

# *Salmonella enterica ssp. enterica*-related infectious spondylitis in a pet corn snake (*Pantherophis guttatus*): diagnosis and successful treatment



Spondylitis is an inflammatory process of the vertebra that may lead to a destructive process with exuberant new bone formation. This condition can produce a distortion of the bone architecture, degenerative joint changes and ankylosis of adjacent vertebra. Reptiles lack intervertebral discs; thus, the term discospondylitis is considered wrong. Histological lesions are categorized as bacterial osteoarthritis related to *Salmonella spp.* and noninflammatory osteoarthritis with foci of chronic inflammation that are negative on bacterial culture. In snakes, segmental, proliferative infectious spondylitis has been reported. Gram-negative bacteria (*Salmonella sp.* and *Pseudomonas sp.*) are usually isolated from affected bones. Antemortem diagnosis is considered difficult in snakes, and for this reason, the prognosis is considered poor. This report describes the diagnosis and successful treatment of *Salmonella enterica ssp. enterica*-related infectious sponditis in a pet corn snake (*Pantherophis guttatus*).

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## BACKGROUND

Spondylitis is inflammation of the vertebra that leads to a destructive process with exuberant new bone formation<sup>1</sup>. This condition can produce a distortion of the bone architecture, degenerative joint changes and ankylosis of adjacent vertebra<sup>2</sup>. Reptiles lack intervertebral discs<sup>1</sup>, and the term discospondylitis is therefore considered wrong. In snakes, segmental, proliferative infectious spondylitis has been reported<sup>3,4,5</sup>. Histological lesions are categorized as bacterial osteoarthritis related to *Salmonella spp.*

and noninflammatory osteoarthritis with foci of chronic inflammation<sup>2,3</sup> with negative result on bacter-

**The CT scan revealed a mixed osteolytic-proliferative bone lesion involving six vertebral bodies in the first third of the spinal tract. A small amount of material obtained from the spinal swelling was used for a bacterial culture positive for *Salmonella enterica ssp. Enterica*.**

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ial culture. In snakes, segmental, proliferative infectious spondylitis has been reported. Gram-negative bacteria (*Salmonella* sp. and *Pseudomonas* sp.) are usually isolated from affected bones<sup>3,4</sup>. *Salmonella* constitutes a genus of zoonotic bacteria of worldwide economic and health importance. *Salmonella* spp. are facultative, anaerobic, Gram-negative, rod-shaped bacteria belonging to the family Enterobacteriaceae<sup>6</sup>. The current view of *Salmonella* taxonomy assigns the members of this genus to two species: *S. enterica* and *S. bongori*. *S. enterica* itself includes six subspecies, including *enterica*, *salamae*, *arizonae*, *diarizonae*, *indica*, and *boutanae*, also known as subspecies I, II, IIIa, IIIb, IV, and VI, respectively<sup>7</sup>. Host-adapted *Salmonella* serotypes produce both enteritis and systemic infection in their natural hosts<sup>7</sup>. In mammals, infection occurs when *Salmonella* serotypes colonize the intestinal mucosa. Before progression to a systemic infection, they face macrophages that line the lymphatic sinuses of lymph nodes<sup>7</sup>.

The granulomas caused by the accumulation of polynuclear granulocytes in inflamed mammalian tissue have also been described in avian species, where it is the heterophiles that are involved and are morphologically similar to inflammatory lesions in reptiles<sup>8</sup>. Different virulence factors have been identified in *Salmonella* to promote infection, such as flagella, invasion, enterochelin and lipopolysaccharide (LPS), and LPS is a major determinant of its virulence<sup>7,9</sup>. LPS is composed by an internal Lipid A embedded in the outer membrane core region and an antigenic O region (LPS O-Ag). O-Ag provides steric hindrance of antibody binding to the bacterial surface<sup>11</sup>. *Salmonellas* are routinely isolated from apparently healthy, wild and even captive reptiles<sup>9,10</sup>. The incidence of reptile-related salmonellosis cases in humans has increased dramatically during the last 20 years<sup>11,12,13</sup>.

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## CASE PRESENTATION

An 8-year-old, 850-gram, female corn snake (*Pantherophis guttatus*) was presented for clinical examination for 2-months history of lethargy and constipation. The body condition score was 3 / 5, hydration status: <2.5%. The patient also showed a loss muscular tone. The animal was fed a single adult dead mouse (*Mus musculus*) every two weeks. A UVB light 2.0 spectrum was provided and changed every 6 months. Complete blood work, X-ray and total body CT-scans were performed. Blood tests were unremarkable. The complete blood count showed moderate heterophilia compared to the reference values. X-rays showed appreciable alterations in both LL and DV projections, and mild to moderate osteolysis of the first third of the spine was evident (Figure 1). Radiology did not show significant alterations of coelomic organs. A total body 2.5 mm interval CT scan without contrast medium administration was also performed. The CT scan revealed a mixed osteolytic-proliferative bone lesion involving six vertebral bodies in the first third of the spinal tract (Figure 2 A, B).

Equal combinations of destructive bone processes and new bone formation were evident. A biopsy of the proliferative lesion for histopathology was performed (Figure 3), but the sample was not diagnostic. A small amount of material obtained from the swelling was used for bacterial culture, which was positive for *Salmonella enterica* ssp. *Enterica*. Culture and sensitivity revealed sensitivity to enrofloxacin and ampicillin and intermediate sensitivity to several other antibiotics. The patient was discharged after 14 days of therapy, which consisted of subcutaneous (SC) rehydration with Ringer's solution (S.a.l.f. S.p.A. - Cenate sotto BG -Italy-), daily administration of meloxicam (Ceva Salute Animale S.p.A.- Agrate Brianza MB -Italy-) at a dosage of 0.2 mg/kg once a day (SID) SC for one week, and enrofloxacin (25 mg/ml) (Baytril® 25 mg/ml, Bayer S.p.A, Milano -Italy-) at 5 mg/kg SID SC for 2 weeks<sup>14</sup>. Ten days after the start of the treatment, the snake became more active and continued spontaneous feeding. Feces became more consistent and less malodorous. One month after the end of the therapy, blood tests were repeated, showing normalization of the complete blood count compared to the first one.

## DISCUSSION AND CONCLUSIONS

In veterinary medicine, spondylitis is reported in small companion animals<sup>15,16</sup>, large animals<sup>17</sup> and exotics<sup>9,18,19</sup>. In reptiles, most papers are related to

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snakes<sup>10,20</sup>, and few regard Sauria<sup>18,20</sup>. In small companion animals, fungi such as *Aspergillus terreus* are the most common aetiological agents involved<sup>22</sup>. Additionally, bacteria such as *Enterococcus faecalis*, *Pseudomonas aeruginosa* and *Staphylococcus epidermidis* are implicated<sup>24</sup>. The pathogenesis of discospondylitis is currently not completely clear. Haematogenous spread of bacteria or fungi is considered the most common cause of the disease<sup>21,23</sup>. One hypothesis is that the presence of subchondral vascular loops in the vertebral epiphysis can make the blood circulation slower, allowing colonization of blood-borne bacteria, which then diffuse through the cartilaginous endplate of the vertebral body. From there, they reach the disc<sup>18,21</sup> and then disseminate to adjacent vertebrae<sup>21</sup>. Foreign bodies, including grass awns, have been associated with discospondylitis in mammals<sup>22</sup>. Awns may be swallowed and migrate through the bowel wall through the mesentery migrating to ventral epaxial muscles and the vertebral column<sup>22,23</sup>. In reptiles, the pathogenesis remains unclear<sup>3,18</sup>. In one study, bacteraemia, with subsequent seeding of vertebrae and joints, was the most accredited hypothesis for development of proliferative bacterial osteoarthritis in snakes<sup>3</sup>. Moreover, the increase in leucocytes, and in particular lymphocytes, monocytes and heterophils, associated with acute, subacute or chronic inflammation, infection, wound healing, parasitism, and/or viral disease<sup>24</sup>. In most reptiles, heterophils represent 30% to 45% of leucocytes in the peripheral blood<sup>24,25</sup>; they appear similar to mammalian neutrophils, with phagocytosis activity against bacteria and foreign material and playing a significant role in innate immunity in response to various inflammatory stimuli<sup>24,25,26,27,28,29</sup>. This is the first reported successful treatment of *Salmonella enterica* spp. *enterica*-related infectious spondylitis in a pet corn snake (*Pantherophis guttatus*). In reptiles, CT-scan offers significant advantages for the detection of skeletal diseases<sup>18,30</sup>. The CT-guided FNA allowed the diagnosis of bacterial spondylitis. Even if the verte-



Figure 1 - X-rays shows osteolysis of the first third of the spine.

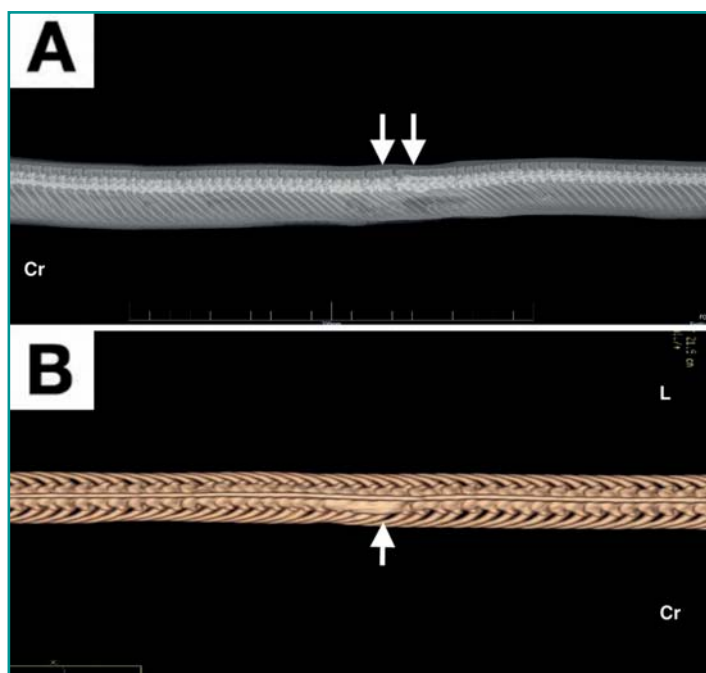


Figure 2 - A, B) Comparison between X-rays (LL view) and CT-scan, that reveal a mixed osteolytic-proliferative bone lesion involving six vertebral bodies in the first third of the spinal tract.

bral biopsy was not diagnostic due to the paucity of the sampled tissue, the bacteriology performed on tissue fragments was positive for *Salmonella enterica* spp. *enterica*. Antibiotic therapy was chosen based on the antibiogram, which confirmed the well-founded suspi-

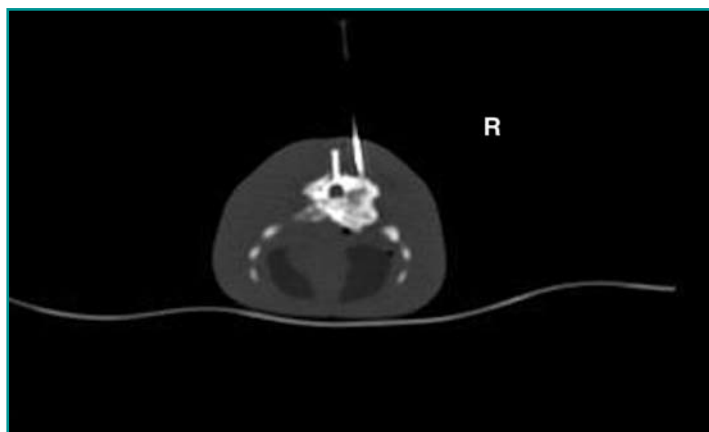


Figure 3 - CT guided biopsy of the proliferative lesion.

In reptiles, CT scans offer significant advantages for the detection of skeletal diseases. The CT-guided FNA allowed the diagnosis of bacterial spondylitis. Even if the vertebral biopsy was not diagnostic due to the paucity of the sampled tissue, the bacteriology performed on tissue fragments was positive for *Salmonella enterica* spp. *enterica*.

cion of an occurring infection. Among the effective tested antibiotics, enrofloxacin was chosen due to its better distribution within musculoskeletal tissue than ampicillin<sup>31</sup>. In fact, enrofloxacin is a broad Gram-negative spectrum fluoroquinolone that is effective against Enterobacteriaceae and various aerobic Gram-positive bacteria<sup>31,32,33</sup>. According to the literature, the recommended dose is 5 to 10 mg/kg PO every 24 h in snakes<sup>14</sup>. In this case, an early diagnosis was a fundamental key for an effective therapy. The use of advanced diagnostic techniques, such as CT-scans, and performing proper diagnostic approaches, such as bacteriology and bacterial sensitivity tests, should always be considered in reptiles to achieve optimal therapeutic success. *Salmonella enterica* is an animal and zoonotic bacterium of worldwide importance, and reptiles act as a reservoir<sup>9,10</sup>. Over the past few years, interest in exotic animals has increased, and reptiles are currently considered “new companion animals”. This case report should also press reptile breeders or snake keepers to adapt adequate hygiene measures whenever they manipulate snakes or clean their cages, avoiding direct contact with faeces or cloacal fluids that could be carriers of zoonotic bacteria, such as *Salmonella enterica*.

#### KEY POINTS

- Spondylitis is an inflammatory process of the vertebra that leads to a destructive process with exuberant new bone formation.
- *Salmonella enterica* is an animal and zoonotic bacterium of worldwide importance, and reptiles act as a reservoir
- In reptiles, CT scans offer significant advantages for the detection of skeletal pathologies. The CT-guided FNA allowed the diagnosis of bacterial spondylitis. Even if the vertebral biopsy was not diagnostic due to the paucity of the sampled tissue, the bacteriology performed on tissue fragments was positive for *Salmonella enterica* spp. *enterica*.

### Diagnosi e trattamento efficace della spondilite causata da *Salmonella enterica* ssp. *enterica* in un serpente del mais (*Pantherophis guttatus*)

#### Riassunto

La spondilite è un processo infiammatorio delle vertebre che può portare ad un'erosione del tessuto osseo con processi di osteosintesi esuberante. Questa condizione può produrre un'alterazione dell'architettura ossea, che porterà ad una degenerazione delle articolazioni con anchilosi delle vertebre adiacenti. Nei rettili non si parla di discospondilite in quanto sono privi dei dischi intervertebrali. Le lesioni istologiche sono quindi classificate come osteoartrite batterica, in questo caso causata da *Salmonella* spp. che portava a osteoartrite non infiammatoria con focolai di infiammazione cronica che risultano negativi alla coltura batterica. Nei serpenti ci sono segnalazioni di spondilite proliferative su base infettiva. I batteri Gram-negativi (*Salmonella* sp. e *Yersinia* sp.) sono i più comunemente isolati. Si ritiene che la diagnosi antemortem sia complicata nei serpenti e, per questo motivo, la prognosi è considerata sfavorevole. Questo caso descrive la diagnosi e il trattamento efficace della spondilite causata da *Salmonella enterica* ssp. *enterica* in un serpente del mais (*Pantherophis guttatus*).



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