

Vivarium Exclusive! The Herpetology of Ima-Gina

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VOLUME 11 NUMBER 2

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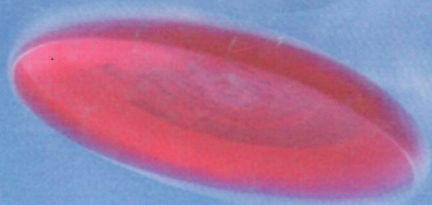
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Sculpting Lizards

by The Vivarium Staff

What determines your management of breeding lizards? Let's say you have an outstanding female bearded dragon — bright yellow highlights, a traditional blocky dragon head, placid disposition. Select a male with equally outstanding characteristics, and there's an excellent chance their offspring will be of superior quality. Right? Breed the best to the best, follow guidelines on egg incubation, and success follows.

A recent paper details cutting edge research by Richard Shine and Sharon Downes in Australia that may add new dimensions to the management of breeding lizards. Here's a brief overview.

The Hypothesis

We know that environment directly influences gravid females, sometimes resulting in changes in the appearance (phenotype) of offspring. An example is smaller offspring from females which are underfed. But, can environmental cues affect gravid females so that changes to the offspring actually help the youngsters adapt to their environment? In other words, can females modify their offspring during gestation to better prepare them for life after birth? This is the question addressed by Shine and Downes (1999).

Research Trials

The investigators picked *Pseudemoia pagenstecheri*, a small viviparous skink from New South Wales, because this species transfers about half of the offspring's nutrients across the placenta during

embryogenesis. If females truly modify their offspring to help them adapt, the prolonged placental contact of this species make it an excellent candidate for study.

The researchers looked at three variables in the environment of gravid females — restricted food supply, restricted basking opportunities, and frequent exposure to the scent of a predatory snake, *Drysdalia coronoides*. A fourth group served as controls. The lizards remained in these groups until birth of the offspring, who were then examined for size, shape and behavioral traits.

Results - The gravid skinks produced offspring that were affected by maternal environment. Those which were underfed delivered smaller neonates, and those deprived of basking sites had delayed parturition. These changes don't necessarily reflect adaptive improvements, although there may be biological significance to the modifications. Other results, however, suggest that changes in offspring are adaptations that would improve fitness and survival in the wild.

Compared to controls, gravid skinks exposed frequently to the scent of a predatory snake produced offspring with significantly longer tails, relative to snout-vent length. The authors propose that longer tails improve the effectiveness of tail autotomy if a predator is encountered. These offspring were also heavier, a trait contributing to overall improved fitness of this group.

Moreover, offspring from the mothers exposed to snake scent were twice as reactive to the snake scent as were offspring from the other groups. Reactions to predator scent included tongue flicks and a raised tail stance. The researchers review the possible mechanisms that could bring about such changes in offspring; much work remains to elucidate the physiological mechanisms.

Applications and Speculations

This paper presents further confirming evidence that the environment of a gravid lizard results in modifications to the offspring — underfeeding produces smaller neonates, and lack of basking sites delays parturition. The data serve as a reminder that we need to carefully manage gravid females.

What's even more exciting for herpetoculturists is the evidence that gravid lizards can respond to environmental cues and modify the appearance and behavior of their offspring to improve fitness, hence survival. Frequent exposure to the scent of a predatory snake while pregnant resulted in longer tails and anti-predator behavior in offspring. While this study focused on a species selected for its prolonged communication between mother and embryos, there's significant evidence suggesting that maternal modification occurs in other animals (see references in Shine and Downes, 1999). Breeders of viviparous lizards such as Jackson's chameleons and prehensile-tailed skinks may especially need to be aware of environmental influences.

It's clear that there's more to breeding lizards than the usual attention we give to temperature, humidity, clutch substrate and the like. Can we affect conformation such as tail length by housing snakes in the same room as our lizards? Do such changes offer potential for improving herpetoculture? Modifications in conformation which serve to improve fitness in the wild may not necessarily enhance the appearances we select for in herpetoculture.

Are there as yet unidentified environmental factors that could distort traditional conformation of lizards? Some bearded dragons marketed today have narrow heads, pointy noses and long backs — the result of indiscriminate breeding or unidentified environmental influences?

For now, we have many more questions than answers. Continued studies by researchers will provide us with the details to make better informed decisions about the husbandry of our herps.

Literature Cited

Shine, R. and S. J. Downes. 1999. Can pregnant lizards adjust their offspring phenotypes to environmental conditions? *Oecologia* 119:1-8.



Little work has been done to determine the effects of environment on the form and proportions of captive-bred lizards such as bearded dragons.



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Carel Brest van Kempen



Reptile Art Show

Sponsored by IRBA and *The Vivarium*
by *The Vivarium* staff

Some of us have this crazy idea of elevating herpetoculture to a level that infiltrates a wide area of culture. For us pioneer herpers, it actually all started as a form of art rather than biology. Once we noticed the gold and silver irises, the intricate details of scalation, the subtle and complex patterns and distributions of color, we found our herpetological epiphanies — and we crazily sought to turn the world on to our madness.

To celebrate the beauty of herps, we invited artists to participate in the Reptile Art Show held at the 1999 multi-event IRBA show held October 9-10 at the San Diego Concourse and sponsored by both IRBA and *The Vivarium* magazine. As often happens when you're overwhelmed with work, organizing the Art Show was a last minute project. Grid walls were purchased only days before the event. Friends and artists were contacted only a couple of weeks before. Almost miraculously, the show assembled itself, the artists came through, and thousands of members of the public had a glimpse of some of the finest herp art out there. And yes, art was bought and sold.

Carel Brest van Kempen, one of the most original and finest herp artists on the planet came to the rescue and not only displayed his masterpieces but also helped with the last minute organization of the show.

Mary Hawley, a prize-winning wildlife artist and one of the world's top herp watercolorists had several pieces on display entered by Chris Estep.

Gamini Ratnavira, another renowned wildlife artist and art event organizer showed his acrylic and oil paintings of herps and tropical forest themes. He has also offered to help organize next year's Reptile Art Show.

Advanced Vivarium Systems displayed several of their paintings by popular herp artist **Marty Capron**.

David Northcott, a photographer regularly featured in *The Vivarium* showed his spectacular large glossy photographs.

Philippe de Vosjoli entered some of his recent photo experiments in macrophotography.

Sam Garcia showed several of his detailed pen and ink drawings, including *Rhacodactylus leachianus*.

Therese Bushen displayed pottery with reptiles and native American themes including clay shaman rattles.

Arlene Matsson showed ink and water color paintings of urban scenes populated by anthropomorphic crocodiles and other creatures.

Special thanks to Carel and Jerry Cole for their invaluable help and good company.



Famous wildlife artist Carel Brest Van Kempen attended and helped organize the 1999 IRBA San Diego Reptile Art Show.



A great variety of art was displayed including many paintings



Therese Bushen

Herp News

from Around the World

by Ellin Beltz



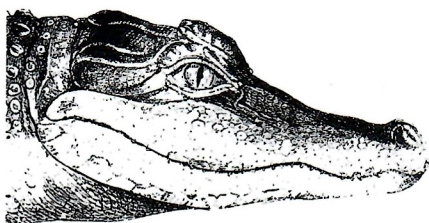
What would we do without us?

• The News of the Weird reports that a 26-year-old man who "habitually carries a live snake around his neck, escaped from police in Tennessee" where he was allegedly being held on suspicion of Driving Under the Influence of alcohol. About six hours later, the same man was arrested in Athens, Alabama "when people reported seeing a guy with a snake around his neck." [*San Jose Mercury*, October 5, 1999 from Wes von Papineau and Andy Via].

• Chuck Shepard also wrote, "if people didn't drink, there wouldn't be enough News of the Weird for a weekly column," and cites a story in the June *New England Journal of Medicine*. Two doctors, repeating earlier work, found that decapitated rattlesnake heads can deliver a venomous bite and added that "young men, particularly while intoxicated" receive most of these bites after grabbing or "engaging" the snake's head. [*Columbia Daily Tribune*, September 23, 1999 from Oliver J. Sieckmann; *Health News*, July 25, 1999 from Alan Rigerman and the *NEJM* story from Gary Ketting June 17, 1999 Volume 340(24)].

• A 24-year-old man rescued his grandmother and his albino Burmese python from their home after an airplane crashed into it, setting the house on fire. Three other residents of the home were not there during the accident. The occupants of the plane, which was owned by a Miami law firm, apparently died in the crash. [*The Miami Herald*, August 14, 1999 from Alan Rigerman].

• The Orlando, Florida Gatorland sponsored a Gator Cookoff to celebrate the success of the Endangered Species Program. Their spokesman said that it



was due to conservation that alligators are again so common that "you can come here and eat them." The top prize was \$1,500; entries included gator pizza, gator linguini and gator fettuccine. None of Gatorland's 3,000 live gators was on the menu. [*The Miami Herald*, September 20, 1999 from Alan Rigerman].

Two-in-two million too

• The *Times-News Weekender* reports that an eight-grade boy found a two-headed snake while he was out flipping rocks with friends. In the past four years, these budding herpetologists had found harmless snakes, snapping turtles and frogs. "Because the two-headed snake is not venomous" the boy's mother let him keep "the pencil-sized reptile... in a 10-gallon terrarium in their home." The boy said that he thinks it's a queen snake because he's "caught a bunch of them." He also reports that both heads eat, and even fight for food items. [Erie, Pennsylvania, October 2, 1999 from Brian Wettekin].

• Meanwhile in St. Louis at the Children's Aquarium, a 3-month-old albino black rat snake with two heads is the star of their new show of captive bred reptiles. The founder of the Aquarium said, "The active head's [eye] pupils are thicker, but it switches back and forth so we know both brains are working." A veterinarian said that the two-headed mutation is one-in-a-million and cannot be induced by captive breeding. [*St. Louis Post-Dispatch*, September 16, 1999 from Vicky Elwood].

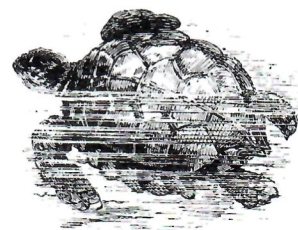
Road kill is so in, you know

Developer Donald Trump's latest golf course project in West Palm Beach, Florida has an area set aside for gopher tortoises, but his representative balked at tortoise-friendly parking and road edging. One local Zoning Commissioner said it was inexplicable because "Donald is known throughout the world for going first-class on everything." [*The Ocala Star-Banner*, September 4, 1999 from Alan Rigerman].

To die for

The most endangered of all sea turtle species is the Kemp's ridley. But few stop

to wonder who was Richard Kemp, for whom this lonely wanderer of the Sargasso is named. He was born in 1825 in Green Turtle Cay, sent the specimen to the Harvard Museum of Comparative Zoology in 1880 and died of chronic bronchitis in Key West at age 83. He may or may not have been related to the other Kemps in the Keys. The only gravestone was of his son, Richard H. Kemp. A local environmentalist is now raising funds to get the patronymic Kemp a head-



stone, with his proper name and dates and a drawing of the odd *Lepidochelys kempii* which bears his name. One local board member said, "It's incredibly cool. Wouldn't you kill to have some species named after you?" [*The Herald*, September 5, 1999 from Alan Rigerman].

Caught whilst hanging out

The *South China Morning Post* reports that a father who bought a python as a pet for his six-year-old child as a pet was fined US\$1,000 for keeping the snake without a license. After several months of keeping the snake without incident, it had escaped and was discovered wrapped around some washing lines by a neighbor who notified authorities. [October 6, 1999 from Wes von Papineau and Eloise Beltz-Decker].

Scary stories from Florida

On August 30, 1999 *The Miami Herald* reported that researchers studying Lake Griffin alligator deaths have found a mysterious toxin, unlike any known previously to science, which causes microscopic sores in a particular area of dead gators' brains. The gators were killed because they were disoriented and even let people pick them up without a fight. Necropsies revealed the lesions. "Scientists are particularly concerned that if

something can kill a species like the alligator which has survived more than 300 million years [that] other, less hardy animals around the lake might be affected, too." On September 10 comes a story that alligator hunters were permitted to take gators from parts of the Everglades previously closed to hunting because of high mercury levels in the food chain. Gators taken from this area are only supposed to be mounted, or used for skins — not eaten. Gator hunters said that they spotted nothing longer than 10 feet and that the ones they caught are "scrawny" and "look terrible." Then, on September 19, the same paper reported that frog leg hunters in Kenansville, Florida are finding that frogs are more scarce than in years past. The "best frogging" according to the hunters occurs in Lakes Kissimmee, Jackson, East Toho, Marian and Okeechobee. [from Alan Rigerman].

Chytrid again?

The *Environmental News Service* reports that more than 30 endangered boreal toads were found dead of a fungal infection in their locality west of Denver, Colorado. Many of the deceased were subjects of five years of intensive research and are tagged with bar codes or radio transmitters that could help provide information to researchers "on why amphibians have been disappearing around the world." [GreenLines, September 8, 1999 from Roger Featherstone].



Wander the web

- Sign an internet petition to stop the sale of wild caught turtles for food in San Francisco at <<http://www.tortoiseaid.org/sfpetition.html>>. [GreenLines, September 13, 1999 from Roger Featherstone].

- Read more about the Asian turtle crisis on the New York Turtle and Tortoise Society website <<http://nytts.org/asianturtlecrisis.html>>. [From Alan Salzberg].

Snake attacks in the news

- The *Orlando Sentinel* reports that an 18-month-old boy was bitten in the face by a 13-foot Burmese python which had been placed in the tub to soak. Surgeons saved the child's eye, sewed up the scalp wounds, and reattached his eye-

lids. Family members said the snake had never been aggressive before and that the children were accustomed to touching and being around it. After the attack the snake was judged to be dangerous, was euthanized and buried in the landfill. [August 6, 1999 from Wes von Papineau].

- An eight-year-old Georgia boy was attacked by a ball python being kept at his school which specializes in children with emotional disorders. The three-foot-long snake curled around the child's neck and bit him. The child was reported to have been playing with the school's pet mice shortly before the attack. The snake was removed from the school. [Yahoo News, October 5, 1999 from Wes von Papineau and Eloise Beltz-Decker].

- The parents of a Centralia, Illinois 3-year-old boy who was killed by the family's pet African rock python have received hate mail, vicious phone calls and have been charged by authorities with child endangerment and keeping a dangerous animal. If convicted, each could face up to 10 years in prison. Their lawyer said that it should be obvious that the parents had "zero criminal intent." The state's attorney said that "parents should know if their child is in danger," and suggested the case should be judged as if the parents were driving drunk or letting a violent or sexual offender into their home. Both parents are out of work; friends helped them get the St. Louis attorney who will represent them at trial. [St. Louis Post-Dispatch, September 19, 1999 from Oliver J. Sieckmann].

Please release me!

"Scientists have determined that the little [sea turtles] experience... a 'swimming frenzy' that's needed for their long journey to the Gulf Stream. Delaying the transition to the water could harm their already-slim chance of survival," according to the *Richmond Times-Dispatch* [August 29, 1999 from Andy Via]. Researchers have long held babies collected on the beaches overnight and released them when they can be easily seen and photographed. New work shows this may influence their survival rate. [Northern Virginia Daily, August 30, 1999 from Bryan McCarty].

Thanks to everyone who contributed to this column and to Marty Marcus, Alan Rigerman, Matthew Aikawa, Carla and Miguel Ochoa. I look forward to receiving contributions from you, too. Just fold up the pieces of newspaper, put one of those holiday address labels on each piece and mail to me at the address on the masthead. Don't delay, the file is almost empty again!



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LETTER TO THE EDITOR

To the Editor:

"Radical Ideas For 21st Century Herpetoculture Part 1" [Vivarium 11(1)] has a proposal for legalizing the sale of baby turtles ("Millenium Headline: Four-Inch Rule Goes the Way of Asian Turtles"). This certainly would make life easier and cheaper for turtle breeders, but that is less important than the public health. Virtually nobody likes regulation less than I do, but if it saves children from horrible and potentially life-threatening diarrhea, it should be kept. It is our public duty to the rest of society to make our hobby safe for society. The Center for Disease Control has recently and clearly stated that thousands of cases of Salmonellosis are traced to pet reptiles. Science will not support the removal of the four-inch (10 cm) size ban on turtles and tortoises and neither should those responsible forces in the herpetological community.

Richard Cary Paull
Homestead, FL

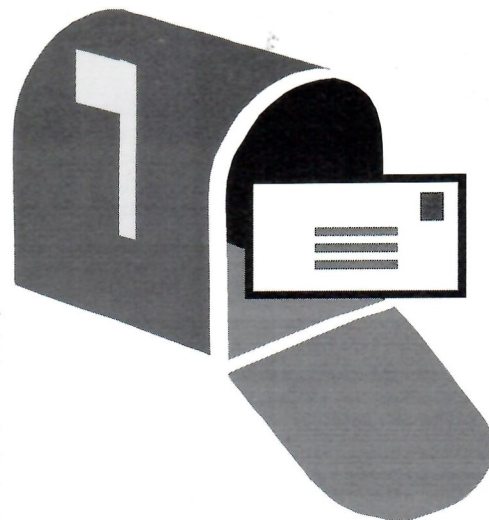
Editor's Note: The US Center for Disease Control and Prevention (CDC) currently estimates

93,000 cases of reptile-associated salmonellosis yearly. Most of these cases arise from green iguanas; the rest are from other lizards, snakes and turtles. They represent no more than 7% of the total number of salmonellosis cases, because most cases in the US arise from food. Salmonella is estimated to contaminate 40% of the US poultry and egg supply, 12% of pork, and 5% of beef. Approximately 20-30% of all cases involve bacterial resistance from the use of low-dose antibiotics in cows, pigs and chickens. Additional documented causes include consumption of contaminated fruits and vegetables, fish and shellfish, raw milk and contaminated pasteurized milk, dairy products, contact with rawhide and pigs-ear chews marketed for dogs, and contact with pet birds, dogs, cats, fish, and reptiles.

Reptiles are inappropriate pets for very young children, and exposure of toddlers to all reptiles should be limited and supervised. Perhaps reptiles should be sold with recommendations of suitability for specific age groups of children, such as the guidelines found on labelling of toys. Banning the sale of all salmonella-shed-

ding animals (including turtles) to minors makes more sense than the current four-inch rule, which singles out chelonians while ignoring the factors that cause more than 93% of salmonellosis cases.

We agree that salmonellosis is a public health problem with serious and sometimes deadly consequences. Yet today's salmonellosis is a different culprit than the one of the early 1970s (when the four-inch regulation was enacted) with regard to prevalence, serotypes, antibiotic sensitivity, and cause.



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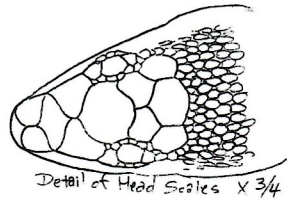
We failed to give credit to Mark Smith for his outstanding photos of the albino green iguana in Vivarium 11.1 page 8. And the Mocha Boa in Vivarium 10.1 page 34.



A Vivarium Exclusive: The Herpetology of Ima-Gina

by The Vivarium staff
Narratives by L. Damaglio, and C.B. Klondike

CRAB EATER
("Tupiranus imaginensis")
Ima-Gina Island, June 1998



Crab Eaters
(*Tupiranus imaginensis*, Klondike 1999) Sketch of crab eaters capturing and feeding on hermit crabs. Close-up of head showing plate-like cranial scales. Illustration by C. B. Klondike.



A Vivarium staff member met a Ms. Luigina Damaglio at a small bar in New Orleans during Mardi Gras in 1999. After a few drinks, the conversation led to an amazing story. On June 13, 1998 Luigina Damaglio and a team of professional SCUBA divers yachting about the world were forced because of a tropical storm to land on a small island located between Brazil and Africa. The crew spent three days on the island waiting for the storm to clear the area so they could resume their voyage toward the South African coast. During their brief stay, all were surprised by the unusual fauna inhabiting this desolate island.

Team member Charles B. Klondike, an ornithologist and scientific illustrator, became captivated by the island's creatures and sketched several over the short period. Lydia Kramer, the team photographer, whose photographic equipment had been damaged by sea water, was able to photograph some of the creatures using an inexpensive plastic bodied pocket camera stored in a nylon backpack.

Upon their return to civilization, extensive research and investigation of maps of the area to locate and identify this island proved futile. The island was named Ima-Gina to honor a lost team member and his surviving spouse.

Just for the sake of it, our staff member asked Luigina Damaglio if she would be willing to submit some of the records of the fauna of Ima-Gina for publication in *The Vivarium*. Much to our surprise, in October 1999, a package arrived in the mail from Italy which, lo and behold, contained what we consider some of the most extraordinary herpetological discoveries of our time. The following are exclusive Vivarium excerpts from the upcoming *Three Days on Ima-Gina* by J. Carter, L. Damaglio, C. B. Klondike, E. Kramer and L. Kramer.

The Crab Eaters

"During our first nights on Ima-Gina, we were startled by what sounded like hundreds of footsteps crunching on gravel. Our imaginations ran wild, wondering if island natives had been watching us all along and had waited until nightfall to capture us for unspeakable tortures ending in the inevitable ritual sacrifices. Lydia and I looked at each other wide-eyed with fright, our hearts pounding in our chests so loud we thought they would explode. Crack, crack, crack, crunch,

crunch, crunch. John turned to Carl and Edward, saying 'Let's take the lights and have a look.' I cried 'You can't leave us here alone.' Edward said 'I'll stay with the girls; let me know if you need help.' They left the tent, flashlights in hand, following the shoreline toward the noise. John returned about twenty minutes later. 'You won't believe this,' he said, 'the noise is coming from large lizards along the beach capturing and eating hermit crabs. Charles is out there trying to sketch the

Dear Mr. de Vosjoli:

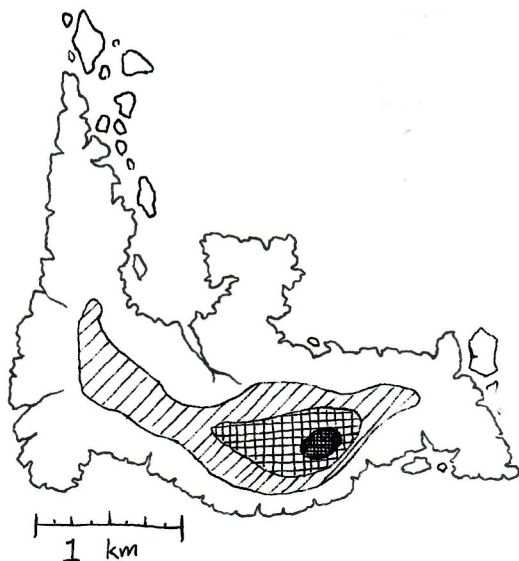
I just received word of your interest in our little adventure on Ima-Gina.

Ms. Damaglio tells me you're interested in seeing some of my sketches from the island.

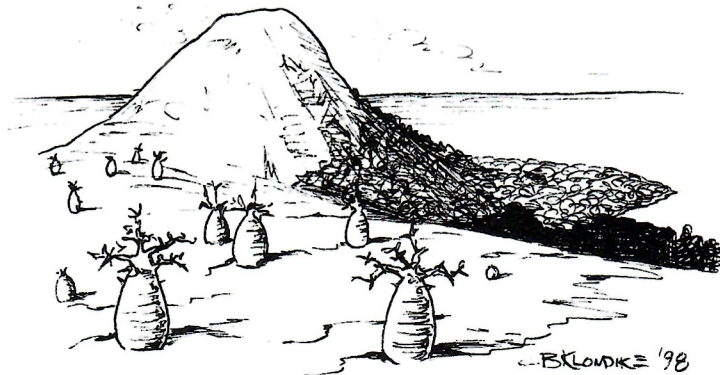
Enclosed please find some original pages from my notebook.

Sincerely,

CHARLES B. KLONDIKE



Rough Map of Ima-Gina Island



Landscape sketch of lava fields and "urn plants"
Ima-Gina Island, June 1998

Map of Ima-Gina. Illustration by C. B. Klondike

Caudexed urn plants contrasted against the barren lava fields. Illustration by C. B. Klondike

Notes on Ima-Gina by C. B. Klondike

"Ima-Gina is a volcanic island; a small dormant volcano with open crater lies near its center. The base of the volcano is covered with lush vegetation but the landscape becomes almost desert-like about half way to the top. Odd plants with urn-like swollen bases are scattered in the glass-like lava in that desolate zone. In the low forest near the base, there are areas in lava pits that hold fresh water and form small pools. I am assuming that rain is stored in the lava and trickles through at a slow rate to feed the pools and small streams. Some pools hold small fish, others a single tadpole of a species we coined the piranha frog. The forest floor has plenty of small lizards, skinks of sorts. Inside deep lava hollows close to the beaches live large big-headed lizards that emerge after sunset to feed on hermit crabs and scavenge along the shoreline. A feature of the open areas of forests are very large silk-orb type spiders. The shores are littered with seashells and crabs.

One of the most unusual creatures on the island was a lizard we called chameleon..." To be continued...

things. He smashed a few crabs with a rock and he's got a dozen around him feasting like dinosaurs.' As it turned out, on day three, the day before our departure, we noosed two of those crab-eaters and had them for dinner."

The Piranha Frog

(*Piranharana carteri*, Klondike 1999)

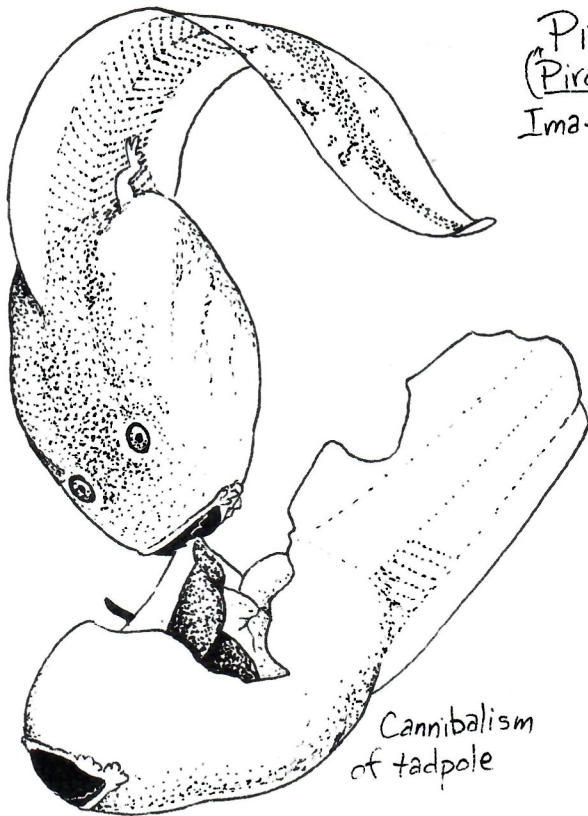
"On the second day our team leader John Carter found this odd large tadpole, as big as a closed fist, in a small pool. Strangely enough it was the only tadpole in that clear pool. Later he ran across several other small pools maybe three feet across, scattered in open areas surrounded by forests. As with the first pool, all he found was one tadpole per pool. In one of the pools the tadpole had hind legs and appeared near to becoming a frog. John decided to scoop out a tadpole for a closer look but as soon as he put his hand in the water, the tadpole swam toward him and nipped off the tip of his finger. Later we decided to tease the things and tossed different objects into the pools. Leaves, pieces of wood and even seashells were attacked by these



Piranha frog tadpole caught gulping air at the surface of a pool. Photo by Lydia Kramer.

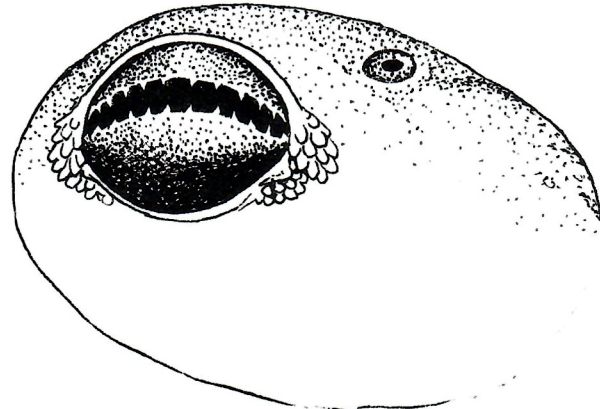
PIRANA FROG
(*Piranarana carteri*)
Ima-Gina Island, June 1998

Piranha frog tadpole feeding on another tadpole. Close-up of beak and teeth of piranha frog tadpole. Illustrations by C. B. Klondike.



Cannibalism
of tadpole

Detail Showing mouthparts of
Tadpole x2



—BK LONDIKE '98

piranha version of frogs. Charles wanted to sketch these man-eating tadpoles but, for obvious reasons, John wanted nothing to do with helping remove a tadpole from the water. Edward volunteered to return to camp and bring back one of our spear guns. He then shot a tadpole in the middle of the gut and brought it on to land. Its sharp beak-like mouth snapped at the air. Charles sketched the thing as it struggled. Once done, Edward and Charles carried the still-living tadpole to one of the other pools and, using a stick, yanked it off the spear. It barely touched the surface when the pool's resident tadpole tore into it, nipping little piece by little piece, its stomach eventually becoming as distended as a balloon. It was grotesque and gave me nightmares."

Kramer of other herp species from Ima-Gina.

Dedicated to Pablo "Ima" Damaglio, artist and friend lost at sea while exploring a sunken vessel off the coast of Brazil.



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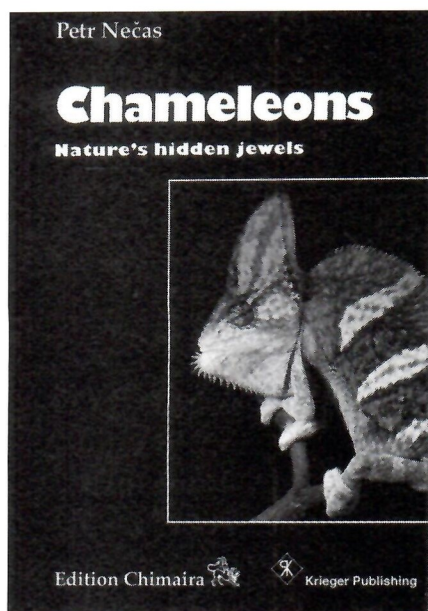


John Carter holding his mutilated finger.
Photo by Lydia Kramer.

The next issue of *The Vivarium* will feature some of the photographs by Lydia

Book Corner

by John P. Levell



Chameleons: Nature's Hidden Jewels

By Petr Nečas, 1999

Edition Chimaira

Distributed in the U.S. and Canada by Krieger Publishing Co.

1725 Krieger Dr.

Malabar, FL 32950

Hardcover, 348 pp. 282 color photos, 3 color and 4 b/w paintings, and 39 b/w text figures. \$47.95

The long awaited English edition of this 1995 German review of Old World chameleons is now finally available in the United States, and with individual accounts for a full fifty species it is easy to understand why English speaking chameleon fanciers everywhere have so eagerly anticipated the volume's release. Covering representative species in the Chamaeleonid genera *Chamaeleo*, *Bradypodion*, *Furcifer*, *Calumma*, *Rhampholeon* and *Brookestia*, these accounts all provide relatively in-depth information on the identification, systematics, zoogeography, habitat, and biology of each form. Species accounts also include brief captive care tips whenever such information is available, and all are further augmented with abbreviated listings of additional pertinent references. Also included are informative, readily understandable introductory chapters covering such topics as the systematics, evolution, distribution, biology and captive care of chameleons in general. A series of Appendices provide a complete list of extant and fossil species with information on distribution and type locality, a chronological review of valid and invalid taxonomic designations, and data on the maximum size, reproductive mode, and habitat and vegetational preferences of all living species. The inclusion of an exhaustive 43-page bibliography greatly magnifies the volume's resourcefulness as well. As if this isn't enough, *Chameleons: Nature's Hidden Jewels* is also profusely illustrated with over 280 color photographs, three color paintings and numerous b/w illustrations. Obviously, this exceptional

volume deserves a prominent place on the bookshelves of all serious chameleophiles. At the same time, however, those with more general herpetological interests will also find *Chameleons: Nature's Hidden Jewels* well worthy of inclusion in their libraries.

Treefrogs of Africa

By Arne Schiotz, 1999

Edition Chimaira

Freidberger Anlage 14

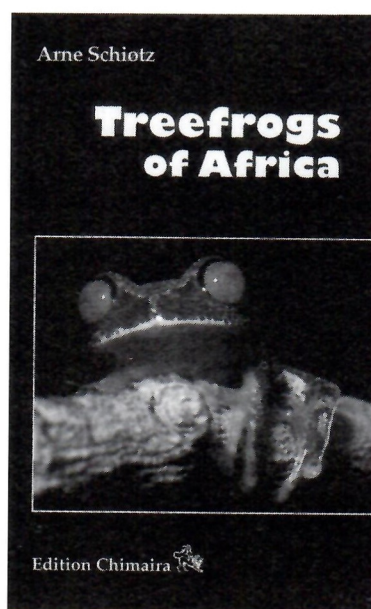
D 60316 Frankfurt am Main

Germany

Distributed in the United States and Canada by Zoo Book Sales. Hardcover \$59.95, 350 pages, over 200 color photos and illustrations, numerous b/w line illustrations, sonograms and maps.

ISBN: 3-930612-24-0

This excellent little volume provides the first English language review of each and every frog in the families Rhacophoridae, Hyperoliidae and Hylidae found not only throughout the African continent, but on the island of Madagascar as well. After the almost obligatory opening chapters reviewing the taxonomy, distributional patterns, conservation, collection, preservation, and captive care of African treefrogs in general, concise standardized accounts provide information on the recognition, voice, reproduction and habitat of all 254 currently recognized species, subspecies and major geographic variants. Well over 200 color photos liberally scattered throughout, and ranging in quality from decent to exceptional, help facilitate species identification and certainly greatly enhance the volume's overall attractiveness. Numerous b/w line illustrations and dot locality distribution maps, as well as an extensive bibliographic listing of additional pertinent references further supplement the text, making this a must have title for anyone with an interest in Africa's herpetofauna.



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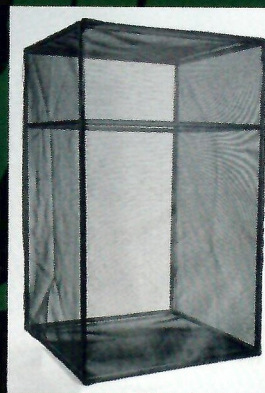
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Neotropical Tree Boas

New Morphs in the *Corallus* Complex
by Danny Mendez. Photos by the author

Snakes belonging to the genus *Corallus*, the neotropical tree boas, have long carried the reputation of being difficult to establish in captivity. They were generally perceived as delicate and high maintenance snakes that generally remained aggressive and poorly adjusted to captivity. It wasn't until fairly recently that herpetoculturists established the protocols and requirements necessary for success with these beautiful snakes. We now understand that high humidity and relatively low temperatures are necessary for tree boas to thrive in captivity. *Corallus* can be successfully maintained in captivity and are a highly rewarding, beautiful group which is worth the slight effort necessary to maintain the necessary minimum requirements.

Two of the more commonly seen tree boas in the herp trade are the emerald tree boa (*Corallus caninus*) and the Amazon tree boa (*C. hortulanus*). Emerald tree boas are unmistakably recog-

nized as one of the most beautiful boids in all of the neotropics and arguably the world. Amazon tree boas have proven to be hardy, multicolored gems with a slight edge to them. Herpetoculturists are now breeding these snakes with some frequency, and we're now seeing these once uncommon species offered for sale. An artifact of captive breeding is that a new and interesting morph or color phase undoubtedly shows up eventually, and the newest trend in herpetoculture is to seek out and refine the appearance of the species with the more attractive individuals. *Corallus* breeding is still in its infancy but we are already beginning to recognize subtle or sometimes dramatic variations that can be truly breathtaking. Here's a little twist on some familiar tree boas.



Hybrid tree boas (*C. caninus* x *C. hortulanus*) can exhibit the morphological characteristics of both their parents.

are showing this characteristic. When born, babies resemble a typical emerald tree boa, with white markings on a red background. Black pigmentation begins to appear soon after the ontogenetic color change is completed. Black emeralds usually have a deep olive to emerald green base color that in extreme cases is obscured by large amounts of black pigmentation. The amount of black varies from small areas which edge white lightning-bolt markings and face to almost completely replacing the green on the snakes' bodies. What makes this morph so appealing is that the black contrasts well with white dorsal markings, giving this specimen a striking appearance.



This closeup of a male granite emerald tree boa shows the distinct increased yellow pigmentation that defines this new morph.

Increased Melanin Emerald Tree Boas (*C. caninus*) - These magnificent emeralds are showing up with some frequency in captive collections and are perhaps the result of a small locality existing somewhere in the Amazon regions of Suriname. Whether or not this trait is genetic hasn't been established yet, but several captive born offspring have popped up randomly and siblings

Granite Emerald Tree Boas (*C. caninus*) - This is perhaps one of the most magnificent looking emerald tree boa morphs known to herpetoculture. It is characterized by a dark olive green to blue background color mottled with a lighter emerald green layer. On top of these two layers of green, heavy yellow speckling covers the majority of the snake, giving it a yellow and two-toned green speckled appearance similar to granite patterns, hence the name *granite emerald*. These animals also show a significant amount of dark green and blue speckling throughout the face and laterally throughout the body. The white markings are typical of most Suriname emerald tree boas and in the upper third portion of the body where the white markings

Continued on page 20

THE VIVARIUM

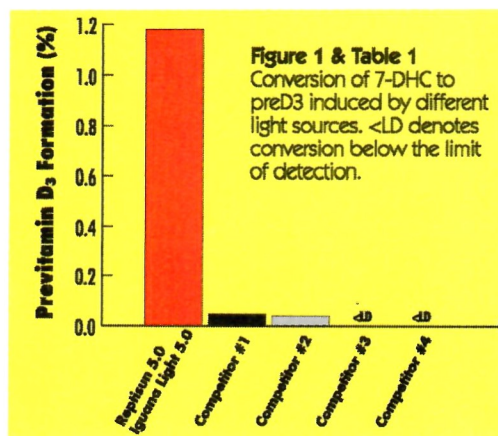
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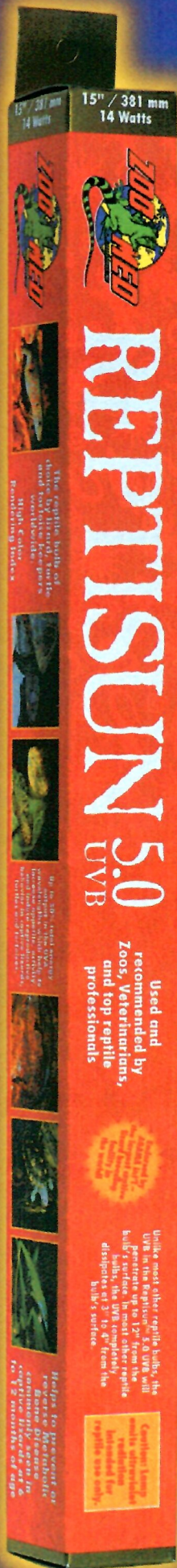
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This neonate tiger Amazon tree boa was produced from a garden phase female and a normal orange male.



This "garden phase" tiger Amazon tree boa gave birth to an orange neonate.

usually dull out to gray in normal emeralds, one finds the gray replaced by several hues of blue and gray. Bellies are typically creamy-yellow, as in usual emerald tree boas, with some green speckling appearing throughout. This is a stunning animal. As for black emeralds, the young start out typically red and white and change over to yellow and green as they mature. It seems that as time goes on, the amount of yellow increases in these animals.

Hybrid Emerald Tree Boas (*C. caninus* x *C. hortulanus*) - We first learned of hybrids when they were born at a fellow breeder's facility to a wild-bred emerald tree boa. Since then, hybrids have continued to stir up interest, even though no one has yet duplicated this event. The hybrids display a bewildering array of colors and interesting morphological characteristics. Although I'm not a fan of hybridizing tree boas, one simply can't ignore the beauty of these specimens. The hybrids we have seen resemble Amazon tree boas in body proportion and emerald tree boas in head morphology. Colors range from the somewhat drab brown, gray, and black seen in "garden phase" Amazons to vivid reds, oranges and greens seen in the colored phases. Hybrids also

tend to show patterning that is completely different than those displayed in emerald and Amazon tree boas. They show a strong propensity for multicolored ocelli and solid circles, rather than the spade markings seen in Amazons and the lightning bolts of emerald tree boas. It seems that the hybrids have inherited double the attitude from both sides of the genus as they are twice as nippy as any emeralds or even Amazon tree boas that I've seen.

Tiger Amazon Tree Boas (*C. hortulanus*) - Amazon tree boas differ from most species of snake in that one generally can't determine the appearance of offspring based on the physical appearances of the parents. Colored Amazon tree boas can produce the duller garden phase varieties and vice versa. Although there is a better chance of producing colored offspring from two colored parents, there is no way to predict the outcome, until now. I was lucky enough to receive a specimen imported from Suriname a few years ago that differed greatly from the rest. This was a garden phase Amazon but it was different from the others I had seen because it was a striped specimen. This young female had two longitudinal well-defined black stripes running distinctly and unbroken from head to tail and two

equally dark but broken stripes running in the same direction along its flanks. The base color was gray-brown and a lighter shade of gray bordered all of the stripes. It was a truly spectacular looking animal that immediately caught my attention as I pulled it out of the bag. Two years later, this female was bred to an orange colored male that came from the same shipment. On a late night in September, I peeked into the tiger Amazon's cage to find that babies were being born. I immediately ran back to get my flashlight and

search within the cage for new signs of life. It was then that I saw the first of the babies climbing precariously on the branches above the female. As I shined the light on one baby, I saw that it displayed full body striping similar to the mother, except that this was on an orange background. One by one as the babies emerged, I could see that the majority were striped! In all, eight babies had been born, and six displayed complete striping. Indeed, the striping gene appeared to be co-dominant. Given the density of Amazon tree boas in the wild, it's unbelievable that this characteristic had not shown up earlier. This may be the first inheritable trait documented in *C. hortulanus* and thus it's the beginning of designer tree boas. We'll see what the future hold for this new and exciting morph.

Tree boas are unlike any other boas commonly seen in herpetoculture today. Incredible coloration together with an arboreal lifestyle make them the ultimate display animal in any collection. Although there are few other species that can rival their natural beauty, these animals can only become more colorful and plentiful through the efforts of dedicated herpetoculturists. Although by no means a beginner's animal, captive born tree boas have proven to be relatively hardy when maintained under appropriate conditions. Hopefully, through the refinement and discovery of some of these new color morphs, we can improve upon one of the neotropical rainforests' most colorful living jewels, the magnificent tree boas.

About the author: Danny Mendez has been working with *Corallus* species for over ten years. He owns and operates *Urban Jungles*, a breeding facility devoted only to the captive propagation of tree boas belonging to the genus *Corallus*. He can be reached at 973-455-0202 and at: danny@urbanjungles.com.



Another example of a granite emerald tree boa. Note the darker green pigmentation on this individual. This should prove to be an exciting morph in *Corallus* herpetoculture.



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Conservation of the Lesser Antillean Iguana, *Iguana delicatissima*



by Jeff Lemm

Photos by the author unless otherwise noted

Female iguanas from many southerly islands may be bright green, however this color is lost in captivity. This female was photographed on Dominica. Photo by Steve Reichling.

Two genera of the family Iguanidae occur in the West Indies — the large, ground-dwelling rock iguanas (*Cyclura* spp.) and the two members of the genus *Iguana*. *Cyclura* are restricted to the Bahamas and Greater Antilles, whereas *Iguana iguana* and *I. delicatissima* are found in the Lesser Antilles, Mexico, and in Central and South America. Once believed to exist on nearly every island in the northern Lesser Antilles, the Lesser Antillean iguana (*Iguana delicatissima*) occupies only a small fraction of its original range today and has already been extirpated from several areas, including St. Kitts, Nevis, Barbuda, and Marie-Galante (Gerber 1997). As a species, Lesser Antillean iguanas are listed as vulnerable (IUCN 1996), although many populations, such as those on Anguilla, are critically endangered.

Natural History

Appearance - Smaller in size than its close cousin, the green iguana (*I. iguana*), male *delicatissima* may achieve an adult mass of about 7.7 lb (3.5 kg) and a snout-vent length (SVL) of about 17 inches (430 mm). Other than overall size, a few characteristics readily distinguish *I. delicatissima* from *I. iguana*. *Iguana delicatissima* lacks the large subtympenic scale so evident in green iguanas. Moreover, Lesser Antillean iguanas also lack any pattern as adults, most being a uniform gray color, although all juveniles and adult females from southerly windward isles are bright lime green in color (Reichling 1995). Interestingly, these females lose their green coloration upon entering captivity, most likely because their captive diet is deficient in some natural food source which gives them this color in the wild. *Iguana delicatissima* also lacks tail banding, a prominent feature of the green iguana. Juvenile Lesser Antillean iguanas are bright

green with white flashes on the jaw and shoulder, but these are lost with age.

Habitats - *Iguana delicatissima* exists in a variety of habitats, up to about 980 feet (300 m) (Lazell 1973), and has been found in xeric scrub, dry woodlands, littoral woodland, mangroves, and low-altitude portions of transitional rainforest (Day et al., in press). Because they live in such a variety of habitats, differences in ecology and natural history exist between the populations. In the xeric, limestone habitats of the northern Lesser Antilles, iguanas lounge in low-lying trees but will scurry to underground burrows or rocks if disturbed. In mesic habitats in the south, animals may be exclusively arboreal (Day et al., in press).

Although they are mainly herbivorous, *delicatissima* have been known to feed on the eggs of birds and carrion (Lazell 1973).

Survival - Natural predators include birds, snakes, and possibly opossums, whereas adult iguanas are believed to have no natural predators (Day et al., in press). As early as 1973, threats to the survival of the Lesser Antillean iguana were recognized (Lazell 1973). Habitat loss and fragmentation is the greatest threat to the survival of the iguana, but introduced animals also prey heavily on them. Dogs have been known to kill adult iguanas, while cats and Indian mongoose, the latter introduced in a failed attempt to rid the islands of snakes and rats, prey heavily on juveniles. On islands where mongooses occur, iguanas are either extinct or severely threatened. Free-ranging goats and other livestock denude the islands of vegetation and may leave only unpalatable or toxic plants for the iguanas to eat. Since

the time of the Amerindians, hunting occurred throughout the iguana's range, earning the iguana its specific name (meaning "pleasing" or "delicious") and although the iguana is legally protected, the animals are still killed for food and may be found in the marketplace (Day et al., in press).

Perhaps the most difficult threat to perceive is hybridization with the green iguana. In 1973, Lazell stated that the two iguana species were equally abundant on Les Iles des Saintes in the 1960's and that they occurred sympatrically. Genetic samples have now been analyzed from a number of islands, indicating that by 1995, only 10 recognizable *I. delicatissima* could be identified from Les Saintes (Day et al., in press). On many islands the two species remain separated. However, due to rafting (as seen during 1995's Hurricane Luis), destruction of habitat, and the fact that people are releasing green iguanas onto other islands, green iguanas are broadening their geographic range and quickly outcompeting or displacing the Lesser Antillean iguana through hybridization.

Since the inception of the American Zoo and Aquarium's Lizard Advisory Group (LAG) in 1990, and the International Union for the Conservation of Nature and Natural Resources/Species Survival Commission West Indian Iguana Specialist Group (WIISG) in 1997, the conservation of West Indian iguanas has been a priority. As a group, West Indian iguanas are the most endangered lizards in the world, all facing a number of threats similar to those previously stated.

Through doctoral research by Mark Day of the University of Aberdeen in the early 1990's, the threats to the Lesser Antillean iguana were communicated to the LAG and a program for its conservation soon followed. To date, a number of critical conservation initiatives and priority projects for the species have been discussed, while baseline research has continued since Day's first study began. Critical initiatives include implementation of



Male *Iguana delicatissima* from Dominica. Photo by Jeff Lemm.



Hatchling Lesser Antillean iguanas are bright green, but soon lose this coloration. This hatchling was photographed on the island of St. Eustatius. Photo by Glenn Gerber.

protected, managed areas, as well as identification and development of protected areas which remain or may be restored to important habitat for the iguanas. Publicity materials about the iguana, including those that stress further prevention of introduction of the green iguana, have already been distributed *in situ*, while a species conservation plan to implement regional and national conservation initiatives is underway. Priority projects, including population surveys of all existing populations, have already begun with a comprehensive survey undertaken by doctoral candidate Glenn Gerber on Anguilla in 1997, with support from the U.K. Foreign and Commonwealth Office. Other projects include assessment of satellite islands to maintain or establish new iguana populations, a long-term study of the Iles de la Petite Terre population of *delicatissima* (as it is the only island free of introduced animals or continuous habitat destruction), and widespread educational programs both regionally and nationally.

Captivity Prior to 1994, no *I. delicatissima* were kept in captivity. A main concern of the LAG and WIISG is that because West Indian iguanas exist on fragile island ecosystems, catastrophic loss at any one site is an ever-present threat. In response, 4.4 subadult animals were brought into captivity in 1994 from the island of Dominica and are still held by three institutions worldwide: Durrell Wildlife Conservation Trust (formerly known as Jersey Wildlife Preservation Trust) (1.1), the Memphis Zoo (2.2), and the San Diego Zoo's Center for Reproduction of Endangered Species (CRES) (1.1).

The *delicatissima* were difficult captives at first, being very flighty and refusing food. Soon, however, the animals calmed



Northern *I. delicatissima* may live in rocky areas as opposed to tall trees. The pink coloration on the jowls of this male is typical breeding coloration. Photo by Glenn Gerber.



The enclosures at CRES are equipped with a number of high perches, nesting areas, and UV-transmitting plastic sunroofs. A second enclosure of the same dimensions is connected to this enclosure via an overhead walkway. Photo by Jeff Lemm

down and began to take a number of different food items, especially sweet potato leaves.

Habitat - Tall, spacious enclosures have been important in keeping the animals comfortable. The habitats also allow keepers to enter the enclosure without disturbing the animals, who seem to prefer basking and roosting at the highest points of the cage. The pair of *delicatissima* at CRES reside in a large, two-room greenhouse that is connected by an overhead walkway. This allows animals to be separated and/or receive sun at any time of the day. The enclosure is heavily planted with *Hibiscus* plants and *Ficus* trees – both of which are heavily grazed by the animals. Temperature gradients similar to those for *Cyclura* are important, as the *delicatissima* seem to desire hot and fairly humid enclosures. Even on days when ambient temperatures are as high as 95°F (35°C) in some areas, the iguanas may be seen basking under skylights or ceramic heat elements.

Diet - The iguanas at CRES are fed a diet consisting mostly of leafy greens such as collard greens, dandelion greens, and kale, while other vegetables, fruit and *Hibiscus* flowers are added to the diet in small portions.

Reproduction - Lesser Antillean iguanas in the wild lay eggs in an extended season which lasts for as long as six months on some islands. Clutches are intermediate in size between *Cyclura* and *I. iguana*, with 22 being the largest clutch, recorded at the Memphis Zoo (Reichling, personal communication). Size of the eggs is also intermediate. Eggs are laid in burrows about 3 feet (1 m) long in sandy, well-drained soil exposed to prolonged sunlight (Day et al., in press). Iguanas at the three institutions have either copulated or laid eggs every year since 1994, however the eggs usually die at an early stage of development or are infertile. Unlike the green iguana, *delicatissima* has been very difficult to reproduce in captivity. One of the major hurdles has been getting the females to properly nest at the appropriate time during egg development.

To date, only one egg has hatched in captivity. This hatchling, a female, emerged at Durrell Wildlife Conservation Trust in 1997 after incubating for 73 days at 85°F (29°C). The hatchling is alive and well, although its growth has been slower than expected. At CRES, copulation had never been witnessed and no fertile eggs had ever been laid, until last year.



This female iguana is in the process of laying eggs in a *Ficus* plant. Photo by Jeff Lemm.



An adult Lesser Antillean iguana photographed on Dominica, showing the arboreal nature of animals from southern islands. Photo by Steve Reichling.



Dead in the shell near term lesser Antiles iguana. Photo by Glenn Gerber.



An unfortunate end, but a new beginning: Although this young iguana died in the egg at full-term, the author is pleased that the animals have now begun to lay fertile clutches. Hopes are high that the 2000 breeding season will produce enough eggs to figure out the proper incubation techniques for the species. Photos by Jeff Lemm.

In early 1998, a number of changes were made to the lizards' enclosures. First, the animals were separated for the first time to allow the female to increase in body mass. The animals were fed a larger quantity of food, while at the same time more basking spots were added to the enclosure, raising the ambient temperatures. Approximately 50% of the roof of the enclosure was replaced by a UV-transmitting Solacryl® plastic which transmits more than 85% UV light. The enclosures were also made higher so that the animals could bask in natural sunlight at a height of nearly 9 feet (almost 3 m).

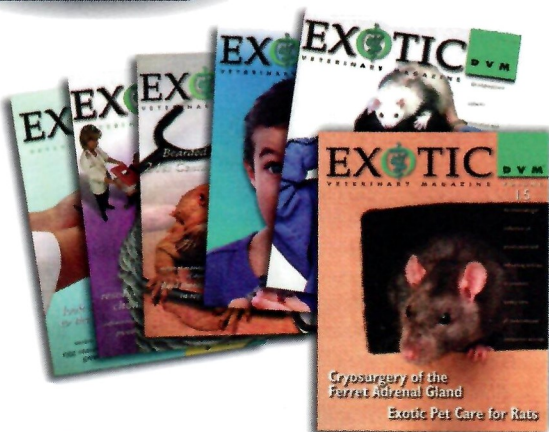
A mirror was also placed in the male's enclosure in the hopes that it would make the male believe another breeding male was in his territory. Within five minutes of placing the mirror in the enclosure, the iguana attacked his "rival". To avoid injury to the iguanas, the mirror was placed out of reach but in visual range. Soon the male iguana began to display more frequently and his head started to turn pinkish in color, a change which commonly occurs in wild males during the breeding season.

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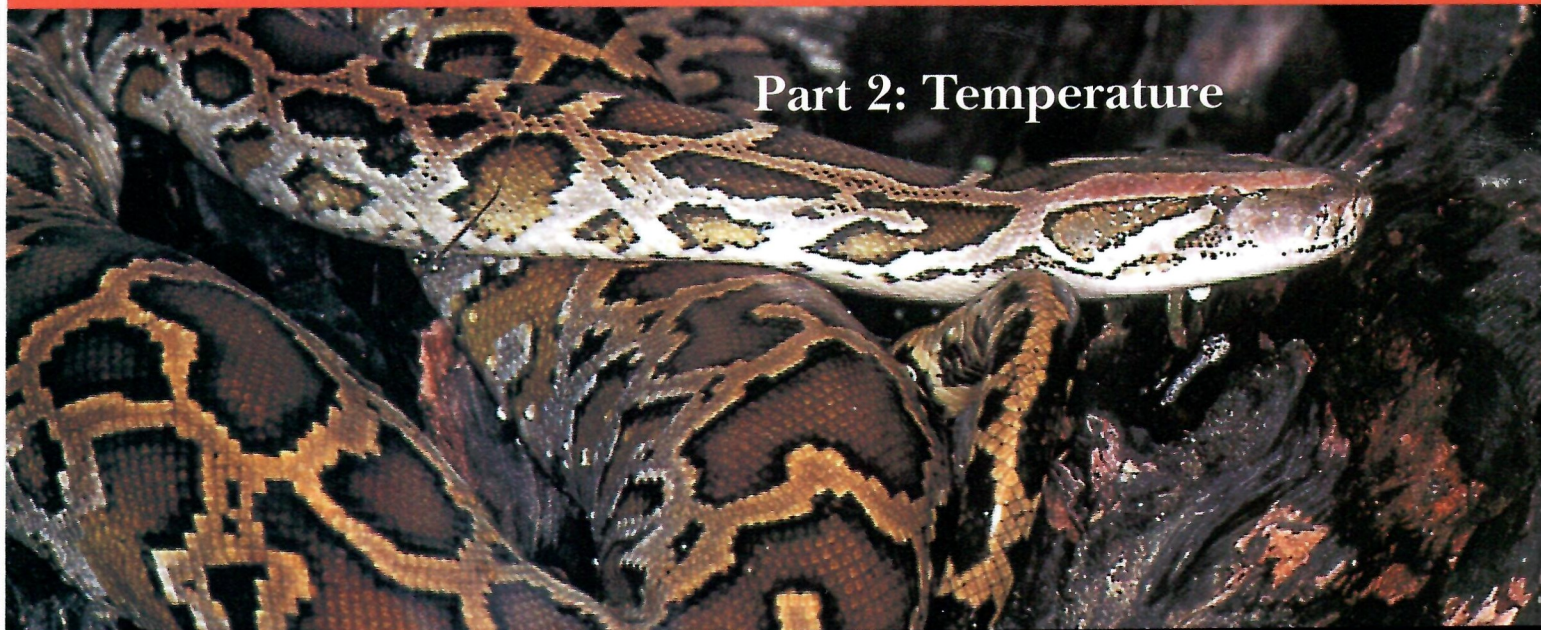
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Part 2: Temperature



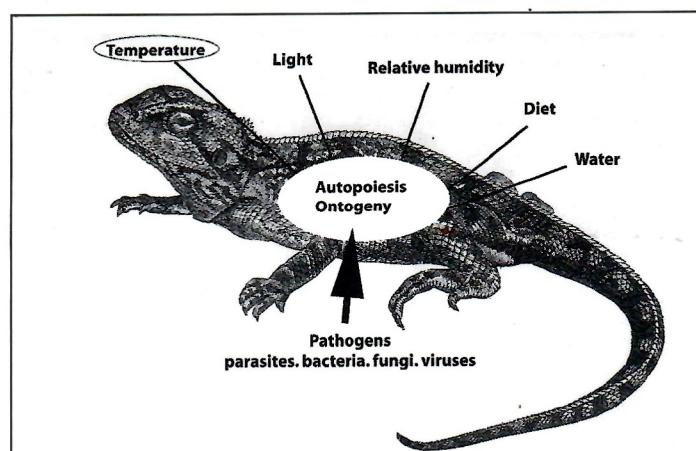
by Philippe de Vosjoli, Susan Donoghue, VMD and Roger Klingenberg DVM

Many Burmese pythons and other large reptiles die every year from respiratory infections because owners fail to provide an adequate heat source. *Photo by David Northcott.*

This second part of the Interactive Multifactorial Model will focus on the role of temperature in the husbandry of amphibians and reptiles with a special emphasis on the influence of temperature on health. Part 1 concerned ontogeny, and appeared in The Vivarium 11(1).

Because amphibians and reptiles are ectotherms, temperature is one of the most important factors controlling their development and health in captivity. It will affect growth, reproduction, and behavior, metabolic rate, heart rate, and immunity, hydration, digestion, calcium metabolism, excretion and kidney health — just about every aspect of an amphibian's and reptile's life. In theory every amphibian or reptile lives in a thermal landscape (the term thermal mosaic has been used), adjusting their behaviors to shifting daily and seasonal temperature patterns to make effective use of energy resources, conserve water and avoid predation. Because it is usually impossible to replicate this thermal landscape in captivity, the standard procedure is to first obtain information on the climate of the natural habitat, and then to provide in the vivarium a thermal gradient based on this information. This will hypothetically provide a species with the opportunity to thermoregulate by moving between a heat source or basking site and an unheated area.

A problem with this reasoning is that all species are not heliothermic (able to thermoregulate by behaviors in relation to solar/heat radiation). Several species of amphibians and reptiles, including many nocturnal or crepuscular species, inhabit areas where the air temperature remains at a fairly high comfortable constant and these animals do not normally bask. This is true of many amphibians and some lizards and snakes. For these species, called *thermoconformers* in the scientific literature (Shine, R. and T. Madsen. 1996. Is Thermoregulation Unimportant for Most Reptiles? An Example Using Brown Water Pythons (*Liasis fuscus*) in Tropical Australia. *Physiological Zoology* 69 pp. 252-269) it will be important that enclosures be uniformly heated or kept in rooms at the desired temperature.



In the Multifactorial Model, various factors influence development and health.

Still, the main reason many amphibians and reptiles do not fare well in captivity is that they are not provided with an adequate temperature gradient. Some species because of misinformation are kept too warm. Many others are kept too cool or with too small of a hot spot/basking site or too great of extremes in the temperature gradient. A common error, where herps are kept at low ambient room temperatures (such as in many homes in the winter or in air-conditioned stores), is to provide a small "hot spot" with the rest of the cage so cool that the animals have to spend all their time basking to maintain their desired body temperature. This is a common sight in many pet stores that simply provide reptiles with a hot rock while the rest of the cage may be in the low 70's°F (about 21°C). Lizards are huddled together under the one warm area of the cage.

With large reptiles, a primary problem in captivity is providing heat over a large area. The baby iguana that could heat up under a spotlight, may have to spend all its time, as an

adult, under a spotlight in order to keep warm, and even then may not achieve an optimal temperature. In time, it may be a victim of kidney or liver disease or become sick because its immune system is depressed. The same thing happens with many large snakes in captivity (a significant percentage of large Burmese pythons die of pneumonia in the winter) and large tortoises (a significant percentage fall ill from respiratory infections in the winter).

In the next section an overview of some of the effects of temperature on ontogeny will be presented. Although writings will emphasize the importance of providing optimal temperatures, in the multifactorial context manipulating temperature along with diet and water availability can be used to achieve a desired goal in herpetoculture. All species have a certain adaptive range that can be taken advantage of, depending on whether we aim for early high reproductive rate, high and rapid growth, slow growth and stunting, and/or high longevity. Little methodical study has been done in this area but anecdotal information and preliminary experiments suggest that it is possible to stunt some of the larger species using a multifactorial approach in which temperature and diet are critical factors. It is also possible to maximize potential growth and early reproductive rate by resorting to an intensive temperature/feeding/watering/activity schedule. As we presented in Part 1, the main point of the multifactorial model is that amphibians and reptiles have an adaptive range and in herpetoculture there may be more than one way to raise an iguana, bearded dragon, python or horned frog.

A Brief Overview of the Effects of Temperature

Temperature is a critical factor in stage I (embryonic), determining survival parameters, the rate of embryonic development, embryonic metabolic rate and oxygen requirements, incubation time, sex determination in certain lizards and turtles, and playing a role in final hatchling size. As with adult reptiles, there is a temperature range below which and above which an embryo will die; this area is more complex at Stage I, because embryos cannot thermoregulate and temperature can have different effects depending on the stage of embryonic development. Generally, early stage embryos can have a greater temperature tolerance than later stage embryos.

In some species eggs may enter a state of diapause during cool winter temperatures. Certain lizards, including some

chameleons (e.g. *Chamaeleo johnstoni* and *C. montium*) and skinks, have an incubation range which is lower than many other reptiles, with long term temperatures over 75°F (24°C) being fatal. In other species, the embryo will tolerate a relatively high temperature until the later stages of development when the metabolic demands of the embryo can exceed the amount of oxygen diffusing through the shell and membranes (one of the few studies on this subject is Ellis, T. 1987. Thermobiology and Energetics during Reproduction of the Ball Python. *Captive Propagation and Husbandry of Reptiles and Amphibians*. N. Cal. Herp. Soc., Spec. Pub. #4, pp 76-86). Late stage embryo death can often be linked to too high an incubation temperature. Obviously, obtaining as much information on incubation parameters of species one is working with will be critical for successful herpetoculture.

At stages II and III (juvenile-subadult), during which there is the potential for rapid growth, keeping animals at the higher end of their preferred temperature range combined with an intensive and nutritious feeding schedule can result in high growth rate and early sexual maturity. So if size is the goal of raising boas and pythons, or African spurred tortoises, or water turtles as a food source, then keeping them warm and feeding them as much as they will eat during these growth stages is what will be required. A reverse effect can be obtained by raising herps at the lower end of their preferred temperature range and reducing dietary intake. For example in some of our experiments we have common boa constrictors (*Boa constrictor imperator*) more than two years old and have not yet reached four feet (122 cm) long. For species that can eventually grow too large for average households, a restricted regimen can help keep animals at a manageable size. In the multifactorial context, low growth regimens may result in sexual maturity (stage IV) at relatively smaller sizes. In tortoises, suboptimal temperatures combined with a high protein diet is believed by some to be a cause of pyramiding of the shell scutes. In several amphibians currently kept in captivity, low temperatures are a primary cause of death and illness at the tadpole stage and during growth. In poison frogs, suboptimal temperature has been linked to spindly leg disease in some species. Many herpetoculturists consider temperature, interacting with diet, to be a factor in metabolic bone disease at this stage.

At Stages IV and V (sexual maturity), temperature plays a critical role in the reproductive cycling of many species,



The crested chameleon (*Chamaeleo cristatus*) is considered difficult to keep in captivity. A key to success is keeping this species relatively cool in the low to upper 70's with a relative humidity of 70-80%.

Photo by David Northcott.



The Chacoan monkey frog (*Phyllomedusa sauvagii*) must be allowed to bask at temperatures in the mid to upper 80's to fare well in captivity. The body temperature of this species and of *Phyllomedusa bicolor* during the day can exceed 90°F.

affecting ovulation and spermatogenesis. Large herps generally heat more slowly but above all cool down even more slowly than small herps. Because growth rate tapers at this stage, processing of nitrogenous compounds through the kidneys may be directly affected by temperature. As a general rule, herps should not be fed at suboptimal temperatures. Much of the speculated harm of "high protein diets" or small amounts of "animal protein" in green iguanas may be more directly the result of inadequate temperature supplied to larger individuals combined with ontogenetic factors. Larger amphibians such as horned frogs and White's treefrogs also risk developing the "water bag" edema signs of kidney disease if fed and maintained at suboptimal temperatures. Not supplying adequate heat ranks as a primary associated cause of disease in larger herps because herpetoculturists often fail to provide systems that allow

large animals to effectively thermoregulate.

At stage VI (old age), "high temperature, stuff 'em" regimens can be detrimental. With older animals of some species, limiting or eliminating a winter cooling cycle may lead to longer lifespans. Moderation may be a key to having herps achieving long lifespans past reproductive age.

Cool-Temperature Herps

Some reptiles and many amphibians with relatively cool temperature requirements suffer in captivity not from lack of heat but quite the opposite — excess heat that stresses the organism and can lead to its early demise. This is true for some temperate and many montane and cloud forest herps ranging from salamanders (most species) and frogs to turtles (e.g. *Geochelone impressa*), chameleons, skinks, colubrids (e.g. *Elaphe mandarina*) and certain vipers (e.g. some of the *Vipera* and *Bothriechis*). The rule is that herpetoculturists should thoroughly research the ecology and captive requirements of a species rather than assume that they fit the standard warm-climate husbandry model. Beware of the writings of herp charlatans and of Internet web information by overnight self-made experts.

Effects of Temperature on Feeding and Nutrition

Habitat temperatures for reptiles and amphibians affect most aspects of feeding and nutrition. Animals which are kept too cold or too hot often fail to consume adequate amounts of food. The resultant calorie deficit may further suppress metabolism in herps kept too cold. It will result in rapid weight loss and emaciation in animals kept too hot. Even if food is consumed, temperature-related digestive disorders will be likely. Temperature impacts many aspects of gastrointestinal function, including enzyme activities, stomach emptying, water and electrolyte transport, intestinal motility, and intestinal cell function. And if somehow food was digested and absorbed under such adverse conditions, utilization of the resultant fuels and nutrients would be impaired.

One of the features of cold-blooded animals (ectotherms) is that they depend on environmental temperatures to help regulate metabolic rate. Basking in the sun and resting on heated surfaces warms reptiles; burrowing into cool soil and leaf litter, and seeking shelter in shade, cools herps. Metabolic rates increase as the ectotherm warms, and decrease as

the animal cools. Metabolic rate is measured usually as the amount of oxygen consumed by an animal; oxygen (working with fats, proteins and carbohydrates) fuels the organs and cells within the body. Metabolic rate is the sum of all oxygen used in the entire body; hence it's the sum of all the parts.

When a herp's metabolic rate falls in a too-cold environment, it isn't just a decline in some abstract physiological measurement. It means that the internal organs and cells aren't using adequate amounts of fuel. It is a signal that organs aren't fully functional. Brains may have clouded thoughts. Kidney filtration units may shut down. Livers may not metabolize toxins. Lymph nodes and bone marrow won't make antibodies and disease-fighting cells.

The opposite end of the extreme — hyperthermia from too-high temperatures — usually results in rapid death, because herps generally are designed to heat up quickly and to cool down slowly. The excess body heat can't be dissipated quickly enough to prevent hyperthermia, in many cases. Sub-lethal but too-hot temperatures represent a metabolic stress that can be partially moderated by diet in endotherms, but hasn't been investigated yet in ectotherms.

The deleterious effects of extreme cold and hot temperatures in herps are readily evident. In contrast, the effects of marginally too-cool and too-warm temperatures may be insidious, yet damaging. This is one of the primary reasons for recommending thermal gradients and options within habitats, to permit animal selection of temperature and lower the risk of temperature-associated disorders.

Feeding and nutrition can also impact metabolic rate directly. Offering too little food to an animal maintained at its optimal temperature results in a self-imposed lowering of metabolic rate in an effort to ward off starvation and preserve life. The animal ceases activity and reproduction, and exhibits declines in heart and respiratory rate, and a slowing of organ function.

The association between food and metabolic rate is so strong that nutritionists often consider requirements of nutrients on an *energy* basis. The need for nutrients is determined mostly by the rate of metabolism within the body, for all nutrients function, directly or indirectly, in some aspect of energy metabolism. For example, the requirement for protein may be reported as a percentage of calories pro-



Contrary to popular herpetocultural myths, there is no evidence that feeding young green iguanas a small percentage of insects will cause kidney or liver disease. Photo by Chris Estep.

vided, and the requirement for calcium may be reported as milligrams of calcium per calorie. The initial measure of the balance of a diet is its energetic efficiency.

How does all of this impact the herps in *your* care? Let's say you have a group of 20 recently hatched bearded dragons. If you keep them too cold with no opportunities for basking, they won't eat an adequate number of crickets. They will appear dark and inactive, and few will hunt prey. Two babies may die within a day or so from dehydration. Perhaps another four die within a couple more days from starvation. Others will be wounded and traumatized from bites by uneaten crickets. Six more develop diarrhea because of malnutrition and die. Another group becomes immune suppressed and die from pneumonia and sepsis. A few may survive, these will be stunted. Such is the impact of too cold temperatures affecting feeding behavior, gastrointestinal function, nutrient absorption and utilization, metabolism, and ultimately, health and survival.

The picture might look somewhat similar if the baby dragons were kept warm but were underfed. Starvation and malnutrition can result from too-little food, or from too-cold temperatures. Both result in lowered metabolic rate and subsequent health problems.

Let's say you have a group of recently hatched veiled chameleons, and you keep them at their optimal temperature and feed them heavily. The babies eat readily and grow quickly. You've never pushed a clutch so hard, but they look great. At two months of age, many develop wrinkled casques, and your vet diagnoses metabolic bone disease. What happened? The dusting schedule that worked for you previously didn't work this time, because this time you pushed high temperatures and high calorie intake, which resulted in rapid growth, hence high demands for all nutrients, including calcium. The

requirement for calcium depends on metabolic rate, hence we need to think about supplying more calcium when we manipulate metabolic rate by raising temperatures and feeding heavily. If lots of calories (in this case, crickets) are provided and temperatures promote rapid metabolism, then calcium (and all other nutrients) needs to be increased too.

On the other hand, a clutch of montium chameleon babies will die quickly if kept like the veileds. Not only are montane species less tolerant of warm temperatures, but their natural growth rates as juveniles appears to be slower. With a naturally lower metabolic rate, nutrient requirements will be lower too.

Effects of Temperature on Health

The key to maintaining good health in a reptile is to maintain the immune system. The key to maintaining the immune system is to provide heat. The second and third most important factors in maintaining the immune system? Providing usable heat, and then a *heat gradient*. Although maintenance of the immune system requires attention to hydration, nutrition, stress, seasonal variations, and age, heat is king.

Providing heat to reptiles is truly an art form, because heat isn't just heat. A veiled chameleon in a cage full of plants and climbing branches won't benefit from an undercage heater. Have you seen a chameleon disembark from its favorite perch to lounge on the floor of its cage to stay warm? This brings up the concept of usable heat gradients (UHG). In order for a reptile to benefit from the heat source provided, it must be able to use it. A kingsnake that burrows in its substrate will enjoy an undercage heater that permits the snake to use the heat as it comfortably hides. The same snake is not going to leave the security of its substrate to climb up branches to utilize a basking lamp placed high in the upper reaches of a vertical cage. The veiled chameleon, in contrast, will use the upper reaches of a vertical cage and bask under an appropriate light. Some reptiles, such as boa constrictors, green iguanas, and certain chelonians, may benefit from both undertank or lower cage heat as well as a basking source.

However, the UHG is nothing without the gradient component. A popular subject for discussion by herpetoculturists is the 'preferred optimal temperature zone' (POTZ). A reptile's POTZ is the temperature range within which it is most comfortable or the temperature that it seeks when a variety of temperatures are pre-

sented. For instance, a green iguana's POTZ has been suggested to be about 85°F (29°C). Once this preference was noted, it was assumed that the perfect cage should be 85°F at all places, no higher and no lower. It was then a shock to find that iguanas maintained in this way were not nearly as healthy as those provided with a gradient of temperatures. While a green iguana may prefer to spend a good deal of its time at 85°F, it also needs to be warmer and cooler as its physiological needs dictate. Provision of a gradient is where heating of reptiles truly becomes an art. In order for a gradient to exist, cage designs need to maintain a balance of size, space, background temperatures, heat sources, humidity, and ventilation.

We know that reptiles are ectotherms and dependent on their environment for heat. And we know to provide our reptiles with a UHG. How do we know then that the immune system of these reptiles, and ultimately their health, is dependent on heat? Certainly experienced herpetoculturists will vouch that reptiles provided with a UHG appear to be healthier, but do we truly know that this is the case? Yes, we do. In the late 1970's and into the '80's a number of studies illustrated the importance of heat to the immune system.

The development of a fever is beneficial, enabling a host to expel or destroy pathogens that cannot survive at elevated temperatures; this helps survival. While reptiles don't have the ability to produce a physiological fever, they can produce a *behavioral* fever. In separate studies, desert iguanas and turtles injected with pathogenic bacteria and then placed in an environment with a UHG were observed to spend more time in warmer parts of the gradient than their normal counterparts. A study of iguanas injected with a pathogen showed increased antibody production at 95°F (35°C) versus 77°F (25°C), and decreased production when moved from 95°F to 77°F. Another study looked at desert iguanas infected with bacteria and housed at four different temperatures, ranging from 93° to 107°F (34-42°C). In a few days, 100% of those housed at the lower temperature were dead, while only 25% had died at 107°F (42°C). In addition, 4% of the iguanas in the control (normal) group held at 107°F (42°C) also died, which illustrated the hazards of healthy iguanas being held at high temperatures. Heat, while important, requires a gradient to avoid excessive exposure to extremes.

From these few studies mentioned here (more have been published) it's appar-



One reason *Phyllomedusa bicolor* has proven difficult to keep in captivity is the failure to provide enough heat. In most anurans, tadpole size and size of froglets at metamorphosis will be directly affected by temperature.

ent that an increase in core body temperature is essential to stimulate the reptilian immune system. It is also apparent that each individual species has a POTZ that will maximize stimulation. However, excessive exposure to temperatures above the species' POTZ may have an adverse effect on the immune system and the ability to thrive. Owners should make an effort to research the natural history of the reptiles they keep to help design an appropriate UHG.

Confused as to what suppression of the immune system really means? One of the more perplexing concepts for reptile owners is that the major source of pathogenic bacteria for reptiles originates not from exogenous (outside) but from endogenous (inside) sources. You might imagine your normal, healthy reptile as containing a Pandora's box of pathogens within its body. The key to the box is the immune system. Once a number of factors combine to undermine the immune system, the box opens, freeing a wide variety of opportunistic pathogens. Keep the immune system healthy, and the box will remain locked and safe.

A practical example of Pandora's box and the immune system is that of *Salmonella* sp. in reptiles. The few studies that have attempted to determine the prevalence of *Salmonella* strains in reptiles have only further confused the issue. However, many reptiles are *Salmonella* carriers, and perhaps we should think of all reptiles as *potentially* carrying this zoonotic pathogen. Why is it so hard to get accurate figures on this issue? After all, if a reptile is a carrier, it is a carrier, right? The problem

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Natural History, Captive Husbandry and Breeding of the New Caledonian Crested Gecko, *Rhacodactylus ciliatus*

Part 3: Diseases and Disorders

by Philippe de Vosjoli and Kyle Billuni. *Photos by the Authors.*

Part 1 covered natural history and appeared in issue 10.6 of The Vivarium. Part 2 covered husbandry and propagation and appeared in 11.1.

Crested geckos are one of the hardest and least disease-prone of reptiles we maintain in captivity. This may be due in part to their secluded origins and relative novelty in the trade. Adaptability to a wide range of temperature and ease of care are other factors that may contribute to this species' hardiness in captivity.

Ants

In southern California, a killer of crested geckos and other soft-skinned lizards is ants. Argentine ants attracted to dead crickets or baby food in an enclosure can swarm and easily kill crested geckos, from babies to adults, with only a few bites. In different areas, other species of ants (not all) may also kill crested geckos. Once swarmed and bitten by ants, crested geckos, even if rescued, will usually go into shock and die within 48 hours. Breeders have learned hard lessons from this experience, losing a number of breeders and babies overnight.

The only solution to ant predation is prevention. A first step is feeding only enough crickets that crested geckos will eat readily. Dead crickets are a primary ant attractor in collections, as are puréed foods. It is important not to offer excessive amounts and to remove dishes of uneaten food as soon as possible. The next important step to ant prevention is to use Diazinon® or other ant killing pesticides around outside edges of buildings where crested geckos are kept. It also means keeping a watchful eye for ant trails in homes, using sprays (carefully) and placing effective ant traps in key areas. The bottom line is that several ant species, such as fire ants and Argentine ants, can present a threat to crested geckos. You have been warned!

Lost Tails

Autotomy — the dropping of a tail — will not cause any significant harm to a crested gecko simply because the tailless condition appears to be normal in adults.



This male crested gecko was bitten repeatedly on the head by another adult male.

However, the cause of tail loss, usually some type of negative stress, needs to be investigated because prolonged stress can impact an animal's health. Feeling threatened is the most common cause of tail loss. As mentioned in earlier sections, the tail of crested geckos will not regenerate.

Lost Toes and Limbs

One of the habits of crested geckos is to rapidly climb to the top of enclosures when exposed. When changing paper or substrate, great attention must be given to avoid closing the top of an enclosure on a foot or toe. This particularly applies when keeping babies in plastic terraria with snap-on lids. The crushing damage from top- and lid-associated accidents can lead to loss of toes or limbs. In rare cases, baby crested geckos may be killed.

Floppy-tail Syndrome

Floppy-tail syndrome consists of the tail flopping over the back when a crested gecko rests upside down on a vertical surface and/or side-flopping, when a tail bends to the side. A dorsal depression and/or lateral bend of the pelvic girdle bones in some wild-caught adults suggests that floppy-tail syndrome may also occur in the wild.

Three factors probably contribute to floppy-tail syndrome of crested geckos in

captivity. One factor may be that the natural condition of adult crested geckos in the wild is to be tailless. Our hypothesis is that there is a weakness of the caudal attachment to the pelvis that can facilitate tail loss. Another factor may be early calcium deficiency that weakens the pre-caudal pelvic bones, leading to a deformity of the pelvic girdle. At the point of least resistance, in undercalcified skeletons, the weight of the tail may cause fracture or bending of the caudal skeleton at the point of attachment. A third factor may be the smooth vertical glass or plastic surfaces of vivaria which encourage behaviors not normally performed in the wild, such as spending extended periods of time upside down or sideways on a smooth vertical surface.

To have crested geckos with nice tails, all three factors should be addressed. First, select specimens which genetically might be more likely to hold on to their tails. Second, supplement properly. Third, provide large caging with climbing areas and cork bark to discourage vertical, head upside down behaviors.

Calcium Crash and Metabolic Bone Disease

If not provided with enough calcium and a source of vitamin D₃ crested geckos are very susceptible to metabolic bone dis-

ease. The onset is usually quite rapid; the bones appear to become soft overnight. The affected animal cannot eat or climb. At best, it crawls on the ground. This is most commonly seen in babies not provided with enough calcium and in females that suffer a "calcium crash" after a clutch of eggs passes through the shell gland.

Under an intense regimen of feeding and vitamin D₃ supplementation, crested geckos can produce a clutch of two eggs every four to five weeks, up to 12 times a year, resulting in a total of 22 (there is a record of 24) eggs per year. This regime has consequences, with a high risk of females becoming calcium depleted. We have found young females that have just become sexually mature to be particularly susceptible to calcium crashes after their second clutch, when kept on an intensive supplementation schedule. As the second clutch passes through the shell gland, calcium depletion is such that almost overnight a female ends up with "jelly bones" signs of metabolic bone disease. She will be unable to move, unable to feed and without urgent care will die. To treat calcium crashes, we initially give a drop of Neo-Calglucon® orally twice daily (first try placing a small drop with a syringe at the tip of the snout so that the gecko may try to lick it off; if not, place a drop inside a carefully opened mouth). Continue up to a week after the animal shows improvement. Only soft, supplemented puréed food is offered during this time but we don't worry if a crested gecko does not feed for the first week after initiation of treatment. With very weak soft-boned animals, the only chance you have is to consult a reptile veterinarian for calcium injections. Handle soft-boned animals very carefully, disturbing them as little as possible in the course of treatment, in order to prevent internal damage. Adjust temperature, feeding, and supplementation schedules.

Shedding Problems

Shedding problems *per se* are uncommon in crested geckos. A failure to shed is usually secondary to other health problems. Because crested geckos pull off and eat their shed skin, health problems that weaken a crested gecko will prevent it from performing this skin-removing activity. One way to assess whether a crested gecko covered with shed skin is having a problem is to pick it up and evaluate its level of vigor and activity. Healthy geckos will display vigor and strength, sick ones will be weak or limp.

Metabolic bone disease is often a primary cause of failure to shed, particularly with babies. If the shed skin is loose, you will be able to remove it relatively easily using finger-tips or round-nosed tweezers. Make sure skin is removed from the head.

After skin removal, you'll need to urgently address the health problem(s).

Gastrointestinal Parasites

Crested geckos may have nematodes; at least wild-caught animals do, and any signs of worms in feces, gradual weight loss, or watery feces (crested geckos tend to have semi-formed feces) should prompt you to get a fecal sample checked for parasites. More common than nematodes in captive-bred crested geckos can be high levels of flagellate protozoans such as *Trichomonas*. Panacur® (fenbendazole, at 50-100mg/kg body weight) is the most commonly used drug for treating nematodes, and Flagyl® (metronidazole at 50-75 mg/kg) is used for the treatment of flagellate protozoans. A qualified reptile veterinarian can advise you on the best course of treatment.

Note for veterinarians

Crested geckos will readily drop their tails if they feel threatened or if traumatized. This means that heavy-handed manipulation or an injection can result in tail loss. This will be of no great consequence for the gecko, but some owners will resent this because for them a crested gecko without a tail will have become a flawed, imperfect specimen. We recommend that owners be advised before treatment that crested geckos will probably drop their tails in the course of veterinary procedures.

In addition, special care is needed when opening the mouth. The mandible of crested geckos is thin and fractures easily, particularly in cases with metabolic bone disease. A little teasing, such as light tapping on the snout or stroking the sides of the mouth, will usually prompt a crested gecko to open its mouth. Once open, the mouth can be inspected and when necessary, oral medication administered. To keep the mouth open, use a wedge made of polyurethane foam, which gives when the gecko bites down.

Future Diseases

Because herpetoculturists tend to keep many species, the risks of transmitting a parasite or pathogen from one species to another is high. This has already happened with leopard geckos and veiled chameleons, where coccidiosis was once uncommon but is now becoming increasingly more common. Some of these diseases, such as coccidiosis, can be highly infectious or tedious to treat. When large groups of animals are infected with such diseases, euthanasia is often the most economical course and ultimately the wisest one to prevent the spread of infection in one's collection. The importance of quarantine and the need to practice hygienic procedures obviously cannot be emphasized enough.



In tail-floppers the pelvic area curves to one side or has a marked mid-dorsal depression.



This is a tail flopping crested gecko. The tail flops to the side or over the head when this animal is in a vertical upside down position. Note the bend at the base of the pelvis.

One good rule is to keep your geckos away from bearded dragons which are a common source of coccidial infections. Wash hands frequently with an antibacterial soap, at least between maintenance of species groups.

Crested Geckos as Pets

In terms of handling, crested geckos are not quite as calm as leopard geckos and fat-tailed geckos, but compared to many lizards they are certainly calm enough and relatively entertaining. Their bites are of insignificant consequence, at most resulting in superficial lacerations.

We have found that some crested geckos are unusually docile, appearing calm in the course of handling and not prone to flight behaviors. This may have a genetic basis and can probably be selected for.

Because as a defensive behavior they will tend to jump off a hand, allowing them to expend energy by walking from hand to hand will reduce their need to jump. Some will quickly get used to being handled and rest quite calmly in or on a hand. Crested geckos can be hand-fed baby food purée with a spoon while they rest on a hand, helping to establish a positive pet-owner relationship. We have found crested geckos to be one of the most enjoyable of all herps to keep in captivity, with great potential as a reptile pet.



A vintage computer monitor and system unit are shown engulfed in bright orange and yellow flames. The monitor is at the top, and the system unit is below it. The fire is intense, with large flames rising from the system unit and surrounding the monitor. The background is dark, making the fire and the white computer components stand out.

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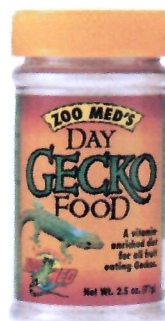


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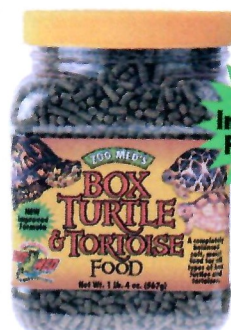
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Herpetoculture of the **Scarlet Kingsnake,** *Lampropeltis triangulum elapsoides*

by Will Brown. Photos by the author.

Scarlet kingsnakes (*Lampropeltis triangulum elapsoides*) are among the most stunning snakes in the genus, yet they are rarely bred in captivity and almost never offered on breeders' price-lists. With an adult length of 14–20 inches (36–51 cm), they are easy to house, and most adults feed readily on pinky mice. So why aren't more hobbyists breeding the scarlet kingsnake? The difficulty doesn't lie in breeding the snakes or incubating their eggs. Problems arise after hatching, when it's time to feed the tiny hatchlings. I hope that the information in this article will encourage others to not only keep these beautiful tricolors, but to breed them as well.

Notes on Natural History

Found from North Carolina, south to the Florida Keys and west to the Mississippi River (Conant 1986), the scarlet kingsnake has an extensive range, but it is most commonly found in the sandy, pine woodlands of the Coastal Plain. Due to a secretive nature, they are seldom seen out in the open. Scarlet kingsnakes are primarily terrestrial, but they can be found off the ground under the loose bark of trees, especially when the ground is wet or flooded from spring rains. Prey includes small mammals, lizards, snakes, and earthworms.

Basic Husbandry

Scarlet kingsnakes are adept at finding small openings and will escape if presented with the opportunity. A 10 gallon (38 l) tank with a secure screen top can house a scarlet kingsnake, but larger enclosures are recommended. Newspaper makes a suitable substrate.

These snakes are ideally suited for naturalistic vivaria, for they won't disturb plants and furnishings as many larger snakes will. Scarlet kingsnakes may even be observed more often in a naturalistic vivarium because they are likely to feel comfortable enough to come out of hiding.

A thermal gradient should be provided to allow the snake to thermoregulate as needed. A temperature of about 75°F (24°C) will suffice for the cool end of the enclosure, while an under-tank heater can be used to create a warm area of around



A juvenile scarlet kingsnake preying on an eastern worm snake.

86°F (30°C) at the other end. A larger enclosure affords the snake a broader temperature range in which to thermoregulate.

If live plants are used, full spectrum lighting should be provided for their benefit. Otherwise, the ambient light of a windowed room will suffice. Provide plenty of hiding spots by using strips of bark, dry leaves, or artificial hide boxes. Shedding can be facilitated by keeping dampened sphagnum moss under one of these hiding spots.

Fresh water in a shallow container should be provided at all times. Adults can be offered several pinky mice every one to two weeks. The feeding of hatchlings is described below.

Breeding

I acquired a pair of wild-caught adults in the early spring of 1998. Because they were wild-caught they had most likely already been through the hibernation period that is conducive to breeding temperate climate species. For further information on hibernating captive kingsnakes for breeding purposes, see Perlowin (1992). The snakes were housed individually for several weeks and fed as above.

In mid-March of 1998, the snakes were introduced and breeding took place immediately. By the end of April, the female's appetite had decreased, yet her girth continued to increase. Bulges were prominent along the posterior third of her body. An egg-laying site was provided, consisting of dampened vermiculite in a small plastic container as described by Perlowin (1992). On 10 May 1998, three eggs were found in the vermiculite. The eggs measured 0.90–0.98 inches (22.8, 23.5, and 24.8 mm) in length.

The eggs were incubated in dampened vermiculite at 80–84°F (27–29°C). The eggs swelled noticeably throughout the incubation, but they were not measured again. On 26 June 1998, two of the eggs had hatched completely and the third egg was slit with the neonate's head protruding. The third hatchling was found completely emerged from its egg the following day.

Neonates

The hatchlings looked like miniatures of the adults, except the neonates had brilliant white bands where the adults had bright yellow bands. The babies were quite small in comparison to other hatchling colubrids that I've worked with. Two measured 6.8 inches (17.2 cm) in total length and the third was a bit shorter,

measuring 6.4 inches (16.2 cm) total length. Within a week they had all shed and were ready to take their first meals.

Even the smallest of newborn mice would have been too large for these snakes to consume, so other prey was offered. The following foods were consumed by these snakes:

- hatchling green anoles (*Anolis carolinensis*);
- hatchling ground skinks (*Scincella lateralis*);
- hatchling Northern five-lined skinks (*Eumeces fasciatus*);
- hatchling Eastern worm snakes (*Carphophis a. amoenus*);
- neonate Northern brown snakes (*Storeria d. dekayi*);
- neonate Northern red-bellied snakes (*Storeria o. occipitamaculata*);
- neonate Eastern earth snakes (*Virginia v. valeriae*);
- autotomized skink tails (both five-lined skinks and ground skinks).

The strongest feeding response was observed while offering ground skinks, five-lined skinks, skink tails, worm snakes, and earth snakes. These prey items were seized and eaten immediately. The other prey items were consumed, but often had to be left in the snakes' enclosures overnight before they were eaten.

Groves and Sachs (1973) successfully utilized brown snakes, Carolina anoles, ground skinks, southeastern five-lined skinks (*Eumeces inexpectatus*), smooth green snakes (*Opheodrys vernalis*), and eastern garter snakes (*Thamnophis sirtalis*) to feed hatchling scarlet kingsnakes. Both live and dead food items were eaten. Herman (1981) used ground skinks to feed a group of hatchling scarlet kings, but interestingly, both newborn brown snakes and small green anoles were refused.

Hatchling scarlet kingsnakes will eat a variety of prey species, but the prey are often difficult to obtain, especially during the winter months. Two solutions are to have a frozen supply of food to last throughout the winter, or to feed heavily throughout the summer and then hibernate the snakes during the winter when food is scarce. If snakes can be fed throughout their first year, I recommend doing so because the more they are fed, the faster they will grow to a size where they can consume easily obtained foods such as pinky mice.

Because of their strong feeding response to skinks, scarlet kingsnakes that have grown to a large enough size should be easily coaxed onto a diet of rodents by food-scenting with skinks.



A juvenile scarlet kingsnake. Note that the light colored bands are beginning to take on the yellow coloration of adults.



A scarlet kingsnake at several weeks of age.

Raising hatchling scarlet kingsnakes takes considerable time and effort, and because of this they may never be offered for sale on a commercial basis. But, if you are up for a challenge and want to work with a species that not every other colubrid enthusiast has in their collection, try the often overlooked scarlet kingsnake. You will find that they are worth the extra effort.

About the author: Will Brown is a professional herpetologist, and works at the National Aquarium in Baltimore. He enjoys herpetological field work and photographing wildlife in his free time.

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Care of Madagascan Rain Frogs

Scaphiophryne spp. (Boulenger, 1882).

Part 2: The Marbled Rain Frog, *Scaphiophryne marmorata*, and Green Rain Frog, *S. pustulosa*

by Kevin Wright DVM



Marbled Rain Frog, (*Scaphiophryne marmorata*). Photo by David Northcott.

Part 1 reviewed the natural history of Madagascan rain frogs and herpetoculture of the red rain frog, *S. gottliebi*; it appeared in The Vivarium 10(2):34-35.

Two Madagascan microhylid frogs, the marbled rain frog *Scaphiophryne marmorata* and the green rain frog *S. pustulosa*, are commonly available on herp price lists, at swap meets and in pet stores. These frogs are relatively inexpensive, often less than \$20 US, and, because of their engaging or bizarre appearance and attractive coloration, they can often be an impulse purchase by someone unprepared for them. Moreover, the green rain frog *S. pustulosa* is somewhat similar in appearance to a young ornate horned frog (*Ceratophrys ornata*), and similar care (mis)information often accompanies the rain frog's purchase. Unfortunately, if a rain frog is cared for in the same manner as a horned frog, it will die. Horned frogs thrive in nearly bare cages at temperatures above 80–82°F (27–28°C) and are equipped to capture and ingest large prey. Rain frogs, in contrast, languish in bare cages, become discolored with stress when kept at constant temperatures above 82°F (28°C), and are microhylids with narrow mouths, feeding upon relatively small insects.

The Scaphiophryninae is an endemic subfamily of Madagascan microhylid frogs,

with at least six species of rain frogs, *Scaphiophryne* spp., commonly accepted. All are poorly known, with scant information published about their natural history. One commonly available reference reports the genus as being "Presumably more or less arboreal at low levels in the forest." (Obst et al., 1988, p. 687). This information conflicts with observations of thriving captive specimens.

Marbled Rain Frogs

Appearance - The marbled rain frog, *Scaphiophryne marmorata*, has a bizarre appearance, with green or brown conical protuberances covering its back and sides. Whereas the green rain, *S. pustulosa*, is predominantly brown separated by green, the marbled rain frog is a patchwork of light green and dark green with fine dark brown lines separating the two colors. The skin has a slight granular texture, and becomes even more so in breeding males.

Marbled rain frogs are small, with adults between 1.4–2.2 inches (3.5–5.5 cm) in snout-vent length (SVL) and 0.35–0.64 oz (10–18 g) in weight. Adult males have a black single subgular vocal sac, and are smaller than adult females. A large metatarsal tubercle assists with digging, but this species also has enlarged triangular toepads. These toepads have provoked spec-

ulation that the marbled rain frog and the red rain frog (*S. gottliebi*) may climb more than other rain frogs (Glaw and Vences, 1994, p. 191), but observations of captive specimens indicate that the toepads offer little, if any, climbing advantage over the narrow toes of the green rain frog. Observations of captive red rain frogs suggest that the toes are used in prey detection and possibly interspecific communication.

Distribution - The marbled rain frog has been collected from several localities in Madagascar — some coastal locales along the southeast, northeast, and midwest, as well as more centrally in the southern part of Madagascar (Glaw and Vences, 1994). The areas correspond to the Madagascan biogeographic zones of the eastern and central domain of the eastern region, and the western domain of the western region.

The eastern domain is predominantly lowland [under 2600 ft (800 m)] rain-forest with no dry season. The central domain consists of forests up to 6500 ft (2000 m) with no dry season. The western domain is a dry deciduous forest with a dry season that lasts up to seven months (Mittermeier et al., 1994).

Humidity - The marbled rain frog has been seen at stagnant pools in forests of

Andasibe, within the central domain. It has been recorded at elevations of 3200 ft (1000 m). Given the diversity of the biogeographic zones which the marbled rain frog inhabits, it's important to consider the specific microhabitats found within the domains. For example, the floor of the dry forests of the western domain are seasonally covered with deep leaf litter during the dry season, which may provide a high humidity microhabitat within an otherwise inhospitable landscape.

The other domains are in areas that are uniformly wet, with rainfall from 59 to 118 inches (150–300 cm) annually, and have leaf-litter floors that create a humid microhabitat. Thus, the literature suggests that the marbled rain frog probably needs high humidity if it is to thrive. Indeed, high humidity is needed for both marbled and green rain frogs to do well in captivity. Simulated rain or mist provokes the most activity, while activity reduces or ceases when the humidity drops below 70%.

Optimal Temperatures - Appropriate temperatures for the marbled rain frog are in question. The seasons in the northern part of Madagascar are less extreme than the southern part, which is farther from the equator. Also, temperatures at sea level are likely to be warmer than at



Green rain frog, (*Scaphiophryne pustulosa*). Photo by David Northcott.

elevations above about 1000 ft (300 m). It seems likely that each population of marbled rain frog has adapted to the local conditions, and may have slightly different temperature requirements. Thus it is important to provide a thermal mosaic in the enclosure, providing cooler temperatures, between 70 and 74°F (21–23°C), and warmer temperatures, between 78

and 84°F (25–29°C), and to carefully monitor where the frogs spend most of their time, in order to determine their preferences.

Continued on page 51



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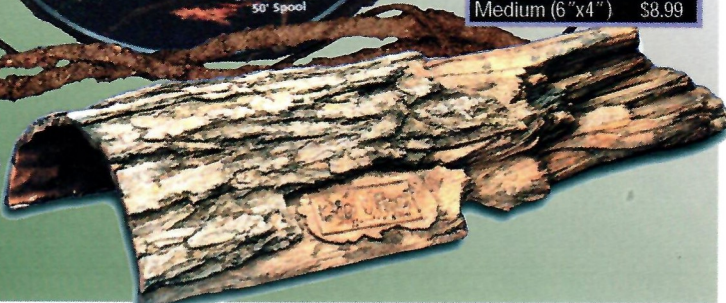
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Design and Observation of a Self-Sustaining Vivarium for Leopard Geckos, *Eublepharis macularius*

by Patrick Ian Huddleson

Complex naturalistic vivaria, termed self-sustaining vivaria, allow the vivarist an opportunity to view animal behaviors with greater depth. "In self-sustaining vivaria animals will breed and increase in number without having to make special efforts or having to remove eggs for incubation." (de Vosjoli 1996). A great deal can be learned from these vivaria, allowing us to view a wide range of behaviors and population dynamics.

Last year I constructed a self-sustaining vivaria for leopard geckos (*Eublepharis macularius*). This lizard was chosen because they have many interesting behaviors and little is known about their interactions within a multi-generational group. Another reason leopard geckos were good candidates for self-sustaining vivaria is that they aren't overly active in smaller enclosures. So I decided to design a vivarium using the 'complex naturalistic vivarium' approach. This approach "uses a three- or four-layered substrate, into which plants are planted directly. With this approach

the plants will put out roots running throughout the vivarium, and thus you create a miniature ecosystem. The great advantage to this system is that you eventually create a type of ecosystem wherein animal-plant-soil interactions will be similar to those found in the wild." (de Vosjoli 1996). It is possible to create a self-sustaining vivarium using a simpler approach. However, the complex approach recreates more of the essential elements of the animal's natural habitat.

Only one pair of geckos was housed in the vivarium during the first year so that the rate of reproduction would be predictable. This article explains how a self-sustaining vivarium was created for this species and describes observations over the first ten months.

Enclosure

Originally, a vivarium measuring 36 x 18 x 24 inches (91 x 45 x 61 cm) was used, but I realized that it would become crowded eventually, so the whole operation was then moved to a larger enclosure.

A glass aquarium measuring 48 x 18 x 18 inches (122 x 45 x 45 cm) with a screen top was chosen. This enclosure was designed just like its predecessor, except this time new and more interesting plants were added.

Substrate - A two inch (5 cm) layer of pond pebbles was placed for drainage with a half-inch (12 mm) layer of pea gravel above that to keep soil from sifting into the drainage layer. Above that, a planting mix of 50% light, high quality potting soil (without perlite) with 25% sand and 25% pumice was used. The surface medium was a blend of oolitic limestone, aragonite, and calcium carbonate sands.

Landscaping - Large limestone rocks were placed on the drainage layer to act as a foundation for the other rocks in the setup. Then various rocks were carefully stacked on top of each other to create shelters and a background shelf. Moistened planting mix was then placed in the vivarium and mounded up where the var-



The author's leopard gecko vivarium provides shelters, activity areas and a "nursery" for egg-laying and hatching. Photo by the author.

THE VIVARIUM

ious succulents were to be planted. The succulents were then planted between rocks and on the background shelf.

Before the surface medium was added, a hot rock was placed in an open spot in the front right corner. This was done because a heat pad would not work effectively with the multi-layered substrate.

The surface medium was then added. More flat rocks were carefully stacked on top of the other rocks to create raised shelters.

Next, an area I call the "nursery" was created. This became a site where the female laid eggs and the neonates remained until their yolk sacs were resorbed and they were ready to hunt on their own. For the nursery, a handful of the surface medium was removed from the left side of the vivarium. Vermiculite (about 50%) was mixed into the planting medium and then a thin layer of the surface mix was replaced, leaving a depression. On the sides of the depression two rocks measuring 6 x 3 x 0.25 inches (15 x 7.6 x 0.6 cm) were pushed into the substrate, down into the drainage layer. Upon these rocks, a flat rock was placed to cover the nursery area. This rock serves as a lid and can be removed if necessary. An entry-way was dug out so the female had access to lay her eggs. A water bowl — a piece of lava rock with a deep depression — was then placed in a spot that allowed for easy access. Epoxy resin was applied to the depression as a sealant, thus creating a natural pool of water.

Smaller rocks and gravel were then placed around the plants and in between the larger rocks. The point was to cover bare areas to keep the female from digging and laying her eggs anywhere but the nursery.

Plants - There wouldn't be much activity during the day since the geckos are nocturnal, so it was decided that the vivarium should have a great diversity of plants to make it interesting to view during the day. Not only were the plants chosen for aesthetics, but for their compatibility with the leopard geckos and their environment.

Three species of Agave were used to balance out the composition and to provide shelter. A climbing aloe (*Aloe ciliaris*) was placed on the background shelf and two other aloes (*A. doriae* and *A. dichotoma*) were placed on the sides. A *Sansevieria* sp. "Kenya" and various Haworthias were used for ground cover. Two interesting bulbous plants of the genus *Ledebouria*

were planted on the background shelf. An unusual euphorbia (*Euphorbia sakarahensis*) was placed mid-shelf with hopes that it would trail down, because it looked like a small wind-swept tree.

Heating and Lighting - Two full-spectrum fluorescent bulbs run the length of the vivarium, for the plants and for general lighting. A 100 watt incandescent light is used to raise temperatures during the day. The light cycle is maintained relative to the gecko's breeding cycle.

For night heating, a hot rock is used. A 75 watt purple moon bulb is above the nursery, keeping it at a steady temperature of about 83°F (28°C). This bulb also provides additional heating and lighting for night observation. The light from this bulb does not interfere with the geckos' activity patterns and allows for hours of enjoyable night observation.

Feeding and Maintenance - The adult geckos are fed various prey (crickets, waxworms, mealworms, and superworms) in dishes which keep the invertebrates from getting loose. Neonates eat from these dishes when large enough to access the bowls. Once the hatchlings have resorbed their yolk, they are old enough to eat appropriately sized crickets, and these prey are released into the vivarium every three days. The number released depends on the number of neonates; usually one dozen crickets per hatchling are released. Behind a rock in the back corner of the vivarium, a commercial cricket diet is kept to prevent the prey from destroying vivarium plants and attacking hatchlings. Usually the crickets are consumed within the three days.

Since leopard geckos regularly use one site for defecation, it is easy to clean out waste. Feces are removed at every feeding. The water bowl is also cleaned at this time. The plants are watered every five days or as needed. Every month the glass is cleaned with a mild glass cleaner and any stray crickets are removed. Unless there are hatchlings within the nursery, this site is sprayed daily with lukewarm water to keep the soil moist.

Observations

The geckos were introduced into the vivarium in November 1998. After a week to let them get used to their new surroundings, the temperature was



Observations on a group of leopard geckos that were allowed to breed, hatch and grow in a naturalistic vivarium revealed the non-predatory relationship of parents with their young offspring. Photo by Bill Love from *The Leopard Gecko Manual* (de Vosjoli, Klingenberg, Tremper and Viets, 1998, AVS Books).

decreased to an average of 76°F (24°C) during the day, and the photoperiod was shortened from 14 hours of daylight to twelve. In early March 1999, the temperature was slowly raised to an average of 87°F (31°C) and the photoperiod was returned to 14 hours of daylight.

In late March, the female showed signs of being gravid, and one night in early May I noticed two little creatures scurrying under a rock. After some work, the wiley little geckos were captured and examined. One of the hatchlings appeared to be perfectly healthy while the other seemed to have a birth defect with one of its eyes. It died shortly after. Since then four other geckos have been hatched, with only the one casualty.

The neonates were numbered from #1 to #6, in the order in which they were born. Neonates #1 and #3 have now reached sub-adult size and are believed to be male. The others are not old enough to be sexed accurately.

A variety of interesting behaviors have been observed between the parents and neonates. Once the hatchlings absorb their yolk sac, they start to venture out from the nursery. An intriguing observation was that the hatchlings stayed within close vicinity to each other and the parents. This may be a protective measure, for the babies would be safer from predators in the wild in groups and around the larger adults. The parents don't seem to mind the neonates and pretty much ignore them. Occasionally they tongue-flick the babies.

Once the hatchlings reach the age where they are beginning to lose their pattern of bands, they start to venture

out on their own. During this time, the juveniles don't seem to be dependent on the security of being around their parents and siblings. The juveniles aren't altogether avoiding them either and they will still rest and bask near adults and siblings.

Surprisingly, as of yet no aggression between any of the geckos has been noticed. They seem to be aware of each other and perhaps to recognize each other. Sometimes it almost seems that they are communicating with each other with body movements, tongue flicks, and nudges. This is something that has to be studied with more detail.

As of this writing, all of the geckos are large enough to eat mealworms and wax-worms. For a treat, about once weekly all of the geckos are fed a dish of these worms. Their response is probably the most enjoyable thing I have witnessed since I started this experiment. The dish is placed on the floor of the vivarium and, one at a time, the geckos come out and feed. Eventually all of the geckos are surrounding the dish, taking turns going at the worms. Owners of leopard geckos know how deliberate these lizards can be with their movements when stalking prey. Just imagine seven of them, all in a circle taking turns feeding from the dish. It's quite a comical event.

What's next? - It isn't known what the full bio-load of this vivarium is. Therefore the neonates are going to stay in the vivarium for the next year, or until it becomes too crowded. During the cool down in November, another adult female will be added to the vivarium. It is hoped that next year's breeding season will be even more productive, with a new female as well as the neonates reaching sexual maturity. It should be interesting to see how the interactions between the geckos change in the next year. Our goal now should be to create more complex vivaria like this one, to learn more about our animals and their behaviors within groups.

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An adult female star tortoise photographed *in situ* in Andigama, Sri Lanka. This region is in a lowland area of the first peneplain in the northwestern part of Sri Lanka. Photo by the author.

Captive Breeding of the **Star Tortoise**, *Geochelone elegans*

by Harry Palmer.

Specimens of the star tortoise, *Geochelone elegans*, can be found in zoos and private collections throughout the world. Despite several successful captive tortoise propagation programs involving other species (*Testudo hermanni*, *Geochelone sulcata*, *G. radiata*, etc.), captive breeding of *G. elegans* is not commonly reported. The author has been successful in producing over 100 hatchling star tortoises on a consistent basis since 1988. By 1998, successful F2 captive reproduction occurred when an unrelated pair of the captive bred tortoises produced nine offspring from two clutches of eggs.

In 1987, a small group of adult star tortoises was acquired for the purpose of establishing a breeding colony. Upon the arrival of this group, it was immediately determined that parasite infestation was of primary concern. Nematode infestation was so abundant as to be visible to the unaided eye. Every tortoise was administered metronidazole (Flagyl®) and fenbendazole (Panacur®) at dosages recommended by Funk (1988) and Klingenberg (1993). Body weights were recorded every three days.

Indoor Husbandry

Since 1987 the colony has been domiciled in northern North America. This presents an ambient weather pattern which is totally alien to *elegans*, requiring the colony to be kept indoors for approximately eight months, generally from mid-September through mid-May. During this indoor time, males are housed separately from females.

Housing - Terraria are constructed of plywood and are completely enclosed, except for sliding glass doors in front. Cypress mulch is used as the substrate; it provides good footing and is quite absorbent.

Shelters are provided, as some of the tortoises remained shy even after years in captivity. Clay flower pots, split in half along the vertical axis are excellent shelters. By providing a secure hide spot, tortoises are able to escape the belligerence of larger, more aggressive individuals. Given the limited space afforded by the terraria, hiding places become important components of stress reduction. The hide spots also interrupt sight

lines, so the tortoises are not in constant visual contact with each other.

Lighting and Temperatures - A fluorescent fixture containing two 40 watt bulbs is affixed overhead. Incandescent 150 watt floodlights are also affixed overhead but positioned towards one end of the terrarium, which allows for a temperature variation from one end to the other. The area directly beneath and adjacent to the floodlights can reach temperatures as high as 95°F (35°C). This area is frequently occupied by basking tortoises. The cooler, opposite end of the terraria allows the tortoises to thermoregulate. Overall temperatures in the terraria vary between 81°F and 95°F (27-35°C). The lights are on a 12 hour on/off cycle.

Water and Food - Due to hygiene considerations, standing water is not available in any of the terraria. In lieu of standing water, larger juveniles and adult tortoises are soaked in tap water every ten to 14 days in shallow tubs for one hour. After each use, the tubs are rinsed with a 1:10 bleach/water solution.

The larger juvenile and adult *elegans* are fed every three to four days with generous portions of food provided on fiberglass trays. The trays prevent accidental ingestion of substrate.

The diet consists of two main ingredients — Italian dandelion greens (*Cichorium intybus*) and spineless cactus pads (*Opuntia* sp.). While these comprise the bulk of the diet, carrots, apples, squash, pumpkin, tomato, kale, cooked sweet potato, green beans, escarole, and Purina Pride 100 horse chow (moistened) are also added. Use of these dietary components is subject to market availability and price. Every other feeding, supplements of calcium, vitamins and minerals (Rep-Cal Research Labs) are added into the food.

Outdoor Husbandry - Starting in late April or early May, when the outdoor daytime temperatures reach 72°F (22°C), the colony is moved outdoors during daytime hours. During this time, daily weather conditions dictate whether the colony is indoors in terraria or outdoors in pens. Typically, it's not until the middle of June that the colony is kept outdoors through the night. Average summer temperatures range from 75 to 90°F (24-32°C), occasionally reaching high temperatures of 100°F (38°C). By September, ambient air temperatures cool and the tortoises are brought inside as temperatures dictate.

Housing - The outdoor facilities for the adult tortoises are comprised of 30 ft² (9 m²) pens. The walls are made from timber 14 inches (35 cm) high. Each pen contains a concrete pool measuring approximately 40 in² (258 cm²) with gently sloping sides that reach a depth of 3 inches (7.5 cm). A drain at the deep end of the pool facilitates emptying. The pools are drained, scrubbed and refilled with fresh water daily.

Various native species of trees and shrubs provide shaded areas in the outdoor pens. A turfgrass lawn of predominantly Kentucky bluegrass (*Poa pratensis*) provides forage for the colony. Varieties of ornamental grasses (*Miscanthus* sp., and *Pennisetum* sp.) are planted in groups, adding shelter for the colony.

The tortoises spent a great deal of time each day grazing upon the turfgrass. They do not receive any other food with the exception of whole carrots, until early July when an on-site garden provides many of the same foods listed above. Supplemental vitamins are added every two to three days. Incidentally, in

Sri Lanka, *elegans* are quite fond of young farm-grown pumpkin plants (*Cucurbita maxima*). Since this is an important agricultural product in Sri Lanka, the pumpkin farmers have determined *elegans* to be a pest and exterminate them on sight (De Silva, pers. comm).

Neonates less than four inches (10 cm) long are housed in predator-proof enclosures constructed of wood with wire mesh covers. These are heavily planted with white dutch clover (*Trifolium repens*). The clover is more tender and of finer texture than the turfgrass, and consequently it is readily consumed by the neonates. Fresh greens (listed previously) are provided every other day. Juveniles larger than four inches long are housed separately in smaller pens under identical conditions as adults.

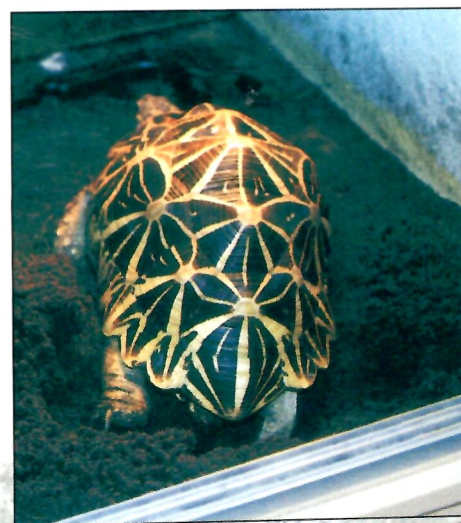
Reproduction

Males and females are reintroduced when the entire colony is moved in early summer to the outdoor pens. Mating activities begin almost immediately and continue throughout the summer months. Male *elegans* have been observed in courtship activities in temperatures of 70 to 100°F (21-38°C), on sunny or overcast days. Mating frequencies increase throughout periods of rain, regardless of time of day or temperature. If it hasn't rained for seven days or more, the pens are sprinkled using garden hoses. The sprinkling results in mating at frequencies similar to that observed during rainy periods.

Each tortoise in the colony is weighed every ten to 14 days. Weight gains in females have been a reliable indication that the tortoise is gravid.

Nesting typically commences in August and continues through February. Nesting activities aren't apparently interrupted despite being moved back inside for winter. Females typically, but not always, embark on nervous and circuitous pacing excursions prior to selecting a suitable nesting site. Nesting typically takes several hours and occurs in mid- to late-afternoon hours. A second clutch typically follows within four to eight weeks.

Since most nesting occurs in the terraria, suitable and enticing indoor nesting sites had to be devised. Tubs measuring 20 x 31 x 8 inches (51 x 79 x 20 cm) were recessed into the terraria floors. The tubs are filled with equal amounts of black dirt, peat moss, and sand. The females became accustomed to the tubs and nest readily in them.



This female has just completed ovipositioning and is in the process of covering the eggs. The nesting box seen in this photo has been recessed into the floor of the terrarium.

After the female finishes nesting, the eggs are removed, cleaned of dirt, and numbered with a pencil. The eggs are placed into Hovabator® incubators within clear acrylic containers measuring 6 x 12 x 4 inches (15 x 30 x 10 cm). Each container is filled to a depth of 1.5 inches (3.8 cm) with a 1:1 (by weight) mixture of vermiculite and distilled water. Each egg is half-buried along its horizontal axis in the mixture. Each incubator holds two containers.

An opaque white spot (chalking) begins to appear on the top of each egg within the first two weeks of incubation. Initially, the chalking covers an area of approximately one-quarter inch (6 mm) at the very top of the egg. Then it spreads, covering the visible portion of the eggshell. In all instances, eggs that don't chalk, don't develop.

Incubation temperatures are recorded on digital thermometers. To establish thresholds for temperature-controlled sex determination (TSD) in *G. elegans*, eggs from each clutch are divided among three incubators. Each incubator is set for one of three temperatures — 83°F (28.5°C), 87°F (30.5°C), and 88°F (31.5°C). The middle temperature is being used to determine the threshold temperature, which, according to Vogt (1994), has a higher probability of producing intersexes.

Incubation periods take from 84 to 166 days with an average of 96 days.

As each egg began to pip, it is removed from the incubator and placed in its own individual container where it is kept

until the hatchling is completely out of the egg and has absorbed its yolk sac. This typically takes 48 to 72 hours. The neonate is then placed in a shallow pan with water, and in all instances the hatchling drinks large volumes. The neonate is then marked with red nail polish on its marginal scutes, using the same numeric code as on the egg, and placed in a terrarium designated exclusively for neonates.

Females average 2.5 clutches annually. In 1995, one female laid five clutches, averaging 29 days between each. Clutch sizes range from two to nine eggs, averaging 5.8 eggs per clutch. Overall hatching success rate since 1988 has been 46%. However, in the 1995-96 season, the hatching success rate increased to 84%.

Neonates begin feeding within two to four days of hatching and yolk sac resorption. Various greens (as for adults) are finely chopped and offered daily. Supplementation is as for the adults. Every three days the hatchlings are soaked in shallow water for 30 minutes.

Neonate terraria measure 16 x 35 x 12 inches (40 x 90 x 30 cm). The substrate is newspaper. Hide spots are half-round sections of hollow tree bark and clay pots. The hides spots are frequently occupied by the neonates, regardless of time of day.

Two neonates, a male and female, were transferred to Dr. William Zovickian. The male had hatched on 3 March 1995, the female on 6 January 1991. By May 1998 the male weighed 18 oz (510 g) and measured 5.25 inches (13.5) cm, the female, 62 oz (1730 g) and 7.75 inches (19.5 cm). On June 24 and again on June 25 copulation was observed. The female laid the first of two clutches of eggs on 31 August 1998. All five eggs from this clutch hatched after incubating for 88 to 95 days. A subsequent



Typical star tortoise habitat in Sri Lanka. Photo by the author.



F2 captive bred star tortoises. The parents of these tortoises were a 3 year old male and a 7.5 year old female. Photo by William Zovickian.

clutch of four eggs was laid by the same female 38 days later. All of these eggs hatched after incubating for 96 to 103 days. Both clutches were incubated in the same incubator at 88-89°F (31-32°C). Ambient air temperatures of the room in which the incubator was located may

have played a role in the extended time it took the second clutch to hatch. The first clutch was occasionally subjected to ambient room temperatures in excess of the incubator temperatures (Zovickian, personal communication).

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Despite conjecture from Obst (1986) and Highfield (1990) that *Geochelone elegans* does not readily breed in captivity, the success reported here suggests that *elegans* can be consistently bred in captivity. Successful F2 reproduction resulted from a 7.5 year old female and a 3 year old male. Key factors for success appear to include micromanagement of all husbandry aspects, cyclical sexual segregation, a varied diet including supplements, and an agenda that focuses on stress reduction.

There is every reason to believe that the success of this program could be applied to other congeners of *Geochelone elegans*, specifically the critically endangered Burmese star tortoise, *Geochelone platynota*. However, until such time as founder specimens of *platynota* can be obtained, these opportunities will not materialize.

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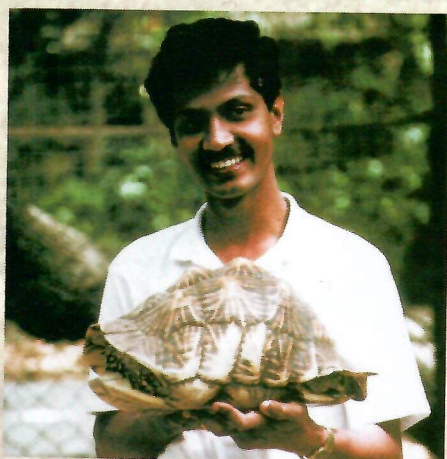
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This female star has a straight line carapace length of fifteen inches (38.1 cm). This specimen is in captivity in Sri Lanka. Photo by Ron Humbert.



A very handsome group of star tortoises at the Colombo Zoo, Sri Lanka. Natural pyramiding is typical trait of star tortoises from Sri Lanka and can be seen in several specimens in this photo. Photo by Ron Humbert.

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Radical Ideas for 21st Century Herpetoculture Part 2

by *The Vivarium Staff*

Biopolitics and the Preservation of Endangered Species Status

There are lots of reasons why amphibians and reptile species become endangered or in some cases extinct. One is biopolitics. When Costa Rican golden toads (*Bufo periglenes*), arguably the most beautiful toad in the world, were clearly declining, several zoos tried to obtain specimens to acquire a base of knowledge on their herpetoculture. Costa Rica felt very proprietary about the golden toad, a flagship species and tourist symbol of the famous Monte Verde Preserve. Wildlife agencies and conservation organizations went along with the biopolitics. In spite of preservation of their habitat, the golden toad declined to the point that it is now believed to be extinct. Similar short-sighted policies are implemented worldwide with various amphibians and reptiles, and conservationists are encouraging emphasizing proprietary rights of species (e.g. indigenous people receiving royalties on monies made from species including captive-breeding or derived products such as pharmaceuticals).

As it stands, much of the endangered status of herps is not real but created or intentionally sustained. It is biopolitics and economics. Herpetoculture and translocation of species could make many supposedly endangered species common but that would not be desirable in the biopolitical world. For example, Galapagos land iguanas, radiated tortoises, rare *Cyclura*, Fiji island iguanas and San Francisco garter snakes are rare or threatened because of politics.

A radical idea would be requiring truth in reporting by wildlife agencies. CITES should state that the Malagasy tree boa is the most common large snake of Madagascar and in no way endangered. It was listed under Appendix I as endangered, presumably to prevent exploitation for the leather trade, which would have been disastrous. Galapagos land iguanas could be captive-produced by the thousands but Ecuador benefits politically and economically by maintaining their endangered status and limited distribution on the Galapagos Islands. In the case of US species, the San Francisco garter snake population is small enough that it should be a priority to establish sizeable captive populations. Although this snake breeds easily in captivity, the federal government is using it as a leverage to preserve natural habitat and is opposed to captive breeding of this species.

A radical idea would be to have a reporting form on threatened and endangered species that accurately identifies population estimates as well as environmental and political factors so that the real status of species could be evaluated in the correct context. The listing of potentially threatened species should be based on more rigorous scientific criteria and their exploitation controlled by quota/tariff systems. Why is the radiated tortoise of Madagascar with a population estimated to be at least 800,000 listed under the US Endangered Species Act while the rhinoceros iguana with a population estimated to be under 30,000 is not? Why is *Dermatemys mawii* listed under Appendix 2 of CITES and yet listed under the US Endangered Species Act, thus impeding research? How about requiring rationalism rather than political agendas and myths as a basis for wildlife regulation?

Got Milk?

Our Moms have been after us for years to skip that Diet Coke and drink milk, for it's common knowledge that milk is a healthy drink. What does milk have to do with reptiles? If you've had to deal with that ubiquitous and nasty parasite, *Cryptosporidium*, you may want to read on to discover the connection.

Studies by those noted Crypto Busters, Drs. Mike Cranfield and Thaddeus Graczyk, have shown that hyperimmune bovine colostrum (HBC) has had early promising results against *Cryptosporidium* sp. infections in both snakes and Savannah monitors.

Colostrum is the antibody-laden "first milk" that appears when pregnant mammals begin lactating. Veterinarians vaccinate mammals not only for the protection of that individual but also for protective immunity to be passed on to offspring through nursing on this gift from the dam.

This ingenious study by Cranfield and Graczyk was initiated by vaccinating cows with *Cryptosporidium parvum*, which is the main strain of crypto active in cattle and also people. The antibodies produced and passed in the colostrum were then used to treat moribund leopard geckos and savannah monitors. The monitors gradually gained weight and crypto oocyst counts dramatically decreased or became negative as the monitors were dosed with HBC. Similar encouraging results in a 1998 study by the same researchers were obtained in snakes (no, they weren't milk snakes). Unfortunately, responses by the leopard geckos to HBC were poor, likely due to the intestinal location of *Cryptosporidium* sp. infections or differences in strains (or species) of *Cryptosporidium* in leopard geckos.

It isn't that far fetched that sometime in the future you could stop by your local pet shop for a vial of HBC. For those of us who've seen herps succumb to crypto, this is an especially pleasant daydream.

Indoors or Out?

Having bred colubrid snakes for over a dozen years, it makes total sense to us that snakes in our care are going to eat well and prosper, doing better than, say, a grey banded kingsnake in the wild that might catch a couple of lizards, but burns off all those calories in the search for more food. It's rough out there in the real world. As colubrid snake breeding has become more routine, most of us realize that when breeding is considered, it's probably better to have lean and fit females as opposed to larger, inactive females. These aren't new thoughts, and opinions on these issues have circulated for years.

However, put commercial breeding aside and let's say that your goal is to take a fairly rare, and perhaps even endangered, species of colubrid snake that you want to breed and release back into its natural habitat. Let's say a snake such as a Brazos County water snake. Which of the following situations is better for the snakes — setting the snakes up inside and raising them as we've bred colubrids for years, or setting up an artificial outdoor enclosure, with some food provided, in which the snakes have to otherwise fend for themselves? Breeding snakes inside under human control would create larger snakes with more plentiful offspring, right? While the outdoor snakes might be more athletic and healthier, certainly they wouldn't be larger and more prosperous — would they?

Dr. John Rossi and his wife, Roxanne, of Jacksonville (FL) tested this scenario for us. Dr. Rossi chose Brazos water snakes, *Nerodia harteri harteri*, as the subjects of the study, due to the need for information on releasing these snakes back into the wild after rehabilitation, and also because of interest in repopulating areas devoid of these once common water snakes.

The snakes maintained indoors were raised in terraria consistent with excellent husbandry conditions for this taxon (the Rossi's are the well-known authors of the acclaimed two volume *Snakes of the United States and Canada*, and they know their husbandry). The outdoor snakes were maintained in a very large outdoor area walled off with 4 x 8 foot (1.2 x 2.4 m) pressure-treated plywood panels, sunk into the ground to prevent escape from underneath. Natural shrubbery and herbaceous plants were added and mixed with piles of rocks that created crevices and faces needed for snake activity. The finishing touch was a pump-driven



A one and a half gallon vivarium for dwarf underwater frogs designed by Advanced Vivarium Systems and Vivarium Research Group containing five dwarf underwater frogs (*Hymenochirus*), a white cloud fish, an *Otocinclus* catfish and a Singapore freshwater shrimp. A small air pump powers a foam filter. Five species of live plants help maintain water quality. The mini tank and its inhabitants have been set up for two years. This is the kind of equilibrium with relatively high bioloads that modern vivarists are striving for. Photo by Philippe de Vosjoli.



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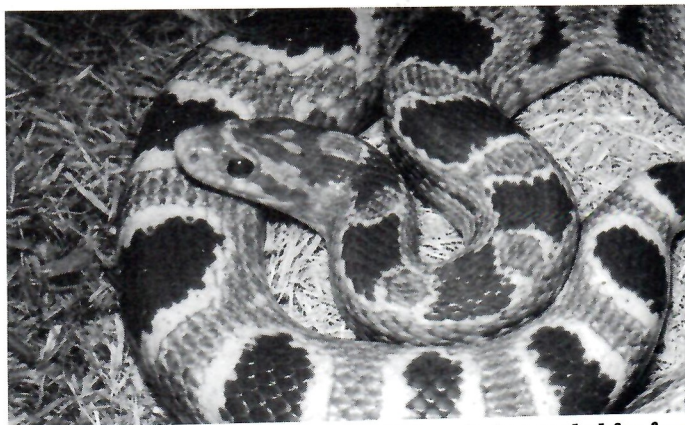
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recirculating stream constructed with natural materials. Pinkie mice were provided in a feeding container on a regular basis in a first-come first-serve fashion, but otherwise the snakes were left to fend for themselves.

Despite facing much more adverse conditions outdoors from attempted predation injuries, dermatitis, starvation, dehydration, heat stress (this study was in Florida) and significant parasite loads, the snakes raised outdoors were *three times* the body weight of their indoor siblings at one year of age! Three times heavier even with uncontrolled parasites!

This study suggests that snakes conditioned to an outside environment are not only going to be more worldly, as evidenced by observed great flight distances and aggression when handled, but larger and more hardy. The authors also observed that some snakes housed indoors for years learned to become wary, hunt more efficiently and ultimately hibernated and mated at the appropriate times when placed in outdoor enclosures as adults. The authors felt that their study would suggest similar outdoor conditioning pens will serve as both a tool for head-starting neonates and also rehabilitating adults prior to release.



Non-feeding corn snakes may benefit from being cooled for four to five weeks before being brought up to higher temperatures and offered food. Photo By Bill Love from the upcoming *The Corn Snake Manual*, (Bill Love and Kathy Love. 2000. AVS Books).

Developing Ethno-ecology and Ecological Engineering

We defined ethno-ecologies in a previous issue of the *Vivarium* as man-made ecological systems that depend on human beings for their generation, long-term survival and maintenance. Examples include gardens and backyards, landscaped parks, vivaria, aquaria, garden ponds, and indoor landscapes. The methodology for achieving long term, more or less self-sustaining systems includes a field called ecological engineering — the application of ecological principles to address environmental and human issues and problems. To date the focus of ecological engineering has been pollution, oil spills, and treatment of waste, sewage and water. Among the feats of ecological engineering by the private sector has been the development by aquarium hobbyists of reef systems including the Berlin system, and more recently the plenum system which utilizes a dead space for anaerobic bacteria that perform denitrification of water.

In the vivarium field, some of the most original work has been done by Canadian Wolfgang Amlung, owner of Genetron Inc., who developed the “breathing wall” system. Besides their aesthetic aspects, his “breathing walls” serve the primary function of removing toxic gases, including formaldehyde, benzene and trichloroethylene, released by building materials such as carpets, varnishes, solvents, adhesives and cleaning products. Collectively, these can lead to what is called “sick building syndrome”, characterized by workers who display various symptoms of illness once they enter a building, but who improve after they leave it. One of Amlung’s latest creations is the 40 x 40 feet Breathing Wall in the head office of Club Monaco, a popular clothing outlet in Toronto. The indoor rainforest accommodates 2000 species of plants, fish and animals including lizards and amphibians. His “breathing wall” technology is now being considered in a variety of environments, from schools to hospitals.

Ideally, ecological engineering could also be developed to create forest nuclei in deforested areas or ethno-ecologies that could serve to harbor and maintain endangered non-native species in different areas of the world. An endangered species in one area of the world could find refuge in another country where it would be spared the cultural and/or environmental pressures that are leading to its demise. The value of further developing sciences of ethno-ecology, ecological engineering and species introduction cannot be underestimated. There may come a time when eco-engineered ethno-ecologies may be the only recourse for keeping alive certain species and the only direct experience most students will have of an ecological system. Should we one day colonize other planets, it will be this kind of knowledge that will allow us to bring species with us and to seed other planets with ecological systems. This is an area full of promise and opportunity that deserves much more attention.

Ending the Conservation Myth

The greatest conservation myth of all is conservation itself. Neither geological records nor fossil records suggest that, overall, conservative states exist for extended periods of time in nature. Varying waves of extinction have punctuated our past, caused by astronomical, geological, climatic and biological events. Most of our conservation efforts will turn out to be moot if a sizeable asteroid strikes the earth. On a smaller scale, we are entering a period of global warming which will have a great impact on both human populations and wildlife within the next century. We already know that in various parts of the world frogs and toads are declining even in what appears to be pristine habitat, with global warming and pollution as possible causative factors. As we have witnessed on several occasions in the last year alone, volcanoes, earthquakes, hurricanes, droughts and floods strike with enough frequency to remind us that few things are permanent. There’s also another inescapable fact that lies in our future, the earth will eventually enter a new glaciation period and this will drastically alter what we call geography and biodiversity. In the past, as habitats changed, many wild populations could migrate to more favorable areas. Today, however, these routes are altered or altogether gone as a result of human development. It’s clear that developing realistic strategies for conservation in a non-conservative world will require radical thinking.

A first step is to acknowledge three truths about reality: to varying degrees the world stays the same, to varying degrees the world is destroyed, and to varying degrees the world changes (innovates). Addressing the conservation of species in terms of these three dynamics is really the only chance we have. Although preserving natural habitat must be the foundation of preserving biodiversity, in a rapidly changing world it should only be one component of conservation policies.

When students ask me what direction they should go in to fulfill their desire to save species and preserve biodiversity, I currently direct them toward reproductive biology and technology. Storing as much genetic information as possible on existing species and developing new reproductive technologies that may allow us to clone and even, Jurassic Park style, grow herps in alternate egg environments seems as valuable an endeavor as preservation of habitat. Herpetoculture also seems a valuable tool for preserving genetic material in a cultural context and more efforts should be made to establish as many species in captivity as possible. Innovation seems a necessary approach to conservation in a non-conservative world.

Snake Refrigeration

It's long been noted by colubrid snake breeders that hatchlings which are difficult to start feeding often respond to a short cooling period. The theory is that many colubrids hatch in late summer, or even early fall, and have to scramble to find meals prior to hibernation. Vigorous hatchlings that obtained excellent food stores from their egg yolk probably don't need to feed at all prior to entering hibernation. Obviously, those individuals that are early successful feeders are more likely to succeed in the real world.

There are risks in cooling a neonatal snake that hasn't eaten, for it's sending a weaker animal into a stressful situation. Studies have shown that reptiles' immune systems are stimulated by heat and impaired by cooling. Moreover, the very young tend to have more fragile immune systems in the first place. On the other hand, if every feeding technique in the universe has been tried and there're too many mouths for assist feeding, what is a snake breeder to do? Fortunately for us, budding scientist Pierce Jacobson (a chip off the old block) decided to investigate this very issue.

Pierce picked 192 baby corn snakes from a pool of over 1000 non-feeding

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hatchlings. These were divided into two groups — one was kept at 55°F (13°C) and the other at 65–70°F (18–21°C). After two weeks, and at weekly intervals thereafter up to nine weeks, 12 snakes from each group were weighed, and moved to a room at 84–88°F (29–31°C). After 24 hours, newborn mice were offered to each snake and consumption was noted at 24 hours. Those that didn't feed were offered another pinkie in 48 hours and checked again 24 hours later.

Not surprisingly, the group of snakes maintained at 55°F lost less weight than the group maintained at 65–70°F. The cooler snakes had less metabolic demands, hence maintained their weights better.

How was the feeding response affected? For four of the weekly intervals, snakes from the cooler group fed better than snakes from the warm group. On only two of the weekly intervals did snakes from the warmer group feed better. The peak feeding response was noted at four to five weeks from the start of the study. Ultimately, snakes in the cooler group which fed numbered 34, and snakes from the warmer group which fed totalled 33. Since the snakes in the cooler group lost less weight, Pierce's conclusion was that non-feeding corn snakes be hibernated at 55°F (13°C) for four to five weeks before they are brought up to an optimum temperature and offered food. Not bad for a 14-year-old researcher!

While this is just one study based on a 9 week time frame, it would seem that a snake breeder faced with a 1000 non-feeding hatchlings might want to refrigerate the snakes to minimize weight loss, leaving more manageable numbers to work with. For example, a breeder might refrigerate the 1000 hatchlings for a few weeks, then remove 200 at a time to work with while the rest slumber on. This is one concept that has great potential for snake breeders in the coming years.

The Vivarati

At the cutting edge of herpetoculture is an odd lot of avant-guard thinkers known as the vivarati — artists who incorporate art, ecological engineering, live plants and animals to create living works of three-dimensional art contained in man-made enclosures. Creating art with standard media is difficult enough but it reaches a higher level of complexity when life forms are incorporated into systems that must be both aesthetic and functional. Vivart, the term to describe the art form of the vivarati, is considered futuristic because it is intended for a culture whose exposure to nature is expected to become limited or mostly illegal. The vivarati philosophy is that nature contained may one day become as precious as fine art today. In a world becoming increasingly metal and plastic we need more vivarati to retain a consciousness of life.

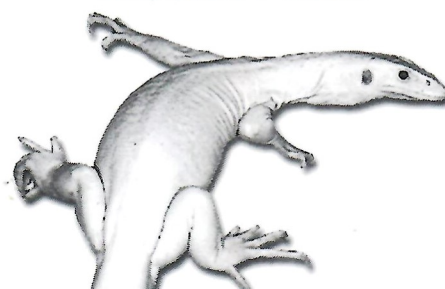
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Danny Salzhandler's Biosculpts are at the cutting edge of the small but growing vivarati movement. Photo by Philippe de Vosjoli.

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If the frogs are inactive, make sure that the humidity is above 85%. If the frogs are still inactive, it is likely that the temperatures provided are too cool, and the temperature should be increased by 2 to 4°F. Inactivity may also result from temperatures that are too warm, and temperatures above 88°F (31°C) aren't recommended. Once the preferred temperature range is determined, the enclosure's thermal gradient should be established to provide some areas that are slightly above and others slightly below the preferred range to allow behavioral thermoregulation by the frogs.

A cooling season may be desirable, to stimulate gonadogenesis in some populations. Specimens have been maintained for several weeks at temperatures in the mid to high 50's°F (13–15°C) without ill effect.

Green Rain Frogs

Appearance - The green rain frog, *Scaphiophryne pustulosa*, is covered with brown to mahogany irregular patches separated by light green to jade green reticulations. The skin on the frog's back is somewhat granular. The green reticulations may fade to white on its side, arms and feet, and the belly is almost entirely white with occasional black stippling. The ventrum of a male may be darker and more heavily stippled than that of a female. The green rain frog lacks the prominent triangular toepads of the marbled (*S. marmorata*) or red (*S. gottliebi*) rain frogs.

Male green rain frogs are smaller than females, and have a darker colored single subgular vocal sac. Adult frogs are typically 1.5–2.0 inches (4–5 cm) SVL, with males typically smaller than females.

Distribution - The green rain frog has a more restricted known range than the marbled rain frog. It has been reported from higher elevations, up to 5600 ft (1700 m), of the central domain, and parts of the high mountain domain (Glaw & Vences, 1994).

Temperature and humidity - The central and the high mountain domains of Madagascar are fairly wet and receive high rainfall. The high mountain domain has a larger daily variation in temperature as well as greater seasonal variations in temperature compared with other parts of Madagascar (Mittermeier et al., 1994). Thus the green rain frog may require cooler temperatures, at least part of the time, than the marbled rain frog.

Seasonal variation may be important to stimulate reproductive activity. Eggs were found in the wild in January (summer).

Captive Care

Habitat - An appropriate enclosure for rain frogs should include a layer of clean soil, about 1.5 inch (4 cm) deep, with a region of moist compacted sphagnum moss, a corner of pea gravel, and a layer of leaf litter and moss overlaying the soil. In addition, moistened sheet moss can be draped across the soil and sphagnum moss to provide additional hiding areas and terrain diversity.

Other furnishings, such as rocks or branches, should be placed in contact with the bottom of the enclosure. This prevents frogs from burrowing underneath and possibly being crushed by heavy objects.

Plants can be used in the vivarium, as the rain frogs are small enough to leave hardier plants undisturbed. A thick layer of groundcover and a well-stratified plant layer may increase rainfrog activity by reducing the light at floor level.

Although the frogs are most active at night, high humidity and reduced daytime light levels may stimulate activity. A shallow pool, about 0.4 inch (1 cm) deep, should be included for a water source as well as a possible breeding site.

Both marbled and green rain frogs have been maintained under more spartan conditions during quarantine at the Philadelphia Zoo. The quarantine enclosures consist of a plastic shoebox with wet brown paper towels as substrate. This is useful for collecting fecal samples and monitoring initial feeding, but is not recommended beyond 30 to 60 days for either species.

Diet - Small crickets, ranging from pinhead size for smaller frogs to 14-day-old crickets for adult frogs, are a good staple diet for rain frogs. Avoid feeding adult crickets, or any large prey items, as rain frogs and other microhylids are specialized for feeding on small prey (hence the term *narrowmouth* in their common name).

Breeding - At least one species of rain frog (Mocquard's rain frog, *Scaphiophryne calcarata*) is an explosive breeder, so a large group may be necessary to stimulate breeding in these species. A minimum group size of 2:2 is suggested if breeding is to be attempted. An enclosure with a floor space of at least 12 x 20 inches (30 x 51 cm) is suggested for four frogs, although larger floor space is recommended for propagation efforts.

Behavior - Green and marbled rain frogs don't appear to be as active as the red rain frog, *Scaphiophryne gottliebi*, preferring to sit in their burrows to ambush insects that wander by rather than hunting them down. Both green and marbled rain frogs are more subtly colored, and are seemingly more adapted to a cryptic life. In contrast, the red rain frog is brightly colored, and it's possible that this frog may be displaying a warning coloration akin to that displayed by the toxic and diurnally active dendrobatid frogs. If this speculation is proved true by detection of toxins in the skin secretions of red rain frogs, this could explain the frog's willingness to be an active, and thereby more visible, hunter.

The green rain frog emits a single goose-like honk if startled. A low trill has been heard too, but it is not known if it was the calling of green or marbled rain frogs.

Although rain frogs are not highly visible animals in a vivarium, their activity is increased during simulated rains and other periods of high humidity. Appropriate vivarium design will keep them visible even when they are in a retreat. They are suitable for mixed-species displays, and suitable *Mantella* frogs, hyperolid frogs, and small day geckos (*Phelsuma* spp.) can be integrated into an enclosure with rain frogs. They are among the more attractively patterned small frogs, are reasonable hardy in captivity, and worthy of herpetocultural efforts to establish them in captivity.

About the author: Dr. Kevin Wright recently changed jobs and is now Curator of Ectotherms at the Phoenix Zoo. He is co-author of *Amphibian Medicine and Captive Husbandry* from Krieger Publishing, due out in Spring 2000.

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Within a few days of reintroduction of the female, courtship and copulation were witnessed. Nearly a month later, with obvious egg bulges visible in her abdominal region, the female iguana began to investigate her nest box, which was filled with a mixture of vermiculite and sand. After nearly a week, on April 1, infertile eggs were found on the floor. The female was then seen near a *Ficus* plant on a shelf approximately 4 feet (1.2 m) off the ground, where she laid another batch of infertile eggs onto the substrate. These infertile eggs (twelve in all) weighed an average of 0.4 ounce (11.3 g), and averaged 1.5 inches (3.78 cm) long, and 0.9 inch (2.33 cm) wide. This result was reminiscent of the previous three years, no matter what type of nesting choices were provided.

The same day, however, the female was seen again near her *Ficus* plant and refused to move away from it when approached. Six eggs were found nested in the soil, about 6 inches (15 cm) deep. Average egg mass was 0.6 ounce (15.7 g), while average egg length and width measured 1.5 inches (3.92 cm) and 1.0 inch (2.63 cm), respectively. The fertile eggs were incubated at 86°F (30°C) on perlite mixed with water at a ratio of 1:1, by weight.

One week later the first egg molded and shrunk, while on June 16, four other eggs were cut open after it was determined they had gone bad. These contained tiny embryos which had died within their first week. On day 77 of incubation, the final egg was opened after it failed to pip. Inside, a fully-formed *I. delicatissima* was found dead; the only obvious problem was ocular tissue adhered to the inside of the shell. The animal was necropsied and preserved.

Although this was a heartbreaking loss, we are confident and excited for the breeding season to come. The enclosures have already been set up with multiple nestboxes and substrates at varying levels in the cage, and there is a possibility that the female may double-clutch this year, as she has already gained a great deal of weight.

In 1999, a USFWS confiscation brought two additional females into the breeding population of Lesser Antillean iguanas in the US. Both females currently reside at the Memphis Zoo and one of these is already reported to be gravid (Reichling, pers. comm).

To find out more about the conservation and research programs of the West Indian Iguana Specialist Group, and to see how you can help, please see the WIISG website at <http://www.scz.org/iguana>

Acknowledgements: *The author thanks Glenn Gerber and Steve Reichling for their valuable information and photos, Mark Day and Michel Breuil for their outstanding work in the field to help preserve the Lesser Antillean iguana, and Allison Alberts for her help in editing this article.*

About the author: *Jeff Lemm is a Research Animal Coordinator for the San Diego Zoo's Center for Reproduction of Endangered Species (CRES) Ecology division. He has travelled extensively to research and photograph a variety of large, endangered lizards and is currently on a one year sabbatical from the zoo to work at Australia Zoo in Queensland.*

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is that a healthy reptile with an intact immune system generally is able to suppress *Salmonella* and there is no evidence of the bacteria, including an absence of shedding of the bacteria and negative fecal cultures. For all practical purposes, these healthy reptiles don't have *Salmonella*. However, if the immune system is hampered, or an immunosuppressant drug such as a corticosteroid is administered, *Salmonella* will often flourish and begin to be shed in the feces, and can even overwhelm the host reptile.

How important are heat gradients? Gastrointestinal disorders are one of the most common reasons for reptiles presenting to veterinarians. These disorders are largely preventable by the provision of a UHG. Reptiles need a heat gradient to successfully digest and process their meals; it's especially critical in those eating relatively large, infrequent meals. Partially digested foods in cool reptiles can lead to anything from a mild GI upset to fatal food poisoning (endotoxemia).

Most reptiles produce uric acid as a metabolic by-product of nitrogen breakdown. Uric acid is highly insoluble and requires a certain level of fluid intake to help with its elimination. Reptile veterinarians are recognizing an increasing trend of kidney problems in adult reptiles, especially green iguanas, which may be multifactorial in origin. Chronic dehydration (by limiting the amount of fluids necessary to help eliminate uric acid) and excessive nitrogen (by increasing the amount of uric acid) are factors that may contribute to kidney disease. As uric acid levels increase in the blood, visceral gout can occur. Heat may enter into this equation by affecting solubility and mobilization of uric acid.

Reviewing the natural history of our reptiles allows us to create environments that meet heat requirements. The work involved with creating usable heat gradients will be rewarded by the health and well-being of the reptiles in our care.



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UPCOMING EVENTS

The Vivarium does not seek out information related to herp events but simply posts the listings received. If you want us to post an event, the first step is to inform us by mail, fax or e-mail. Event information must include the name of the event, dates, locations, and contact names and phone numbers. Because herp events are sometimes cancelled, changed or reported inaccurately, *The Vivarium* assumes no responsibility for the accuracy of the events posted. Those interested in attending herp events should verify the information through more direct sources e.g. by contacting the event organizer.

Jan 15, 2000: All Ohio Reptile Shows, Ohio National Guard Armory, 4904 Sullivan Ave. - Info: (615) 264-2583.

January 22-23, 2000: NY Metro Reptile Expo, Westchester County Center, White Plains, NY - Info: (914) 526-4845 or snake114@aol.com.

Feb 12, Mar 11, April 1, May 6, June 10, July 8, Aug 12, Oct 7, Nov 4, 2000: All Maryland Reptile Show, Havre de Grace Community Center, 100 Lagaret Lane, Havre de Grace, MD 410-526-4184 or 410-838-5876
www.pythons.com/mdshow.html

Feb 13, Mar 26, April 9, May 7, June 11, 2000: Pittsburgh Reptile Show, The Palace Inn, Monroeville, PA - Info: (412) 361-0835.

Feb. 26-27, Hillsboro, OR: 14th Unique Animal Expo and Pet Fair, Washington County Fairgrounds, Exit 61, Off Hwy 26. Info: Jean (503) 738-6996.

Mar 11-12, Mesa, AZ: The Arizona Reptile and Exotics Expo, The Mesa Holiday Inn, 1600 S. Country Club Dr. Info: (480) 813-6035.

Mar 19, 2000: NOAH Reptile & Amphibian Showcase, National Guard Armory, Cleveland, OH - Info: (440) 237-9067 or reefmasters@hotmail.com.

May 6-7, 2000: Carolina Reptile & Exotic Animal Show, Dorton Arena, N.C. State Fairgrounds, Raleigh, NC - Info: (919) 496-7872

April 1-2, Gainesville, FL: All Florida Herpetological Conference, The Sheraton Hotel, 2900 SW 13th St. Info: Max Nickerson (352) 392-1721.

April 7-9, Pomona, CA: 11th Annual America's Family Pet Expo, Fairplex, Fairplex Exit, Off 10 Fwy. Info: (800) 999-7295.

April 8, Pottstown, PA: Eastern Herpetological Expo, Sunnybrook Ballroom, E. High St. Info: G. Leonard Knapp (215) 257-6088.

April 30 and October 22: New England Reptile Expo in Manchester, NH, The Holiday Inn just off of I-293 exit 5, less than an hour north of Boston. More info at www.reptileexpo.com or call (914) 526-4845.

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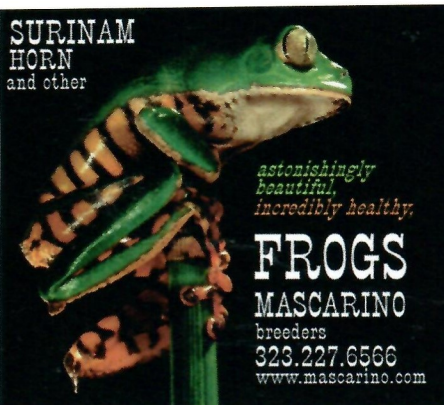
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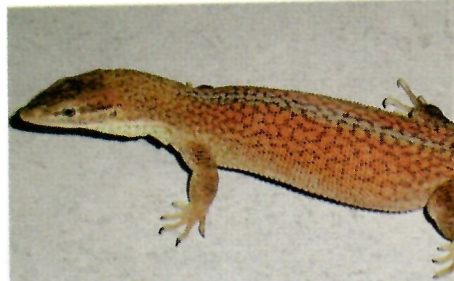
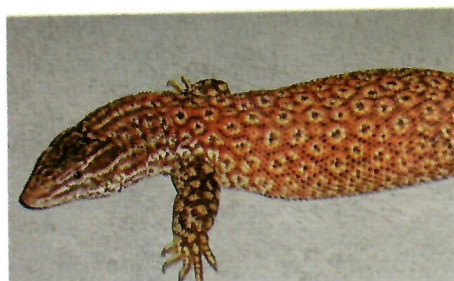
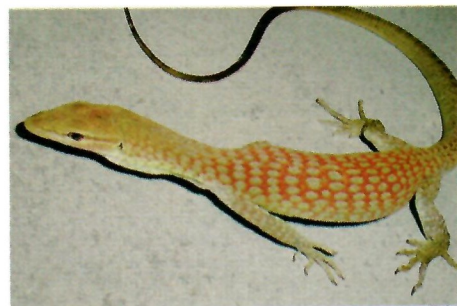
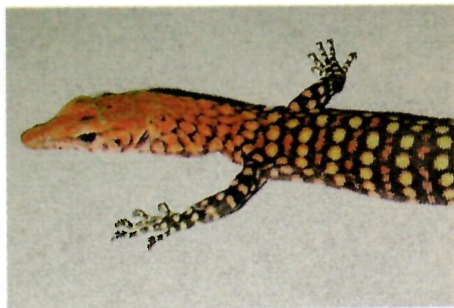
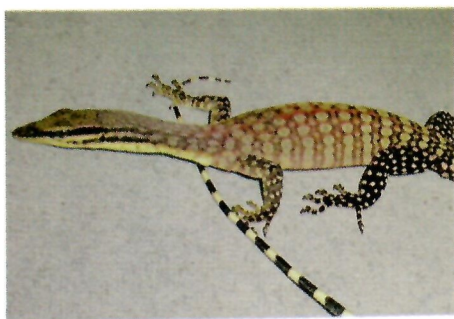
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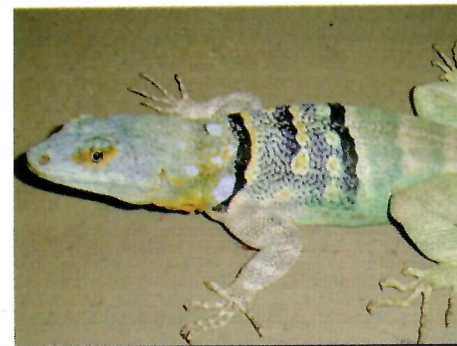
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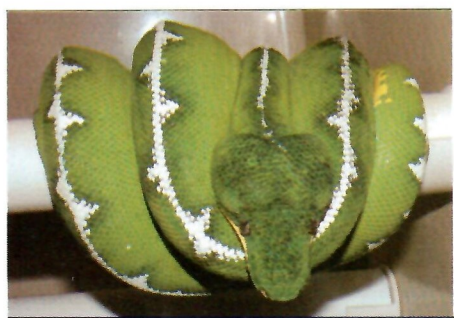
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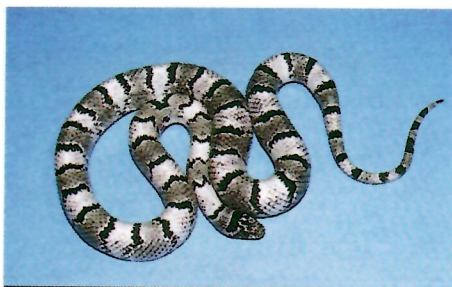
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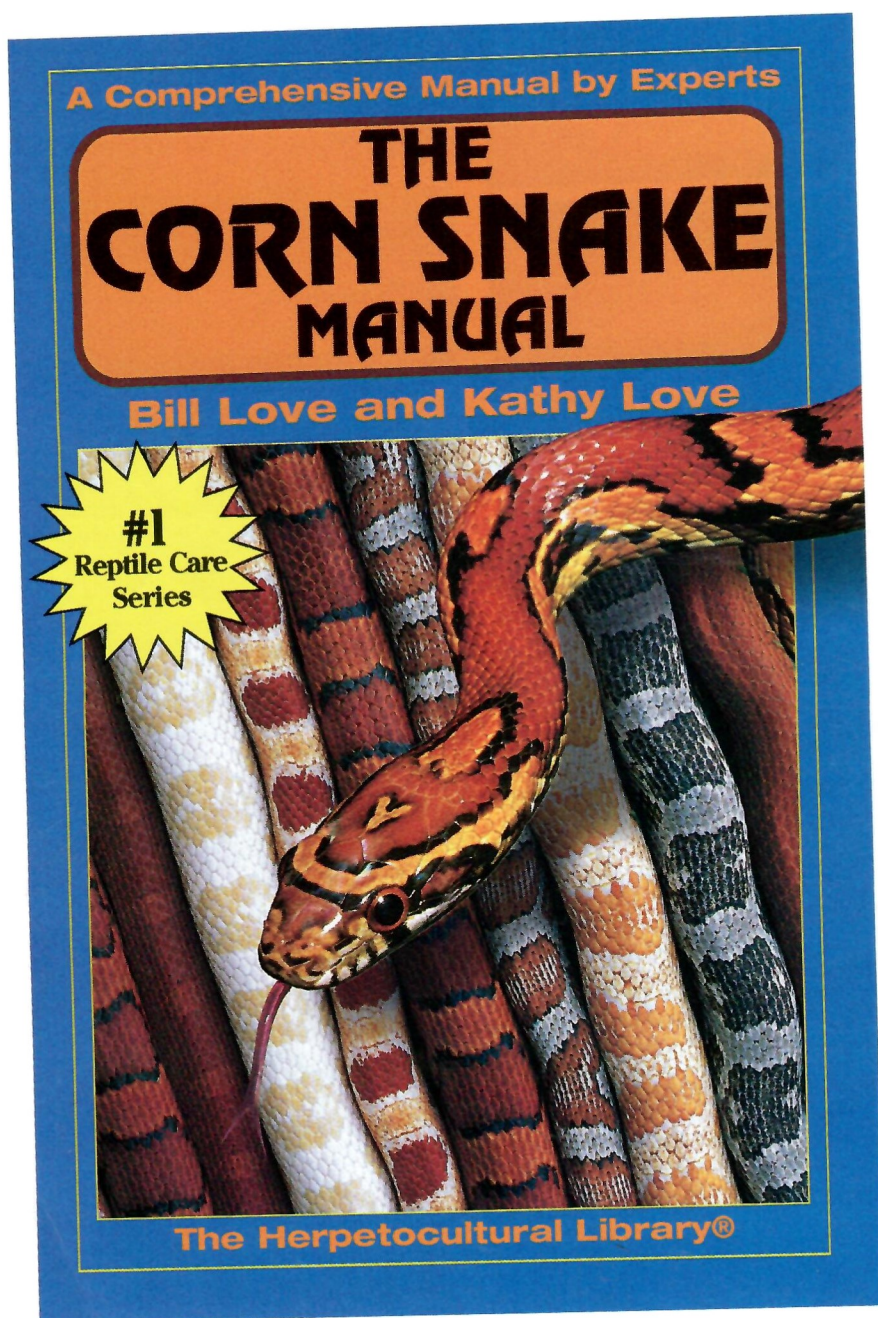
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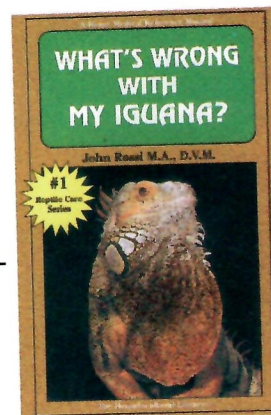
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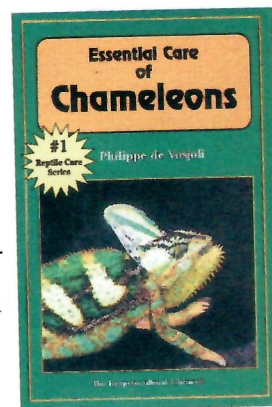
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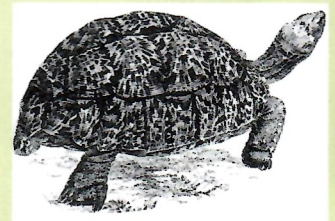
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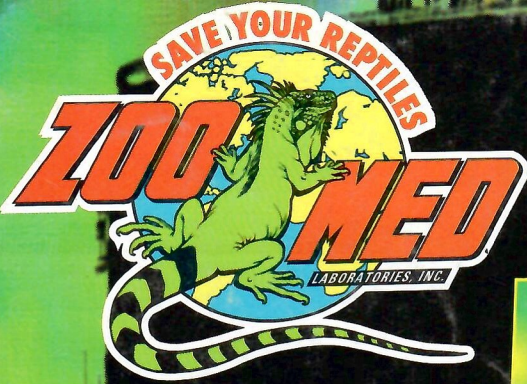


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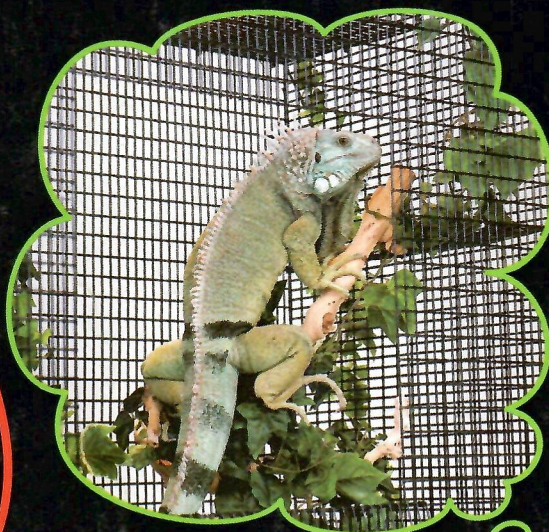
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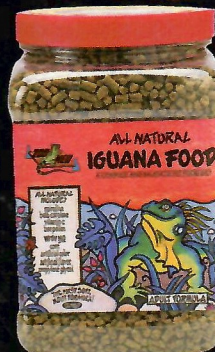
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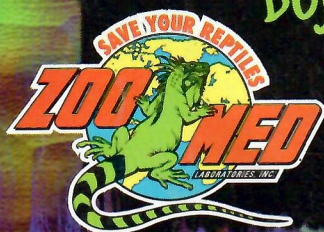
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