Abdominal lipomatosis attributed to tall fescue toxicosis in deer

Barbara A. Wolfe, DVM, PhD; Mitchell Bush, DVM; Steven L. Monfort, DVM, PhD; Sonia L. Mumford, DVM; Allan Pessier, DVM; Richard J. Montali, DVM

Ingestion of tall fescue forage infected with the endophytic fungus *Acremonium coenophialum* may be a factor in the development of abdominal lipomatosis.

- Eld's deer and other Asian species of deer are susceptible to abdominal lipomatosis, which is a potentially fatal disease with pathophysiological characteristics that are unclear.

A 6-year-old hand-raised female Eld's deer (*Cervus eldi tamin*) at the National Zoo's Conservation and Research Center in Front Royal, Va, was admitted to the veterinary hospital because of anorexia and depression of 2 days' duration. The deer, reluctant to stand and easily handled without sedation, was anesthetized for examination by an intramuscular injection of ketamine hydrochloride (3.0 mg/kg [1.36 mg/lb] of body weight) and xylazine hydrochloride (0.6 mg/kg [0.27 mg/lb]). A 5 × 6-cm firm subcutaneous mass was palpable overlaying the right body of the ilium, and loose tarry feces and blood were found on the tail and perineum. Due to anesthesia, vital signs (heart rate, 40 beats/min; respiratory rate, 16/min; capillary refill time, 2 seconds) were considered normal. On abdominal palpation, a large, firm mass was found in the right portion of the abdomen near the 18th rib. Abdominal radiography revealed 2 large radiopaque perirenal masses. Microscopic examination of a fine needle aspirate and biopsy of the subcutaneous mass revealed irregular lobules of necrotic fat separated by dense connective tissue. Laboratory test results were within expected limits except for the number of platelets, which was low, and fibrinogen concentration, which was 800 mg/dl (reference range, 200 to 400 mg/dl). Abnormalities on serum biochemical analysis were markedly high concentrations of BUN (270 mg/dl; reference range, 20 to 35 mg/dl), creatinine (16.9 mg/dl; reference range, 1.1 to 2.5 mg/dl) and a creatine phosphokinase activity of 607 U/L (reference range, 60 to 260 U/L). The deer was given 5% dextrose solution (40 ml/kg [18.2 ml/lb], IV), ranitidine hydrochloride (1.3 mg/kg [0.59 mg/lb], IM), ketoprofen (2.6 mg/kg [1.18 mg/lb], IM), and cefotiofur sodium (2.2 mg/kg [1 mg/lb], IM) and was allowed to recover from anesthesia.

From the Departments of Veterinary Services (Wolfe, Bush, Monfort) and Pathology (Pessier, Montali), National Zoological Park, Washington, DC 20008; and the North Carolina State University College of Veterinary Medicine (Mumford). Dr. Wolfe's present address is North Carolina Zoological Park, 4401 Zoo Parkway, Asheboro NC 27203.

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![Figure 1—Photograph of masses of necrotic fat surrounding ureters and causing proximal dilatation of the ureter (arrow) and renal pelvis in a female Eld's deer.](image)

Two days later, the deer had not improved despite continued supportive treatment. Abnormalities on laboratory tests included low Hct (24.5%; reference range, 30 to 45%) and high concentrations of BUN (300 mg/dl), creatinine (19.0 mg/dl), and phosphorus (16.2 mg/dl; reference range, 3.6 to 11.1 mg/dl), and high activity of creatine phosphokinase (6,400 U/L). An exploratory laparotomy was performed and the abdominal cavity was found to contain large, firm white masses that adhered to most of the abdominal organs. The deer was euthanatized. At necropsy, the masses consisted of firm to hard deposits of lobulated necrotic perirenal and sublumbar fat that partially enveloped the kidneys. The necrotic fat associated with the right kidney measured 15 × 10 × 6 cm, whereas that surrounding the left kidney measured 30 × 10 × 9 cm and displaced it cranialmedially. The necrotic fat surrounded and constricted the ureters bilaterally (Fig 1) as well as the intestinal tract at the cecocolic junction, which resulted in bilateral hydronephrosis and cecal impaction. Numerous smaller (approx 1-cm diameter) nodules of necrotic fat were distributed throughout the omentum, and a 2 × 1 × 1-cm nodule was observed in the subcutaneous tissues at the thoracic inlet.

This deer was a member of a herd of 46 deer maintained since 1975. From March to November, females were housed on two 2-acre pastures, consisting mainly of tall fescue with varying amounts of orchard grass, bluegrass, red clover, crowned vetch, and alfalfa. From November through February, females were housed indoors and fed a combination of alfalfa and pelleted diet consisting of wheat middlings, soybean hulls, alfalfa, corn, cane molasses, beet pulp, soybean oil, and vitamin/mineral supplements (crude protein, 12.5%; crude fat, 3.0%; crude fiber, 21%; moisture, 11%).

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From November to July, males were housed individually in indoor/outdoor stalls and fed the same diet. From July to November, males were housed on pasture of similar composition to those housing females.

A retrospective analysis was undertaken to identify deer that had been housed at the Conservation and Research Center for at least 2 consecutive years from 1975 to 1998 and that had been necropsied. Of 48 deer that had died in those 23 years, 24.4% (5 males, 6 females; 3 to 13 years old; mean age, 7.8 years) had evidence of fat necrosis at necropsy. Seven of those affected (63.6%; 1 male, 6 females) had unilateral or bilateral hydronephrosis associated with ureteral constriction by necrotic fat. Five of these deer died because of the resultant hydronephrosis and renal failure. Deer that died because of adipose fat necrosis were female, and these deaths had occurred since 1994.

Necropsy results were similar; masses of necrotic perirenal and sublumbar fat, measuring between 3 x 8 x 4 cm and 15 x 10 x 8 cm, were found that surrounded and constricted the ureters, which resulted in proximal hydronephrosis and hydronephrosis. These masses were grossly and histologically similar to the masses in the deer of this report.

Histologically, masses of abnormal fat were characterized by locally extensive areas of coagulative necrosis of adipocytes containing foci of saponification that were separated and surrounded by bands of mature fibrous connective tissue (Fig 2). Inflammation was not a prominent feature and, when present, consisted of small, focal accumulations of foamy macrophages. Two deer had foci of osseous metaplasia within necrotic areas that corresponded to red gritty foci observed grossly.

Physical examinations were performed, and radiographs were taken of most of the herd to assess the prevalence of fat necrosis. Of sixteen 3- to 15-year-old females examined, 15 had palpable firm sublumbar masses; 60% of these had radiographic evidence of mineralization (Fig 3). Of seven 9- to 15-year-old males examined, only 1 had palpable firm abdominal masses, and these masses were not visible radiographically. Fat necrosis was not detected in deer < 3 years old.

In general, females between 3 and 12 years old were in excellent to moderately obese body condition. Females tended to retain body condition throughout the year, whereas males generally decreased food consumption and lost 15 to 20% of their body weight during the reproductive months (ie, December to May) each year. Laparoscopic evaluation confirmed the presence of firm masses of sublumbar fat in the 15 females that had abnormal fat evident on palpation and radiography. In some females, small nodules or whitish streaks of firm fat were found in the omentum.

Fat necrosis has been described in several species, although the pathophysiologic characteristics are not well understood. Steatitis, which is one cause of fat necrosis, is a nutritional condition often induced by diets high in polyunsaturated fats and low in vitamin E. Steatitis generally affects all body fat, and can develop in animals of any age. Fat necrosis as a result of pancreatitis or pancreatic necrosis generally affects abdominal fat, and is accompanied by infiltration of neutrophils. Acute necrotizing pancreatitis is an important disease in dogs and has been described in cats, horses, mice, pigs, and nonhuman primates. Abdominal fat necrosis in ruminants, or lipomatosis, is a well-defined clinical entity attributed to obesity, genetic predisposition, and consumption of tall fescue forage infected with the endophytic fungus *Acremonium coenophialum.*

Tall fescue (*Festuca arundinacea*) is considered the most abundant and economically important cool season perennial grass in the United States, and constitutes over 35 million acres of primary ground cover. Tall fescue was introduced as a grazing cover in the midwestern and southern United States in the 1940s and was not associated with problems until the 1960s. In 1977, infection of tall fescue with the endophytic fungus *Acremonium coenophialum* (formerly *Epichloë typhina*) was associated with a multitude of symptoms in cattle, which included decreased feed intake, weight gain, milk production, and reproductive performance, increased body temperature and respiration, rough coat, excessive salivation, lameness, and dry gangrene of the feet and tail. Abdominal fat necrosis, first described by Williams et al., has been established as one manifestation of fescue toxicosis. To date, endophyte-infected fescue-associated physiologic problems have also been identified in mice, rats, rabbits, horses, and sheep.
Fescue samples from 4 pastures, including those on which female Eld's deer are maintained during the summer months, were analyzed for the presence of A coenophialum by the Auburn University Fescue Toxicity Diagnostic Center, using the grow-out technique. These 4 pastures were 89, 97, 96, and 23% infected, respectively. This Eld's deer herd has been noticed to preferentially eat tall fescue compared with other grasses, alfalfa hay, and pelleted feed, particularly during the cool season when tall fescue is considered most palatable.

Chronic ingestion of endophyte-infected tall fescue was considered to be the primary causative factor in the high incidence of lipomatosis observed in this herd, although genetic predisposition, obesity, and sex were likely to be contributing factors. Genetic predisposition for necrosis of abdominal fat and susceptibility to tall fescue-induced fat necrosis have been well-documented among domestic cattle breeds. Furthermore, other species of Asian deer in captivity such as swamp (C duvaucelii), sika (C nippon), and sambar (C unicolor) deer can have similar histologic changes in abdominal fat. Obesity and sex were incidental causes, because males in the herd of this report used most of their stored body fat during the annual rut. This may in part explain the small amount of fat necrosis in males compared with females, which do not exhibit such a circannual metabolic cycle. Additionally, males were exposed to pasture for only 5 months of the year, whereas females grazed 9 months. Finally, the predominance of endophyte-infected tall fescue in these pastures, and the deer's preference for it, suggest fescue toxicosis was a contributing factor. The increasing incidence of lipomatosis in recent years may be explained in part by the biologic characteristics of the plant-fungus symbiont. Acremonium coenophialum does not produce spores in vivo, and therefore is spread only through seeds, not by wind or mechanical means. Moderately infected pastures tend to become more infected, because an infected plant is more insect- and disease-resistant than a noninfected plant. It is likely that the degree of infection of these pastures has been increasing for a long time, resulting in a high incidence of lipomatosis in this herd of Eld's deer.

Pastures were treated with herbicide and reseeded with other grasses in summer, 1996. Diet alterations were also instituted to reduce overconditioning in females. Since this time, laparoscopic evaluation of females has failed to detect gross changes in the appearance of abdominal necrotic fat masses, and the incidence of clinical signs attributable to abdominal fat necrosis has dramatically decreased.

Ketaset, Fort Dodge Laboratories Inc, Fort Dodge, Iowa.
Xylazine-100 Injectable, The Butler Co, Columbus, Ohio.
Zantac, Glaxo Pharmaceuticals, Research Triangle Park, NC.
Ketolen, Fort Dodge Laboratories Inc, Fort Dodge, Iowa.

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**From My Armchair: W. W. Armistead**

**Environmental Hazards**

Veterinarians were environmentalists before the term became fashionable. Successful veterinary practice, especially farm practice, requires an understanding of how illness relates to overcrowding, inadequate shelter, nutritional deficiency, contaminated premises, and polluted air and water. Long before activists made ecology a household word, veterinary students were learning how interactions of various animal species, including humans, influence the spread of disease. This special emphasis in their training has enabled veterinarians to adapt quickly to work in preventive medicine and public health.

Awareness of health hazards in the workplace and the natural world is mostly a 20th-century phenomenon. Ancient Romans did not suspect that they were in danger of poisoning from their lead plumbing. Until well into this century, miners, asbestos workers, and house painters were only vaguely aware of a connection between their occupations and their chronic health problems.

Pierre and Marie Curie, while recognizing the potential benefits of their 1898 discovery of radium, likely did not initially grasp the extent of its dangers. But in the 1920s and 1930s, some of these were demonstrated tragically by watch-factory workers who developed disfiguring cancers of the mouth and jaw. For years, they had been employed to hand-paint luminous watch dials with paint loaded with radium and were in the habit of using their lips to point the tiny brushes.

Wilhelm Roentgen in 1901 received the first Nobel Prize in physics for his discovery of the x-ray. As with radium, ignorance of the extent of the dangers led to early abuses. For a while, enterprising shoe stores even used x-ray machines to help fit children’s shoes. The practice was halted when the dangers of electromagnetic radiation became known. Many veterinarians of my generation developed deformed fingernails from repeatedly using their bare hands to restrain small animals while they were being x-rayed. One nationally prominent veterinarian in the 1930s had to have both feet amputated because of damage from self-treating his athlete’s foot with a primitive, uncalibrated x-ray machine.

Since midcentury, veterinary medicine has expanded into new fields with important implications for public health—developments that are receiving added impetus from growing public concerns about environmental deterioration, genetic engineering (cloning), endangered animal species, and animal rights. Animals share our increasingly crowded planet. Loss of natural habitat through human encroachment threatens many animal species with extinction. Animals are victimized by the same natural disasters, environmental pollutants, and many of the same diseases that threaten humans. Therefore, veterinary medicine is important not only to animals, it has also become a practical necessity for human health and welfare.

*W. W. Armistead*