In collaboration with the American College of Veterinary Radiology

What Is Your Diagnosis?

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History

A 2-year-old sexually intact female southern tamandua (*Tamandua tetradactyla*) originally owned by a private collector was purchased by the Columbus Zoo and Aquarium and was evaluated because of hematochezia. The animal was sedated for phlebotomy and radiography (Figure 1).

Formulate differential diagnoses, then continue reading.

Radiographic Findings and Interpretation

Full-body radiography revealed well-defined smooth periosteal bone formation centered on the long bone diaphyses and extending to the proximal and distal metaphysis of the humeri, radii, ulnae, femurs, tibiae, and fibulae bilaterally (Figure 2). The medullary cavities of radii, ulnae femurs, tibiae, and fibulae were diffusely sclerotic. The distal humeral medullary cavities were also sclerotic with a long zone of transition to a more appropriate appearance in the proximal diaphyses. The ribs were also subjectively sclerotic (compared to age-matched tamandua) with a decreased distinction between the cortex and medullary bone. The osseous changes were relatively symmetric. The epiphyses were affected to a lesser degree, with the articular margins unaffected. There was also smoothly margined osseous proliferation bridging multiple intervertebral disk spaces, consistent with spondylosis deformans. There was narrowing of the lumbosacral intervertebral disk space. There was diffuse soft tissue swelling throughout the thoracic and pelvic limbs corresponding to areas of bone thickening and medullary sclerosis. No mineralization was observed in the periarticular soft tissue, large vasculature, or viscera of the tamandua. Differential diagnoses for benign polyostotic long bone diaphyseal lesions included nutritional etiologies like hypervitaminosis D, hyperparathyroidism (primary or secondary), hepatozoonosis, or hypertrophic osteopathy.

Caitlin Kiefer, MS; Eric T. Hostnik, MS, DVM, DACVR, DACVR-EDI; Randall Junge, MS, DVM, DACZM, DACAW

1School of Veterinary Medicine, The Ohio State University, Columbus, OH
2Columbus Zoo and Aquarium, Columbus, OH
*Corresponding author: Dr. Hostnik (hostnik.1@osu.edu)

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Treatment and Outcome

Blood for CBC, serum biochemical analyses, ionized calcium, mineral and vitamin levels, and parathyroid hormone radioimmunoassay was submitted. Mineral and vitamin concentrations, ionized calcium, and parathyroid hormone radioimmunoassay were also evaluated because of the radiographic findings. A fecal sample was submitted for analysis and bacterial culture. The only abnormality found on the vitamin and mineral panels (Michigan State University Diagnostic Center for Population and Animal Health) was a high 25-hydroxyvitamin D concentration of 287 nmol/L. Correspondence with a board-certified endocrinologist determined that the range for 25-hydroxyvitamin D in tamandua species is 8 to 129 nmol/L (based on a sample size of 39 tamandua). The reference range for most mammal species is between 50 and 100 nmol/L. Vitamin A concentration was 122 ng/mL; the normal value for southern tamandua is unknown, but most mammals are between 200 and 500 ng/mL. Results for a CBC and serum biochemical analyses (Antech Diagnostic Laboratories) were within reference limits. The calcium concentration was 8.8 mg/dL (reference range, 7.5 to 14.2 mg/dL). The ionized calcium concentration was 1.64 mmol/L (reference range, 1.52 to 2.10 mmol/L). The parathyroid hormone radioimmunoassay (Michigan State University Diagnostic Center for Population and Animal Health) did not detect parathyroid hormone in the serum sample. Results were negative for fecal analysis (Sheather sugar flotation solution and direct microscopic examination) for parasitic ova, and bacterial cultures performed on feces were negative for *Salmonella*, *Shigella*, and *Campylobacter* spp. Computed tomography was also performed as part of a general screening; however, findings and descriptions were not included in the present report because they did not influence case management or decision-making.

Bone biopsies were acquired from the left radius and femur, and histologic examination (Northwest ZooPath) revealed well-differentiated woven and lamellar bone, frequent lamellar bone reversal lines, and hypertrophic osteoblasts in some trabeculae, consistent with periosteal hyperostoses. Evaluation of the diet suspected that a single daily egg provided to the animal was a large enough source of vitamin D to cause hypervitaminosis D. The previous owner started supplementing 1 egg each day, and this was continued by the zoo. Treatment plans centered around modifying the diet to eliminate the egg from the diet.

On recheck examination 2 months later, radiographic features of benign polyostotic long bone lesions were static, and there was no new bone proliferation or remodeling of the affected bones. The 25-hydroxyvitamin D concentration was 128 nmol/L. Because this was within the expected range for this species and bone proliferation had halted, clinicians decided to perform a recheck examination in a year and keep the diet free of supplements (including the egg). At recheck examination nearly a year after the initial presentation, radiography revealed markedly reduced periosteal proliferation with better cortical and medullary distinction previously deposited due to hypervitaminosis D (Figure 3). The animal's 25-hydroxyvitamin D concentration remained within the normal range at 100 nmol/L. The cause for hematochezia, one of the initial presenting complaints,
was not identified but resolved shortly after the initial presentation.

**Comments**

Tamandua are an insectivorous species that subsist almost completely on ants and termites in the wild. Feeding these animals in captivity can be a challenge, as their nutritional requirements are generally unknown, and therefore preparing a diet for professionally managed tamandua can be difficult. The tamandua in this case was being fed a single chicken egg daily, known to be one of the highest density sources of vitamin D in human diets. Vitamin D is a lipophilic hormone that is essential for calcium homeostasis, immunocompetence, cardiovascular function, and proper bone formation. However, if given in excessive doses through diet, hypervitaminosis D can occur and has been documented in other species. Because vitamin D is responsible for mobilizing stem cells to osteoclasts for remodeling bone and mobilizing calcium stores to form bone, hypercalcemia caused by hypervitaminosis D could be the cause of the long bone hyperostosis seen in this tamandua.

Hypervitaminosis D has been shown to cause sustained hypercalcemia, leading to metastatic calcification and mineralization of soft tissues in several different species kept in captivity including small mammals and rodents. Vertebral hyperostosis has been documented in 5 captive tamandua in a previous study, and the cause was attributed to elevated levels of liver vitamin A as well as vitamin D. Hyperostosis was found to develop more slowly or ceased formation in animals fed diets containing lower levels of vitamin A and D. On necropsy, affected tamanduas were shown to have extensive soft tissue calcification, which has been shown to occur in other species due to hypervitaminosis D. The tamandua of the present report did not show gross soft tissue mineralization or calcification on radiography. There is little known on the calcium and vitamin D metabolism in tamandua; however, our management of this individual with documented periosteal hyperostoses and concurrent hypervitaminosis D that subsequently resolved after eliminating the high source of vitamin D and normalized vitamin D concentration is a strong case of cause and effect. Research to better understand the specifics of calcium and vitamin D in this species is needed to understand their susceptibility to sources of vitamin D.

**References**