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BIOLOGY, MEDICINE, AND SURGERY OF SOUTH AMERICAN WILD ANIMALS

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SEE "SPECIFIC NUTRITIONAL DISORDERS" P.25

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Class Reptilia, Order Chelonia (Testudinata) (Chelonians): Turtles, Tortoises

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INTRODUCTION

Turtles are easily distinguishable from all other reptiles by their characteristic morphology: a body encased by a bony shell covered with horny scutes of epidermic origin. The shell consists of the dorsal carapace and the ventral plastron, firmly fused together in most species. Neural and costal bony plates of the carapace are fused to the neural arches of some vertebrae and to the ribs, respectively. Shell morphology reflects turtle ecology, with tortoises usually having a domed carapace. Detailed discussions of turtle anatomy and physiology may be found in the references.[1,11,49]

About 250 living species of turtles are known worldwide.[49] In South America there are 40 species of freshwater turtles, 4 species of tortoises (Table 3.1), and 7 species of marine turtles.[28] According to the International Union for the Conservation of Nature (IUCN), 22 of these species are considered to be threatened (critically endangered, endangered, or vulnerable).[27] Natural populations of Amazonian species in the *Podocnemis* genus are being protected by the efforts of local conservation projects being developed in Brazil[8] and neighboring countries[31,47] and apparently are recovering. Conservation projects are also important in the protection of marine turtle nesting beaches in Brazil[33] and other South American countries.[51]

BIOLOGY, MANAGEMENT, AND FREE-LIVING POPULATIONS

Flavio de Barros Molina

Feeding Habits and Behavior

Chelidae species are predominantly carnivorous, eating a variety of prey items, including crustaceans, insects, and fish.[12,16,35,43,50,52,56,57] *Chelus fimbriatus* is completely carnivorous, and some species may be highly omnivorous, e.g., *Phrynops rufipes* and a northern population of *Phrynops geoffroanus*.[16,32]

Species in the family Pelomedusidae are primarily herbivorous, eating mostly aquatic plants and fallen fruit,[3,12,16,48,52] but they also consume some mollusks, crustaceans, insects, and fish.[48,52] In captivity, some species will take meat and fish.[12,52]

TABLE 3.1. Distribution of South American freshwater turtles and tortoises. IUCN status of threatened and near threatened species

Scientific Name	Distribution	IUCN
Acanthochelys chacoensis	AR	VU
Acanthochelys macrocephala	BR/PA/BO	NT
Acanthochelys pallidipectoris	AR/PA/BO?	VU
Acanthochelys radiolata	BR	NT
Acanthochelys spixii	BR/UR/AR/PA?	NT
Chelus fimbriatus	BR/GU/FG/SU?/VE/CO/EC/PE/BO/TR	
Hydromedusa maximiliani	BR	VU
Hydromedusa tectifera	BR/UR/AR/PA?	
Phrynops dahli	CO	CR
Phrynops geoffroanus	BR/GU/VE/CO/EC/PE/BO/PA/AR?	
Phrynops gibbus	BR/GU/FG/SU/VE/CO/EC/PE/TR	
Phrynops hilarii	BR/UR/AR/PA?/BO?	
Phrynops hogei	BR	EN
Phrynops nasutus	FG/SU/BR?	
Phrynops raniceps	BR/VE/CO/PE/BO	
Phrynops rufipes	BR/CO/PE?	NT
Phrynops tuberculatus	BR	
Phrynops vanderhaegei	BR/PA/AR/UR?/BO?	NT
Phrynops williamsi	BR/UR/AR/PA	
Phrynops zuliae	VE	VU
Platemys platycephala	BR/GU/FG/SU/VE/CO/EC/PE/BO	
Peltocephalus dumerilianus	BR/FG/VE/CO/EC/PE	VU
Podocnemis erythrocephala	BR/VE/CO	VU
Podocnemis expansa	BR/GU/VE/CO/EC/PE/BO/TR	CD
Podocnemis lewiana	CO	EN
Podocnemis sextuberculata	BR/CO/PE	VU
Podocnemis unifilis	BR/GU/FG/SU/VE/CO/EC/PE/BO	VU
Podocnemis vogli	VE/CO	
Rhinoclemmys annulata	CA/CO/EC	NT
Rhinoclemmys diademata	VE	
Rhinoclemmys melanosterna	CA/CO/EC	
Rhinoclemmys nasuta	CO/EC	NT
Rhinoclemmys punctularia	BR/GU/FG/SU/VE/TR	
Trachemys adiuthrix	BR	EN
Trachemys dorbignyi	BR/UR/AR	
Trachemys scripta callirostris	CO/VE	NT
Trachemys scripta chichiriviche	VE	NT
Trachemys scripta venusta	MX/CA/CO	NT
Chelydra serpentina acutirostris	CA/CO/EC	
Kinosternon dunni	CO	VU
Kinosternon leucostomum	MX/CA/CO/EC/PE?	
Kinosternon scorpioides	MX/CA/TR/BR/GU/FG/SU/VE/CO/EC/PE/BO/AR	
Geochelone carbonaria	CA/BR/GU/FG/SU/CO/VE/BO/PA/AR	
Geochelone chilensis	AR/PA	VU
Geochelone denticulata	BR/GU/FG/SU/CO/VE/EC/PE/BO/TR	VU
Geochelone nigra	GI	VU

Source: Information from references 27 and 28. AR, Argentina; BO, Bolivia; BR, Brazil; CA, Central America; CO, Colombia; EC, Ecuador; FG, French Guyana; GI, Galapagos Islands (Ecuador); GU, Guyana; MX, Mexico; PA, Paraguay; PE, Peru; SU, Suriname; TR, Trinidad; UR, Uruguay; VE, Venezuela. ?, unconfirmed distribution. CR, critically endangered; CD, conservation dependent; EN, endangered; NT, near threatened; VU, vulnerable.

Most species in the family Emydidae are opportunistic omnivores, eating plant material and animals (like leaves, fruit, aquatic plants, mollusks, and insects).[12,13,44,52] Exceptions include the herbivorous *Rhinoclemmys annulata*,[12] and the predominantly carnivorous young of *Trachemys scripta*,[12,13] and *Trachemys dorbignyi* (personal observation).

In the Testudinidae family, *Geochelone carbonaria* and *Geochelone denticulata* are opportunistic omnivores, eating plant and animal material (like fruit,

leaves, flowers, snails, insects, and carrion).[12,45,52] *Geochelone chilensis* is apparently omnivorous; its diet includes fruit, shrubs, cacti, grasses, and probably carrion.[60] In captivity, all three of these species will take meat and fish.[52,60] *Geochelone nigra* is herbivorous, eating leaves, berries, cacti, and grasses.[12,59]

Kinosternidae species and *Chelydra serpentina* are omnivorous, eating algae, aquatic plants, worms, mollusks, insects, carrion, and diverse vertebrates, including fish, frogs, turtles, and aquatic birds.[12,13,44,52] Molina[35] analyzed the feeding behavior of 14 species of South American turtles and found that most of them located their prey by olfaction. An exception is the matamata turtle, *Chelus fimbriatus,* which is an ambush predator.[35,50,52] Other unique feeding behaviors include spear fishing[25,35,43,50] and consuming surface particulate matter by neustophagia.[54]

Thermoregulation and Thermal Preferences

Chelonians are ectotherms. Basking behaviors are key factors affecting thermoregulation. The most important behaviors performed by freshwater turtles and tortoises during basking activities are moving from water to land (and vice versa) and exposing different body parts to environmental heat. Tortoises move from sunny areas to shady ones (and vice versa), but they may also enter water. Environmental factors affecting basking behaviors include water and air temperatures, light intensity, and wind.[5,58]

Basking may be divided into atmospheric and aquatic basking. Atmospheric basking is important for thermoregulation, elimination of ectoparasites, assisting in the shedding of shell scutes, and for the synthesis of vitamin D_3.[1,5,9,44,58] Aquatic basking is important for thermoregulation.[9] The preferred body temperature of *Trachemys scripta* is 28–29°C, and the species is most active at 25–30°C.[58] Thermal preferences for most species of freshwater turtles and tortoises seem to fall between 23 and 33°C, and the critical thermal maximum is around 39 to 41°C for freshwater species and 43°C for tortoises.[1,13,58] Thermoregulation mechanisms, thermal preferences, and basking behaviors of most South American species are poorly known.

Reproductive Biology and Behavior

Breeding is usually seasonal in reptiles and young hatch during a period of favorable environmental conditions. Photoperiod, temperature, rainfall, and food availability are important environmental factors. Tropical reptiles breed more frequently than temperate ones, their breeding season is usually longer, and in some species reproductive activity is seen throughout the year.[10,11]

Little is known of the mating season and mating behavior of most South American turtles. The mating season varies according to the species.[38,39,40,41,52] For *Podocnemis expansa* mating depends on the water level fluctuation in each geographic locality.[52] Mating behavior may be divided into four phases, i.e., search for female, pursuit of female, precopulation, and copulation. The pattern may be simple, as in *Phrynops geoffroanus,*[38, 39] or elaborate, as in *Phrynops hilarii*[4] and *Trachemys dorbignyi.*[38]

Nesting behavior is more stereotyped than courtship and usually may be divided into five phases: nest site selection, nest excavation, egg laying, nest covering, and return to water.[37,38,40,41] Clutch size varies from 1 large egg in *Platemys platycephala* to more than 100 eggs in *Podocnemis expansa.* Some species may lay more than one clutch per season.[12,52] Eggs may be brittle shelled, as in *Podocnemis unifilis, Phrynops geoffroanus,* and *Rhinoclemmys punctularia,* parchment shelled, as in *Trachemys scripta* and *Trachemys dorbignyi,* or leathery shelled, as in *Podocnemis expansa.*[40] Incubation time is variable, depending on the species involved, temperature, and other environmental conditions, such as the water level in local rivers. It may be short, ranging from 45–60 days in *Podocnemis expansa,*[8,12,52] or lasting for more than 330 days, as in *Phrynops geoffroanus.*[36]

Management

SEXING, MARKING, AND MEASURING Sexual dimorphism is usually evident only in adults. Useful characteristics include tail length and plastron shape. In all species of turtles and tortoises, males have longer and thicker tails with cloacal openings more distally situated, when compared with those of females. The differences are extreme in *Kinosternon scorpioides* and *Podocnemis expansa.* Males of chelid, kinosternid, and, especially, testudinid species usually have a concave (or slightly concave) plastron. Color dimorphism may be seen in *Trachemys scripta* and *Trachemys dorbignyi,* with males showing an ontogenetic melanism.

Chelonians over 2 years of age and adults may be easily marked according to Cagle's method, which consists of making a notch in the marginal scutes of the carapace following a predetermined code.[7] Newborn and young less than 2 years of age have a less-resistant carapace, so hand drawings and black and white photographs of the pattern of shell markings are preferable for identifying each specimen. Photocopies of the plastron may also be useful for identification.[24] These techniques should be repeated yearly as the chelonian grows.

It is important to record the growth rate of young and adults. Carapace length and width, plastron length

and width, and shell height should be measured according to Medem.[34] Weight should also be recorded.

HOUSING, ENVIRONMENTAL ENRICHMENT, AND DIET The minimum area of an exhibit and other specifications may be defined by national law, as in Brazil.[26] Chelonians may be kept in mixed groups, and, if so, the exhibit must include diverse environments. Diversity is important to improve the behavioral performance of turtles and tortoises. A simulating natural environment contributes to public education. An area exposed to the sun is important for basking, and an area planted with dense arboreal vegetation offers additional options for thermoregulation. Both types of area are important for the nest site selection activities of females of different species.

A substrate of soil covered with dead leaves is a good choice in the area planted with trees and/or shrubs. Bromeliads, philodendrons, and epiphytic plants may be used to aid in the natural environment simulation. *Trachemys dorbignyi* and *Phrynops geoffroanus* females will never nest in areas planted with dense arboreal vegetation. *Trachemys dorbignyi* females prefer to nest in sandy areas without vegetation, and *Phrynops geoffroanus* females prefer to nest in soil with sparse herbaceous vegetation. *Geochelone carbonaria* females are generalists and prefer soil without vegetation in shaded areas, soil with sparse herbaceous vegetation in open areas, and sandy beaches.

An artificial pond is a fundamental requirement for freshwater species, and even tortoises enjoy entering the water. Pond depth should depend on the species involved, but must be deep enough to allow the male to place himself over the female during copulation. The substrate must be smooth to avoid damaging the plastron, and the banks must allow egress from the water. Aquatic plants, such as *Eichhornia* and *Pistia*, may be placed in the pond. Partially submerged stones or logs offer atmospheric basking.

Air and water temperatures depend on the species and the season. Air temperature may be kept between 20 and 30°C. Higher temperatures (e.g., 35°C) should be avoided, and turtles must always have access to adequate microenvironments to thermoregulate, such as a pond of water or a shaded refuge. Lower temperatures (e.g., 18°C) may be tolerated by some southern species (*Trachemys dorbignyi* and *Phrynops hilarii*), but may be critical for northern species (*Podocnemis* spp., *Rhinoclemmys* spp., *Kinosternon* spp., *Geochelone carbonaria*, and *G. denticulata*). Northern species will do better if kept between approximately 24 and 30°C; southern species will do better if kept between approximately 20 and 26°C. Water temperature may usually be kept between 22 and 28°C. Pelomedusids (but less markedly, *Podocnemis unifilis*) are particularly sensitive to cold water. Some southern species, e.g., *Trachemys dorbignyi* and *Phrynops hilarii*, may tolerate lower temperatures (e.g., 15–18°C). Northern species will do better if water temperature is kept between approximately 24 and 28°C; southern species will do better if water temperature is kept between approximately 22 and 26°C. Obviously, water temperature is more important to freshwater species than to terrestrial ones, the opposite being true for air temperature.

Turtles and tortoises may be maintained in indoor exhibits, including aquariums and terrariums, but must be periodically exposed to natural unfiltered sunlight or artificial ultraviolet light (UV) of appropriate wavelength (UVB) to allow the endogenous synthesis of vitamin D_3.[2,18,23]

Naturally designed exhibits are best to provide environmental enrichment for turtles and tortoises. Edible vegetation planted inside the exhibit may stimulate foraging behavior. It is important to determine that plants are not toxic.[18,19] *Geochelone carbonaria* and *G. denticulata* may spend a great deal of time grazing and are particularly fond of *Paspalum notatum* grass.

Mixed exhibits are an interesting option for environmental education and enrichment. Many species of freshwater turtles may be kept together. At São Paulo Zoo (Brazil), the following species have been housed together: *Trachemys dorbignyi* and *Phrynops geoffroanus; Podocnemis expansa* and *P. unifilis; Trachemys scripta elegans, Phrynops hilarii,* and *P. expansa.* Because of the risk of hybridization, housing closely related species should be avoided (e.g., *Trachemys dorbignyi* and *T. scripta, Phrynops geoffroanus* and *P. hilarii, Geochelone carbonaria* and *G. denticulata*). Aggressive species such as *Chelydra serpentina* should not be housed with vulnerable species. At Belem Zoo (Para/Brazil) *Kinosternon scorpioides,* a somewhat aggressive species, is kept together with *Rhinoclemmys punctularia.*

Turtles may be kept in enclosures containing caimans (*Caiman* spp.), but problems may develop if the exhibit becomes overpopulated.

The following procedures are suggested when maintaining mixed exhibits: avoid overpopulation of any of the species involved, keep all the reptiles well fed, know and monitor the caimans' hierarchy.

Chelonians may be kept with mammals, as well. At São Paulo Zoo mixing the following species was successful: *Trachemys dorbignyi, Phrynops geoffroanus,* and *Myocastor coypus* (nutria); *Geochelone denticulata, G. gigantea,* and *Hystrix africaeustralis* (porcupine); *Geochelone denticulata, Tupinambis merianae* (Tegu lizard), and *Myrmecophaga tridactyla* (giant anteater).

Animal matter usually offered in captivity consists of meat (e.g., beef), fish, and invertebrates. Meat must be supplemented with a powdered calcium source, such as steamed bone meal or calcium carbonate, and cannot be the base of the diet. A prolonged deficiency of calcium in the diet, as well as an unbalanced calcium/phosphorus ratio, may lead to metabolic bone disease, a syndrome that is extensively reviewed by Fowler.[17]

Fresh whole fish (including head, viscera, scales, and bones) are not calcium deficient. However, it is important to be sure that the spines and scales will not injury the turtle's digestive tract. An enzyme called thiaminase is found in some species of fish and becomes active after the death of the fish, causing hypovitaminosis B_1. Thawed frozen fish should be supplemented with thiamin.[2,18,19]

Freshwater turtles readily accept earthworms, mealworm larvae, and crickets. Mealworm larvae and crickets must be supplemented with calcium,[2,18,19] and mealworm larvae should be offered only sporadically because of its high level of fat[2] (see Table 3-1 in Frye[18]). Allen and Oftedal[2] discuss the nutrition of carnivorous reptiles, and Frye describes the rearing of some invertebrate prey species.[18,19]

Plant matter usually offered in captivity consists of fruit, leaves, flowers, and other vegetables. Fruit, readily taken by turtles and tortoises, includes banana, papaya, apple, mulberry, pumpkin, and tomatoes. Leaves include chicory, kale, cabbage, mulberry, hibiscus, *Elodea*, and lettuce. *Geochelone carbonaria* and *G. denticulata* are fond of the flowers of hibiscus and *Malvaviscus; G. nigra* readily accepts prickly pear (*Opuntia*). Carrots are also readily eaten by chelonians. Diets containing an imbalance in the calcium/phosphorus ratio, with an excess of phosphorus, must be supplemented with powdered calcium carbonate, bone meal, or a similar calcium-rich material (see examples in Table 7-6, in Fowler[17]). Turtles and tortoises usually accept pelleted commercial dog or cat chows, but these should not be offered in excess.[18,19] Baer discusses many aspects of the nutrition of herbivorous reptiles.[6] Tortoises must have access to fresh drinking water.

Visual and olfactory stimuli are important to stimulate normal foraging behavior. *Geochelone carbonaria* and *G. denticulata* are attracted by red, orange, and yellow colors. Frequency of feeding should depend on the temperature at which the chelonian is kept. During warm months they may be fed five times a week; during cold months they can be fed three times a week.

Special attention must be paid to the diets of the young of such species as *Trachemys scripta* and *Trachemys dorbignyi* that prefer animal matter. To ensure that they also eat plant matter, it is necessary to vary their daily diets, routinely feeding only vegetables on selected days. Another problem that needs special attention is the influence of group hierarchy on food access. Monitoring is necessary to ensure that every turtle in a particular group is feeding well. Hierarchy interference was observed in a group of young *Trachemys dorbignyi* maintained at São Paulo Zoo (Moraes and Molina, personal observation).

EGG COLLECTION, INCUBATION TECHNIQUES, AND HATCHLING CARE After selecting a proper nest site females of all chelonian species lay eggs, usually in cavities dug into the substrate. To achieve the best results, the eggs should be removed from the nests as soon as possible, measured, and artificially incubated. It is advisable to keep the eggs in the same position as they are found in the nest;[1,14,18] parchment-shelled and leathery-shelled eggs may be easily damaged when not handled with proper care. Records should be kept of the nesting process; such facts as female identification, female nesting behavior, nest site selected, nest measurements,[34] and weather conditions, are important to improve knowledge about South American chelonians.[40,41] The eggs should be placed in a plastic container and covered with 1 or 2 cm of moist vermiculite. A 1:1 ratio of vermiculite and tap water, by mass, has been suggested.[34,46] A closed container must be opened periodically to allow aeration; the vermiculite in an open container must be moistened periodically to compensate for evaporation. Egg containers should be placed inside a Styrofoam box supplied with ordinary lamps and thermostats.

At São Paulo Zoo chelonian eggs were incubated at temperatures between 25 to 30°C. *Phrynops geoffroanus, P. vanderhaegei, Podocnemis unifilis, Trachemys dorbignyi, Trachemys scripta, Kinosternon scorpioides, Geochelone carbonaria,* and *G. denticulata* have been successfully hatched. Temperature affects length of incubation,[1,14,42] and in many species determines the sex of the hatchlings.[14,15,29,46] The eggs must be regularly inspected and the increase in the chalky white band must be monitored.[14] Decomposing eggs should be immediately removed.

Newborns should be cleaned with tap water to wash away small flecks of vermiculite that may obstruct the eyes and nares. Sometimes newborns hatch prematurely with a persistent yolk sac. This seems more likely to happen with species that lay parchment-shelled eggs, such as *Trachemys dorbignyi*. Premature hatchlings should be maintained for 24–48 hours between two layers of highly moistened cotton, close to a heat source (at about 30°C). After this period the greater part of the yolk sac will have absorbed and the young are no longer at risk.

Young turtles and tortoises should be kept in individual plastic containers in a heated room (at about 26°C) for 1 or 2 months, during which time they should be

measured and identified (by photographs, line drawings, or photocopies). Usually, normal hatchlings are fed for the first time at the end of the first week. They should be allowed to bask outdoors almost every day.

After 1 or 2 months, they may be transferred to small outdoor enclosures or to 1000-L tanks, where they will live in groups. Internal space may be divided into one-fourth sand and three-fourths water at a depth of 15 cm. Tanks of this size can house about 30 newborns of medium-sized species (e.g., *Trachemys dorbignyi* and *Phrynops geoffroanus*).

At 2 years of age, the tanks can house 10 to 20 young. Individuals older than 2 years of age should be transferred to larger tanks or exhibits. Group density affects growth and survival rates. In studying groups of 5, 10, and 30 young of *Trachemys dorbignyi* maintained in the same kinds of tanks, an inverse relationship between turtle densities and growth and survival rates was observed.

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CHELONIAN INFECTIOUS DISEASES AND GENERAL MEDICINE

Eliana Reiko Matushima

RESPIRATORY TRACT DISEASE

Inadequate temperature and humidity, suboptimal hygiene conditions over inadequate substrate, and vitamin A–deficient diet have been associated with respiratory tract disease.

The absence of a diaphragm in chelonians has functional significance, resulting in an inability to cough and expel secretions and exudate from the lungs. This anatomical restriction undoubtedly contributes to the progress of a respiratory tract infection to pyogranulomatous pneumonia.[2]

Numerous etiologic agents have been associated with respiratory disease in chelonians. Bacterial pathogens such as *Pasteurella* sp., *Streptococcus* spp., *Staphylococcus* negative coagulase; fungal agents such as *Sporotrichium* sp., *Cladosporium, Parcilomyces* sp., *Candida* sp., *Penicilium* sp., and *Aspergillus* sp.; viral agents such as herpesvirus and iridovirus; and *Mycoplasma* have been isolated, as well as metazoic parasites.

Clinical signs of respiratory disease include nasal and ocular discharges, dyspnea and open-mouth breathing, anorexia and weight loss, and lethargy. Aquatic and semiaquatic turtles often show inability to swim or float in proper position due to consolidation or collapse of pulmonary parenchyma.[2]

Diagnostic methods include radiographic examination and tracheal wash using sterile saline. Fluid should be submitted for culture and sensitivity, as well as cytology. Viral isolation may be done if indicated.[3-7]

Therapy for respiratory infections is identical to that employed in higher vertebrates. Based on culture and sensitivity results, a broad-spectrum bactericidal antibiotic should be administrated. Nebulization with antibiotic and mucolytic agents may aid in treatment.

GASTROINTESTINAL TRACT DISEASE

Turtles and tortoises commonly present with chronic hypophagia or anorexia. This clinical sign may result from numerous causes, including infectious or metabolic diseases, parasitism, or gastrointestinal obstruction. Conditions of improper husbandry, including low temperature, stress, inappropriate diet, and failure of the animal to adapt to captivity, all may result in anorexia.[2] Bacterial enteritis, including salmonellosis, may be a chronic condition associated with pneumonia and septicemia or may present acutely resulting in systemic shock and death.

Clinical signs include dehydration, anorexia, lethargy, and decreased body weight. It is common to find bacterial enteritis, amoebic enterohepatitis, chronic parasitism, foreign body ingestion, and obstruction or impaction.

Antibiotic treatment may be recommended based on culture results as well as systemic fluid and electrolyte replacement.

Amoebic enterohepatitis is characterized by clinical signs similar to those of gastroenteritis. The presence of *Entamoeba invadens* is confirmed by the presence of elongated uninuclear trophozoites or rounded quadrinucleated cysts in fecal samples. Treatment with metronidazole at recommended dosages is usually effective, but the patient may succumb to associated hepatitis.[2]

Impaction caused by sand or foreign body ingestion is commonly seen in captive chelonians. Diagnosis is made through radiograph examination and endoscopy,

followed by surgical removal of foreign bodies. Impactions caused by sand ingestion may require surgical procedures, fiber ingestion, or rehydration therapy.

REPRODUCTIVE DISORDERS

Dystocia is the most common reproductive disorder encountered in chelonians. Causes of dystocia include poor environmental conditions leading to chronic debilitation, metabolic disorders, anatomic anomalies of the reproductive tract or eggs, and repeated copulation resulting in broken eggs.[2]

Common clinical signs include anorexia, lethargy, history of straining to pass eggs, and hemorrhagic discharge from the cloaca. Diagnosis is usually based on radiographic evidence of retained eggs.

Treatment should be based on radiological evaluation. If no evidence of obstructive dystocia is present, administration of calcium gluconate and 5% dextrose may stimulate oviposition. Oxytocin should be used with extreme caution and only in animals that do not respond to initial treatment. If radiographs reveal fractured eggs or anatomic abnormalities preventing oviposition, surgical intervention is recommended. Eggshell fracture, oviduct laceration, and contamination of the ceolomic cavity with yolk commonly result in yolk seroceolomitis. Surgical repair may include copious lavage of the ceolomic cavity with warm physiologic saline. Antibiotic therapy should be instituted. In chronic cases, prognosis for recovery is poor once fibrinous ceolomitis occurs.[2]

Male chelonians occasionally demonstrate penile prolapse as a result of trauma, infection, neurologic deficiency in the retractor apparatus or cloacal sphincter, or impaction of urate material in the cloaca. Simple cases of prolapse may be treated by cleansing, lubricating, and replacing the penis. A temporary cloacal purse-string closure may be indicated for retention. If the prolapse is accompanied by swelling of the penis, application of a hygroscopic fluid may reduce swelling and permit replacement. If the penis is traumatized or desiccated, amputation may be indicated.

METABOLIC AND NUTRITIONAL DISEASE

Dietary imbalances commonly cause disease in captive chelonians. Usually it results from improper mineral balance, vitamin deficiencies, and excessive protein levels in the diet.

Metabolic bone disease is one of most common nutritional disorders in captive chelonians. For a discussion of this disease, see Specific Nutritional Disorders.

Excessive dietary calcium and vitamin D_3 may be problematic when chelonians are fed commercial pet foods. Mineralization of smooth muscle and renal tissue is often a secondary necropsy finding in animals that have been maintained on dog, cat, or monkey food.

Vitamin A deficiency is most commonly observed in captive turtles maintained on a high-protein, vitamin A–deficient diet. Clinical signs include conjunctivitis, blepharitis, and swelling of the adnexae. In vitamin A deficiency, mucin production decreases, and the glandular structure of the eyes and respiratory passages undergo squamous metaplasia. Hyperkeratosis and squamous metaplasia of ocular, nasal, and pharyngeal mucosal epithelia result in secondary invasion of these surfaces by opportunistic pathogenic microorganisms. Administration of parenteral or oral vitamin A and correction of dietary deficiencies are recommended. Chronic cases of vitamin A deficiency usually require antibiotic therapy for pathogenic microorganisms that have secondarily invaded damaged mucous membranes.[2]

Hyperuricemia or gout occurs frequently. Diets containing excessive levels of animal protein, reduction of renal perfusion caused by dehydration or nephrosis, and renal tubular insult from nephrotoxic drugs may all result in visceral, articular or periarticular gout. Terrestrial chelonians fed concentrated sources of animal protein will develop a high serum concentration of uric acid. Iatrogenic hyperuricemia may result from the administration of aminoglycosides or sulfonamides at elevated dosages or in the presence of clinical dehydration.

Clinical signs of hyperuricemia include lameness, joint swelling, and elevated serum uric acid concentrations. Radiographs of affected areas may reveal radio-opaque lesions associated with urate crystal deposition. Therapy must include correction of the primary cause of hyperuricemia. Urate depositions can be removed aseptically from affected joints. Subsequent anti-inflammatory therapy has proven beneficial. Systemic therapy should be monitored by sequential measurements of serum uric acid concentrations.[2]

DISEASES OF THE SHELL AND SHELL REPAIR

Abnormalities of the shell are usually the result of trauma or improper environmental conditions, although several organisms have been isolated in association with shell disease. There are reports of shell lesions in captive chelonians caused by *Mucor* sp., *Proteus* sp., *Escherichia coli*, *Pseudomonas* sp., and *Baneckea chitinovora*, and even viral agents such as poxvirus.[3,9] Additionally, the detachment and loss of keratin scutes has been associated with elevated serum uric acid concentrations during

renal failure. Treatment of shell disease typically involves debridement and topical antimicrobial therapy. After associated infection has been resolved, the defect can be repaired with epoxy resin.

A specific disease syndrome, septicemic cutaneous ulcerative disease, has been identified in aquatic turtles. It is characterized by cutaneous ulceration, anorexia, lethargy, and septicemia progressing to death as the ulcers deepen. Soft-shelled turtles of the family Trionychidae are most frequently affected, and the associated etiologic agent has been identified as a gram-negative bacteria. This disease has been treated with bactericidal antibiotics and supportive care.[8]

Traumatic shell injury is one of the most common clinical presentations of all types of chelonians. Whole-body radiographs should be assessed to determine the extent of injury to the bony shell and appendicular skeleton. If limb paralysis or paresis is present, prognosis for recovery is poor.

Areas of shell trauma should be debrided and devascularized fragments of bone removed. Lavage with sterile saline will greatly reduce associated infection, and antibiotic therapy should be initiated. In grossly contaminated fractures or old injuries, final shell repair is done after a healthy bed of granulation tissue has been established. Repair of the shell may require placement of wires to hold pieces in apposition, or layers of sterile fiberglass cloth impregnated with rapid polymerizing epoxy resin may be used to bridge defects. The periphery of the defect should be cleaned with ether or acetone, and the epoxy resin mixed and applied to the periphery of the defect, avoiding contact with the edge of the shell or soft tissues.[2]

Alternatively, shell defects may be repaired with hoof repair acrylic or dental acrylic. Dental acrylic is useful if the shell repair contacts soft tissue, because this material is nontoxic and does not generate heat in association with polymerization. Hoof acrylic is more difficult to manipulate than resin but is extremely strong and durable for shell repair of giant tortoises.

NEOPLASIC DISEASE

The most frequent neoplasic disease observed nowadays is fibropapilloma in sea turtles. It is a neoplasia that originates in the epithelium and is benign. It may be a papilloma or a fibropapilloma, depending on stromal and/or epithelial proliferation.

Papillomatous formations may be variable, with solid tissue projections varying in consistency from soft to firm and diameters from 0.5 to 10 cm. These formations may have vegetative and verrucous forms, with papillar aspects or a more regular surface. The color may vary from whitish to grayish or be several tones of pink. Some papillomatous formations, as a result of their high stroma vascularization and traumas suffered by the animals, present ulcers with discrete hemorrhage and may or may not be parasitized by small trematode larva. The papillomatous formations may be in pelvic or thoracic limbs, head, dorsal cervical area, eyelid, oral region, inguinal or pericloacal area. It is possible to find papilloma in all of the areas mentioned in a single animal. The number of papilloma found in a single sea turtle may vary from 2 to 100.

Through the use of polymerase chain reaction (PCR) amplification, an alphaherpesvirus, a retrovirus, and a papillomavirus have been identified in fibropapillomatous lesions of sea turtles.

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CHELONIAN NONINFECTIOUS DISEASES

Margarita Mas

SPECIFIC NUTRITIONAL DISORDERS

Most nutritional problems arise during active growth. Malnutrition may be the major cause of mortality in juveniles and young adults. Deficiencies and over feeding generally appear in combination, for example a tortoise with a softened shell caused by an inadequate calcium/phosphorus ratio in the diet may also suffer generalized edema in its limbs as a result of renal failure caused by too-high ingestion of protein.

METABOLIC BONE DISEASE

By far, metabolic bone disease is the most common of nutritional disorders of chelonians, usually resulting from ignorance of the requirements for an adequate diet. Instead, animals may be fed a diet with an inadequate calcium level, a too-high level of phosphorus, an unsuitable level of vitamin D_3, and too much protein. Turtles that in freedom eat a great variety of prey receive only minced meat in captivity, and tortoises that usually eat many different plants are fed lettuce as the major food item.

These management errors lead to progressive distortion in the shape, size, and consistency of the shell. These distortions are first evidenced by the softening of the plastron and motor function difficulties. When decalcification becomes severe, there is smoothing and lordosis in the region above the pelvis, and often dyspnea also occurs as a consequence of the decrease of the pulmonary space and pain when touched (Fig. 3.1 and Fig. 3.2). Radiographically, a loss of bone density and spontaneous fractures may be seen.

Management is diet correction, improvement of the environment and administration of calcium and vitamin D_3.

VITAMIN A DEFICIENCY

Although vitamin A deficiency is found in both tortoises and turtles, it is more common in turtles. Vitamin A is fat soluble, and a deficiency leads to squamous metaplasia of glands around the eye and in the oral cavity, kidneys, and respiratory and digestive systems.

Clinical signs observed are palpebral edema and conjunctivitis, dyspnea or a respiratory illness, stomatitis, skin hyperkeratosis, and, in severe cases, renal failure, hepatic failure, and death.

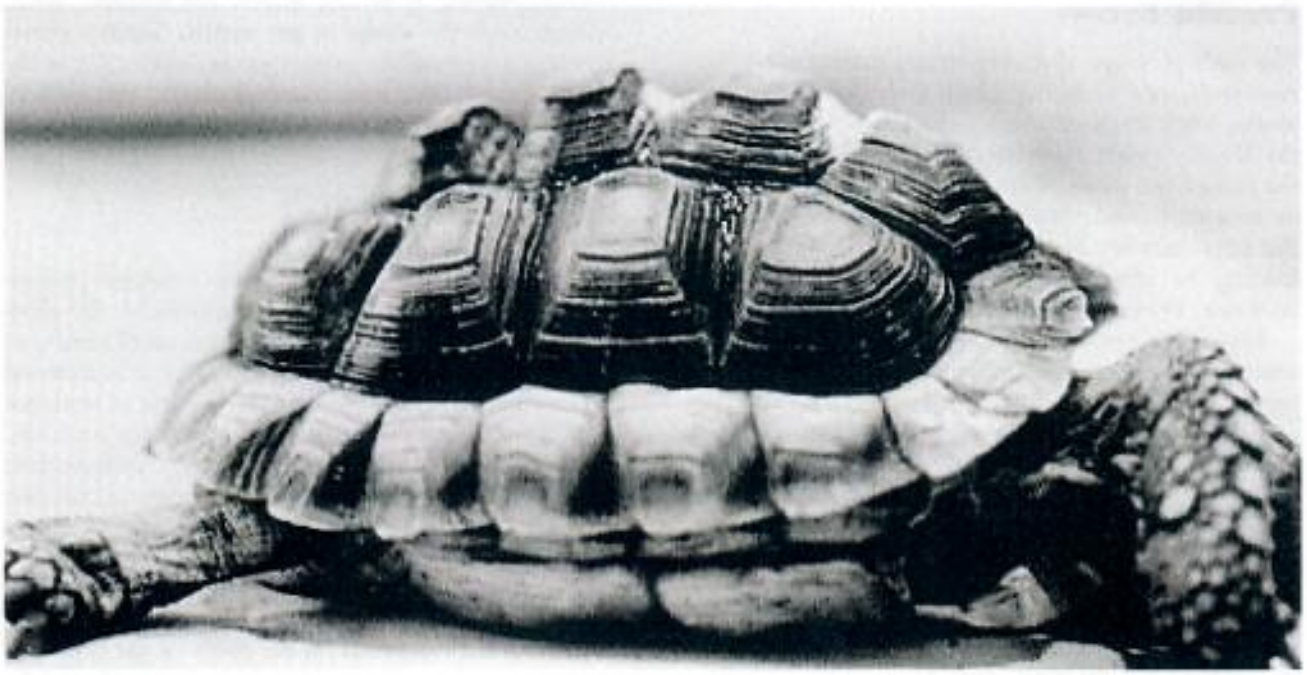

FIGURE 3.1. High levels of protein stimulate excessive growth of the carapace.

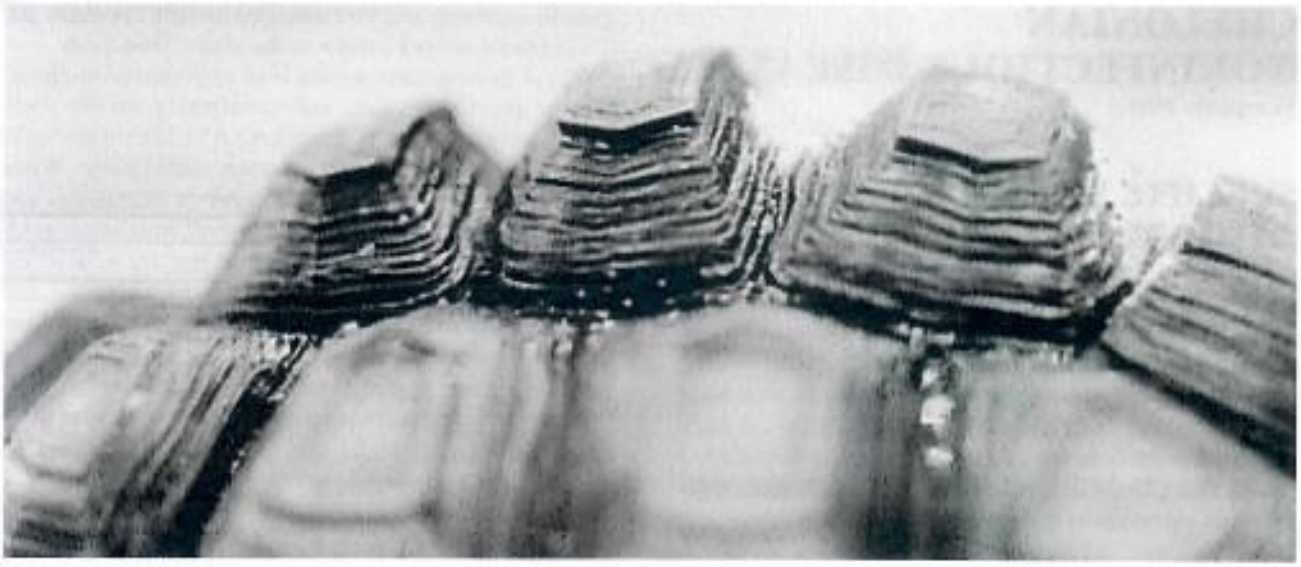

FIGURE 3.2. Nonreversible pyramidal shape of the carapace as a result of high-protein diet during growth.

Management

Management is vitamin and mineral supplementation, correction of the diet by adding natural sources of vitamin A, such as fruits and vegetables containing carotene, and treatment of the secondary infections. Excessive levels of vitamin A may cause toxicity, resulting in lesions similar to those caused by deficiency, such as skin thickening and sloughing with serious secondary effects.

Protein Excess

The main problem of protein excess occurs in herbivorous testudines when fed a high protein diet of animal origin. High levels of uric acid and urea accumulate in the blood, causing a precipitation of these elements into the tissues and joints, a process known as gout (visceral or articular). Also, formed crystals may precipitate in the renal tubules, blocking them (renal constipation), leading to renal failure. Affected tortoises show anorexia, edema and, finally, death.

High levels of protein in the diet of growing chelonians cause an abnormal development of the shell, with pyramidal distortion of the shields (Figures 3.1 and 3.2), melanistic coloration resulting from hyperplasia of the keratin coat and softening of the shell because of nutritional osteodystrophia and, as a consequence of renal complications, edema and death caused by renal failure.

Other diseases related to nutritional imbalances are steatitis, common in aquatic turtles that ingest high levels of fatty acids. This condition is characterized by obesity, accumulation and degeneration of fat deposits, and icterus because of hepatic lipidosis.

INTOXICATIONS

Most intoxications occur accidentally when certain poisons are incorporated into the environment or captive surroundings, either directly or indirectly. The use of disinfectants, such as alcohol or phenol derivates, or aerosol or liquid insecticides is a common cause of iatrogenic intoxication when they are used improperly as external antiparasitic agents.

Intoxications in private homes are frequent when owners paint the shells of pet turtles. Garden plants may also be hazardous (potato leaves, lobelia, lily of the valley, lupine, foxglove, rhododendron, delphinium, cyclamen, and certain mushrooms).

CONSTIPATION

Another frequent problem, especially in tortoises, is constipation, which may be caused primarily by the accumulation of dry matter, e.g., cage litter, small stones, or other materials in the intestine. In turtles, it is common to find stones or gravel ingested, because the animals are often fed in an area where these materials are available.

Secondary constipation is caused by dehydration, tumorous masses, a retained egg, or cystic calculi that compress the intestine by occupying the celomic space. Traumatisms and metabolic bone disease may lead to a paresis of the hind and fore limbs, with fecal retention as a result.

Management depends on the cause of the constipation. With primary constipation, animals should be

hydrated and bathed with warm water (30°C) once or twice a day to stimulate defecation. Mild laxatives such as vaseline or milk of magnesia may be administered orally or by enema. In serious cases a celiotomy is necessary.

ANOREXIA

Anorexia is a common ailment of chelonians. If turtles fast for 3–4 weeks or fail to drink for 10 days, it is a sign of illness. Posthibernation anorexia is common, especially in malnourished animals or those subject to low temperatures during the winter. Anorexia also occurs in females with egg retention and animals infected with parasites or that suffer from metabolic illnesses. Anorexia may also be induced by factors related to the environment, such as below-optimal temperatures, inadequate habitats or terrariums, and the use of diets that do not encourage an interest in food. Although not related to pathologic causes, male anorexia is common during the breeding season.

Management should begin with correction of environmental factors, hydration, reestablishment of glucose levels, and decrease of uremia. Forced feeding using a gastric tube may be necessary.

ENDOPARASITES

Flagellate Protozoans

Many factors may be involved in fostering the presence of flagellates in turtles and tortoises, including inadequate management of the diet (low in fiber or extremely rich in sugar), high population density, incorporation of new individuals into a mixed group, poor sanitation, and high temperature and humidity. Some protozoans such as *Trichomona, Giardia,* or *Leptomonas* are considered to be nonpathogenic in the majority of reptiles, but a large number of one or more of these parasites combined with other infectious or parasitic agents may contribute to illnesses, including diarrhea, dehydration, anorexia, and emaciation.

Diagnosis is accomplished by observing the parasite or parasites in fresh fecal samples. The recommended treatment is administration of metronidazole and immediate correction of the predisposing factors.

Hexamita parva is a highly pathogenic flagellate of the urinary system, capable of producing acute or chronic nephritis that may lead to renal failure in either tortoises or turtles. Some tortoises, such as *Geochelone* spp., are particularly sensitive. Signs include anorexia, weight loss, polydipsia, and green-colored urine containing mucous filaments, excessive sediment, and blood remnants, and with a strong, penetrating odor.

Diagnosis may be accomplished by microscopic examination of fresh or manually removed urine. Treatment and improvement of environmental conditions should be immediate.

Other Ciliate Protozoans

Nyctotheurus kyphodes, N. teleacus, and *Balantidium* spp. have been found in species of the genus *Geochelone,* but they have not been proven to be agents of illness. It is possible that they are normal microflora and participants of the digestive process.

Coccidia

Although coccidial organisms are commonly found, signs must be present to diagnose disease.

MANAGEMENT Numerous drugs have been used in treatment. Trimethoprim sulfadiazine, in doses of 15–30 mg/kg every 48 hours for 10–14 days, works well.

Helminths

Nematodes are the most common parasites found in chelonians. The best known are roundworms, of which the ascarids (8–10 cm long, yellowish and white) and oxyurids (1.5–8 mm long, thin and whitish) are by far the most common.

Signs depend on the number of parasites present, but include anorexia, vomiting, diarrhea, or, in some cases, constipation caused by obstruction of the intestine.

THERAPY Fenbendazole in a dose of 50 mg/kg, repeated after 14 days, or oxfendazole, at 60 mg/kg in a single dose, is recommended. The largest expulsion will occur during the first 7–10 days, decreasing remarkably after the second dose of fenbendazole. It is advisable to conduct routine fecal examinations every 6 months.

EXTERNAL PARASITES

Fly strike and myiasis are common following lacerations or trauma. Ticks may also be found.

A pyrethrin solution can be used topically around the wound, but not in it. The most important action is thorough cleansing of the wound, eliminating larvae, and careful disinfection with povidone iodine or a dilute hydrogen peroxide solution, along with administration

of local and systemic antibiotics. Amitraz (2 mL/L water) is used for tick control. Ivermectin is toxic for chelonians and should not be used.

HANDLING

Small tortoises may be managed easily by applying mild pressure to the head or tail area to cause the opposite end to be exposed. The head may be grasped immediately behind the occipital crest. A brief struggle may ensue, but relaxation will occur. In larger tortoises, the operator should sit, put the animal between his or her knees, and softly tap on the caudal shield with the fingers until the head appears. The head should then be grasped firmly with one hand, using the other to manipulate, probe, and examine the mouth.

When handling box turtles, which have kinetic plastral hinges, it is necessary to use scissors (Mayo) or another instrument as a lever to open the shell. The opening may be blocked with a sponge or one of the limbs may be held outside the shell to avoid closure of the trap door on the handlers fingers.

Terrapins and soft-shelled turtles (*Trionix* spp., *Phrynops* spp.) may bite or claw severely, especially those with long necks that can be extended backward or laterally and that have long sharp nails. Small individuals may be handled from the back by placing a finger in the inguinal fosse. For larger animals it is necessary to use gloves or to allow them to bite on an object to extend the head.

Special care should be taken with the snapping turtle (*Chelydra sepentina*) because the jaws are hooked and prominent, and they may bite suddenly, inflicting severe lacerations or crushing injuries. If the operator suspects a serious personal risk, especially with large or aggressive individuals, chemical immobilization is recommended to produce restraint sufficient for a thorough examination and/or therapy.

ANESTHESIA

Preanesthetic requirements are the same for all species of reptiles and needn't be reiterated here. It is important to obtain an accurate weight for calculating anesthetic agent dosage and fluid loss after surgery.

Preanesthetic Drugs

The use of atropine sulfate (0.01–0.04 mg/kg) is recommended for small turtles to avoid excessive secretions. Acepromazine maleate (0.1–0.5 mg/kg) may be used to reduce the amount of the induction agent required. Administration of the combination of zolazepam with tiletamine (4–6 mg/kg) helps diminish muscle rigidity produced by tiletamine and aids in induction for intubation, but it is not advisible as the only anesthetic drug.

Injectable Anesthetics

Injectable anesthetics are used, but inhalant agents are much preferred. When ketamine hydrogen chloride is used as the sole anesthetic, total analgesia is not achieved. It should not be used in patients with renal or hepatic pathologies or in dehydrated animals because of the slow metabolic and detoxification mechanisms of chelonians. In healthy tortoises, doses are 60–80 mg/kg. A dose for producing relaxation before endotracheal intubation is 20–40 mg/kg.

Inhalant Anesthetics

Although halothane is frequently used, the recommended agent is isoflurane. With the latter, induction and recovery are rapid. Both agents require the use of a precision vaporizer. The anesthetic level should be checked with a pulse oximeter, with the sensor attached to a flap of skin on the hind limb. The heart should be monitored with an ECG and reflexes should be tested (palpebral, corneal), as well as the pain response, Figure 3.3.

SURGERY

Common chelonian surgeries include limb amputation (Figure 3.4), penis amputation, and celiotomy (egg retention, stones, ingested foreign bodies). General surgical principles should be followed.

Cystotomy

Urolith formation is not uncommon in tortoises. It is generally related to nutritional disorders or long periods without water. Signs vary according to the size and number uroliths, but include depression, lethargy, constipation, and hind limb paresis. The majority are urates and they may be as large as 10 to 12 cm in diameter. They may be palpated during a physical examination and are easily diagnosed through radiography.

When uroliths are small, a lateral celiotomy may be performed by placing the tortoise on its right side with the hind leg withdrawn caudally. The celomic cavity is entered through an incision and division of the muscles until the bladder and its stones are detected. Special care should be taken with the bladder wall, which is generally thin. The incision in the bladder should be closed with absorbable sutures 4-0, in a two-layer inverting pattern.

FIGURE 3.3. Anesthetic control with a sensor and an oximeter pulse connected with MPD, and three ECG leads to monitor heart rate. Body temperature is maintained through a heating pad.

FIGURE 3.4. Amputated rear leg. In chelonians it is advisable to amputate the entire leg to diminish skin abrasion.

The muscles should be closed with continuous sutures and the skin with everted sutures. Larger uroliths require a window to be opened through the plastron. The technique is described in many reptile medicine texts.

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