

# Nutritional Secondary Hyperparathyroidism in Reptiles

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**N**utritional secondary hyperparathyroidism (NSHP) is one of the most common disorders in captive reptiles. Veterinary technicians can play a primary role in client education, which is the foundation of preventing NSHP. With knowledge of the pathophysiology of NSHP as well as the dietary and husbandry protocols for managing it, veterinary technicians can help clients establish proper husbandry practices.

## Homeostasis of the Skeletal System

Bone health comprises several internal and external factors that work together to maintain the integrity of the skeletal system.

### Calcium

Calcium is responsible for many biologic functions, such as muscle contractions, blood clotting, nerve transmission, myocardial function, and the development and integrity of bones and teeth.<sup>1</sup>

### Phosphorus

The most important functions of phosphorus are to build and maintain teeth and bones. For these functions, a serum calcium:phosphorus ratio of 1:1 to 2:1 must be maintained.

### The Ultimobranchial Gland

The ultimobranchial body is located in the same area as the thyroid gland, thymus, and parathyroid glands.<sup>2</sup> In reptiles, an increase in the serum calcium level causes the ultimobranchial gland to release calcitonin, which pulls calcium from the blood.<sup>3</sup> This prevents calcium from being pulled from bone.<sup>4</sup>

### The Parathyroid Glands

The parathyroid glands produce parathyroid hormone (PTH) to help regulate blood calcium homeostasis. PTH helps prevent hypocalcemia by increasing the blood calcium level if it gets too low. PTH does this by causing the kidneys to resorb more calcium, causing the intestines to absorb more calcium from food, and withdrawing calcium from bones.<sup>3</sup>

### Vitamin D and Ultraviolet Radiation

By acting as a hormone, vitamin D<sub>3</sub> helps the body to absorb calcium. Reptiles produce vitamin D<sub>3</sub> in a conversion process that

involves ultraviolet (UV) radiation.<sup>5</sup> UVB radiation is critical to the overall well-being of reptiles because it helps convert cholecalciferol into an inactive form of vitamin D in the skin. Through pathways that involve the liver and the kidneys, the vitamin is further converted into vitamin D<sub>3</sub>. This cannot occur without UVB radiation.

## Pathophysiology

In NSHP, the parathyroid gland produces a high level of PTH as a result of hypocalcemia due to (1) mismanagement of the patient's diet and husbandry and (2) abnormal intestinal absorption. To maintain an appropriate blood calcium level, calcium is pulled from the skeletal system, resulting in weakened bones.<sup>5</sup> As the blood calcium level decreases due to NSHP, PTH is released, resulting in chronic bone resorption, renal tubular reabsorption of calcium, and phosphate excretion by the kidneys.<sup>5</sup> This calcium level deficit results in partial depolarization of nerves and muscles due to an increase in the threshold potential. Clinical signs presumed to occur in reptiles include paresthesia around the mouth and on the digits, carpedal spasms, and hyperreflexia.<sup>5</sup>

## Affected Reptiles

Herbivorous and insectivorous reptiles, including Chinese water dragons (*Physignathus cocincinus*), green iguanas (*Iguana iguana*), and leopard geckos (*Eublepharis macularius*), have a high incidence of NSHP because they depend greatly on UVB radiation, vitamin D supplementation, and proper diet to maintain proper levels of vitamin D and calcium. It is uncommon for carnivorous reptiles to present with NSHP unless they are fed an inappropriate diet of infant or young-adult prey, which do not have fully calcified bones.

### Key Points

- NSHP is due to poor husbandry and dietary mismanagement of captive reptiles.
- Treatment is aimed at reversing the effects of PTH and bone loss, establishing new bone growth, and correcting husbandry and dietary mismanagement.
- Client education is the cornerstone to reducing the incidence of NSHP.

## Husbandry

Failure to provide an environment that mimics a reptile's natural habitat is a primary contributor to NSHP. Therefore, it must be made clear to clients that NSHP can be treated only if they commit to correcting poor husbandry.

## Temperature

Proper environmental temperature is essential for maintaining a reptile's normal functions for survival. Most reptiles are ectotherms: they use a thermal gradient to facilitate digestion and increase antibody production; therefore, their enclosures should provide a thermal gradient, specific to their species, within the preferred optimal temperature zone.<sup>6</sup> Most diurnal reptiles require a daytime air temperature of 80°F to 95°F with a basking area of 85°F to

100°F. Nocturnal or montane reptiles do well with a daytime air temperature of 70°F to 80°F, depending on the species. For most reptiles, the nighttime air temperature should not drop below 70°F during their active season, which varies by species and native habitat. For most reptile species, an environmental temperature of 60°F to 70°F for an extended period of time does not allow optimal immune function or healthy digestion.<sup>7</sup> Temperatures that are too high for a species can induce stress, resulting in life-threatening behaviors, such as anorexia.

## Photoperiod

Day and night cycles are associated with the overall well-being of reptiles. If the cycles are too short or too long within 24 hours, psychologic and physiologic problems can develop. For example, abnormal photoperiods can lead to obesity.<sup>7</sup> Animals that should hibernate or stop eating during the winter continue to eat if they are not exposed to appropriate photoperiods.<sup>7</sup>

Photoperiods are based on daily and yearly activity

requirements. Many tropical and subtropical areas have approximately 10 hours of daylight in the winter and 14 hours of daylight in the summer; temperate areas have approximately 8 hours in the winter and 16 hours in the summer.<sup>8</sup> Native photoperiods should be replicated when possible in captive environments.

## Lighting and Heating

Many owners think that placing a reptile's cage or tank in a sunny window provides adequate UV light. However, glass and plastic filter out necessary UV radiation. In my experience, many novice reptile keepers use regular household lightbulbs for their reptiles. These bulbs lack natural radiation or other qualities of sunlight needed by reptiles and can emit high levels of heat, which can burn reptiles. If these bulbs are used, mercury vapor or fluorescent UV bulbs must also be provided. The physiologic well-being of reptiles, including normal behaviors and activities, is improved with the use of fluorescent bulbs that provide qualities similar to sunlight.<sup>8</sup> Most reptiles need bulbs that emit UVA and UVB radiation. Radiation from UV bulbs decreases over time, so they need to be replaced with new bulbs every 6 months. Because enclosure lamps can pose a threat to reptiles, the manufacturer's recommendations should be observed carefully.

Any heat source can cause burns if a reptile can come into direct contact with it. Even if the heat source is hidden, the reptile may find a way to get near it. Hot rocks often become progressively hotter with age and burn large reptiles.<sup>7</sup> Therefore, hot rocks should not be used.

Along with UV radiation, vitamin D<sub>3</sub> synthesis requires heat.<sup>8</sup> Heat can be provided using substrate heaters, heat strips, heat tapes, and various lights. The target temperature range varies depending on the reptile species.

## Water and Humidity

Inadequate ventilation can promote bacterial and fungal growth when the humidity is high. This can contribute to respiratory, fungal, and bacterial infections.<sup>7</sup> If the humidity level is too low for a reptile species, chronic dehydration can develop.

Arboreal reptiles do not spend much time on the ground, so providing their primary water source on the floor of their enclosure is not appropriate. Water dishes that are too tall, wide, slippery, or otherwise difficult for reptiles to enter or exit can result in dehydration or drowning.<sup>7</sup> Many reptile species lose water through their skin when deprived of appropriate soaking areas or subjected to excessively dry environments.<sup>8</sup>

The appropriate water and humidity levels for reptiles depend on the natural environment of the species.<sup>8</sup> The many ways to provide these requirements include misting the environment several times a day, setting up a drip system, and providing foods with a high water content. A warm-water soak once a day or a few times a week has also proven to be of value.

## Enclosures

Fish aquariums have always been used for housing reptiles; however, these enclosures may not be suitable for many common, captive

## Glossary

**Arboreal**—pertaining to tree-climbing reptiles

**Dusting**—placing insects and a powdered supplement in a sealed bag and shaking it until the insects are coated with the powder

**Ectothermal**—pertaining to reptile behaviors for maintaining internal temperature through the environment

**Gut loading**—ensuring a balanced diet by adding supplements or natural foods to a diet of insects or other prey

**Hyperuricemia**—a high level of uric acid in the blood

**Montane**—a cool, moist ecologic zone that is usually near a timberline

**Myocardium**—muscular layer between the epicardium and endocardium of the heart

**Paraplegia**—motor and sensory paralysis of the entire lower half of the body

**Photoperiod**—number of daylight hours suited for growth and maintenance

**Pinkies**—neonate rodents used to feed carnivorous reptiles

**Temperate**—a climate that is neither very hot nor very cold

**Temperature gradient**—a temperature change from one area to another

species. Most fish aquariums are too small or have a shape that is not conducive to behaviors or ventilation necessary for a reptile's optimal health and well-being. In addition, some aquariums may allow reptiles to escape. Reptiles that continually try to escape through glass or pace the bottom of their enclosure may damage the rostral portion of their noses and jaws.<sup>7</sup> Placing nontransparent barriers along the bottom of the enclosure can prevent some lizard species from trying to escape through the glass. Glass enclosures specifically designed for reptiles are available.

Wire cages should never be used to house a reptile. They cannot provide the necessary environment for a healthy reptile. Appropriate temperatures and humidity levels cannot be achieved, and the spaces in the wiring can result in injuries.

Unless cages made of wood are obtained from a reputable reptile cage manufacturer, they are inappropriate because they can be difficult to clean and disinfect. The surface of the wood can be abrasive, and high humidity can warp the wood over time. This can weaken the cage, possibly resulting in escape or injury of reptiles.<sup>7</sup> Reptile owners can make their own cage, but this requires a lot of research, time, and money.

**BOX 1** lists companies that manufacture appropriate cages for various types of reptiles.

There are no maximum limits to the size of an enclosure because any reptile will do better in the largest space possible.<sup>7</sup> Regardless of the style of enclosure, all reptiles need room to move and thermoregulate. Arboreal species should be housed in enclosures that are taller than they are long, with tree branches placed vertically.<sup>9</sup> To meet their need for floor space, terrestrial species should be housed in enclosures that are longer than they are tall.<sup>7</sup> Terrestrial species should also be provided with hiding places such as boxes, tree trunks, or rocks.<sup>8</sup>

Cleanliness is essential to keeping reptiles healthy. Obvious soiling of the environment should be cleaned daily, and the entire cage and furniture should be thoroughly cleaned weekly or biweekly. This can help prevent the growth of harmful bacteria and fungi.<sup>8</sup>

### Substrates

Natural substrates that are inappropriate or improperly maintained can contribute to medical problems in reptiles. Sand or crushed pecan or walnut shells can cause (1) intestinal impaction if ingested by small lizards or (2) fungal outbreaks if not cleaned properly. Many types of wood chips can harbor bacteria or fungi in moist, improperly ventilated environments, and pine or cedar chips can be dusty and too dry for some species, contributing to respiratory infections.<sup>7</sup>

Substrates should be easy to clean and safe for reptiles and should not allow microbial growth.<sup>10</sup> If a sand substrate is used, the reptile's food should be provided in a dish—not on the sand. Newspaper is easy to clean but may leave nontoxic ink marks on reptiles. Most veterinarians and other reptile professionals recommend Astroturf or reptile carpet because it is easy to clean and can be replaced. In my opinion, peat moss or bark designed specifically for reptiles can also be used, but it must be cleaned and maintained daily.

### Box 1. Manufacturers of Appropriate Reptile Cages

- Big Apple Pet Supply ([bigappleherp.com](http://bigappleherp.com))
- Cages by Design ([www.cagesbydesign.com](http://www.cagesbydesign.com))
- Cen-Tex Custom Reptile Cages ([centexreptilecages.com](http://centexreptilecages.com))
- Custom Cages ([customcages.com](http://customcages.com))
- Lizardcages.com

### Dietary Management

Because the dietary needs of reptiles can be confusing as well as challenging to meet, most reptiles are categorized according to four dietary groups. This facilitates discussion of dietary recommendations with clients. However, clients should also be advised to research the dietary recommendations for their pet's species, as the requirements may be more specific.<sup>6</sup> To help ensure that the information is accurate, veterinary hospitals can provide client handouts.

### Supplementation

A complete and proper diet can help contribute to overall health. However, clients should be given information on supplementation, especially for juvenile reptiles, which grow rapidly. Powder supplementation can contribute to toxicities due to oversupplementation or nutrient deficiencies due to undersupplementation or lack of absorption.<sup>10</sup>

It is best to use a broad-spectrum supplement. A separate supplement should provide calcium only or calcium with vitamin D<sub>3</sub>, but without phosphorus.<sup>10</sup>

### Herbivores

Many nutrient deficiencies in herbivores are due to misunderstanding the dietary requirements of the species. A high amount of protein, usually from animal sources, can result in primary visceral gout (secondary to hyperuricemia<sup>9</sup>) and renal failure. Animal proteins should not be fed to herbivorous animals. It is thought that green iguanas have developed soft tissue calcification from being fed cat food.<sup>11</sup> Feeding oxalate-rich produce, such as spinach and carrots, or cruciferous vegetables, such as broccoli, can prevent calcium absorption by the intestines.<sup>10</sup>

Herbivorous reptiles are the most challenging to feed. Most of the diet must consist of vitamin- and calcium-rich leafy greens such as kale, okra, sprouts, collard greens, dandelion greens, and bok choy. The rest of the diet should consist of other vegetables, such as green beans, corn, peas, bell peppers, and zucchini, as well as mushrooms (which are fungi). Approximately 10% of the diet can include the following fruits: bananas, apples, peaches, pears, plums, strawberries, apricots, and melons.<sup>8</sup>

### Insectivores

The most commonly fed invertebrate prey are crickets and worms, both of which contain a lot of fat and protein but are usually deficient

in calcium.<sup>10</sup> Dusting may not be as valuable as once thought and may be less effective than gut loading. A balanced diet can consist of approximately 90% dark green or colored vegetables and approximately 10% crickets and/or worms. In addition, a wide variety of insects, including moths and flies, should be included in the diet. Feeding *Hermetia illucens* (i.e., Phoenix worms) has become increasingly popular. Their larvae (fly maggots) are higher in calcium than other commonly fed insects and are accepted by most reptiles.

### Carnivores

Reptiles fed primarily pinky mice or rats will not get enough calcium. The skeletons of these neonate prey are not sufficiently calcified and, therefore, do not provide the correct calcium:phosphorus ratio. Organs (liver, heart, kidney, gizzard) or muscle meats (ground beef, chicken, turkey) have an incorrect calcium:phosphorus ratio and, therefore, should not be fed to carnivorous reptiles on a long-term basis.<sup>6</sup> These reptiles need a high level of good-quality protein along with a high level of animal fat.<sup>12</sup> Recommended foods include adult fish, mice, and rats—preferably frozen to prevent them from injuring the reptile.

### Clinical Signs

Early signs of NSHP include a swollen, deformed jaw, and affected reptiles may drag themselves along the ground due to decreased density of their skeletal system. As the disease progresses, spontaneous fractures can distort a reptile's spine, ribs, or tail.<sup>11</sup>

In adult reptiles, the clinical signs tend to be associated with the nervous system. Early signs include twitching of the toes, limbs, or tail. Twitching and muscle tremors become more severe and frequent, resulting in weakness and muscle flaccidity.<sup>13</sup> Pathologic fractures and seizures are other presenting signs.

### Diagnosis

In most cases, reptiles present with jaw swelling, facial deformities, and anorexia. Abnormalities of the jaw may prevent proper breathing and mastication. Compression fractures of the vertebrae may cause paraplegia and decrease the growth rate of juveniles.<sup>13</sup>

Biochemical measurements of calcium and phosphorus are used to confirm NSHP, not to rule it out. A normal calcium level is 8 to 11 mg/dL.<sup>4</sup> The total plasma calcium level is usually normal until the terminal stage of the disease. Therefore, the ionized calcium level may be more useful than the total calcium level. Because of various factors that affect the total calcium measurement, it is best to measure the ionized calcium level to confirm a diagnosis of NSHP. This helps determine the physiologically active blood calcium level for developing a treatment plan.<sup>4</sup> The calcium:phosphorus ratio should also be determined. A low calcium level in conjunction with a high phosphorus level suggests, but does not confirm, NSHP.

Radiographs may show bone fractures and decreases in the diameter of bones. Radiography is also useful for assessing ileus, retained eggs or follicles, bone mineralization, and secondary renal hyperparathyroidism.<sup>13</sup>

### Treatment

Immediate treatment protocols focus on the following medical interventions<sup>5</sup>:

- Reversing hyperactivity of the parathyroid gland
- Reversing bone loss
- Promoting new bone growth

### Medical Treatment

Treatment protocols are based on the individual patient and are related to clinical signs and length of illness. In many cases, aggressive therapy using fluids, medications, and changes in husbandry must be used. If injectable medications are warranted, they should be used with care because they could increase damage to the skeletal system.<sup>13</sup>

Calcitonin can cause hypocalcemia when it begins to pull calcium from the blood. Therefore, adequate calcium supplementation for 1 week, followed by rechecking of the calcium level,<sup>13</sup> is important before injection of calcitonin.<sup>14</sup>

Vitamin D<sub>3</sub> should not be injected unless the patient has a history of vitamin D<sub>3</sub> deficiency.<sup>14</sup> If this vitamin is administered, a maximum dose of 200 IU/kg IM q2–4wk should be sufficient while avoiding toxicosis.<sup>10</sup>

Initially, injectable calcium may need to be given to maintain a normal blood calcium level. This treatment is dangerous if it is not given slowly. Once the patient can drink and eat on its own, calcium supplementation can be administered in the drinking water or by oral dosing using a syringe.<sup>14</sup>

Fractures can be splinted, but this may be ineffective because softened bones due to NSHP may provide inadequate support. In many cases, cage rest is sufficient for healing fractures.<sup>14</sup> A warm cage, preferably at the high end of the patient's ideal temperature range, without climbing branches can allow recovery.<sup>14</sup>

Most reptiles with NSHP die if treatment is not implemented. For patients that receive early treatment, the prognosis can be good. Most of the physical abnormalities due to NSHP, such as an underbite and scoliosis, are irreversible, even with proper healing and hardening of bone. In some cases, this interferes with the reptile's ability to eat and mobility. If spinal cord injuries are present, the prognosis is poor.<sup>14</sup>

### Conclusion

NSHP is common because many reptile owners lack proper information about diet and husbandry.<sup>14</sup> Veterinary technicians must be at the forefront of client education so that clients understand their reptile's natural environment. This includes providing adequate nutrition and a captive environment that allows their pet to heal and thrive.

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**1. NSHP**

- a. is not life threatening to reptiles.
- b. affects the skeletal system of reptiles.
- c. is not common in reptiles.
- d. none of the above

**2. In reptiles, hypocalcemia triggers**

- a. calcitonin production.
- b. bone mineralization.
- c. phosphorus excretion by the kidneys.
- d. PTH production.

**3. Clinical signs of NSHP**

- a. are never seen in reptiles.
- b. do not progress in reptiles.
- c. include spontaneous fractures in reptiles.
- d. are seen in juvenile reptiles, but not adult reptiles.

**4. In reptiles, treatment of NSHP includes**

- a. immediate medical intervention and correction of husbandry.
- b. high doses of injectable vitamin D<sub>3</sub>.
- c. calcium supplementation following calcitonin injections.
- d. medications, supportive therapy, and cool temperatures.

**5. Husbandry mismanagement**

- a. does not contribute to NSHP in reptiles.
- b. does not promote stress in captive reptiles.
- c. does not mimic a reptile's natural environment.
- d. none of the above

**6. Dietary mismanagement**

- a. affects only lizards.
- b. is not a concern regarding captive reptiles.
- c. does not promote NSHP in reptiles.
- d. of carnivorous reptiles may include primarily feeding pinky mice or rats.

**7. Proper dietary management of reptiles**

- a. is not challenging for most owners.
- b. is common because of abundant, accurate data.
- c. over the long term can help treat NSHP.
- d. does not require identification of species.

**8. Reptile husbandry**

- a. includes changing full-spectrum bulbs after 6 months of use.
- b. should not focus on the reptile's natural environment.
- c. focuses only on lighting systems.
- d. should not be changed once NSHP develops.

**9. Dietary supplementation**

- a. is not necessary for adult reptiles.
- b. for reptiles should include a high level of phosphorus.
- c. for reptiles should include calcium.
- d. for reptiles is necessary only while treating NSHP.

**10. The prognosis for reptiles with NSHP is**

- a. always grave.
- b. favorable without treatment.
- c. good, even with injury to the spine.
- d. good with early diagnosis and therapy.