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Foot Infections Associated with *Arcanobacterium pyogenes* in Free-living Fallow Deer (*Dama dama*)

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ABSTRACT: We describe foot infection associated with *Arcanobacterium pyogenes* in three adult male free-living fallow deer (*Dama dama*) from Sueve Regional Hunting Reserve (Principality of Asturias, Spain). Affected fallow deer were culled in November 1997 and 1998 during the hunting season. Necropsy, radiography, and microbiologic analysis were carried out for each animal. Unilateral swelling of one extremity at the coronary band was observed in all three cases. Areas of bone loss, severe periosteal reaction, and soft tissue swelling were seen on radiography. Lead fragments were observed in one fallow deer. Seven bacterial species were isolated, but only *Arcanobacterium pyogenes* was routinely found. Weather conditions in the area (mild temperatures and high humidity), the land (alternating pasture land and rock), the animal population density (both fallow deer and domestic herds of cows, horses, sheep, and goats, live side by side in the same areas), and hunting activities could be related to the frequency of these infections.

Key words: Dama dama, fallow deer, foot infections, *Arcanobacterium pyogenes.*

Foot infections are frequently described in domestic ungulate species (Timoney et al., 1988; Scott et al., 1991); however, studies on wild ruminants are scarce and most focus on footrot, which mostly affects captive animals, although cases have been reported in free-living populations (Drager, 1975; Catusse et al., 1996). Mixed bacterial infections in the feet of deer have been reported in free-living and captive animals (Wobeser et al., 1975; Roeder et al., 1989; Haigh and Hudson, 1993; Thorne et al., 2002; Chirino-Trejo et al., 2003). There are no reports of foot infections in free-living fallow deer and only a few cases have been reported in captive wild animals (English 1984, 1988; Zulty and Montali, 1988). The present report describes three cases of foot infection in free-living fallow deer in Spain.

Fallow deer (*Dama dama*) were introduced into the Sueve Regional Hunting Reserve in Principado de Asturias (N Spain, 43°15°N, 5°15′W) in 1960. This 8,300-ha reserve is 5 km from the sea. The climate is mild and there is abundant rainfall throughout the year (average rainfall from 1,400–1,500 l/m^2). Above 800 m, there is abundant subalpine pasture land that alternates with rocky and wooded areas. The highest population density of fallow deer is found at this altitude, and the population has been increasing since they were introduced. The population is now more than 1,000 and, between May and December, there are also 1,200 cows, 550 horses, and 850 sheep and goats. Fifty percent of these animals are found in the area most used by fallow deer, at between 800 and 1,000 m in elevation.

The fallow deer affected with foot infections were found during the hunting season, in November 1997 and 1998, and all were male adults. Two affected fallow deer were observed to be moving with severe difficulty. They spent long periods of time lying down, kept their feeding time to a minimum, and in general had a poor appearance with bristling, loss of coat sheen, and weight loss. The third animal had difficulty in moving and was culled for study. Each animal was subjected to a complete necropsy, radiographs were taken of the affected extremities, and samples were obtained for microbiologic analysis. Samples were cultured on 5% sheep blood agar and MacConkey agar and incubated at 37 C aerobically in 5% CO_2 and anaer-

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FIGURE 1. Dorsopalmar radiograph of the left forelimb foot showing a mild soft-tissue swelling (arrow) on the axial aspect of the distal interphalangeal joints.



FIGURE 2. Dorsoplantar radiograph of the left rear-limb foot demonstrating the bony lesions and the lead particles due to fragmentation of a bullet.

obically. Colonies growing anaerobically were subcultured to a blood agar plate and incubated at 37 C in an atmosphere of 5% CO_2 to assure that they were obligate anaerobes.

One affected male was shot in November 1997. There was slight swelling of the left foreleg at the coronary band as a result of accumulation of pus. Radiographs (Fig. 1) showed moderate soft tissue swelling on the axial aspect of the middle and distal phalanges of the second and fourth digits. No signs of periosteal reaction or degenerative joint disease were observed. Bacterial species isolated from coronary band tissue were *Arcanobacterium pyogenes* and *Fusobacterium necrophorum.*

Another adult male was shot in November 1997. There was significant swelling on the left hind leg at the metacarpal-phalanx and proximal interphalangeal joints, with partial loss of the medial digit hoof and purulent exudate. Radiographs (Fig. 2) showed proliferative periosteal reaction with fractures of the proximal and distal phalanges of the fourth digit, loss of bone, and presence of radiodense areas later confirmed to be lead fragments. The third digit showed traumatic amputation of the distal half of the middle phalanx and the whole distal phalanx. Severe soft tissue swelling was also observed. The bacterial species isolated from tissue of coronary band and metacarpal-phalanx and proximal interphalangeal joints were *A. pyogenes, Prevotella* spp., and *Peptostreptococcus indolicus.*

The third affected male was shot in November 1998. There was significant swelling of the right foreleg at the metacarpal-phalanx and proximal interphalangeal joints, with partial loss of the hoof of the medial digit and all of the lateral digit and with associated production of pus. Radiographs (Fig. 3) showed complete loss of

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FIGURE 3. Dorsopalmar radiograph of the right forelimb foot demonstrating a severe periosteal reaction and the loss of both distal phalanges.

the fourth digit of the distal phalanx and loss of bone in the distal aspect of the middle phalanx. There was loss of bone in the distal phalanx of the third digit. Both digits also had severe periosteal reaction and degenerative joint disease affecting several joints. Soft tissue swelling was also observed. Bacterial species isolated from the metacarpal-phalanx and proximal interphalangeal joints were *A. pyogenes* and *F. varium.*

Arcanobacterium pyogenes is frequently associated with production of pus and abscesses, particularly in ruminants and occasionally in other animals (Timoney et al., 1988; Lavin et al., 1998). It is maintained on mucous membranes of these species (Natterman and Horsch, 1977). Infections in domestic animals usually are sporadic. This microorganism is therefore an opportunist that will enter wounds or abrasions of the skin (Timoney et al., 1988). *Fusobacterium necrophorum,* isolated from one deer, is a commensal of the alimentary tract of many animal species and humans (Nicolet, 1986; Timoney et al., 1988). This bacterium, under suitably humid conditions, can survive for up to 10 mo in the ground (Nicolet, 1986). The organism has little or no ability to invade normal epithelia but readily enters and multiplies in tissues damaged by trauma and in the instance of viral or bacterial infection (Timoney et al., 1988; Leighton, 2001). *Fusobacterium necrophorum* and *A. pyogenes,* either individually or together, account for most cases of foot abcessation in sheep, but infections involving other organisms also occur (Jensen and Swirt, 1982; Scott and Henderson, 1991). *Fusobacterium necrophorum* facilitates establishment and growth of *A. pyogenes* in tissues, and *A. pyogenes* contributes to growth of *F. necrophorum* (Timoney et al., 1988; Scanlan, 1991).

Foot abscesses are a common cause of lameness in individual sheep, and a careful examination of the foot is necessary to distinguish the condition from footrot (Scott and Henderson, 1991). In sheep, foot abscesses cause acute pain, especially during the active stage of infection, because of inflammation and swelling of tissues within the hoof (Scott and Henderson, 1991; Linklater and Smith, 1993). Foot abscesses have been described in farmed red deer (*Cervus elaphus*) after capture and in adverse climatic conditions (Griffin, 1987). We did not isolate *Bacteroides nodosus* from our fallow deer, which, along with *F. necrophorum,* is responsible for footrot in small ruminant animals (Bruguere-Picoux, 1987). Mixed cultures including aerobic and anaerobic bacteria were isolated from our deer. With the exception of *F. necrophorum* and *A. pyogenes,* the other bacteria isolated are not normally considered pathogens in the extremities of animals (Timoney et al., 1988; Egerton, 2000).

Since introduction of fallow deer in the reserve, the most frequently observed pathologic conditions were foot infections, which occurred in approximately 1% of all

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animals in the reserve, although no systematic studies have been performed. Lameness is most frequently observed in males. Males are predisposed to *A. pyogenes* infections associated with the cerebral abscess syndrome in white-tailed deer (*Odocoileus virginianus*) (Baumann et al., 2001). The occurrence of foot infections in fallow deer is probably related to multiple factors. The climate of the reserve is one of mild temperatures with high humidity, which may be associated with softening of the hoof and which also supports microorganisms in the environment for long periods of time. The land is characterized by interspersed meadowland and rock, which could easily cause minor injuries to the hooves. The density of animals, including fallow deer and domestic livestock living together in the same area, could contribute to an increased presence of microbes in the environment. Finally, hunting, which on certain occasions can cause hoof injuries, may facilitate penetration of microorganisms into the foot. Further studies are needed to evaluate 1) the prevalence of foot infections in this population of fallow deer, 2) the microbes involved, and 3) the relation of both to infection in domestic animals.

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