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Nutritional secondary hyperparathyroidism in a puppy *Leopardus geoffroyi* (d'Orbigny and Gervais, 1844)

Hiperparatireoidismo secundário nutricional em filhote de Leopardus geoffroyi *(d'Orbigny and Gervais, 1844)*

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ABSTRACT: Nutritional Secondary Hyperparathyroidism (NSH) is a metabolic disorder that mainly affects young animals. This disease causes imbalance between the levels of calcium and phosphorus, culminating in bone changes. Wild animals raised in captivity can develop the disease when they are given an inadequate diet. The aim of this study is to report the clinical findings, the complementary exams and the therapeutics utilized in *a Leopardus geoffroyi* (Geoffroy's cat) cub originated from captivity with NSH. The animal went through complementary imaging exams and biochemical evaluation that respectively revealed generalized osteopenia and pathological fracture of the right femur, reduction of serum calcium level and elevation of serum phosphorus level. The diagnosis of NSH was established by associating the history, clinical signs, and findings of ancillary exams. The treatment was based on diet correction, mineral and vitaminic supplementation and sun exposure. The NSH diagnosis was stablished by associating history, clinical signs, imaging exams findings and serum biochemicals. The early identification of this disease is of paramount importance, because in this way corrections can be made in food management, in order to provide successful clinical recovery and promote quality of life for wild captive animals.

KEYWORDS: Geoffroy's cat; wild animals; calcium; osteopenia.

RESUMO: O hiperparatireoidismo secundário nutricional (HSN) é uma desordem metabólica que acomete principalmente animais jovens. Essa doença cursa com desequilíbrio entre os níveis de cálcio e fósforo, culminando com alterações ósseas. Animais silvestres quando criados em cativeiro podem desenvolver a doença quando recebem uma dieta inadequada. O objetivo deste estudo é relatar os achados clínicos, os exames complementares e a terapêutica utilizada em um filhote de *Leopardus geoffroyi* (gato-do-mato-grande) proveniente de cativeiro com HSN. O animal passou por exames complementares de imagem e avaliação bioquímica que revelaram respectivamente osteopenia generalizada e fratura patológica de fêmur direito, redução dos níveis séricos de cálcio e elevação do fósforo. O diagnóstico de HSN foi estabelecido associando o histórico, sinais clínicos e achados dos exames complementares. O tratamento foi baseado na correção da dieta, suplementação mineral e vitamínica e exposição solar. A identificação precoce dessa doença é de suma importância, pois dessa forma podem ser feitas correções no manejo alimentar, afim de proporcionar a recuperação clínica com êxito e promover qualidade de vida para os animais selvagens de cativeiro.

PALAVRAS-CHAVE: Gato-do-mato-grande; silvestres; cálcio; osteopenia.

INTRODUCTION

Nutritional Secondary Hyperparathyroidism (NSH) is a metabolic disorder that mainly affects young animals, when they are strictly fed with homemade food containing meats, which contain inadequate levels of calcium and phosphorus. (JERICÓ; KOGIKA; ANDRADE NETO, 2015). This disease has been described in a multitude of wild felids such as *Panthera tigres altaica* (tiger) (PRAZERES et al., 2016; WON et al., 2004), *Panthera leo* (lion) (ASI et al., 2014), *Puma concolor* (puma) (MEIRELES et al., 2012), *Leopardus guttulus* (southern tiger cat) (NAKAMOTO; QUEIROZ; FAVARO, 2019) and *Panthera pardus* (leopard) (FEIGIN; MAYER; SOLANO, 2006).

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Leopardus geoffroyi is a neotropical small size felid, distributed in some South American countries such as Bolivia, Paraguay, Argentina, Uruguay and Brazil. In Brazil it can be found mainly in the south of the state of Rio Grande do Sul (KASPER et al., 2014; TIRELLI; TRIGO; TRINCA, 2018). Regarding the degree of extinction threat, in Rio Grande do Sul the species is considered vulnerable, while it's global status is of little concern according to the International Union for Conservation of Nature IUCN red list. (PEREIRA; LUCHERINI; TRIGO, 2015). Thus, the aim of this study is to report the clinical findings, the complementary exams and the therapeutics utilized in a *Leopardus geoffroyi* (Geoffroy's cat) cub originated from captivity with NSH.

MATERIAL AND METHODS

A melanic cub of *L. geoffroyi* (Geoffroy's cat), approximately three-months-old, weighing 0,740 kg, was referred to the Wild Fauna Rehabilitation Center of the Federal University of Pelotas (NURFS-UFPel) with locomotion difficulty. According to a report by those responsible for the animal's delivery, it had been under human care for approximately three weeks and was given a diet exclusively composed of chicken and ground beef. It was also reported that when the cub was found, it already had difficulty in locomotion of the pelvic limbs, but two days before being delivered it stopped walking.

In the visual evaluation, it was observed that the animal could not remain in standing position and presented difficulty in ambulation. In order to perform the physical evaluation, pharmacological containment was used by volatile anesthetic induction of isoflurane (Isoforine®, Isofluorane, Cristália, Brazil) used a 4% calibrated vaporizer, followed by mask maintenance at 1,5% with 100% oxygen concentrator.

It was noticed through clinical inspection normocolored mucosa, reduced skin turgor, 3 seconds capillary refill time, dehydration (5%) and no alteration in pulmonary or cardiac sounds and frequency. In the evaluation of the musculoskeletal system, crackling was noticed in the right femur proximally to the coxofemoral joint. After physical evaluation, blood samples were collected to perform blood count and serum biochemicals (Tab. 1).

The initial therapeutic approach to pain management was made with methadone (MYTedom®, Methadone Hydrochloride, Cristália, Brazil), 0.2 mg/kg, intramuscularly (IM), every 12 hours (BID), for 3 days; dipyrone (Dipyrone®, Dipyrone Monohydrate, Medquímica, Brazil), 25 mg/kg, orally, BID, for 5 days; meloxicam (Elo-xicam® 0.2%, Meloxicam, Chemitec, Brazil), initially at a dose of 0.1 mg/kg, and then 0.05 mg/kg subcutaneously (SC), every 24 hours (SID), for 5 days; and fluid therapy (Ringer with

Table 1. Hematologic and serum biochemical values during a therapy regimen carried out over the course of a 60-day period following the arrival of the profiled *L. geoffroyi* (Geoffroy's cat) cub to our veterinary center.

Parameters	0 day	30 days	60 days	Reference values
Hematology				
RBC (10^6/µl)	6.30	6.88	8.57	7.98 ± 1.27*
Hgb (g/dL)	7.7	9.7	13.4	13.2 ± 1.7*
Hematocrit (%)	23.9	27.2	36.5	41.5 ± 6.3*
MCV (fL)	37.9	39.5	42.6	51.4 ± 4.4*
MCHC (g/dL)	32.2	35.7	36.7	32.9 ± 2.7*
Platelets (10^3/µl)	421	356	399	333 ± 53*
WBC (10^3/µl)	4.300	5.500	7.400	9.800 ± 4.420*
Band neutrophils (/µl)	86	0	0	0*
Neutrophils (/µl)	2.795	3.795	4.440	6.260 ± 2.906*
Lymphocytes (/µl)	1.240	1.375	2.510	2.096 ± 1.058*
Monocytes (/µl)	129	220	74	281 ± 286*
Eosinophils (/µl)	43	110	370	556 ± 889*
Biochemistry				
ALP (UI/L)	188.5	-	270.3	25-93***
Calcium ionized (mg/dL)	0.84	6.8	5.90	4.5-5.5**
Phosphorus (mg/dL)	9.8	10.1	11.3	5.1 ± 1.4*
BUN (mg/dL)	102.33	-	59.61	39 ± 29*
Creatinine (mg/dL)	0.2	-	0.5	1.6 ± 1*

Reference values: * CUBAS et al., (2014); ** SCHENCK; CHEW, (2008); *** KANEKO; HARVEY; BRUSS, (2008). (-) = Not rated.

lactate®, Ringer's lactate solution, Fresenius Kabi Brazil Ltda, Brazil), 50 ml/kg, SC, SID, for 5 days.

On the following day, radiological imaging exam showed pathological fracture in the proximal diaphysis of the right femur, with no apparent bone activity and generalized reduction of bone and thin cortical layer radiopacity (Fig. 1). Mineral and vitamin supplement (Cal-d-mix®, Food supplement, Vetnil, Brazil) 1 ml/kg, orally, SID, for 30 days was added; and daily sunbathing for 40 minutes. After 3 days, analgesia was changed to tramadol (Tramadon®, Tramadol Hydrochloride, União Química, Brazil) 4 mg/kg, orally, BID, for 5 days.

On the sixth day after the beginning of treatment, the animal began to sustain itself in standing position and move with difficulty. The solid diet offered since its arrival consisted of chopped *Mus musculus* (mouse) three times a day, in an amount that corresponded to 20% of the body weight. The first meal of the day consisted of supplementation of 2g of crushed *Gallus gallus* (domestic chicken) eggshell and 2g of breast milk substitute for dogs and cats (Pet milk®, Food supplement, Vetnil, Brazil) for 30 days. On the 13th day, the animal was walking and showed a significant improvement in its clinical condition.

One month after the first management, physical examination, kyphosis was observed in the thoracic region of the spine, but no neurological sign. Imaging and blood examinations were reevaluated, where, in the radiographs, it was found that, in the femur fracture, there was a process of bone consolidation and normalization of generalized bone radiopacity (Fig. 2), in addition to alterations morphology of the twelfth thoracic vertebra (T12) with consequent decreased vertebra and shape change (Fig. 3). The biochemical parameters showed improvement. Two months after its arrival, a new blood sample was collected for hematological and biochemical evaluation (Tab. 1).

RESULTS AND DISCUSSIONS

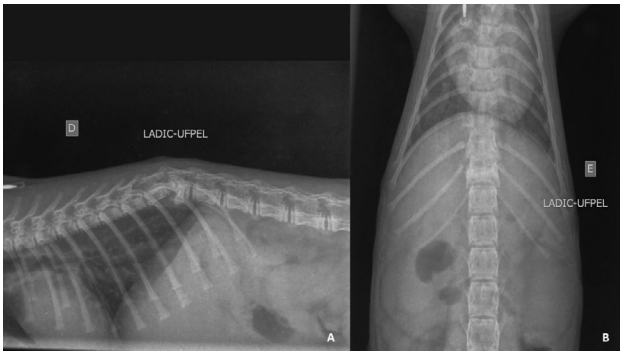
In carnivores, NSH can occur in animals that are fed exclusively with meat (boneless and viscera), which contains high phosphorus content and low calcium levels, since a calcium-to-phosphorus ratio of 2:1 is required for normal skeletal development. Diets composed exclusively of meat contain a calcium-to-phosphorus ratio between 1:10 and 1:50 (FEIGIN; MAYER; SOLANO, 2006). Persistent deficiency of calcium in the diet can cause chronic hypocalcemia, which results in osteopenia due to excessive calcium reabsorption, making bones more susceptible to fractures and skeletal defects (ASI et al., 2014). According to the animal's history, it received an exclusive diet of meat, which triggered the episode of malnutrition and fragility of the bones. This disease has already been described in a three-month-old female *Panthera tigris altaica* (Siberian tiger), where it received 6% to 12% of the body weight of beef daily, which triggered an acute event of

Font: Diagnostic Imaging and Cardiology Laboratory (LADIC).

Figure 2. Radiography findings for an *L. geoffroyi* (Geoffroy's cat) performed after 30 days of therapy. These findings demonstrated moderate smooth bone proliferation (i.e., a bone callus) in the proximal diaphysis of the right femur, with misalignment of the femoral bone axis and restoration of the usual bone radiopacity. (A) Mediolateral projection of the right femur. (B) Ventrodorsal projection of the pelvis.

Font: Diagnostic Imaging and Cardiology Laboratory (LADIC).

Figure 1. Radiography findings for an approximately three-month-old *L. geoffroyi* (Geoffroy's cat) demonstrated bone discontinuity in the right proximal femoral shaft, with deviation of the caudal bone axis of the distal segment, without radiographic signs of bone proliferation. In addition, a generalized reduction in bone radiopacity was observed, as well as thin cortical bones. (A) Right laterolateral projection of the pelvis. (B) Ventrodorsal projection of the pelvis.



Font: Diagnostic Imaging and Cardiology Laboratory (LADIC).

Figure 3. Radiography findings for an *L. geoffroyi* (Geoffroy's cat) with kyphosis. Alterations morphology of the twelfth thoracic vertebra (T12) with consequent decreased vertebra and shape change. (A) Right laterolateral projection of the thoracolumbar segment of the spine. (B) Ventrodorsal projection of the thoracolumbar segment of the spine.

claudication (WON et al., 2004). In another case of NSH, a seven-month-old tiger received a diet based composed of bovine heart and muscles in addition to little sun exposure, which also triggered clinical signs in the locomotor system (PRAZERES et al., 2016). For keeping animals in captivity is necessary to know the nutritional management of each species, to avoid metabolic/nutritional diseases.

Clinical signs in animals with NSH are closely related to the locomotion of the animal, since it begins with claudication events by pathological fractures of long bones and vertebrae. In most cases of wild felids described, presented lesions in long bones, pelvis and vertebrae (ASI et al., 2014; MEIRELES et al., 2012; NAKAMOTO; QUEIROZ; FAVARO, 2019; PRAZERES et al., 2016; WON et al., 2004). The clinical signs described in the present study are similar to those described in the literature, because the animal could not move due to pathological fracture in the femur and later presented kyphosis. In domestic cats, signs of claudication and motor incoordination are notorious, and may evolve severely between the fifth and fourteenth week of life, consequently disabling the animal of sustaining its own weight (PRAZERES et al., 2016). Prognosis is poor in animals with neurological symptoms such as convulsion, tremors and difficult excretion of urine and feces (JERICÓ; KOGIKA; ANDRADE NETO, 2015).

The most practical method of NSH diagnosis is radiological investigation in long bones or axial skeleton. These evaluations can be conducted by subjectively or through optic densitometry, in which changes in bone density can be quantified (MEIRELES et al., 2012). A 30 to 50% loss in bone mass is necessary before osteopenia is radiographically evident. In the described case, the radiographic findings were a decrease in generalized bone radiopacity, which is compatible with osteopenia, in addition to thin cortical bones and pathological fracture in the femur and twelfth thoracic vertebra (T12) (FEIGIN; MAYER; SOLANO, 2006).

Hematological analysis do not assist in the diagnosis of NSH, however can be part of the protocol of general state evaluation of the animal. In our case, normochromic microcytic anemia was observed, which occurs in chronic diseases or nutritional deficiencies (JERICÓ; KOGIKA; ANDRADE NETO, 2015). The urea values were elevated in the first evaluation, this marker could be altered by a multitude of factors, such as protein-rich diet, kidney injury or proteic catabolism (KANEKO; HARVEY; BRUSS, 2008).

The dosage of serum levels of calcium, phosphorus and alkaline phosphatase not always reliable for the diagnosis of NSH, since the evaluation of serum calcium may be normal because of compensatory mechanisms, and the concentration of inorganic phosphorus and phosphatase activity may be elevated in animals in growth phase (WON et al., 2004). Feigin; Mayer; Solano (2006) reported a case in which it was detected increased serum phosphorus in a five-month-old *Panthera pardus* (leopard) with NSH, while serum calcium was within the normal range for the species. Asi et al. (2014) followed a case in which a three-and-a-half-month-old individual of *Panthera leo* (lion) presented alkaline phosphatase increase, slight calcium decrease and normal phosphorus levels. In the case described, the calcium concentration was reduced and the phosphorus was high.

In the case of the three-and-a-half-month-old *P. leo*, the animal showed improved clinical signs after treatment with calcium carbonate and vitamin D (ASI et al., 2014). In the reported case, the treatment instituted was done with correction of food management, nutritional supplementation based on vitamins and minerals and pain control. In domestic cats lack the ability to synthesize vitamin D3 in the skin, likely because of high activity of 7-dehydrocholesterol- Δ7-reductase. For this reason, cats require dietary supplementation with vitamin D to meet nutritional requirements (PARKER; RUDINSKY; CHEW, 2017).

CONCLUSIONS

The early identification of nutritional deficiencies and appropriate correction of the food management are essential to ensure clinical recovery, given that, the analysis of history, clinical signs and findings in imaging and serum biochemical examinations are important tools for the diagnosis of NSH.

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