DR. MARK SEWARD'S GILA MONSTER PROPAGATION

SECOND EDITION

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Preface to 2nd Edition

In 2000, I wrote a little book called *Dr. Mark Seward's Gila Monster Propagation*. It was truly a labor of love. I wanted to share what I had learned working with a large breeding group of my favorite lizard. I wanted to help increase the success of those that share my passion for this unique animal. Although this was the first book to cover this subject, I expected the specialized nature of the information it contained to elicit a limited response. I was subsequently surprised and pleased by the number of requests for the book that came—literally from around the globe.

Beyond being surprised by the success of *Dr. Mark Seward's Gila Monster Propagation*, the most important thing to me has been the many phone calls and email messages that have come in from around the world. It has been a real joy for me to see so many breeding successes come to those passionate individuals working with this lizard.

I am proud to say that this new edition contains much new information and many new insights into the successful propagation of this species. My goal in writing this edition of *Dr. Mark Seward's Gila Monster Propagation* was to make sure anyone that already had the first edition got their money's worth from this one. There are 28 new pages and 18 new photographs and illustrations. This edition also introduces the much-anticipated Hygroscopic Incubation Technique. Several years in the making, this technique has proven to be a simple and reproducible way to successfully hatch Gila eggs.

I am sure there will be another edition of the book in the years to come—after more information about this mysterious creature comes to light. I hope you find this edition worthy of your time and that you'll write to tell me what you think. I look forward to hearing from you.

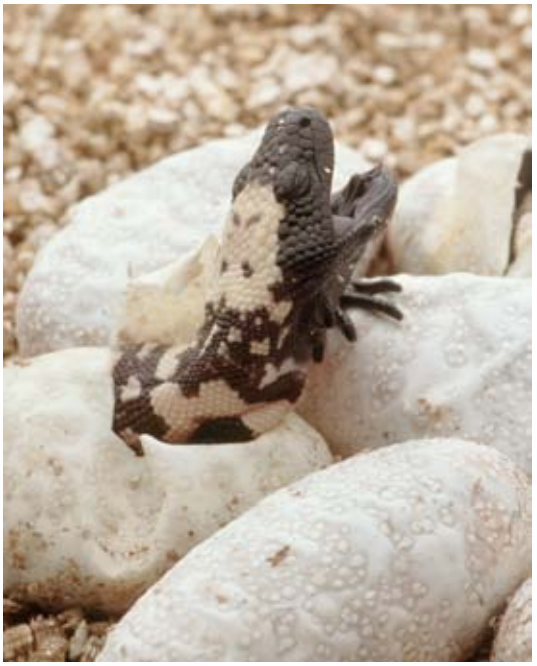
Mark Seward
Colorado Springs, Colorado

Introduction

In their 1956 monograph of the genus *Heloderma*, Bogert and del Campo wrote, "There is scarcely any precise information concerning the breeding habits of either species of *Heloderma*." Since this statement was published a lot has been learned about the reproduction of the Gila monster *H. suspectum*, and they have been bred in captivity with some regularity since the mid-seventies. However, there are still many questions yet to be answered.

What factors are responsible for the inconsistencies many people experience in their attempts at captive reproduction? What factors prevent some breeders from getting fertile eggs or any eggs at all every year? What factors explain the low success rate many experience in bringing fertile eggs to full term?

Producing a clutch of eggs involves a huge energy investment for a female Gila. Does a free ranging Gila invest that much of herself into producing eggs only to have the same poor success that is typically seen in attempting to hatch Gila monsters in captivity? I don't think so. It is obvious that we just don't have a complete understanding of their reproductive requirements. There *are* answers to the problems seen in the captive propagation of Gila monsters. The answers lie in the understanding of how this animal is uniquely adapted to its environment. After all, Gila monsters do what they



This sight is your reward for learning the requirements for reproducing Gila montsters in the captive environment.

do, and they do it how they do it because of unique adaptations to their environment. If the techniques for captive reproduction used with success in other reptile species fail to produce consistent results with Gilas, it is only because Gila monsters have adapted in unique ways.

Anyone working with Gilas can add interesting and important information to our understanding of this fascinating animal. This photo shows a newly hatched Gila returning to the egg to consume all the remaining contents. They actually start consuming the liquid contents of their egg as soon as they pip. Although this is a routine occurrence in Gilas, it is a habit that has been previously undocumented.

This book is written to further our collective understanding of this unique animal and the requirements to successfully reproduce it in captivity. It is directed to anyone interested in breeding Gilas as well as anyone just interested in learning more about this fascinating animal. It will provide an overview of existing literature on the subject, as well as contain never before published information. Although you will find many answers and new insights, understand that there is still a lot we don't know. Consider this a framework on which to build your own understanding of this challenging species. There are a lot of discrepancies in the literature on Gila breeding. If you've ever attempted to make sense of it all, it probably left your head spinning. I will bring it together in an easy to understand

format. I will rely heavily on what we can infer from our understanding of free ranging Gilas. I will always try to explain the reasoning behind my conclusions—this will allow you to make your own determination about the accuracy of my assumptions.

One of the most exciting aspects of working with this amazing lizard is the opportunity anyone has to make significant contributions to our understanding of their captive reproduction. Good luck, and enjoy the process.

Natural History

In discussing the natural history of the Gila monster, I will focus my comments on those facts that will contribute to our attempts at captive reproduction. If we understand the climatic, physical, and social aspects of free-ranging Gilas we will be better equipped to understand the requirements for captive propagation. Understand, however, that because of their reclusive nature, there are many aspects of their life history that we have yet to learn.

Unique Adaptations

How would we describe the characteristics of a Gila monster? It is predominantly diurnal, prefers relatively cool temperatures, and loves water. Now let's look at the environment in which it lives—the desert is characterized by extreme heat during the day and very dry conditions. How can we reconcile these apparent discrepancies? The answer lies in how Gila monsters are uniquely adapted to this environment. An clear

Yavapai County, Arizona

understanding of these unique adaptations will provide insights into the requirements for their captive propagation. Let's look more closely at how a Gila fits into its ecosystem.

Activity Patterns

One of the reasons Gila monsters are so poorly understood is the fact that most of their life is spent underground and out of sight. Although Gilas can be seen throughout the year, even basking at the entrance of their shelters on unseasonably warm winter days, most of their above ground activity occurs during a very narrow window of time in the Spring. Understanding this is key to understanding the unique adaptations we have been talking about. Their reproduction, their feeding, even unique metabolic controls, as we will learn later, are uniquely adapted to this short activity period.

After a winter of hibernation, Gilas emerge in the spring to feed and mate. After this 90-day peak activity period they rarely come to the surface. In fact, even during this spring activity period they are active for only brief periods of time. Consequently, more than 99 percent of the Gila monster's life is spent inactive and underground.

Adult Gilas are predominately diurnal, not nocturnal as previously thought. To avoid the extreme heat of the desert, most of their activity occurs in the morning and the late afternoon. Sometimes they are seen out after dark during the summer monsoon season, especially in the southern part of their range.

Mean body temperatures of Gila monsters in southern Utah by month while resting in shelters. (Beck 1990)

Temperature and Moisture

Gila monsters prefer relatively cool temperatures when compared to other diurnal desert lizards.

In a group of Gila monsters in southern Utah, the mean monthly body temperatures at rest ranged from 82 F in July to 54 F in December.

These Gila monsters spent more than 83% of the year at body temperatures of 77 F or less, and over 50% of the year at or below a body temperature of 68 F. The body temperature during activity ranged from 75 F to 98 F. The air temperature during activity was 50

to 93 F and the ground temperature was 69 to 90 F.

Basking behavior was observed in southern Utah Gilas from March through early May. Lizards typically exited within an hour of sunlight hitting the shelter entrance and pressed their ventral surface against the ground, flattening out their body. They would frequently enter, then exit, then re-enter the shelter many times over a 4-5 hour period as they regulated their body temperature. One animal observed over several days in late April and early May maintained a mean body temperature of 83.3 F during basking periods, despite considerably lower environmental temperatures. Its' body temperature would return to around 68 F overnight.

Gilas have relatively "leaky" skin. They avoid dehydration by spending most of their lives in moist and humid shelters. Gilas probably don't have much access to standing water in the wild, so most of their water intake is from their food and possibly from moisture absorbed through their skin.

Food and Metabolism

Gila monsters are adapted to eating large meals infrequently. In fact, an adult male Gila can consume its entire yearly energy budget in three or four meals! This is because of the large meals they can consume as well as their limited food requirements. This allows them to consume most of their food during the limited Spring activity period. Their food requirements are reduced by a low metabolic rate, as well as the relatively cool body temperatures they maintain for most of the year.

Pima County, Arizona

Gila monsters specialize in feeding on the young and eggs in vertebrate nests. The Gila monster's main activity period coincides with the availability of their main food source. For example, Gambel's quail nest in April and May, and the peak of desert cottontail nesting is also in April and May.

Foraging for such nests requires a search over a relatively large area. Since they are able to consume large quantities of food (up to 1/3rd of their body weight) and their resting metabolic rate is so low, the energy expenditure for such foraging activities are more than offset by their long periods of inactivity.

Gila monsters also have unique physiology to assist them in storing food for their long periods of inactivity. Immediately after eating, large quantities of a hormone-like molecule called exendin circulate in the Gila's blood. With this unique mechanism of metabolic control, the act of eating primes the organism to receive the incoming nutrients, by, for example, stimulating insulin secretion. A synthetic version of this protein is currently being developed as a treatment for human diabetes.

Gilas have specially adapted tails that allow them to store fat away for future needs. A well-nourished Gila will have a thick, robust tail. The ability to store fat in the tail is particularly apparent in a reproductively active female. As she converts stored fat into yolk in the developing ovarian follicles, her tail will change from thick and round to thin and bony.

Intraspecific Interactions

In a study of southern Utah Gila monsters it was observed that from late April through late May some shelters were occupied by as many as six Gila monsters at the same time. This was not a "den" where Gilas would congregate for hibernation, but rather they would

gather in the spring from up to more than a mile away.

Male-male combat was observed that was very similar to the combat seen in captive males. After driving off the loser, the winning male was observed rubbing its cloaca on the ground near the shelter. Three days after this combat, another Gila joined the winning male and they may have mated.

This study describes common shelter use and seasonal movements that bring animals back to communal areas, establishment of dominance through male-male combat, and scent marking as elements of a structured social system.

Acquisition

Acquiring a breeding group of Gilas is the first step. Don't underestimate the importance of how you establish your breeding group, as it can have a profound effect on your success.

Gilas are protected throughout their range and cannot legally be taken from the wild. There are, however, animals being removed from the wild illegally that show up in the trade. Avoid acquiring any animal unless you have proof that it is legally captive bred. Not only will you avoid the potential legal implications of dealing with poached animals, but also you will increase your chance of successful propagation. Captive bred Gilas are more likely to breed in captivity than animals taken from the wild.

Should you get adult animals or raise your own from hatchlings? The advantage of acquiring adult animals is in avoiding the two and one-half year wait raising hatchlings before your first breeding attempts. The biggest disadvantage is you usually can't be certain about the history of the animal. Are you certain it is captive bred? Is it healthy? Have the previous owners failed at their attempts to breed it—if so, why? Are you taking over someone else's failure?

Putting together a group of Gilas is a significant expense. If you are serious about being successful breeding Gilas, I believe you are better off buying high quality captive bred hatchlings from a reputable source and raising them yourself. I am not trying to claim that you can't achieve success starting out with adult animals—you most certainly can. My first breeding success with Gilas was with a pair acquired as adults from an individual that had been unsuccessful breeding them for several years. That pair produced six eggs my first season with them—and all six eggs hatched. If

High quality captive bred Gilas, like this newly hatched Banded Gila Monster, Heloderma suspectum cinctum, make ideal founders for a breeding project.

you have the patience, I still feel it better to raise your own breeding stock.

A significant advantage of raising your future breeders yourself is you have complete control over the environment to which your animals are exposed. Reproduction in Gila monsters is a very tightly synchronized event and preparation for it starts at least a full year before egg laying. By raising the Gilas yourself, you have control of the nutritional as well as seasonal cues that stimulate the animals to eventually reproduce. We will discuss this in more detail later on.

How many animals should you acquire if you want to successfully breed Gila monsters? Certainly one can be successful with a single pair of Gilas, however, a larger group is better. With the difficulty in determining the sex of animals (especially hatchlings) and the uncontrollable differences in the willingness of individual animals to breed, the larger the group, the greater your chance of success. I would consider a group of eight animals to be a good start to a successful breeding program. If you were working with both subspecies, a larger group would be better. Considering the cost of acquiring legal animals, the answer to how large a group you should start with usually comes down to economics.

Even if financial constraints limit the initial size of your group, with some initial breeding success you should be able to build a sizable breeding colony. Through sale or trade, any offspring produced can help to acquire additional and unrelated bloodlines.

Regulations

A word about regulations involving Gila monsters is appropriate. Gila monsters are protected throughout their range in the U.S. and Mexico. Although there is no U.S. Federal regulation controlling the trade or possession of Gila monsters, individual states or local jurisdictions may have regulations affecting their possession. All states where they naturally occur (Arizona, New Mexico, California, Nevada, and Utah) currently require permits for all activities involving these protected lizards. For example, California currently provides a permit system allowing private individuals to possess Reticulated Gila Monsters, *Heloderma s. suspectum*. However, the possession of Banded Gila Monsters, *Heloderma s. cinctum* is prohibited (*cinctum* naturally occurs in California). I am aware of a couple of individuals in New Mexico that have been issued permits to keep captive produced Gilas within the state. In Arizona, permits have been issued to individuals to keep Gila monsters salvaged from urban areas, but these animals remain the property of the state and breeding is prohibited. I am not aware of any private individuals that have received

permits for the possession and breeding of Gila monsters in Arizona, Utah or Nevada, although permits are issued for legitimate scientific purposes.

The regulations in other regions of the country vary from state to state. The state Fish and Wildlife or Fish and Game departments are usually the agencies to contact for information about current regulations.

In addition to state regulations, there may be local jurisdictions that regulate Gila monsters. For example, in my state of Colorado there are no state regulations controlling the trade or possession of Gila monsters. However, if I lived within the city limits of Colorado Springs, I would need a permit to legally keep Gilas.

Be certain to check with the appropriate state and local authorities before attempting to acquire Gila monsters. Also, be aware that regulations involving reptiles are frequently changing around the country.

International trade in Gila monsters is regulated by the Convention on International Trade in Endangered Spe-


CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA

FEDERAL FISH AND WILDLIFE PERMIT

Import/Export License

Any port authorized by regulation or permit

PERMITTEE IS LICENSED TO ENGAGE IN BUSINESS AS AN IMPORTER OR EXPORTER OF WILDLIFE IN ACCORDANCE WITH THE PROVISIONS OF TITLE FIFTY OF THE CODE OF FEDERAL REGULATIONS.

THE LICENSEE IS NOT EXEMPTED FROM OTHER REQUIREMENTS ESTABLISHED BY LAW GOVERNING THE IMPORTATION OR EXPORTATION OF WILDLIFE.

NONE

ORIGINAL

US Fish & Wildlife Service
National Eagle & Wildlife Property Repository
Rocky Mountain Arsenal Bldg. 619
Commerce City, CO 80022

CITES permits are required for any international trade in Gila monsters. In addition, an Import/Export License is required to ship Gilas into and out of the U.S.

cies (CITES, pronounced "site—ease"). Gila monsters are currently listed as Appendix II. Species listed on Appendix II are those not considered threatened now with extinction, but could become threatened unless their trade is strictly regulated. For international trade the originating country issues a CITES permit. In the United States, the U.S. Fish and Wildlife Services issues the permits only if documentation is provided proving legal origin—including a complete paper trail back to legal founder animals. In addition to the CITES permits, anyone shipping reptiles out of the country is required to have an import/export license, also acquired from the U.S. Fish and Wildlife Service. Contact the U.S. Fish and Wildlife Service, Office of Management Authority, 4401 N. Fairfax Drive, Room 700, Arlington, Virginia 22203, 1-800-358-2104 for more information.

Husbandry

Raising Hatchlings

Once you have your group of hatchlings, how can you raise them in the best way? My goal in raising hatchlings is to bring them to sexual maturity as soon as possible without compromising their health in any way. If raised optimally, one can expect the first breeding to occur as early as 2.5 years of age. However, if raised in sub-optimal conditions it may take many years longer. What do I mean by *optimal* conditions?

Some background is warranted. Gilas are obviously "cold-blooded". This doesn't mean they can't control their body temperature. Instead, it requires them to use behavior to control their body temperature as opposed to producing heat internally. Their body temperature and their metabolic rate can vary dramatically. As discussed in the section on natural history, Gila monsters are very uniquely adapted to their environment. In summary, they spend most of their lives inactive, underground, and at relatively cool temperatures. Most of their above ground activity occurs in a three-month window of time in the spring. This is when their food source is most abundant. They can consume large, infrequent meals and are very efficient at metabolizing this food. They are also uniquely equipped to store this food away for future use. And finally, they have very low resting metabolic rates. Understanding these natural adaptations is important in creating optimal growth in our Gilas.

One frequent problem seen in captive Gilas is obesity. Recognizing their natural adaptations, it becomes clear how this can happen. Their metabolic needs are very low. It has been suggested that a Gila's entire yearly energy budget can be satisfied in three or four large meals. In other words, they are very

This Gila monster could be ready to breed as soon as 2 ½ years from now.

easy to overfeed. An obese Gila is not a reproductively fit Gila.

I want a young Gila to grow quickly, but remain long and lean. Such optimal growth depends on three important factors: temperature, amount of food, and frequency of feeding. I'll address these separately.

Access to the proper temperatures is an essential aspect of optimal growth. The important point here is to provide adequate choices. Gilas, like other reptiles, use heat for a purpose. Their preferred body temperature varies based on their metabolic needs. When a young growing Gila is metabolizing a meal, it will select temperatures that are surprisingly warm. I recommend a temperature gradient ranging from the mid 70's on the cool end to the low 90's on the warm end. Observe the animals and see what they are telling you. If they spend all of their time directly over the heat source, you need to ask yourself if they are able to get warm enough. Conversely, if they spend all their time at the coolest end of the cage, perhaps it is not cool enough. I provide heat by way of under cage heating controlled with a thermostat.

You want to provide an amount of food that will allow for maximum growth, but maintain a long and lean animal in the process. A juvenile Gila is more likely to put food into growth than into fat, but you can definitely overfeed it. I start hatchlings on small fuzzy mice or pinky rats and increase the size or quantity of the food items as the Gila grows. By the time a Gila is one year old, it is easily eating an adult mouse.

A young Gila appears to grow more rapidly with an increased frequency of feeding. I begin feeding hatchlings twice every week and continue these frequent feedings until they are about 18 inches in total length. Again, as long as the animal is remaining long and lean, you are not feeding it too much. Adult Gilas are fed

This obese female Gila is only 18.5 inches long, but weighs 1200 grams (2.6 pounds).

appropriately sized food items every two weeks for maintenance. This could be a large adult mouse or small rat.

Healthy, captive-bred Gilas are usually aggressive feeders and will readily take a live pinky mouse or rat as their first meal. When they first hatch they typically have abdomens that are distended with absorbed yolk—consequently, it may be a week or two before they are ready to eat for the first time. After their first meal or two, they should readily take a frozen-thawed small fuzzy.

Only occasionally will a hatchling be reluctant to eat. If so, try a split-head pinky—split the cranium of a dead rat or mouse pinky and offer it. Alternately, dip the snout of the pinky in pasteurized egg whites (available at most supermarkets). Using this product instead of whole raw eggs will avoid the possibility of transmitting Salmonella. Gilas universally love eggs, and using this technique is usually the easiest and most successful way to get a reluctant feeder started.

Most hatchling Gilas are quite snappy and defensive. Another technique to try is to hold a pink mouse or rat with tongs and try to get the Gila to bite it out of defense. After a good bite, even out of defense, most Gilas will proceed to consume the pinky.

Occasionally, an otherwise reluctant feeder will readily eat if the food item is gently placed in its mouth with forceps. This is not force-feeding, but could be more accurately called assist-feeding. Hold the Gila securely around the neck and shoulders with one hand and hold the head of the food item in forceps with the other hand. Gently press the snout of the killed rodent against the side of the Gilas mouth. The Gila should eventually open its mouth and clamp down on the food. Most often the Gila will proceed to swallow the food voluntarily. Even if the Gila releases the food after the first attempt, additional attempts will usually prove successful.

If you acquire an adult Gila that is a reluctant feeder, try a variety of foods. Some Gilas prefer rats to mice. I have one Gila that will readily take a freshly killed rat, but usually refuses a frozen/thawed rat or mouse. One of the most readily accepted foods for an adult Gila is a live pink rat. Even the most reluctant of feeders will usually be swayed by the food dipped in egg white as mentioned above.

One of the pleasures of working with Gilas is their almost universal willingness to eat. I have never hatched a Gila that did not eat voluntarily.

General Husbandry

Gilas have been rightfully characterized as a difficult species to reproduce in captivity. On the other hand, when

you consider general husbandry, they make hardy, undemanding captives. In fact, some of the characteristics that make them so well suited for their particular niche in the wild make them ideal specimens in captivity.

Housing

Since Gilas spend most of their lives in small spaces underground, they don't require large cages to be healthy and happy. There is one important consideration in determining cage size—it should be large enough to provide for an adequate thermal gradient. Not only important for raising Gilas optimally, such thermal regulatory opportunities are critical to successfully propagate them in captivity. So, whatever cage you use should be large enough and ventilated well enough to provide a cool end in the low to mid 70's and a warm end in the low 90's. A cage dimension of about 3 feet by 2 feet should be adequate for an adult Gila. I have successfully used a large, 65-quart Rubbermaid® blanket box in a rack system as well as other custom made cages. An appropriately sized aquarium with a secure lid would be fine also. In addition, there are several commercially available reptile cages that would work well.

This is an example of caging built especially for housing Gilas. It provides top ventilation to aid in creating a good thermal gradient. Heat is supplied underneath the back of the cage.

I use several inches of a chipped aspen product (Sani-Chips®) in the bottom of the cage. It is inexpensive, dust-free, absorbent and easy to spot clean. Other bedding products would work fine as would newspaper.

Heating is accomplished with under cage heat tape (Flexwatt®) controlled with a thermostat. Other sources of heat would work as long as the proper temperature gradient can be established. For example, if an incandescent bulb is used to heat an enclosed cage, it may be difficult to prevent warming the entire cage. I find under cage heating an easier source for providing the appropriate temperature gradient. Place the heat under one far end of the cage. Set the thermostat so that the temperature on the surface of the substrate over the heat source is in the low 90's. Carefully check the cool end to ensure that it is no warmer than the mid 70's. A non-contact thermometer is ideal for checking the temperatures in the cage

as well as the temperatures of the animals themselves.

A thermal range extending as high as the low 90's is not necessary for general maintenance of a Gila. They would do quite well with the warmest temperatures in the low to mid 80's. However, for optimal growth and especially for the thermal needs of reproduction, I recommend a full range from the low to mid 70's to the low 90's. You can't provide too much heat as long as there is a choice for cooler temperatures. In the wild, Gilas monsters have access to temperatures as high as 120 degrees F and even higher; they just never choose such temperatures.

I don't mean to imply that Gilas need to have a body temperature in the 90's for successful growth and reproduction. If you have good ventilation and a good thermal gradient in the cage, a Gila sitting on a 92-degree hot spot won't have a body temperature of 92 degrees—it will usually be significantly lower. So, if a Gila optimally needs a body temperature of 85 degrees at a certain stage in the reproductive cycle, the best way to allow the Gila to maintain that temperature is to provide a significantly higher hot spot. The bottom line is to provide enough choices to allow the Gilas to select the appropriate temperatures for the task at hand—provide a chance for them to do what they are designed to do.

I have clean water available at all times. It is provided in a 16-ounce deli container set inside a 4" PVC coupler (available at any home improvement center). The PVC coupler supports the deli container and prevents the Gilas from tipping it over. It makes it very easy to change the water—simply remove and discard the deli container and replace it with a new one. Some keepers provide a water bowl large enough for the Gila climb in and soak (as Gilas are fond of lounging in the water for hours or days at a time). If this is done, the bowl will need daily cleaning.

Another example of a caging system used successfully to house multiple specimens.

Although Gilas come from an arid portion of the U.S. and Mexico, they spend most of their lives in relatively humid burrows or shelters. Perhaps this explains their fondness for soaking in their water bowl. I doubt that free ranging Gilas have access to such frequent soaking, but they do have access to high relative humidity and contact with moisture in the substrate of their burrows. I think it is appropriate to monitor and provide for

adequate humidity in their captive enclosures. One way to increase the humidity in an enclosure is to decrease the amount of ventilation. In addition, placing the water container close to or on top of the under-cage heat source will raise the level of humidity within the cage.

Handling

Although a Gila bite is not life threatening, it should be considered a medical emergency and should obviously be avoided. If proper care and judgment is exercised, a bite is something that never needs to happen. The bite of a Gila monster won't kill you, but will make you wish you were dead! It is very painful. The biggest threat of a bite comes from the fact that the typical adult Gila is a very calm and docile animal—it would be very easy to become complacent handling them. Never put yourself in a position where a bite could occur, no matter how much trust and familiarity you have with your animals. Perhaps the general calm nature of adult Gilas in captivity is related to the fact that they have few if any regular predators in the wild.

Gilas of all sizes can safely be handled using a pair of heavy leather gloves. Since Gilas don't have the hollow fangs of front-fanged venomous snakes, even if their teeth could penetrate the leather, little or no venom would reach your hand. Experienced Gila keepers frequently handle them without the aid of gloves. With proper experience and care this can be done safely. They are gently, but securely grasped around the neck in a way to restrict the lateral movement of their head. Their body weight can then be supported with the other hand. Gilas are very strong animals and are capable of quick and powerful lateral biting movements—a careful and secure grip is important. I recommend that all handling of your Gilas be accomplished wearing appropriate leather gloves as protection.

This is NOT an example of how to safely handle a hatchling Gila monster. They are best handled with heavy leather gloves.

Just as the typical adult Gila is a calm and docile animal, the typical young Gila is quite snappy. I would call it more defensive than aggressive. This is perhaps due to the fact that small Gilas are easier prey to a number of predators than are their adult counterparts. Due to their small size and attitude, hatchling and young Gilas are more difficult to handle. Not only are they more likely to bite, but in a six inch lizard the part you grab is much closer to the part that bites! Even so, they can very easily be handled with the before mentioned gloves.

I recommend that Gilas not be regularly handled except for husbandry needs. This is both for safety reasons as well as for the welfare of the animals.

Preparation

Stimulating Gila monsters to breed in captivity is mostly about preparation. Preparation involves providing the necessary environmental cues to stimulate reproductive cycling. These cues range from nutrition to seasonal changes in temperature and photoperiod. Preparation also involves accurately determining the sex of potential breeding stock.

Determining Sex

One of the first problems encountered in trying to breed Gilas in captivity is the difficulty in determining the sex of individual animals. Many techniques have been proposed, and many have turned out to be of little use.

Observing copulation or egg laying is certainly an accurate method of determining sex. However, it is more useful to determine the sex of your animals prior to the first mating attempts.

Tinkham (1971) proposed differences in preanal scalation and the length of the claws of the forefeet as a means of determining sex. These differences have not held up to closer scrutiny and they are not accurate methods of determining sex in Gilas.

Probing, when done correctly, is a safe and accurate method of sexing many snakes. Wagner, et al (1976) recorded differences in probing depths that correlated with the sex of Gilas in collections at the Seattle and Los Angeles Zoos. Time has shown that this is not an accurate technique to sex Gilas. There is no consistent correlation between the depth of probing and the sex of a Gila.

There are differences in body form, but these differences are difficult to quantify and they are not consistently expressed. Mature males typically have a

Observing egg-laying or copulation is an accurate method to determine sex in Gilas, but it would be a lot more helpful to accurately sex them prior to successful breeding.

stouter build and a broader head. Mature females, by comparison, have a narrower head and a more pear-shaped body. Be aware that these are general trends. There are animals that appear in-between these extremes and are, therefore, difficult to accurately sex from appearance. I have one Gila that anyone would swear was a male from its appearance, but is actually a female. Hemipenal bulges are sometimes visible at the base of the tail of the males and absent from the females. These differences based on body form are somewhat subjective and some experience is required to become good at the technique. I don't consider using body form a consistently accurate method of determining sex in Gilas.

Behavior has been used to identify the sex of Gilas. The best way to use this technique is to have a known male and observe his reaction to other animals placed with him. During the breeding season, males will act aggressively towards one another in a very ritualized form of combat. Again, be aware that these interactions can be misinterpreted. Any combination of sexes can act aggressively towards one another when first introduced. That is why it is recommended to have a known male as a reference when attempting this technique. For example, if you placed two Gilas of unknown sex together and they fight, they could actually be two females and not two males. During the breeding season a known

This photo shows the difference in body form between a female (top) and male (bottom).

male will usually act with interest and not aggression towards a female. He will do a lot of tongue flicking and following her around. Although experience will increase the accuracy of this technique, I don't consider it a consistently accurate method either.

Saline injection has been used successfully in sexing Gilas. In this technique sterile isotonic saline is injected into the base of the tail. A large amount of saline is frequently needed to create adequate pressure to evert a hemipene. To be accurate, the Gila should be anesthetized to relax the retractor muscle that may otherwise prevent the eversion of the hemipenes. This technique carries with it the risks of anesthesia.

A technique has been described that utilizes radiographic examination of the pelvic bones to differentiate sex. It relies on measurable differences in the length and width of the ischial bones. I have radiographed several Gilas in my collection and have not been able to get consistent results with this technique.

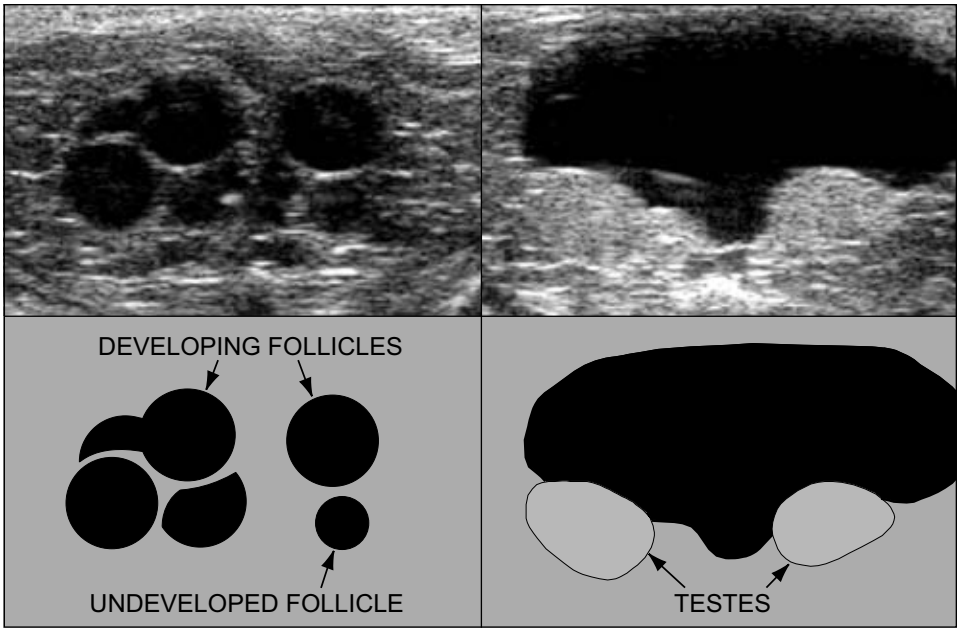
Laparoscopy has been used successfully in Gilas. In this technique the vet actually visualizes the gonads with a laparoscope through a small incision. It is a surgical procedure and carries with it the risks of surgery and anesthesia. In addition, there is a simpler, safer and very accurate way to sex Gilas.

Currently, the only simple, accurate and safe method available for determining the sex of Gilas utilizes ultrasound examination to image the gonads. A related technique involves imaging the base of the tail to observe the presence of hemipenes. This is more difficult to do accurately. It is far easier to image the gonads themselves. The testes in a mature male are clearly visible on ultrasound. In addition, in the mature

Ultrasound examination is a useful tool in learning about the reproductive cycles in Gila monsters. Note the developing ovarian follicles as they appear on emergence from winter cooling.

female, follicles are visible in the ovaries regardless of the time of year the examination is made. Since this technique is so easy to master, as long as your vet has an ultrasound and the willingness to try it he or she could probably sex Gilas accurately on the first attempt.

When performing this technique, I use a linear array ultrasound probe, although a convex probe should work fine. Ultrasound scanning gel can be used between the probe and the ventral surface of the animal, or, alternately, the animal's body can be submersed in water for scanning (I always use a water bath as I find it much simpler and less messy). Position the probe about one quarter of the way up the body from the vent and scan through the ventral surface. Both the testes and the ovaries are up on the body wall close to the ribs and lateral to the spine. If the Gila is in the process of shedding and has old skin on its ventral surface, it should be removed prior to ultrasound imaging. The air pockets that will form under the old skin will prevent the proper penetration of the sound waves and result in a dark, un-



Ultrasound imaging of the gonads is an easy and safe method to accurately determine the sex of Gila monsters. The ovarian follicles and testes are clearly visible regardless of the time of year they are imaged.

readable image. Ideally, the Gila being imaged should have an empty gut. Trying to image through a recent meal can make a clear view of the gonads more difficult.

The ideal time to perform ultrasound sex determination is from the Fall through the Spring. During this period of time, the developing female ovarian follicles are larger and are easier to see. However, with experience, ultrasound sex determination can be accurately performed at any time of the year.

Using ultrasound to determine the sex of Gilas is ideal in that it is completely safe, very accurate and can be accomplished any time of the year (not just during the breeding season).

Hibernation

In many vertebrates, including reptiles, after breeding there is a "refractoriness" to light and temperature stimulation. In other words, under conditions of light or temperature that would normally stimulate the reproductive system no stimulation occurs. A period of short days or cold temperatures is required to break this refractoriness and regain sensitivity to the conditions of light or temperature that will stimulate the reproductive system. In Gila monsters, this can be accomplished by holding them at cold and dark conditions in the winter.

Most recommendations involve a three-month cooling period with temperatures in the mid 50's. Hibernation is begun by slowly decreasing the temperature until the final cooling temperature is reached. The Oklahoma City Zoo has been successful when taking a full month to lower the temperature, holding the final temperature for a full month, and then taking another month to bring the temperature back up. Most reach the final hibernating temperatures more quickly than this.

With my breeding colony I suspend feeding at least two weeks prior to cooling. This allows the Gilas to fully digest their last meal before winter cooling. Beginning the first of December, my animals are slowly cooled and then maintained at a temperature of 53-57 F. On the first of March, the temperatures are slowly returned to normal. I don't believe it is critical how slowly the temperatures are changed.

Water should be available during hibernation both for drinking and to increase the humidity of their hibernating environment. Provide it in a container that can't be easily tipped over. I feel it is important to provide adequate humidity during hibernation to prevent dehydration of the animals.

When I had a small enough collection, I was successful cooling animals in an old refrigerator. This can be an ideal

solution when a small group of animals is involved, especially in those parts of the country where winter temperature don't allow for adequate cooling otherwise. A used refrigerator can usually be found at a reasonable price. As long as it works reliably and is large enough for the animals in question, it should create a perfect hibernaculum. It will require some simple modifications, however. The built-in refrigerator thermostat is not designed to maintain the temperature range we are looking for. To overcome this I simply plugged the refrigerator power cord into another thermostat. As long as the secondary thermostat is set at a temperature warmer than the refrigerator's built-in thermostat, the external thermostat will be the one to control the temperature. This prevents the need to hard-wire a new thermostat into the refrigerator itself. I used a Johnson Controls thermostat that I picked up at a local heating and air parts supplier. For one last alteration, I had a small aquarium air pump that supplied a slow but steady stream of fresh air into the refrigerator. Alternately, one could simply open the refrigerator door frequently enough to provide adequate air exchange.

In many parts of the Gila's range the eggs and nestlings of the Gambel's Quail make up a large part of the their diet.

The Gilas can be transferred to containers smaller than their regular caging, allowing more animals to fit in the refrigerator. Since Gilas are not very active at the winter cooling temperatures, they can be confined to relatively small containers during hibernation. The containers should be large enough to hold the Gila as well as a water bowl. An 18-quart plastic container is more than adequate.

Currently, I winter my colony in the room where the Gilas are housed the remainder of the year. That way they stay in their normal caging and the whole process is simpler. I turn off the heat to the cages and without any supplemental heat or cooling the room stays in an ideal range. Those of you living in warmer climates will need to explore alternate ways to cool your animals. I feel it is important to keep winter cooling temperatures below 60 degrees F. Maintained above 60 degrees F, Gilas seem to stay too active during the winter cooling period.

Feeding

Egg production requires a huge energy investment for Gilas.

Goldberg and Lowe (1997) found that most females collected in the early spring in southern Arizona already had enlarged follicles and suggested that vitellogenesis (yolk deposition) may

start during the winter cooling period. Through ultrasound examination, I have found that ovarian follicles don't develop to any significant degree during winter cooling, but, rather, start developing well before the female enters hibernation.

Several questions come to mind. What factors initiate the development of follicles? What factors determine the number of follicles a female will produce for a given season? At what time in the yearly cycle do these factors act to influence the development of follicles? Is it simply the amount of body fat present when the next season's follicles are recruited, or is it the quantity of food present, or the frequency of feeding?

Most of a Gilas above ground activity occurs in a three-month window of time in the spring. This is when most of their yearly food is consumed. I would speculate that the abundance of food in the spring is important for the *following* years egg production. Consider the fact that they will spend most of the summer and fall inactive in their burrows (without food) as well as the fact that by fall they have already started follicle maturation for the next years reproductive season. It is also interesting to note that female Gilas, unlike many other reptiles, do not stop eating when they become gravid. They will frequently continue to eat until a week or so before egg laying. Can you begin to see the picture here? Many animals that are subjected to unique environmental conditions develop unique reproductive strategies. As an example, in most male snakes testicular growth and sperm production occur prior to mating. It only makes sense. In a garter snake *Thamnophis sirtalis parietalis,* testicular growth and spermiogenesis occur *after* mating. How can this be? In turns out that when they mate the male is using sperm produced and stored from the previous year. This unique adaptation is a response to the extremely shortened warm season in their extremely northern range. The season is not long enough to produce sperm, mate, and gestate a litter of babies all in the same year.

Again, the point is when an animal occupies a unique niche it develops unique adaptations. Gilas certainly occupy a very unique niche and they have undoubtedly developed unique

This female Banded Gila Monster, Heloderma suspectum cinctum is in good breeding condition—a little excess weight, but not obese. I prefer to keep males a little lighter.

reproductive strategies. When we try to understand the difficulty in propagating Gilas in captivity, we need to consider their uniqueness. So, how do we manage our animals in captivity in light of this discussion?

I not only want females to go into hibernation with adequate fat reserves, but I want them to have an adequate quantity and frequency of food the *previous* spring, both for that year's egg production as well as the next year's. I feed females on a four-day feeding schedule as soon as possible after they emerge from hibernation. They will typically resume feeding within a week of warming up. Many will start feeding almost immediately. I start with a few smaller than normal meals before continuing with regular feedings. I will continue to feed them even when they are gravid. After oviposition, the frequent feedings are continued until the females regain their pre-hibernation weight. For these post-oviposition feedings, I will offer the females as much as they will eat at each feeding (it may be as much as 5-6 large mice, depending on the female. I want females to return to their ideal breeding weight as quickly as possible after oviposition.

The daily shower of radiation from the sun synchronizes the internal "biological clocks".

Given their limited periods of activity and the huge amount of nutrition that goes towards egg production, I would speculate that Gilas don't breed yearly in the wild. However, if their nutrition is managed adequately in captivity, they are capable of reproducing successfully on a yearly basis.

As discussed before, Gilas will overeat and become obese if allowed to do so. I prefer to keep my males somewhat lean. Males will typically go off feed during the breeding season, so I usually feed them a little more than usual in the month or month and a half after they warm up. I prefer to allow my females to keep a little extra weight on them (not obese).

At other times of the year for a maintenance diet Gilas are fed adult mice or young rats every two weeks or every month. I recommend that you weigh your animals regularly and keep records of their weight.

Circadian and Circannual Rhythms

All organisms, whether unicellular or vertebrate, can show daily rhythms

in behavior and physiology. This timing of biological processes is important to insure that events happen at the proper time of day. Interestingly, these daily rhythms continue even in the presence of constant environmental conditions. This suggests that these rhythms are controlled by an internal "biological clock" that has a period approximating the rotation of the earth (24 hours). *Circadian* (*circa*, about: *dies*, a day) is the term used to describe such rhythms. These internal clocks are not capable of keeping perfect time unless they are reset or synchronized to the daily cycle. They are synchronized or "entrained" by certain environmental stimuli, such as regular changes in light or temperature.

In addition to these daily rhythms, some species show seasonal changes in physiology without the influence of external stimuli (variation in temperature or light). These built-in, endogenous rhythms having a period of about one year have been termed *circannual*. It is suggested that yearly changes in photoperiod are responsible for entrainment of these circannual clocks. In poikilotherms (cold-blooded animals) it is reasonable to consider that yearly temperature fluctuations could also entrain these circannual rhythms.

Let's relate this information to our Gilas. To review, Gila monsters have a narrow three-month period of time when most of their above ground activity occurs (feeding as well as social interaction including mating). To be successful Gilas need to synchronize all these activities with the environment as well as with one another (for mating). I think it is reasonable to assume that these circadian and circannual rhythms are important in synchronizing reproductive activities. Alternately, it is possible that the winter cooling period exogenously drives the reproductive response (the winter cooling period or the termination of the cooling period could synchronize reproduction). However, as we'll discuss in a moment, follicular development as well as testicular development begins *before* the winter cooling period.

It is clear that we don't know the exact environmental conditions necessary to drive the entire reproductive process in Gila monsters. Even the most experienced breeders have too many failures. In my mind, until we have the process figured out completely, the best approach would include duplicating as many of the environmental factors influencing free-ranging Gila as we can within the constraints of the captive environment. Let's look at the process

This image shows the appearance of the testes at the time of winter cooling. Development has already begun by this time.

by which males and females get into reproductive readiness.

Testicular Development

Goldberg and Lowe (1997) published a very interesting paper on the reproductive cycle of the Gila monster in southern Arizona. This study is based on the examination of reproductive organs of 112 preserved specimens collected at various times of the year. Through histology they found that males collected in March and April had developing testes, but no sperm yet. In May 20 out of 20 males were producing sperm, in June 5 out of 8 were producing sperm and in July through August the testes of all specimens were regressed. In September, testicular development starts again. No specimens were examined for the months of December through February. I have confirmed through ultrasound examination of my captive animals that testicular development has already begun by the time winter cooling is underway.

This ultrasound image of an ovary was taken just as the female went into hibernation. The largest follicle is already 1 cm. in diameter at this point.

If testicular growth starts in September, what factors are responsible for initiating this development? Is it directly controlled by exogenous factors such as decreasing temperature or light cycle, or is it controlled by endogenous factors such as circannual clocks (entrained by temperature and/or photoperiod)? What can we do in the captive environment to stimulate testicular development at the appropriate time? We will discuss this under the subjects of thermoregulation and photoperiod. First, let's look at follicular development.

Follicular Development

At any time of the year, a mature female Gila has numerous ovarian follicles. For a given reproductive season, some of these follicles will develop through a process of yolk deposition (vitellogenesis) to eventually be released from the ovaries (ovulation). The released ova will enter the oviduct where fertilization takes place. The fertilized ova travel down the oviduct to be shelled and eventually released from the body through a process called oviposition.

Goldberg and Lowe (1997) also looked at the seasonal ovarian cycle in Gilas. Enlarged follicles (>8mm) were found in the months of March through May. Oviductal eggs were seen in the only female collected in June and in one specimen collected in August. No female

specimens were examined for the months of October through February.

I have examined females in my collection with an ultrasound. Adult females going into winter cooling already had follicles 1 cm in diameter (little development occurred during the cooling period). Since follicular development is starting before winter cooling, we need to ask ourselves the same questions as before. Is the initiation of follicular development controlled by exogenous factors such as decreasing temperature or light cycle, or is it controlled by endogenous factors such as circannual clocks (entrained by temperature and/or photoperiod)? What can we do in the captive environment to stimulate follicular development at the appropriate time? Let's examine temperature and photoperiod.

Thermoregulation

As stated before regarding raising hatchlings, providing opportunities for thermoregulation is important. This is especially important for breeding Gilas. Several temperature dependent processes need to occur successfully, including sperm development and follicular development, as well as the synchronization of these two processes.

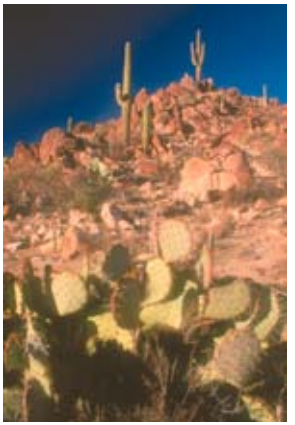
I recommend maintaining a wide range of temperatures in the Gila's enclosure to allow adequate choices. Providing adequate choices will allow the Gilas to select the most appropriate temperatures for the occasion. A temperature gradient from the mid 70's in the coolest part to the low 90's in the warmest should provide adequate thermoregulatory opportunities. I also recommend a 10-degree nighttime temperature drop. Considering the fact that adult Gilas are predominantly diurnal, they are exposed to relatively cool temperatures at night in their burrows. Again, I want to duplicate as much as practical what we know of their free-ranging conditions.

I have not provided any seasonal temperature variation for my captive Gilas except for the winter cooling period. Both males and females in my group have initiated development of their gonads in the fall when kept an uniform temperature conditions

Access to a wide range of temperatures is important for a number of biological processes, inlcuding testicular and follicular development.

Photoperiod

There are two ways to explain the initiation of testicular and follicular development that occurs in the fall before the winter cooling period. One possibility is that exogenous factors such as decreasing temperatures or a decreasing light cycle initiate the reproductive cycle (note that, as stated before, my captive Gilas have started the fall testicular and follicular development even though they were held at unchanging temperatures before winter cooling). The other possibility is that endogenous factors such as the circannual clock time the initiation of the reproductive cycle. If a circannual rhythm is responsible, seasonal variation in photoperiod and temperature may be important to synchronize or entrain this clock. In other words, regardless of the mechanism behind the timing of the reproductive cycle, I believe that photoperiod is an important factor to control in our captive environment.



Seasonal changes in photoperiod are likely important in synchronizing reproductive cycles in free ranging Gilas. Consequently, providing seasonal photoperiod variations should be a part of a captive breeding program.

I don't provide individual lighting to the Gilas in my collection. However, I do provide a photoperiod and lighting by way of a window in the reptile room. I rely on the natural photoperiod available at my location in southern Colorado. If natural light is not available one could accomplish a similar result by wiring the room lights to a photocell that would automatically turn lights on at dawn and off at dusk. Alternately, one could use an appliance timer and manually advance or retard the setting to provide a changing photoperiod. In this age of inexpensive, computer regulated lighting controls designed for residential use, someone with a little ingenuity could create a system that creates a changing lighting schedule to match the photoperiod of any location in the world.

Controlling photoperiod is not an essential aspect of captive reproduction in some reptiles. Some reptiles will continue their reproductive cycling even when held at constant temperature and photoperiod. Until I have evidence that controlling photoperiod is not helpful in the successful captive propagation of Gila monsters, I will continue to include it in my protocol.

Reproduction

Mating

Many individuals have recommended keeping multiple males and females together in a group during breeding season. This is both because of the difficulty in determining sex as well as the thought that combat between males will facilitate successful breeding. It is the opinion of the author that this approach can be counterproductive to success. In the wild, Gilas demonstrate a structured social system including establishment of dominance through male-male combat. However, in the typical captive group setting the dynamics of the male-male interactions are very different from what occurs in free-ranging Gilas. In a typical captive setup, males lack an avenue for escape. Dominant males will often fight one another incessantly at the exclusion of all other activities, including mating.

The hypothesis is that in free-ranging Gilas as well as in other squamate reptiles, the "winner" of these male-male fights gains access to females. Several questions come to mind in relating this behavior to captive situations. What determines the winner of such bouts? It appears to be a test of endurance, so the larger and physically stronger male would have the advantage. In the wild, since these fights also involve access to territory and shelters, one could assume that the resident animal would have an advantage also. How does the loss of a fight affect the willingness of the loser to mate? In other words, when we allow males to combat in a captive environment, we may be increasing the willingness of one male to mate and decreasing the willingness of another.

How can we mimic the social interactions occurring in free-ranging Gilas in the captive environment? One approach is to identify a male that you wish to breed and keep him in his own cage (resident animal). Introduce

Successful mating will occur if the required environmental and social needs are fulfilled.

a smaller (subordinate) male into the breeder male's cage. Allow them to combat. Remove the smaller male (loser) and introduce a female into the breeder male's cage. One risk of this is the potential injury to either male as a result of the combat. Although this fighting is frequently just a form of stylized posturing with each male attempting to gain the superior position, it can erupt into a vicious brawl including biting. This is more likely to occur in captive situations where there is a lack of escape. Watch the animals closely! I assume that another risk could be that your breeder male could lose the fight and be discouraged from breeding. By keeping him in his own cage and introducing, then removing the other male, in theory, the breeder male will interpret it as having run off the subordinate male.

Gilas will breed successfully without male combat. I house the Gilas separately and simply introduce females into the male's cage individually usually without any male-male pairing. Individual housing of the Gilas also facilitates their husbandry.

Animals are paired beginning the first week in April and copulation is typically observed by the middle of April (4-6 weeks after emergence from hibernation). Multiple females can be rotated through the cage of one male

During copulation the male grasps the female by the base of the tail and approximates their cloacas for intromission. Copulation has been observed to last from 15 minutes to 2.5 hours.

leaving each female in for several days. I will usually breed a given female several times.

It is easy to breed a single male to two females during a given reproductive season. More females are possible but more difficult to manage successfully. In my breeding colony, reproductive activity is very tightly synchronized. All mating in the entire group starts and is finished within a two-week period of time. Considering the desire to breed each females several times and the limited mating potential of a single male within a two-week period of time, I would recommend a 1.1 or 1.2 breeding ratio.

Copulation has been observed to last from 15 minutes to as long as 2.5 hours.

Ovulation

After the developing ovarian follicle is fully mature it is released from the ovary through a process called ovulation. Fertilization occurs after ovulation and before the eggs are shelled in the oviduct. Once ovulation occurs eggs will be produced. Prior to ovulation the mature follicle can be reabsorbed if not released from the ovary. If successful fertilization has occurred, fertile eggs will result. If fertilization has not occurred, shelled, infertile eggs will result. This process is important to understand when we try to understand the cause of our reproductive failures.

It is not known whether courting or actual mating is important for the final maturation and release of the mature follicles. It is also not known how close to ovulation mating needs to occur in order to result in a fertile clutch of eggs.

The female will fill out in the posterior 1/3rd of her body as follicular development progresses. It is sometimes noted that as the female's body girth increases, her tail diameter decreases. This is the result of her mobilizing fat stores in her tail for the development of the follicles. This may not be as apparent if the female has significant fat reserves.

In some boids, the timing of ovulation is visible as a sudden mid-body

This is the appearance of a gravid Gila. The posterior of her body is filled out; note that she is in her pre-oviposition shed.

swelling that subsequently disappears. It has been suggested that this sudden swelling is caused by the release of the mature follicles from the ovaries. As the released ova line up in the oviduct the mid-body swelling disappears.

For several years I have noticed a pronounced bloating in many of my females that are reproductively active. The timing of this bloating is consistent with when ovulation would occur. I hope to confirm with ultrasound this coming season that this is in fact a visible sign of ovulation in Gilas. The ability to observe the timing of ovulation would be helpful in the management of the animals. For example, a female with an enlarging abdomen may be thought to be gravid, but if ovulation has yet to occur her increase in girth is simply the result of enlarging follicles. This confusion could result in separating the female from the male too early.

A short time before oviposition, the gravid female will retire to the nest box.

Gravid Females

Once it is determined that a female is gravid, she should be separated from her cage-mates if she is not already alone. This will prevent unnecessary stress to her and will prevent cage-mates from eating her eggs.

Breeders of snakes will be familiar with the pre-egg laying shed. Egg laying frequently occurs a consistent number of days after this pre-egg laying shed. In Gilas also, females frequently shed about three weeks prior to oviposition. However, many females will not exhibit this pre-egg shed. When it occurs, this shed appears different than normal Gila sheds. Under most circumstances, Gilas will shed over a long period of time, with the exfoliated skin coming off in small patches. Characteristically, this pre-egg laying shed starts and is finished in a shorter period of time, with the shed skin coming off in large sheets.

Through close observation one can observe distinct changes in the behavior of a female from copulation to oviposition. The first stage is marked by behavior that I characterize as "quiet but alert". She will spend long periods of time motionless but very alert, frequently basking in a warm part of the cage. A

couple of weeks before oviposition, she will become very active, digging about the cage. By this time she should be provided with a nest box. I use damp sphagnum moss as an egg-laying medium. A short time before oviposition, the gravid female will retire to this nest box and remain relatively inactive.

Currently, I convert the entire cage into a nest box by replacing the usual chipped aspen bedding with several inches of slightly damp sphagnum moss. This provides a greater volume of moss, which is easier to keep uniformly damp without drying out as quickly.

Oviposition

Prior to egg laying the female provides an adequate environment for the developing eggs assuming she has an opportunity to thermoregulate. It is important to provide an environment in the nest box that will be supportive to the developing eggs, also. This means appropriate moisture and temperature. I am careful not to keep the egg-laying medium too wet, spraying at least daily to maintain slight uniform moisture. Keep the temperature in the nest box the same as the incubation temperature (about 79 degrees F).

As the time of oviposition approaches, I change the heating of the cages from the normal thermal gradient of the mid-70's to the low-90's with a 10 degree nighttime drop to a uniform temperature of 79 degrees F. I don't want a female to lay her eggs on an 80-degree nighttime hotspot only to have the daytime temperatures kick in and cook the eggs. Since I am using the entire cage as a nest box, I basically want to create the same environment in the cage, as I will in the incubator (high humidity, low contact moisture and 79 degrees F). I accomplish this by turning off the supplemental cage heating and maintaining a room temperature of 79 degrees F. How you accomplish the same result will depend on the specifics of your own setup. If you are using a nest box inside your main cage, just be certain that the temperature in the egg box is approximately 79 degrees.

I am also careful to anticipate ovi-

It is important to provide temperatures and moisture in the nest box that will be supportive to the eggs.

position and remove the eggs as soon as they are laid. I will even remove the eggs one by one and get them in the incubator as they are laid—if I can do so without disturbing the female. Otherwise, I will remove the clutch after the female has completed the process of oviposition.

This custom made incubator meets the requirements of a good incubator: it is well insulated, has good air circulation and maintains stable temperatures.

Females will lay eggs at any time of day or night, however, in my colony they seem more likely to lay at night. A normal, healthy clutch of fertile eggs is usually laid over a period of several hours. Eggs that are laid over longer periods of time (sometimes over several days) are more likely to be infertile or non-viable. Females on occasion will lay an infertile egg or two and then a week or so later lay a fertile clutch. More commonly I have seen females lay a normal clutch, then many days later drop an infertile egg or two.

Following the protocol outlined here, I have observed an extremely tight synchronization of reproductive activity in my considerably sized breeding colony representing both subspecies. As previously stated, mating typically starts and is finished for the season within a two-week period of time. Egg laying also starts and is over for the entire group of animals within a two-week period of time. I consider this tight synchronization of reproductive activity a reflection of the success of the protocol. It appears that the animals are getting in a very clear way, the environmental cues necessary to stimulate and synchronize their reproductive cycles.

Time from successful mating to oviposition appears to be 42-55 days.

Gilas have been known to lay from 2-13 eggs, the number being somewhat proportional to the size of the female.

Once you've succeeded in getting eggs, determine if they are fertile. This is a very important step. If the eggs subsequently go bad and you don't know if they were fertile, you won't know where to direct changes to your procedure. For instance, if the eggs were fertile and the embryo was growing, a subsequent failure is more than likely the result of incubation technique. If they weren't fertile in the first place, you need to examine everything that goes on before egg laying.

It is very simple to tell if a newly laid egg is fertile. In a darkened room, hold a small flashlight up to the egg. This is a technique called candling. A newly laid fertilized egg will show a distinct blood ring about the size of a nickel when candled. If the embryo is growing, this blood ring will double in size in the first few days. The blood ring should be very well defined. A diffuse blood ring indicates an egg that has been fertilized, but is no longer alive. When this is seen, something went wrong between fertilization and oviposition.

After fertilization and shelling, the egg has a determinant period of time in which to be laid—otherwise it will die. If you observe a fertile, but dead egg, perhaps an inadequate nest area may have caused the female to delay oviposition. Another possibility is that the female was exposed to inappropriate temperatures after fertilization causing death of the developing embryo.

You may also see eggs that were not fertilized. Infertile eggs may appear smaller and more yellow than fertile eggs and will not be as turgid (they may appear "deflated"). Some infertile eggs will look every bit as good as a fertile egg from the outside. However, on candling there is no sign of a blood ring and they look more opaque on the inside (fertile eggs appear translucent when candled).

There are several possible explanations for infertile eggs. One possibility is the female was not inseminated at the optimal time (more likely too late in the cycle—too close to ovulation). Another explanation is a problem with the viability of the male's sperm. Perhaps he did not have access to appropriate temperatures earlier in the season and his sperm was unable to development properly.

Previous techniques involved placing Gila eggs in a relatively dry mix of vermiculite. Frequent monitoring of moisture levels was required.

Let me emphasize the importance of understanding the underlying processes involved in the reproductive cycle. If you take a cookbook approach to breeding Gilas you will limit your chances for success. If you simply cool in December and warm in March and pair a month and a half later you may see some success (if you are lucky). On the other hand, if you observe the animals and relate what you are seeing to the biological process underlying reproduction—you will increase your success. If you understand your successes and failures in terms of what they tell you about these underlying processes—you will increase your success.

Incubation

A lot of conflicting information has been published regarding the incubation of Gila eggs and many breeders have had difficulties bringing eggs to full term.

A Banded Gila Monster, Heloderma suspectum cinctum hatches. Gilas use an egg tooth to make several slits in their eggs before hatching

It is important to consider three factors that affect the environment of the developing Gilas. These factors are temperature, moisture and oxygen tension.

Suggested temperatures for incubating Gila eggs range from 79-85 F. It has been suggested that incubating them over 85 degrees F can result in failures.

Goldberg and Lowe (1997) have suggested that in the wild, eggs laid in June do not hatch until the following May. That is a 10-month incubation period! Others have also suggested that Gila eggs over-winter. In captivity, a clutch of eggs typically takes between 120-145 days when incubated at 80-85 degrees F. Assuming that development is suspended during the winter months it is still hard for me to believe that Gila eggs can make it until May *unless* they incubate in the wild at temperatures lower than are typically used in captivity. Beck (1990) found that Gilas in southern Utah spent more than 83% of the year at body temperatures of 77 degrees F or less, and over 50% of the year at or below a body temperature of 68 degrees F. If Gilas remain that cool for most of the year, it certainly is possible that their eggs are exposed to cooler temperatures

than the 80-85 degrees typically used to incubate eggs in captivity.

The above information combined with the fact that many people experience failures trying to bring eggs full term, leads me to incubate eggs cooler than most do. I keep the eggs at 77-80 F—never over 80 F.

Most breeders use vermiculite as an incubating medium, although other substrates have been used. Suggested water-vermiculite ratios range from 1:1 to 1:4 (by weight). I am of the opinion that excessively wet incubation medium is harmful to Gila eggs and is responsible for many failures. I have been surprised at how dry the medium can become without the eggs denting in or losing weight. I once allowed the medium to dry out to a 1:7 ratio without any dents occurring in the eggs. That's one part water to seven parts vermiculite! I believe that Gila eggs are adapted to dry conditions and intolerant of wet conditions. Although Gila eggs should not be exposed to excessive contact moisture, they do need to be exposed to adequate humidity.

When hatching colubrid eggs the amount of water is not critical as long as there is enough. Many people just add water to vermiculite until it looks or feels right and they are successful. Such a casual approach is not appropriate when dealing with Gila eggs. With the relatively wet substrate used to hatch the typical colubrid eggs, a lot of water can be lost to evaporation before the water tension to the eggs changes. With the dry conditions recommended for Gila eggs, a small amount of water loss significantly changes the amount of water available to the eggs.

Consider two different egg containers—one set up for snake eggs and the other for Gila eggs. The snake egg container has 400 grams of water and 400 grams of vermiculite (a typical 1:1 ratio). The Gila egg container has 100 grams of water and 400 grams of vermiculite (a 1:4 ratio). Over time, due to evaporation, 50 grams of water is lost from each container. This same 50 grams of water represents 50% of the water in the Gila container, but only 13% of the water in the snake container. You can see the biggest problem in the dry conditions required for Gila eggs—it takes vigilance to maintain a stable environment for the eggs.

In the wild, the huge volume of earth surrounding the eggs would maintain a small but relatively stable amount of moisture in contact

There is not a sight more exciting than this after many months or years planning for success.

with the eggs. Placing a small number of eggs in single container with a large volume of vermiculite will create more stable moisture as well as more favorable oxygen availability for the developing embryos.

In the past, eggs were set up in a relatively dry mix of vermiculite. I would carefully weigh the water and vermiculite to create a ratio of 1:4. The eggs were half buried in the vermiculite with the embryo on the top. Setting up the eggs with the embryo on top allowed me to more easily monitor the growth of the developing Gilas.

With my previous incubation setup, maintaining the proper moisture required the addition of water to the vermiculite many times during the incubation period. I was careful to add water of the same temperature as the incubator to prevent thermal shock to the developing embryos (this was done by keeping a water bottle in the incubator at all times). The humidity in the incubation chamber as well as the amount of ventilation to the incubator and the individual egg containers would affect the rate of water loss. The egg containers were periodically weighed to determine water loss and water was added to compensate. I weighed each container weekly until I got a sense of how much water was lost how frequently. I was careful to not place water directly on the eggs as this has been suggested to contribute to egg death. Eggs exposed to inadequate amounts of moisture will begin to dent. I would occasionally remove the eggs from the incubation medium and remix the substrate to maintain an even distribution of the moisture.

In the wild, Gila monster eggs are thought to hatch about 10 months after oviposition. Gila eggs are adapted to the relatively dry conditions of their environment. In captivity, eggs will thrive in conditions of low contact moisture and high humidity.

This technique was successful at hatching Gila eggs, but also had it's problems. It was difficult to maintain stable conditions for the developing eggs. The frequent tinkering required to maintain appropriate moisture levels over the entire four and a half months of incubation was no less than a real pain. For several years I have been ex-

perimenting with alternate techniques to incubate Gila monster eggs. I wanted to develop a technique that fulfilled certain criteria. The primary and most obvious goal in creating the new protocol was to create an environment ideally suited to the development of Gila eggs. Equally important, though, was to create a stable environment that needed little attention during the long period of incubation. Additionally, I wanted a technique that was easily reproducible; I wanted anyone to be able to use the technique with success equal to my own.

After many years of trying different materials and different procedures, I have come up with a technique that I believe fulfills all these requirements. I call it the Hygroscopic Incubation Technique.

Hygroscopic Incubation Technique

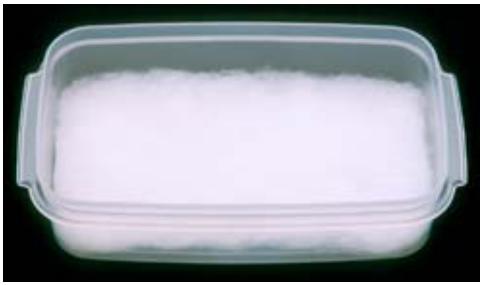
To review, the three requirements for incubating reptile eggs are temperature, moisture and oxygen tension. Appropriate incubation temperatures are easy to maintain with the proper incubator. Whatever incubator you use, it should be able to maintain stable and accurate temperatures. Any incubator appropriate for reptile eggs will work for Gilas. Whether you use a homemade incubator or acquire any of the commercially available incubators, it simply needs to provide accurate and consistent temperatures. Placement of the incubator is also important. Since you will be maintaining a relatively low incubation temperature of 79 degrees F, the ambient temperature of the room containing the incubator needs to remain below this temperature.

Providing appropriate moisture is trickier. Gila eggs do well in an environment of high humidity and low contact moisture. The Hygroscopic Incubation Technique is designed to provide these requirements in an easy to manage system. It consists of an inner as well as an outer container. The inner container holds the eggs and the outer container holds the inner egg container as well as a reservoir of water.

Properly implemented, the Hygroscopic Incubation Technique will provide an appropriate and constant level of humidity as well as an adequate oxygen tension for the developing eggs.

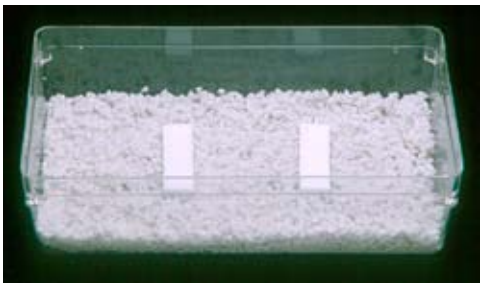
The following photos illustrate how to how to make the Hygroscopic Egg Chamber:

Step 1 – GATHER MATERIALS
Inner box, perlite, water, supports, outer box, polyester batting.



Step 2 – PREPARE INNER BOX
Cut polyester batting to fit the bottom of the inner box.

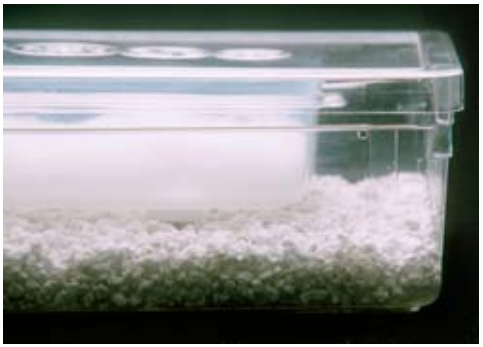
Step 3 – PREPARE OUTER BOX
Drill four 1/8th inch holes at the corners of the outer box.
Add about 1 inch of perlite to the outer box.
Add water to perlite until the water line is about ¾ inch deep.



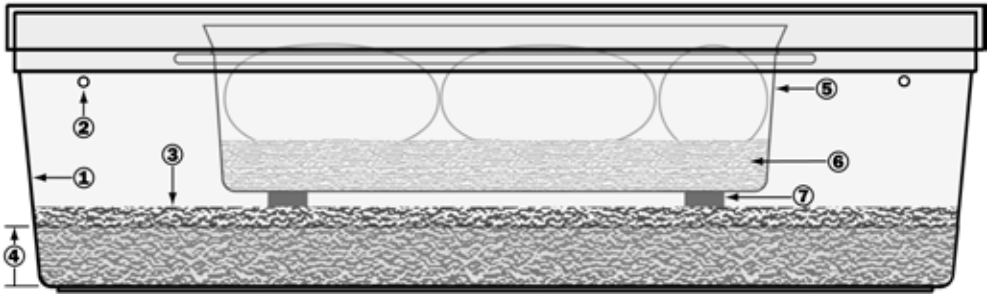
Step 4 – ASSEMBLE COMPONENTS
Place supports on perlite.

Place inner box on supports.

The lid on the outer box completes the hygroscopic egg chamber.



Place the prepared egg chamber in the incubator well ahead of anticipated egg laying.



1. STYRENE SHOE BOX

This clear, hard plastic outer box measures 12 ½" x 6 ¾" x 3 ¾". I prefer the visibility provided by the styrene. The size also allows for efficient use of space in the incubator.

2. VENTILATION HOLES

A 1/8th inch drill bit is used to drill holes in the outer box at the corners to provide ventilation (4 total). Care should be exercised in drilling the hole to prevent cracking the hard, brittle plastic. Placing a piece of scrap wood behind the plastic will reduce the risk of cracking the box. Alternately, a soldering iron can be used to melt the holes through the plastic.

As the embryos develop, they have increasing oxygen requirements. It is important to prevent the oxygen tension in the individual egg containers from falling to a level that would inhibit the development of the embryos, particularly towards the end of incubation as the oxygen requirements of the developing Gilas increase. These four 1/8th inch holes will provide enough ventilation for the entire incubation period assuming there is adequate air exchange between the main incubator and the outside room.

3. PERLITE

Perlite is added to the outer box to a level of approximately 1 inch. The purpose of the perlite is two-fold. First, it provides a reservoir for the water that provides the humidity in the system. Second, the porous granules of the perlite provide a large surface area for the water to evaporate from. This aids in maintaining the required humidity level inside the box. One inch of perlite in this size box provides enough of a reservoir of water to last for the entire incubation period.

4. WATER LEVEL

It is important to keep the water level below the top level of the perlite.

The standing water will wick up to the surface of the perlite and evaporate. If the water level completely covered the perlite, the advantage of the huge surface area of the perlite granules would be lost. Because of the ventilation provided in the outer box, the system will lose moisture and the level of water in the perlite will lower. As long as you can see standing water in the perlite, the level of moisture evaporating from the surface of the perlite will remain the same. Water can be added at any time during the incubation period (be sure the water is the incubation temperature to avoid thermal shock to the developing embryos).

5. INNER EGG BOX

The inner egg box is a Rubbermaid® Servin'Saver® Rectangle 1.5 Pint box. The inner box is used without its lid. It will easily hold a 7-egg clutch. Larger clutches can be divided between two egg boxes or a larger inner box could be used. For it to work in this styrene outer shoebox, the height of the inner box needs to be limited to about 2 inches.

6. POLYESTER BATTING

The bottom of the inner box is lined with polyester batting (available at a fabric store or hobby center). Simply cut a piece to fit the bottom of the inner egg box. The loose batting provides a support for the eggs as well as allowing the humidified air to circulate completely around the eggs.

7. SUPPORTS

The inner egg box is held up off the perlite with small supports. I use two ¼ inch high pieces of Styrofoam. Note that the top of the inner box is not in contact with the top of the styrene outer box. This allows good circulation of the humidified air around the eggs.

Any material can be used for the supports as long as it is appropriate for wet conditions. The purpose of these supports is to hold the inner egg box off the top of the perlite to allow the full surface area of the wet perlite to be exposed to the air. Consequently, you could also increase the lateral dimensions of the inner box without decreasing the surface area of the perlite.

CAUTION

In my incubator the top lid of the outer box forms condensation on the inside. This occurs to an increasing degree towards the end of the incubation period due to greater temperature differential as the developing babies increase the temperature slightly inside the container. In my very well insulated incubator this condensation did not drip onto the eggs. If your incubator is not as well insulated or if the temperature is not as

stable, you could have a greater amount of condensation. The bottom line is you don't want water to drip onto the eggs. To overcome this possibility, you could cover the inner box and provide ventilation holes in the side.

VARIATIONS

It would be possible to change the dimensions of the inner and outer boxes and still achieve the same effect as long as you stick to the principles outlined above. With the large number of clutches that I produce in a given season, incubator space is at a premium. The dimensions of the system as described above work perfectly for me.

I set up the incubation boxes and place them in the incubator several days before eggs are due. That way they are at the incubation temperature before the eggs go in. Once I set up the eggs in their containers, I don't need to touch them again until they hatch. Did you hear that? I don't touch them for 4 ½ months. Now that's what I call a nice incubation technique!

In the main chamber of the incubator, I keep the humidity level up around 90%. This is accomplished by placing a shallow open pan of water at the top and at the bottom of the incu-

The Hygroscopic Incubation Technique is a simple way to provide ideal conditions for the entire development of the eggs—from egg laying to hatching.

bator. At the top of the incubator is a fan that keeps the temperatures inside the incubator uniform. This fan draws air over the pan of water helping to keep the inside of the incubator humid.

Several factors will determine whether you will need to add water to your egg boxes during incubation: the humidity inside the main chamber of the incubator, air movement inside the incubator and the amount of air exchange between the incubator and the outside room.

The high humidity inside the incubator reduces the water loss from the individual egg boxes. If you don't keep your incubator humid enough, the individual egg boxes will still stay adequately humid, but you will have an increased rate of water loss from the egg box, necessitating closer monitoring of the water level. You may need to add water to the perlite during the incubation period.

If you have a fan in your incubator, you will have a greater rate of water loss from the individual egg boxes than if the air is more stagnant. As stated before, I have a fan that provides a lot of air movement and I don't have to add water at all during the period of incubation because I maintain high humidity inside the incubator.

The amount of air exchange between the incubator and the outside room influences the humidity inside the incubator and, consequently, the rate of water loss from the egg boxes. I have ventilation holes in the incubator that provide good air exchange, and as stated before, with high humidity inside the incubator and with each egg container set up as described, the system remains stable for the entire incubation period without any intervention.

If you have a sealed incubator (no ventilation) you will need to consider opening the incubator door periodically to provide some air exchange to allow a sufficient oxygen tension to the developing embryos.

Following the above described incubation technique, expect the eggs to remain turgid until the last few weeks of incubation. If an egg or two dent in slightly, don't be concerned. If any eggs collapse significantly before the end of incubation, the humidity level is too low. It is normal for the eggs to start to

A few weeks before hatching, it is normal for the eggs to begin to collapse. If they collapse to any significant degree earlier in the incubation period, the level of humidity is insufficient.

collapse during the last few weeks before hatching, although some eggs may not collapse at all, even at the last stages of incubation.

Properly implemented, the Hygroscopic Incubation Technique is a simple, low maintenance way to provide an ideal environment for optimum embryonic development in Gila monsters.

Egg death

There are several possible causes of death of a fertile egg. The most obvious (and common) cause is related to incubation technique. The Hygroscopic Incubation Technique should take the guesswork out of providing an ideal environment for the eggs.

It is also possible for a fertile egg to die because of factors completely out of your control. During the complex process of embryonic development there are many opportunities for things to go wrong, even if environmental factors are ideal. Egg death due to developmental mishaps can occur at any stage of embryonic development, but are more likely to occur in the earliest stages—it may even occur before the eggs are laid.

As the time of hatching nears, the eggs become more translucent and the baby Gilas can be seen through the leathery egg shells.

The first clue that an egg is dead is usually the appearance of fungal growth on the egg. It will usually start in a small spot on the egg and grow in size, eventually taking over the egg. The egg will eventually collapse and completely discolor. The fungus is a consequence of a dying or dead egg and not the cause of death. Some have felt that if they can remove the fungus or treat the egg with anti-fungal medicaments, they can save the egg. A healthy egg will not become overgrown with fungus. Any attempt to save such an egg will fail.

On occasion you may observe a small amount of fungus develop on a thin or hypo-calcified spot on an egg. If the egg is healthy, this will be self-limiting and will not cause any problem for the developing embryo—nothing needs to be done.

A healthy egg can rest next to and in contact with a dead, decomposing egg with no consequence. Most people prefer to remove decomposing eggs and since

Gila eggs do not adhere to one another it is a simple matter to remove an obviously dead egg from the egg box.

Hatching

If all goes well, after about 124 to 150 days of incubation a young Gila will arch its head back within the egg and, with several biting motions, slice through the egg membrane and shell with its egg tooth. After pipping, young Gilas will frequently take a few days before emerging from their eggs. During this time they will absorb the considerable remaining yolk into their abdomen. Do not remove the Gilas prematurely.

Once Gilas pip, they will begin to drink the liquid contents of their egg. If you are lucky and you peer into the slit in the egg you may observe the Gilas tongue go in and out as it takes its fitst drink. Even after exiting the egg, hatchling Gilas will return to the shell and consume all that remains within it. This is likely an adaptation to living in a harsh and arid environment.

It is best to leave hatchling Gilas alone and let them pip and exit the egg naturally. A normal and fully developed baby Gila should have no trouble exiting its egg without any assistance. If you "help" by enlarging the slits in the shell or if you open the egg prematurely, the Gila may, in turn, exit the egg prematurely—before all the yolk has been absorbed. If this happens, it is important to keep the attached yolk moist and usually it will continue to absorb. Keeping the Gila on moist paper towels will accomplish this (ideally moistened with isotonic saline). If it is unable to absorb the yolk completely, the tissue could become necrotic, risking infection. If the Gila is unable to absorb the yolk do not just cut the stalk attaching the yolk to the abdomen (there is a significant vascular supply to the yolk). Instead, tie a ligature tightly around the stalk as close to the body as possible. Dental floss is readily available and should serve the purpose perfectly. Be sure to tie it tightly and securely to completely isolate the necrotic tissue from the Gila. Eventually, what is left of the yolk will dry up and fall off. A much better approach is to listen

After pipping, Gilas will remain in their egg for several days while they resorb any remaining yolk. It is important to not disturb them at this time.

to what I said originally—contain your excitement leave them alone to hatch naturally!

Hatchling Gilas should be kept in individual housing. This facilitates feeding and makes maintenance easier. Water should be provided at all times. It is easier for a hatchling to dehydrate than for an adult due to a hatchling's greater surface to volume ratio.

Unlike some other hatchling reptiles, Gila hatchlings always eat commonly available food items (baby domestic mice or rats). I have never had a hatchling Gila that did not eat. That being said, some may not accept what is offered to them for their first meal or two. When they first exit the egg, they have an abdomen distended with absorbed yolk. In essence, they

When a Gila leaves the egg, it has an abdomen full of yolk. It may take a week or so before it is ready to eat for the first time.

have already had their first meal and it may be a while before they are ready to eat. Some will eat within a few days of leaving the egg, but most will wait for a week or two.

I routinely offer a live pink rat or mouse a week or two after hatching—which most hatchlings will readily accept. Sometimes it helps to just leave the food in the cage for a day or overnight. For those that don't eat voluntarily the first time, there are several techniques to try. Refer to the previous section on Raising Hatchlings for specifics.

I feed hatchlings once or twice a week, increasing the size and number of food items as the Gila grows. Gilas make undemanding captives and will grow rapidly when provided with adequate food and appropriate temperatures.

Comments

Principles to consider in a successful reproduction program for the Gila monster, *Heloderma suspectum,* include annual climatic cycles, adequate nutrition, appropriate management of social interactions, and a supportive environment for the developing eggs.

Two things should be emphasized to those individuals interested in success with this species. First, apply the discussed principles in a controlled and consistent manner. If things are done inconsistently, the factors responsible for a success or a failure cannot be easily understood. For example, if the factors important in incubation (temperature, moisture, and oxygen tension) are not controlled accurately, it is impossible to know why a success or failure occurred. Second, keep accurate records of everything you do and everything that happens. A review of these records over time will provide information valuable to your success as well as the success of others.

Attention to the principles discussed and careful observation of the animals themselves will result in the successful captive propagation of this fascinating and misunderstood inhabitant of the Sonoran Desert.

Troubleshooting

PROBLEM	POSSIBLE CAUSE
No mating	*Male* • Innapproprate photoperiod any time of year • Male too fat • Hibernation not cold enough • Hibernation not long enough • Multiple males kept together combat at the exclusion of mating. • Social needs not met--consider controlled combat. • Males and females not put in and taken out of cooling at the same time. *Female* • Inadequate frequency and amount of feeding of female during current or previous spring • Innapproprate photoperiod any time of year • Not enough stored fat on female • Female too fat • Not cool enough in winter • Not long enough cooling • Males and females not put in and taken out of cooling at the same time.

PROBLEM	POSSIBLE CAUSE
Mating, but no eggs	*Male* • Temperatures too hot or too cold after winter cooling In- • nappropriate photoperiod any time of year • Males and females not put in and taken out of cooling at the same time. *Female* • Temperatures too hot or too cold after winter cooling In- • nappropriate photoperiod any time of year • Hibernation not cold enough • Hibernation not long enough • Males and females not put in and taken out of cooling at the same time. • Inadequate frequency and amount of feeding of female during current or previous spring

PROBLEM	POSSIBLE CAUSE
Infertile eggs	*Male* • Temperatures too hot or too cold after winter cooling In- • nappropriate photoperiod any time of year • Males and females not put in and taken out of cooling at the same time. *Female* • Temperatures too hot or too cold after winter cooling In- • nappropriate photoperiod any time of year • Males and females not put in and taken out of cooling at the same time.

PROBLEM	POSSIBLE CAUSE
Fertile eggs go bad	Incubation technique: temperature, humidity, amount of water in incubation medium.
	Female retained eggs due to inadequate nest area.
	Spontaneous developmental defects.

PROBLEM	POSSIBLE CAUSE
Full term Gila dead in egg	Incubation technique: possible dehydration late in incubation, inadequate oxygen to eggs. Spontaneous developmental defects.

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