to a pair of previously sedentary Savannah Monitors, *Varanus exanthematicus*.

I just mentioned tofu, in a somewhat facetious manner, and yet I recently discovered that many Solomon Island Prehensile Tail Skinks, *Corucia zebrata*, love this food. Some also like cottage cheese, mancaroni and cheese, and other equally bizarre (for a lizard) food items. Although I can't consciously recommend a diet of these foods, I see nothing wrong in offering them periodically. After all, in most cases the foods we are providing our captives in North America are not what they would be consuming in the wild in the Solomon Islands.

One of the most exciting discoveries for me in recent years was with our colony of Egyptian Mastigures, *Uromastix aegypticus*. These are the old world equivalent of the Chuckwalla, *Sauromalus obesus*. They come from the extremely hot climates of the deserts of North Africa and are herbivorous. Although I read everything I could find on this species when first acquiring the group, I made the mistake of not really considering the data pertaining to this species. In these accounts it was often stated that they were herbivorous and that they consumed certain species of plants found within their environment. It often also mentioned that they ate the flowers, seeds , and main stalk of these plants. We set our group up in an enclosure which we felt was adequate (although, this was later altered considerably) and we offered them a mixed vegetarian diet. They readily consumed lettuce, carrot, banana, melon, squash, etc., and for two years fed on this mixture and appeared to be doing fine. Although they appeared to be in good health, they were neither breeding, nor showing signs of precopulatory behavior.

We had, by this time altered the environment through the addition of a large underground den (simulating their natural sleeping and retreat burrow, and the provision of specialty light fixtures and bulbs to create a high candle-power light output and the ultra-violet radiation we considered necessary). We were also regulating seasonal temperatures in an effort to simulate those found within their native environment. None of these improvements produced the desired effect in initiating courtship or copulation.

In an effort to determine that aspect of their ecosystem which was missing, and which we were failing to provide, I re-read the literature pertaining to this species. In doing so, I forced myself to seriously consider the captive conditions which we were offering, as related to those scientifically determined for their existence in nature. The obvious, glaring, omission was their diet. I discovered that stomach content analysis with these, and similar species, revealed that they consumed great quantities of flowers, nuts, and seeds. I immediately offered a number of flowers that I knew to be non-toxic and was delighted to observe their preference for carnations, roses, dandelions, and apple blossoms. What I was unprepared for was their great interest in seeds. I placed a dish of mixed seed in their enclosure, and they became different animals. Wild bird seed, sunflower seed, lentils, a variety of dried beans, split peas, etc. were provided, and they went 'crazy'. They immediately exhibited more energy, enthusiasm, and territorial behavior than they ever had cumulatively in the previous two years. Literally within hours they were exhibiting courtship behaviors heretofore unobserved. There was head-bobbing, aggression, tail biting, and attempted mounting. This has yet to result in egg-laying, but I believe we are much closer to success. To this day, they continue to consume seeds in preference to any other food item. Lentils seem to be their favorite, and you cannot go into the room in which they are housed without hearing the delightful crunching sounds coming from their enclosure.

Most people consider the Gila Monster, *heloderma suspectum*, and Beaded Lizard, *Heloderma horridum*, to be rather lethargic and slow moving creatures. But, try capturing a wild specimen and you will see a side of these lizards virtually unknown in captivity. Exposure to strong ultra-violet radiation changes the activity and behavioral patterns of these species remarkably. And, since this is a more natural situation, I can't help but think that it is the proper method in which to maintain them. The same is, undoubtedly true for other genera. Likewise, there has been a continuation of the ignorance concerning the preferred diet of *Heloderma*. Yes, they will consume egg, but that is neither their total diet, nor even a major component in the wild. Provide mice, birds, insects, fish, frogs, and other protein sources in their diet, and you will see a remarkable change in your captives.

My personal experience with the large monitors is almost totally restricted to my work with *Varanus bengalensis*, the Bengal Monitor. After obtaining a group of twelve animals, deciding that I wanted to maintain them in a group situation, and realizing that we could not provide adequate caging for this number of animals, we established them in a room with about 375 sq. ft. of floor space. The trials and tribulations of this extablishment have been recorded elsewhere, but suffice it to say that it was a long and frustrating experience. However, its ultimate value was realized when the group began displaying behaviors previously unobserved. Interaction in feeding, and seeking perches and retreats was evident daily, and courtship rituals soon commenced.

At various times in our work with this species we had attempted to simply house a pair together. Not only did we fail to observe courtship behavior, but we encountered extreme aggression by the male toward the female, and it was ultimately necessary to separate the animals because the female was suffering from extreme psychological and nutritional stress. When established in a large group, the male aggression was still evident, but it was directed toward other males, and the females were left alone, except for mating.

One of the more remarkable encounters which we observed, was upon introduction of a small male, about 18 inches in total length, to the larger group. The dominant male, who measures 52 inches in total length, immediately advanced to 'initiate' this intruder; which was an expected behavior. But, much to our surprise and that of the dominant male, the small newcomer became extremely aggressive; jumping on the larger animal, biting his head and neck, and digging his claws into the shoulders of the larger animal. He rode around on the bigger male for several hours. The victim of this attack made numerous attempts to dislodge the smaller individual, but even when successful, the aggressor circled around and lept on the bigger animal's back once again. I believe that this sort of interaction is very important. Film I have seen of the Komodo Monitor, *Varanus komodoensis*, and of the Lace Monitor, *Varanus various*, in the wild has pictured similar behaviors, both with males of like stature, and with those of disparate size.

I feel that I must add a section bout the apparent intelligence of the varanides. Over the years I have tried to refrain from becoming anthropomorphic in my descriptions of behaviors and when relating by fascination with reptiles and amphibians, but I have more difficulty in being objective concerning monitors than any other group which I have worked with. Bengal Monitors exhibit a high level of intelligence, and I found myself regularly enticed by their personalities. A favored pastime was to enter their encloseure, sit on a rock pole and engage myself in some activity such as reading or eating my lunch; the whole while feigning interest in the lizards, but observing them in a circumspect manner. Whenever I did this, some of the animals would approach me. Their initial interest appeared to be the determination of whether or not I had food with me. Following that, curiosity seemed to be the key motivator. It was always the dominant male, and some of the subservient males that exhibited this curiosity. Only rarely would a female become bold enough to approach closely, and she would usually then be chased away by one of the males. This frequently resulted in a mounting and pseudo-copulation attempt by the male. The dominant animal, Brutus, would become very bold, and given enough time, would climb on my back or shoulder. He would proceed to check behind my ears, in my ears, in by pockets, sift through my hair, and look in by mouth. He never once attempted to bite or defend himself in any way. If I made a sudden movement (as often happened when he stuck his tongue in my ear, or tickled me in some manner), he would leap away or rear back and hiss until I resumed by previous position and demeanor.

I later made a game of the whole encounter by hiding some food morsel in one of my pockets, and he rapidly learned that there might be a treat for him lurking in some hidden location. He was rather comical in his attempts to stick his head in my trousers or shirt pocket to extract an egg, or a juicy waxworm. The only negative aspect to this ritual was that he tore a number of my shirts, broke a few eggs while they were still in my pocket, and left a few scratches on by flesh - not in aggression, but simply in and attempt to gain a better purchase for his investigations.

It is my belief that recognition of this presumed highly developed degree of intelligence may lead to a break through in the herpetoculture of this genus.

It is not possible to go into specific breeding successes and details. I have merely given some suggestions which I sincerely hope will stimulate your thought processes. However, I am including a bibliography on the large lizards with suggested references. (Editor's note: See bibliography in <u>Notes from the Varanid Workshop</u>). I would encourage you to search them out if you either presently keep large lizards, or if you are contemplating the herpetoculture of them in the future.

I would like to end with two quotes of George Bernard Shaw. The first is: "Some men see things as they are and say, why? I dream things that never were and say, why not?"

This, I believe is the philosophy that we must adopt in herpetoculture. The second quote is just an interesting thought: "The reasonable man adapts himself to the world: the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man."

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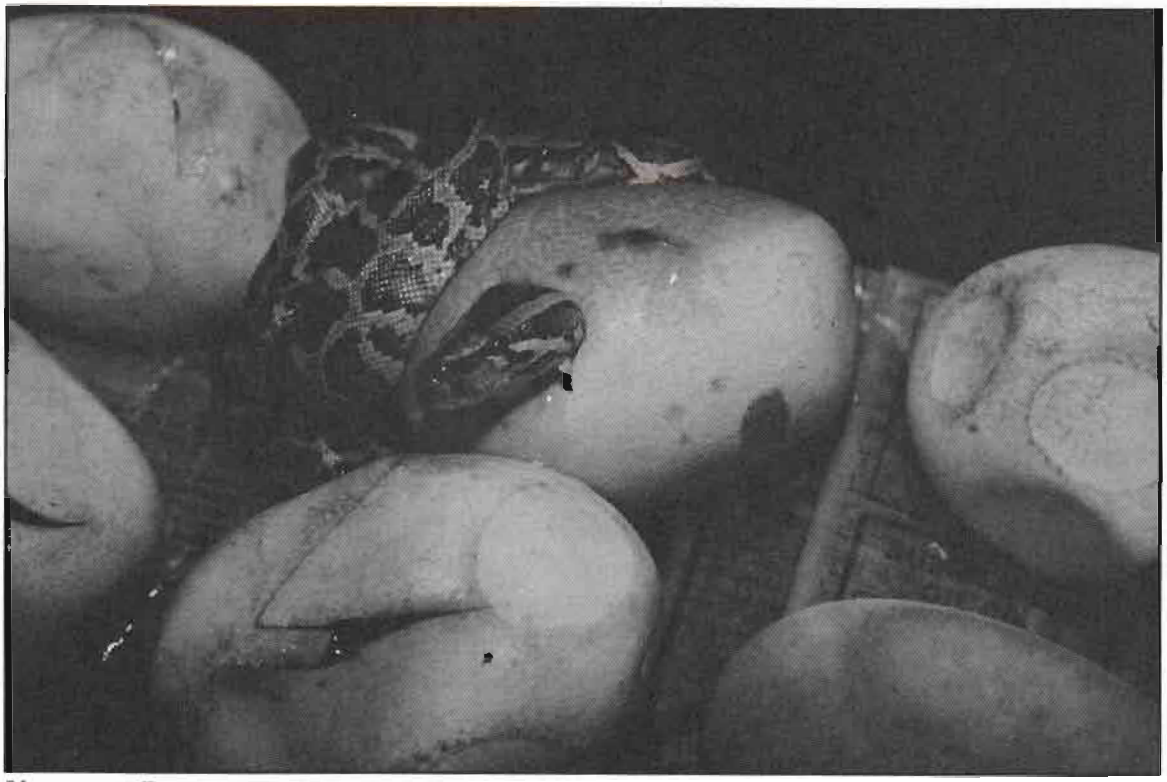

Neonate Burmese Python (*Python molurus bivittatus*)
Photo by Dr. Michael J. Uricheck

NOTES ON THE VARANID WORKSHOP

Michael J. Uricheck, Ph.D.

The large attendance at the varanid workshop most likely reflects a marked increase in interest in the husbandry and breeding of these animals in recent years. Of the thirty-one species and fifty-eight subspecies of monitor lizards, few have reproduced regularly in captivity and many not at all. Some notable exceptions are Hans-Georg Horn, who has bred *Varanus varius* (Lace Monitor) through seven generations, and the work at the Gladys Porter Zoo, which has bred the Water Monitor *Varanus salvator* for four consecutive years (Hairston and Burchfield, 1990). Reports of monitor breeding have been recorded in the International Zoo Yearbook for more than twenty years, but over fifty percent of successful breedings were recorded since 1980.

One of the problems facing prospective breeders is that data for captive propagation are scarce and widely scattered throughout the literature. It was emphasized at the workshop how imperative it is to publish breeding data, which should include:

A. Species.
B. Date of mating.
C. Date that eggs are laid, along with clutch size.
D. Length of incubation (monitors are oviparous and there is a lack of incubation data).
E. Method of incubation (medium and temperature).
F. Results, i.e., hatching dates, percentage of eggs hatching, and hatchling sizes.

A number of observations and suggestions were made for captive breeding of Varanids. It is necessary to be aware of the climate in their natural habitat, especially temperature range, relative humidity, and number of hours of sunshine. This would prevent mixing desert dwellers with rain forest species and would also support the belief that the closer the conditions of the natural habitat are approached, the greater the chance for breeding. It was also pointed out that having mates from different geographical regions may make it difficult to synchronize timing of sexual activity; one partner may be active following hibernation while the other is dormant. It is also important to try and match natural diets; for example, captive tree monitors are frequently fed a diet of rodents, though in the wild their diet consists of geckos, frogs, birds, insects, and eggs.

Monitors often become sexually active after a sudden change in conditions - such as cooling, diet, alterations to cage, and a change in location. There seems to be substantial evidence that monitors do not breed when their existence becomes routine.

A substantial portion of the workshop was devoted to the problem of sex determination in monitors (they cannot be probed). Sex can be assigned to an individual in copulation, but only if a hemipene is observed, because courtship behavior and mounting can be misleading. Success was reported in sexing using the "tail injection" technique, which is a test for the presence of the hemipenes. With this method, a sterile isotonic solution, such as physiologic saline or lactated ringer's solution, is injected so as to surround the hemipene and simulate the vascular pressure, causing eversion. The problem is, how invasive is this? The hemipene has to be slowly manipulated back to the inverted position.

Other options suggested for sexing were:

1. Examination of the gonads with a fiberoptic endoscope.
2. Observation of cloacal swabs for the presence of spermatozoa.
3. Blood hormone analysis (requires sophisticated laboratory techniques).
4. Ultrasonography to detect developing ova in females.

As is usually the case, more questions were raised than solutions offered, but enough interest and enthusiasm were generated to warrant similar workshops at future symposia.

Tom Huff, co-chairman of the workshop, prepared a bibliography of significant literature on Varanid husbandry and breeding:

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Carpenter, Charles C. et. al. 1976. A Further Analysis of the Combat Ritual of hte Pygmy Mulga Monitor, *Varanus gilleni (Reptilia: Varanidae)*. Herpetologica 32(1):35-40.

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Thursday, June 20

8:00 am **Registration Open**

9:00 am **Welcome & Opening Remarks**
--Brian P. Backner, M.D., President, IHS, Inc.

Moderator: Brian P. Backner, M.D.

9:20 am **Disppearing Amphibian Populations -- What is the Message? Chicken Little or the Boy Who Cried Wolf?**
--George C. Gorman, Ph.D., Stanford University Center for Conservation Biology, Stanford, CA

9:50 am **The Current Status of the Pacific Giant Salamander and the Herpetofauna of the Pacific Northwest**
--Vic Palermo, Department of Fisheries, Vancouver, B.C., Canada

10:15 am **New Concepts in Colubrid Egg Incubation - A Preliminary Report**
--Stephen Hammack, Herpetarium Supervisor, Fort Worth Zoo

10:40 am **The Husbandry and Propagation of Budgett's Frog, Lepido Batrachus laevis**
--Phillipe de Vosjoli and Robert Mailloux, D & M Herpetoculture. Lakeside, CA

11:05 am **Reproductive Biology of the Rubber Boa**
--Richard Hoyer, Corvallis, OR

11:30 am **Lunch**

Moderator: Michael J. Uricheck, Ph.D.

1:00 pm **The Use of Ciprofloxacin, a New Antibiotic, in Snakes**
--Roger J. Klingenberg, D.V.M., Greeley, CO
--Brian P. Backner, M.D., Sharon, MA

1:25 pm **Advanced Management Protocols for the Captive Propagation of Endangered Reptiles**
--Howard Lawler, Curator of Herpetology and Icthyology, Arizona - Sonoran Desert Museum, Tuscon, AZ

1:50 pm **The "Jungle" Carpet Python Morelia spilota variegata, Husbandry and Breeding**
--William B. Montgomery, Private Breeder, Austin, TX

2:15 pm **Mating Systems of Snakes: Theory and Empiricism**
--Gordon Schuett, Department of Zoology and Physiology, University of Wyoming, Laramie

2:40 pm **Break**

2:50 pm **Workshop on Turtle Husbandry**
--Brett Stearns. Institute for Herpetological Research, Stanford, CA

3:50 pm **Break**

4:00 pm **Workshop on Tortoise Husbandry**
--Brett Stearns, Institute for Herpetological Research, Stanford, CA

7:00 pm **Icebreaker with Open Bar**

9:00 pm **"Name-That-Herp" Slide Show**
--John Tashjian

Friday, June 21

8:00 am - **Registration:** Open

Moderator: David Hulmes

9:00 am - **Tortoises of the World: Their Conservation and Current Status**
--Peter C.H. Pritchard, Ph.D., Florida Audubon Society, Maitland, FL

9:45 am - **Breeding the Desert Horned Viper, Cerastes cerastes, in Captivity**
--Larry Moor, Port Coquitlam, B.C., Canada

10:10 am **The Conservation of Endangered Snakes: Management of Propagation Programs**
--John McClain, Curator of Reptiles, San Antonio Zoo

10:35 am **Conservation, Cooperation and Consensus -- How Herpetological Organizations Can Work Together**
--Frank L. Lundberg, President, Idaho Herpetological Society, Boise, Idaho

11:00 am **Reptiles and Amphibians as Renewable Resources: Are We Ready for The Future?**
--William Lamar, School of Science, University of Texas, Tyler, TX

11:25 am **Lunch**

Friday, June 21

Moderator: Richard A. Ross, M.D.

1:00 pm - **Acclimation and Captive Husbandry of Boelen's Python**
--Ernie Wagner, Private Breeder, Seattle, WA

1:25 pm - **Poison Dart Frogs -- Wild and Captive**
--Jack Cover, Curator of Rain Forest Exhibits, National Aquarium, Baltimore, MD

1:50 pm - **Captive Husbandry of Johnstone's Crocodile Under Treatment For Bilateral Mandibular Fractures**
--Jon Birkett, Herpetofauna Department, Melbourne Zoo, Australia

2:15 pm - **Lizard Management at the Oklahoma City Zoo with Special Reference to Uromastyx, Chameleo and Heloderma**
--David Grow, Curator of Herpetology, Oklahoma City Zoo

2:40 pm **Break**

2:50 pm **Workshop on European Amphibian Husbandry -- Breeding Tropical Frogs**
--Dr. Elke Zimmermann, Konstanz University, Germany

3:50 pm **Break**

4:00 pm **Workshop on Varanid Management**
--Tom Huff, Herpetoculture Information Search Service, Picton, Ontario, Ontario Canada
--Michael J. Uricheck, Ph.D., Department of Chemistry, Western Connecticut Connecticut State University, Danbury, CT

7:00 pm **Banquet**

8:30 pm **Special Guest Speaker Gary Larson**

????? **Auction**

Saturday, June 22

8:00 am	**Registration Open**
	Moderator: Giovanni Fagioli
9:00 am	**Dart poison Frogs (Dendrobatidae): Biology, Breeding and Conservation** --Dr. Elke Zimmermann, Konstanz University, Germany
9:25 am	**Maintenance and Breeding of Australian Elapid Snakes** --John Weigel, Park Manager, Australian Reptile Park, Gosford, Australia
9:50 am	**Ecology of the Water Python, Liasis fuscus** --Richard Shine, Department of Zoology, University of Sydney, Australia
10:15 am	**Conservation Strategies for the Managascar Angulated Tortoise, Geochelone yniphora** --James Juvik, Ph.D., Center for Island and Ocean Resource Management, University of Hawaii at Hilo --Lee Durrell, Jersey Wildlife Preservation Trust, Channel Islands, Great Britain
10:40 am	**Metabolism of Embryonic Reptiles** --Michael Thompson, Lecturer in Biological Sciences, University of Sydney, Australia
11:05 am	**Analysis of Body Size and Growth in an Introduced Population of the Western Fence Lizard, Sceloporus occidentalis in Northern Puget Sound** --Herb Brown, Professor of Biology, Western Washington University, Bellingham, WA
11:30 am	**Lunch**
1:00 pm	**Workshop on Lizard Husbandry** --David Grow, Curator of Herpetology, Oklahoma City Zoo --Allen Anderson, Private Breeder, Des Moines, IA
2:00 pm	**Break**
2:10 pm	**Workshop on the Breeding of Rare Pythons and Boas** --Don Hamper, Private Breeder, Columbus, OH
4:00 pm	**Buses Leave for Woodland Park Zoo**
6:00 pm	**Barbecue**
8:00 pm	**Buses Return to Hotel**
10:00 pm	**Hospitality Suite Open**

Sunday, June 23

Moderator: Michael J. Uricheck, Ph.D.

9:00 am — **"State of the IHS" Report**

9:50 am — **The Status of Madagascan Herptiles**
--Quentin Bloxam, Curator of Reptiles, Jersey Wildlife Preservation Trust, Channel Islands, Great Britain

10:15 am — **Natural History of the Diamond Python, Morelia spilota spilota**
--Richard Shine, Department of Zoology, University of Sydney, Australia

10:40 am — **Legislative Protection of Reptiles in Australia and Its Impact Upon Herpetoculture, Research and Conservation**
--John Weigel, Park Manager, Australian Reptile Park, Gosford, Australia

11:05 am — **A Regional Herp Management Plan for Australasia**
--Jon Birkett, Herpetofauna Department, Melbourne Zoo, Australia

11:30 am — **Lunch**

Moderator: Brian P. Backner, M.D.

1:00 pm — **The Secret Life of the Bog Turtle**
--John Behler, Curator of Herpetology, New York Zoological Society, Bronx, NY

1:25 pm — **Conservation and Ecology of the Fijian Crested Iquana**
--James Juvik, Ph.D., Center for Island and Ocean Resource Management, University of Hawaii at Hilo

1:50 pm — **Problems Encountered with The Husbandry of Emerald Tree Boas**
--Matthew Moyle, Ph.D., Walnut Creek, CA
--Richard A. Ross, M.D., M.P.H., Institute for Herpetological Research, Stanford, CA

2:15 pm — **Break**

2:25 pm — **The Husbandry and Headaches of Maintaining Large Lizards in Captivity With Special Reference to the Varanids**
--Tom Huff, Herpetoculture Information Search Service, Picton, Ontario, Canada

2:50 pm — **Ethological Contributions to the Propagation of Reptiles in Captivity**
--David Chiszar, Ph.D., University of Colorado, Boulder
--James Murphy, Curator of Reptiles, Dallas Zoo

3:15 pm — **"Herpabolics Anonymous - The Dream Lives"**
--Stephen Hammack, Herpetarium Supervisor, Fort Worth Zoo

3:40 pm — **Closing Remarks**
--Brian P. Backner, M.D., President, IHS, Inc.