REVIEW OF MUSCULOSKELETAL PATHOLOGY IN REPTILES

Drury R. Reavill, DVM, Dipl ABVP (Avian and Reptile & Amphibian) Dipl ACVP
Zoo/Exotic Pathology Service, 2825 KOVR Drive, West Sacramento, CA 95605 USA

ABSTRACT

This paper will cover the diseases of the musculoskeletal system of reptiles. It is not a comprehensive review. More in-depth disease descriptions can be found in the articles and reference books listed in the literature cited.

The paper is divided by etiologic disease categories involving the musculoskeletal system. A short discussion of the disease conditions is found in each section. For the purposes of this paper, chelonian will refer to all of the shelled reptiles. The term “tortoise” will be used to describe the large land animals that have stout elephantine feet and “turtle” for those from an aquatic environment.

Skeletal Muscle

Congenital

Muscular dystrophy is described in variety of lizards and snakes. The lesion is characterized by irregular atrophy, with myofibers lost and replaced by fat. In a series of evaluations, no sex bias or species-specific findings were noted.

Non-Inflammatory

Nutritional Myopathy

Muscular degeneration and necrosis are relatively common conditions in reptiles. This most frequently occurs from catabolic states prior to death. Subacute disease with decreased food consumption will result in a loss of heart fat, atrophic coelomic fat pads, followed by muscle wasting. Reptiles with chronic disease often have severe loss of body condition characterized by reduced abaxial muscle mass in snakes, girth of the tail in lizards, and sunken eyes in all reptiles. Cachectic myopathy in marine turtles has been associated with chronic bacterial and parasitic infections.

Of all the causes of nutritional muscular degeneration, vitamin E/selenium deficiency remains an important condition. The inability to open the mouth and extend the tongue were the presenting signs in a veiled chameleon (Chameleo calyptratus). Histologic changes are of muscle fiber degeneration (variable size of the fibers, hypercontraction, fragmented) without inflammation. Fibrosis and mineralization can be seen in chronic lesions. Additional lesions may develop in the heart, liver, and central nervous system. A thorough dietary history and response to
supplementation coupled with the histologic findings of rhabdomyogeneration generally confirms the diagnosis.\textsuperscript{30}

**Fibrosing Myopathy**

A veiled chameleon previously treated for stomatitis and glossitis developed progressive difficulty in opening his mouth. The tissues collected from the temporal muscle identified a non-inflammatory fibrosing myopathy. Both nutritional and cachetic myopathies would affect multiple muscle groups. The focal lesion suggests a sequela to muscle injury, possibly from a severe myositis.\textsuperscript{40}

**Inflammatory Diseases**

**Infectious Disease**

Although not common, a variety of infectious agents can cause myositis. The infections can be associated with trauma, extension from adjacent tissue, or hematogenous spread of infection.

**Mycotic infections**

Chromomycosis is caused by pigmented fungal organisms from the genera *Cladosporium, Fonseccacae, Philophora, Rhinocladiella, Hormodendrum, Curvularia,* and *Drechslera* among others. These fungi are saprophytes that live in soil and decaying vegetable matter and they are potentially zoonotic. In tissue they produce characteristic amber-brown, thick-walled septate structures known as sclerotic bodies and can result in a granulomatous myositis. Chromomycosis infection is most commonly described in amphibians but has also been reported in a radiated tortoise, pythons, boas, and a mangrove snake with a concomitant fibrosarcoma.

The fungal organism Chrysosporium anamorph of *Nanniziopsis vriesii* (CANV) has been described in bearded dragons, chameleons, geckos, anoles, and other reptilian species as a keratinophilic fungus that appears to result in a fatal granulomatous dermatitis. Associated fungal cellulitis and myositis is common with more chronic infection of CANV.\textsuperscript{5}

*Sarcocystis*-like parasites were associated with hind limb paresis in a black headed monitor (*Varanus tristis tristis*). Grossly the epaxial spinal musculature was atrophied, and histologically large numbers of sarcocystis-like parasites were within muscle cells. Muscle fiber degeneration and necrosis were present with the parasitic cysts.\textsuperscript{21} Most *Sarcocystis* sp. have a two-host life cycle and are generally adapted to their host causing little disease. Large numbers of the organisms and possibly stress may play a role in the development of clinical signs.

Amoebic myositis has been described in a common water monitor lizard (*Varanus salvator*). The initial lesion was of multiple subacute ulcerated skin wounds assumed to be due to trauma by the enclosure mate. Gross examination revealed scattered caseous foci in the skeletal muscles and liver. Histopathologic examination revealed severe necrotizing and granulomatous myositis, hepatitis, and enteritis accompanied by large numbers of intralesional, 10–20-mm diameter,
periodic acid–Schiff-positive, amoeboid protozoa. Polymerase chain reaction identified the protozoa as *Entamoeba invadens*. The muscular infection by *E. invadens* likely resulted from a combination of direct invasion of trophozoites via skin wounds and hematogenous spread.7

Parasitic infections into the intramuscular connective tissue by *Foleyella* species is described in various old world chameleons.4

**Neoplasia**

Rhabdomyoma and Rhabdomyosarcoma: Primary tumors of skeletal muscle are infrequently reported in reptiles. From a large survey rhabdomyosarcoma was described in 2 snakes and 5 lizards.15 A site predilection for these tumors was not observed. Grossly, benign tumors were tan red and resembled normal skeletal muscle. They are comprised of striated myofibers and readily visible cross striations.

**Bone and Cartilage**

Congenital

Schistosomus Reflexus (SR) is a rare and fatal congenital malformation syndrome occurring during embryonic development. These congenital malformations have been described in the olive ridley sea turtle (*Leptochelys olivacea*). Malformed turtles showed a marked lordosis and other vertebro-column malformations such as scoliosis, kyphosis, and vertebral and rib alterations (number, shape, and fusion). The shell was underdeveloped: bone and scute-agenesis, subnumerary and deformed scutes. Flippers displayed malformations: arthrogryposis, and dysmelias: amelia, phocomelia, syndactily, among others. The high prevalence of SR in this species suggests a primary genetic etiology, although environmental factors may be involved.2

**Nutritional/Metabolic Disease**

**Osteomalacia/Rickets**

The name applied to this condition depends on the age of the animal. Rickets is seen when the skeleton is still growing. Osteomalacia occurs in the mature animal. These problems are due to a failure of mineralization of matrix leading to bone deformities and fractures.

Osteomalacia and rickets are both reported in terrapins, either due to an inadequate diet or inappetence due to altered metabolic rates in an animal kept outside it POTZ (Preferred Optimal Temperature Zone).27

**Osteodystrophy**

This is a broad category of metabolic bone changes. Fibrous osteodystrophy, a common bone lesion in reptiles, belongs to this group of metabolic bone diseases. The presentation in lizards is a variable and sometimes symmetric swelling of the limbs. It is characterized by extensive
osteoclastic resorption of bone and replacement of the bone with fibrous tissue. Initially in the endosteum, the resorbed bone is replaced by highly cellular connective tissue. In later stages, the connective tissue is more fibrous and less cellular. The bony structures, especially cortical bone, can be replaced by perpendicularly arranged woven bone with chondroid metaplasia and fibrous and cartilaginous tissue.

Osteoclastic activity is enhanced by prolonged and excessive secretion of parathyroid hormone. This persistently elevated parathyroid hormone can be a physiologic response to chronic low blood calcium (nutritional or from chronic renal disease), or the result unregulated release of parathyroid hormone from a neoplasia of the parathyroid.

Nutritional secondary hyperparathyroidism is caused by a diet that is either deficient in calcium/vitamin D, or contains excessive phosphorus, or any combination. The absolute or relative deficiency of vitamin D3, the main cause of osteodystrophy in reptiles, results in reduced calcium absorption from intestinal contents. With decreased plasma calcium levels, mineralized bone matrix formation is retarded, or arrested entirely, and release of parathyroid hormone is stimulated.

Vitamin D metabolism is complex across the reptile groups. Basking in the sun is important to many lizard species both for thermoregulation and stimulation of cutaneous synthesis of vitamin D. Some species of lizards require ultraviolet light B (UVB) from 290 to 315 nm wavelength to maintain adequate circulating levels of vitamin D. The cutaneous conversion of the vitamin D precursor, 7-dehydrocholesterol, to pre-vitamin D (pre-D3) occurs during exposure to UVB. Skin temperature is important in the subsequent conversion of pre-D3 to vitamin D.

Renal secondary hyperparathyroidism occurs when the kidney is so severely damaged that it is unable to excrete excess phosphorous and is not able to produce sufficient 1,25 dihydroxycholecalciferol. High plasma phosphate depresses ionized calcium and thereby stimulates the release of parathyroid hormone.

Degenerative Bone Disease, Trauma, Toxin

Osteochondrosis

Osteochondrosis is characterized by interruption of the blood supply of a bone, in particular to the epiphysis, followed by localized bony necrosis. This disorder is defined as a focal disturbance of endochondral ossification and is regarded as having a multifactorial etiology. Articular cartilage sites are associated with chondrocyte necrosis and cartilage dissection. This has not been described in modern reptiles although it has been recognized in extinct hadrosaurs, Iguanodon, and an unspeciated sauropod.38

Ischemic Necrosis

Ischemic necrosis of bone may be caused by neoplastic interruption of vascular supply, primary vascular disease, infection, and trauma with or without fracture. Ischemic necrosis occurred in the
tails of a carpet python (Morelia spilota variegata) and a red-bellied black snake (Pseudechis porphyriacus) from intravascular dissemination of a Fusarium species infection. The tail ends were swollen and the skin of the tails was dry and flakey, with petechial hemorrhages.\textsuperscript{22}

Necrosis of the shell (epidermal, dermal, and osseous) in free-ranging desert tortoises (Gopherus agassizii), river cooters (Pseudemys concinna), and yellow-bellied turtles (Trachemys scripta) is associated with a variety of infectious disease agents; gram negative and positive bacteria as well as fungus. The plastron lesions associated with fibrosis extended into the underlying bone. These lesions may have started as a chronic shell dermatitis and osteitis.\textsuperscript{23,31}

\textit{Toxic Bone Disease}

Several studies have evaluated the levels of lead in tissues, including the shell bone of turtles. Lead can impair skeletal calcification and competes with calcium ion uptake. One study demonstrated no positive relationship between concentration of lead in shell bone and severity of shell disease. The turtle shell may serve as a sink for bioaccumulated lead, reducing concentrations found in visceral tissues.\textsuperscript{3}

\textit{Inflammatory Bone Disease}

\textit{Osteomyelitis}

Osteomyelitis is may be caused by a variety of aerobic and anaerobic bacteria, Mycobacteria, and fungi including Aspergillus, and Mucor. The common isolates are of Gram-negative organisms, such as Pseudomonas spp., Escherichia coli, Salmonella spp., and Proteus spp., as well as Gram-positive organisms, including Staphylococcus spp. and Streptococcus spp. The infection can be localized, or be part of a generalized disease. Trauma, embolized microbes, or an infection secondary to a neoplastic disease are possible origins.

Osteomyelitis radiographically appears as soft tissue swelling, bone lysis, and variable periosteal proliferation. There may be associated fractures that may be difficult to differentiate from a primary fracture. Caseous (heterophilic) material with a variable number of microbes are expected in the lesion. Histologically early lesions will have large numbers of heterophils with increasing numbers of plasma cells, macrophages, and giant cells seen with time.\textsuperscript{37}

A large necrotic wound in the carapace of an Aldabra tortoise (Geochelone gigantea) developed most likely after breeding trauma and was associated with Proteus mirabilis, Klebsiella pneumoniae, and Enterobacter agglomerans. The bone of the shell was necrotic.\textsuperscript{10}

In a Kemp’s ridley sea turtle (Lepidochelys kempii), systematic granulomatous disease due to Mycobacteria chelonei was associated with an osteomyelitis.\textsuperscript{17}

Osteomyelitis due to Salmonella enterica ss arizonae swept through a colony of ridgenose rattlesnakes (Crotalus willardi). The lesions presented as firm subcutaneous nodules associated with the ribs and vertebral bodies. Radiographically extensive new bone production with areas of
bony lysis was typical. The portal of entry was suspected to be intestinal although vertical transmission was also postulated.\textsuperscript{36}

Vertebral osteomyelitis is commonly diagnosed in snakes and these lesions that result in ankylosis of the vertebrae are generally due to bacterial infections. The fusing of the spine can involve up to 12 successive vertebra. The lesions have been described as proliferative osteoarthritis and in the lesions without inflammation, osteoarthrosis. \textit{Salmonella} was a common isolate in a series review of 15 snakes.\textsuperscript{25}

Paravertebral bony lesions resulting in fusing of the vertebrae of the tail is clinically well recognized in large lizards such as iguana and monitors. These are strongly suspected to be the results of an infection and are lesions of osteomyelitis.\textsuperscript{39} In the iguanas, dense, irregular bony enlargements around coccygeal vertebrae were recognized radiographically. New periosteal bone formation was on the surface of the affected vertebral bodies with a distinct border between new bone and lamellar bone of the vertebrae. These lesions were clinically associated with tail rigidity.\textsuperscript{8}

A colony of Malborough green geckos (\textit{Naultinus manukanus}) developed skin lesions and necrotic toes secondary to humidity extremes. The fungus \textit{Mucor ramosissimus} was isolated from the skin lesions and seen in the necrotic osteomyelitis of the toes.\textsuperscript{16}

Neoplastic Disease

\textit{Chondroma}

Chondromas are firm masses comprised of well-differentiated cartilage. They are infrequently seen and appear to have a slow growth. A periosteal chondroma near the right shoulder joint on an adult \textit{Uromastyx maliensis} was associated with atrophy of the surrounding skeletal muscle.\textsuperscript{14}

\textit{Chondrosarcoma}

Chondrosarcomas are malignant tumors with tumor cells that produce a matrix of cartilage with no osteoid or bone forming elements. They can arise in bone or periosteum although the latter site is rare in animals. Chondrosarcomas are comprised of poorly differentiated cartilage and have a high mitotic index. They are more common than the benign chondromas. In a review of reptile tumors, one chondrosarcoma, site not provided, was listed in a corn snake (\textit{Pantherophis guttata}).\textsuperscript{32} Additional cases in corn snakes include vertebral chondrosarcomas,\textsuperscript{15} most arising in the vertebral articulations and being locally invasive and sometimes associated with pathologic fractures. One vertebral chondrosarcoma and one arising from the mandible developed multiple visceral metastasis to the heart, kidney, lung, pancreas and eye.\textsuperscript{11,42} A previous case of vertebral metastatic chondrosarcoma metastatic to the liver was reported in a rat snake (\textit{Elaphe obsoleta obsoleta}).\textsuperscript{24} Chondrosarcomas have been reported in a snake of undetermined species\textsuperscript{18}, an Indian monitor (\textit{Varanus dracoena})\textsuperscript{41}, and unspecified saurians.\textsuperscript{20}
Osteoma and Osteosarcoma

Neoplasms originating from the mesenchymal precursors of bone or cartilage are rare in reptiles. These tumors typically present as firm swellings associated with bone. The diagnosis of a bone or cartilage tumor is greatly enhanced by including both the clinical and radiographic findings with tissue sample submissions.

Osteomas are benign lesions that originate from bone, generally the mandible and long bones. Rarely these bone tumors arise from the integument (osteoma cutis). In a European pond turtle (Emys orbicularis) the removal of an osteoma returned normal neck movement.12

Osteosarcoma of the vertebra and proximal ribs is described in a California mountain kingsnake (Lampropeltis zonata).29 Three snakes from a large survey were identified as having an osteosarcoma arising from the vertebrae. The tumors were locally invasive but no metastases were identified.15

An osteochondrosarcoma (compound osteosarcoma) has been reported in the cervical area of a Bengal (yellow tree) monitor (Varanus bengalensis).13 Chondroblastic osteosarcomas (osteoid chondrosarcoma) were identified in two young (5 and 6 mo) and related spiny-tailed monitors (Varanus acanthurus).33 The tumors were large, firm, multilobulated masses arising in the pelvic girdle. A similar tumor developed in a desert monitor (Varanus griseus) mandible and had metastases to the tail, ribs, and femur.43

Diseases of the Joints

Articular gout is the deposition of monosodium urate crystals in the joints. It is seen in reptiles that synthesize uric acid as their principal end product of nitrogen metabolism (uricotelic). The deposition can occur secondarily to elevated blood uric acid levels from reduced renal perfusion through dehydration, hemoconcentration, nephrosis, or renal tubular degeneration. The deposits can be articular, periarticular, and even within the medullary cavity of bones. Gout tophi is granular to spiculated materials surrounded by multinucleated giant cells, epithelial macrophages, and smaller numbers of heterophils and lymphocytes. Aspirate of the synovial fluid may reveal brown, needle-like crystals, some with a starburst pattern. The fluid itself may be thick, chalky white and have a grainy consistency.6,26

Pseudogout is a disorder of calcium metabolism that clinically mimics gout. Pseudogout is formed by various forms of calcium phosphate deposited in the periarticular tissues such as the joint capsule and may cause arthritis. This is more commonly described in turtles and tortoises and uncommonly in lizards. Joint trauma may be an initiating factor in the formation of pseudogout.26 Articular calcification (pseudogout) is separable from other types of metastatic mineralization because the viscera is frequently not involved.
Inflammatory Disease

Infectious arthritis in reptile may be due to bacteria including *Serratia marcescens, Morganella morganii, Mycoplasma*, and others. Grossly, in acute cases there is exudate and fibrin in the joint. Histologically an infiltration of heterophils and a few macrophages is common whether the condition is bacterial, viral, or due to *Mycoplasma*. Inflammatory cells variably infiltrate the synovium.

Septic arthritis and foci of osteomyelitis were described in a leatherback turtle (*Dermochelys coriacea*). Although no specific microbes were isolated the pattern of the lesions suggested hematogenous spread.\(^{34}\) Renal disease in a spur-thighed tortoise (*Testudo graeca*) was associated with a septic coxofemoral arthritis and pelvic abscessation.\(^{35}\)

Bite wounds and/or gastric ulcerations may have resulted in a bacterial septicemia leading to a bacterial arthritis in a west African dwarf crocodile (*Osteolaemus tetraspis*). *Serratia marcescens* was isolated from the blood.\(^{19}\) *Serratia* septicemia was also associated with septic arthritis in a tegu (*Tupinambis teguixin*).\(^{1}\)

Exudative mycoplasma arthritis is well recognized in crocodiles and alligators. Multiple joints are generally involved with swelling, progressive lameness, and paresis. In early infections the joint fluid is turbid and becomes yellowish and inspissated. The infection is commonly associated with a pneumonia.\(^{9,28}\)

**LITERATURE CITED**


