

# Septicemic Salmonellosis in Two Cats Fed a Raw-Meat Diet

Salmonella gastroenteritis and septicemia were diagnosed in two cats presented for necropsy. Both cats resided in the same household and were fed a home-prepared, raw meat-based diet. Salmonella was isolated from multiple organs in both cats and from samples of raw beef incorporated into the diet fed to one of the cats. Subtyping of the bacterial isolates yielded *Salmonella newport* from one cat and from the diet it had been fed. This report provides evidence that the practice of feeding raw meat-based diets to domestic cats may result in clinical salmonellosis. *J Am Anim Hosp Assoc* 2003;39:538-542.

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## Introduction

*Salmonella* are Gram-negative, aerobic or facultative anaerobic bacilli of the family Enterobacteriaceae and have a diverse animal reservoir, including mammals, birds, reptiles, amphibians, and invertebrates.<sup>1</sup> All *Salmonella* infections are considered zoonoses except *Salmonella typhi*, *Salmonella paratyphi* A, and *Salmonella paratyphi* B, which are specific to humans and lack a nonhuman reservoir cycle.<sup>2</sup> *Salmonella typhimurium* (*S. typhimurium*) is most commonly isolated from domestic cats; however, naturally acquired infection is uncommon in this species.<sup>3,4</sup> Modes of infection include fecal-oral transmission, ingestion of contaminated feed, ocular transmission, and possibly aerosolization and transplacental transfer.<sup>1,2,5</sup> Clinical syndromes described for cats with salmonellosis include gastroenteritis, bacteremia/endotoxemia, localized infection of extraintestinal organs, conjunctivitis, abortion, and subclinical infection or an asymptomatic carrier state.<sup>1,3,6-9</sup> This report describes two cases of feline *Salmonella* gastroenteritis and septicemia in cats from a multicat household, which were fed diets containing uncooked beef. In one case, *Salmonella newport* (*S. newport*) isolates from multiple tissues were identical to isolates from raw beef used in a home-prepared diet.

## Case Reports

### Case No. 1

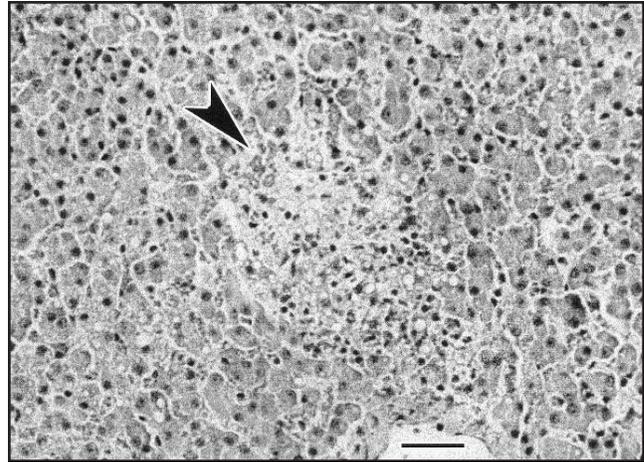
A 14-year-old, intact male exotic shorthair cat was presented deceased on arrival to the referring veterinarian and was submitted for necropsy to the Tifton Veterinary Diagnostic and Investigational Laboratory (TVDIL) at the University of Georgia's College of Veterinary Medicine. The cat had a history of weight loss, soft stools, and anorexia of 1 week's duration. Gross findings included weight loss, matted facial hair (suggestive of salivation or nasal discharge), ulceration of the ventral surface of the

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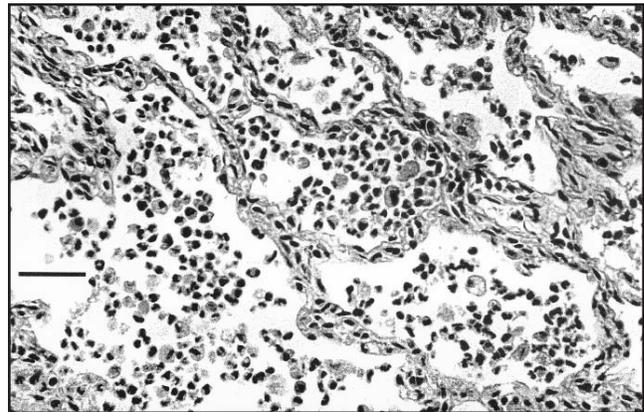
tongue, and soft, semiformed feces in the colon. Virus isolation was performed using two tissue homogenates; the first consisted of pooled lung, kidney, and spleen; the second consisted of small intestine. Tissue homogenates were plated onto three cell lines (CrFK-Crandell Feline Kidney cells, DK-Dog Kidney cells, and Vero-Green Monkey Kidney cells) and were observed for 14 days. Cytopathic evidence of viral infection was not observed. Histopathological examination revealed moderate, multifocal, necrotizing hepatitis with multifocal, random, small areas of hepatocellular necrosis and associated mild neutrophilic and histiocytic inflammation [Figure 1]; and moderate, diffuse, subacute to chronic enteritis with neutrophilic, lymphoplasmacytic, and histiocytic infiltrates within the lamina propria. Mild, multifocal, interstitial pneumonia with mild, multifocal, interstitial aggregates of neutrophils, macrophages, and lesser numbers of lymphocytes was present in the lung. Bacteriological culture yielded *Salmonella* Group B isolates from the lung, liver, spleen, and kidney. Normal flora was cultured from the intestine. The *Salmonella* isolate was susceptible to aminoglycosides, cephalosporins, fluoroquinolones, and potentiated sulfonamides and was resistant to penicillins, macrolides, tetracyclines, chloramphenicol, and nonpotentiated sulfonamides. This isolate was submitted to the National Veterinary Services Laboratory (NVSL), USDA-APHIS, in Ames, Iowa for subtyping and was identified as *S. typhimurium*.

#### Case No. 2

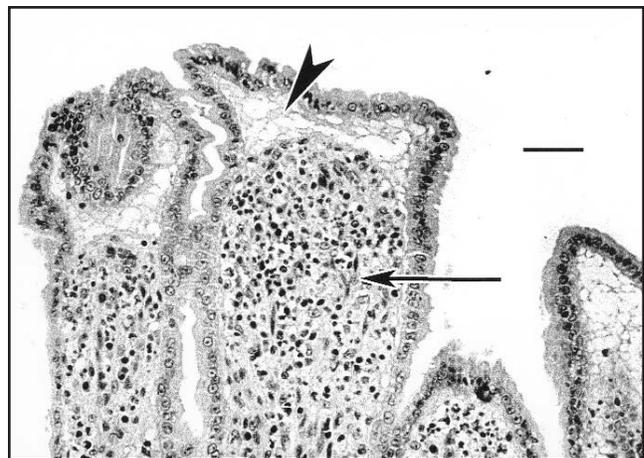
Nine months after case no. 1 was seen, a 10-week-old, intact male exotic shorthair kitten from the same household was presented moribund to the referring veterinarian, with a history of possible respiratory obstruction. The kitten had previously received one feline panleukopenia vaccination. Antemortem diagnostic testing was limited to an in-hospital enzyme-linked immunosorbent assay test<sup>a</sup> for feline leukemia virus antigen, which was negative. The kitten was euthanized at the owner's request and submitted for necropsy to the TVDIL. Grossly, the kitten was mildly dehydrated and had reduced fat and muscle stores, serous nasal discharge, and bilateral corneal opacity. The lungs were consolidated and mottled dark red-gray. Histopathological examination revealed severe, acute, suppurative pneumonia with severe, multifocal, coalescing alveolar and bronchiolar infiltrates of viable and degenerate neutrophils and macrophages; moderate, multifocal, alveolar edema and fibrin deposits were also present [Figure 2]. In the small intestine, there was moderate, acute enteritis with blunting and erosion of villi; dilated crypts and glands; mild, diffuse lymphohistiocytic and neutrophilic infiltrates of the lamina propria; and mild to moderate multifocal, proprial edema of apical villi [Figure 3]. Fluorescent antibody tests for feline coronavirus, herpesvirus, and calicivirus were negative. *Salmonella* Group B isolates were cultured from the lung and small intestine; they were susceptible to aminoglycosides and fluoroquinolones and were resistant to penicillins, cephalosporins, macrolides, tetracyclines, and potentiated and unpotentiated sulfonamides. Additionally, *Bordetella bronchiseptica* was isolated from the lung. The *Salmonella* isolates were also submitted to NVSL and identified as *S. newport*.



**Figure 1**—Histopathology of the liver from a cat with septicemic salmonellosis (case no. 1). Arrowhead indicates a focal area of hepatocellular necrosis (Hematoxylin and eosin stain, 100 $\times$ ; bar=25  $\mu$ m).



**Figure 2**—Histopathology of the lung from a cat with septicemic salmonellosis (case no. 2). Marked alveolar infiltrates of neutrophils and macrophages (Hematoxylin and eosin stain, 100 $\times$ ; bar=25  $\mu$ m).



**Figure 3**—Histopathology of the small intestine from a cat with septicemic salmonellosis (case no. 2). Diffuse proprial infiltrates of leukocytes with necrosis in villi (arrow) and apical proprial edema (arrowhead) (Hematoxylin and eosin stain, 100 $\times$ ; bar=25  $\mu$ m).

### Analysis of Raw Meat Specimens

The owner of the two cats was advised by her veterinarian to discontinue the practice of feeding raw meat-based diets to her remaining cats. Subsequent to this recommendation, the owner submitted specimens of raw beef to the TVDIL for bacteriological culture that had previously been incorporated into a home-prepared feline diet. Suspect colonies were identified using an automated identification system,<sup>b</sup> and the identity was confirmed using a *Salmonella* latex agglutination test.<sup>c</sup> Beef samples were aseptically sampled and homogenized in sterile phosphate-buffered saline and cultured on blood agar, Hektoen Enteric Agar (HE), and in Tetrathionate Broth (tetra). Growth in the tetra tube was subcultured on HE and blood agar plates. An initial specimen yielded *Salmonella* spp. in addition to *Escherichia coli* (*E. coli*), *Moraxella osloensis*, *Citrobacter* spp., *Pantoea agglomerans*, and an alpha-hemolytic *Streptococcus* spp.

Twenty-two days later, the owner submitted two additional specimens consisting of both trimmed and ground beef. According to the owner, portions of these specimens had been incorporated into the diet fed to the kitten in case no. 2. Bacteriological culture of the trimmed beef specimen was performed as described; it yielded *Salmonella* Group B and a mixed population of other bacteria, including *Streptococcus*, *Pseudomonas*, *Staphylococcus*, *Aeromonas*, *Pantoea*, and *Hafnia* spp. From the ground beef, *Salmonella* Group C and an additional *Salmonella* species were isolated. Additional isolates from this specimen included *Proteus*, *Staphylococcus*, *Pantoea*, *Acinetobacter*, *Morganella*, *Myroides*, *Corynebacterium*, *Streptococcus* spp., and *E. coli*. Again, all three *Salmonella* spp. isolates were submitted to NVSL and identified as *Salmonella bardo* (specimen 1) and *S. newport* (specimens 2 and 3).

### Discussion

Feline salmonellosis is considered an uncommon disease, although the actual prevalence may be higher than estimates based solely on fecal swab culture results and routine isolation methods.<sup>1,3,5</sup> Reported frequencies of *Salmonella* spp. isolations from asymptomatic cats range from 1% to 18%.<sup>1,4,5,10,11</sup> In cats, modes of infection for systemic disease include ingestion of contaminated food or water, direct fecal-oral transmission (via coprophagy, grooming), ocular transmission, and possibly via transmission of airborne fomites<sup>1</sup> and transplacental infection.<sup>9</sup> To the authors' knowledge, recovery of identical *Salmonella* species from domestic cats with clinical salmonellosis and from samples of their diet has not been previously reported. In this report, *S. newport* was isolated from both the lung and small intestine from a kitten (case no. 2), as well as from two specimens of raw beef that had been fed as part of a home-prepared diet. The two cases had a temporal separation of nine months, and, unfortunately, samples of raw beef fed in case no. 1 were unavailable for bacteriological culture. Consequently, isolation and identification of *Salmonella* species from both this cat and its diet could not be performed as in case no. 2. A report of feline stillbirth

associated with *S. typhimurium* described the feeding of raw chicken to the queen during gestation; the phage type of *S. typhimurium* recovered from the aborted fetuses was consistent with one commonly found in poultry; however, specimens of poultry fed during gestation were not available for bacteriological culture.<sup>9</sup>

Reported *Salmonella* isolates from cats include serovars *typhimurium*, *cholerasuis*, *dublin*, *newport*, *arizonae*, *saint-paul*, *krefeld*, *typhisuis*, *enteritidis*, *hadar*, *manhattan*, *infantis*, and *virchow*, with *typhimurium* most commonly isolated.<sup>7,11-13</sup> The feeding of foodstuffs containing raw meat contaminated by *Salmonella* has been documented, and increased recovery of *Salmonella* isolates from the feces of sled dogs, greyhounds, and exotic cats fed raw-meat diets has been described.<sup>14-16</sup>

Healthy adult cats appear to have high immunological resistance to the development of clinical salmonellosis. In one study, experimental infection of healthy cats required inoculation of infectious organisms in numbers far exceeding those likely encountered in natural infection.<sup>3</sup> Susceptibility to and severity of *Salmonella* infection is dependent on multiple factors, including inherited virulence factors of the pathogen, infectious dose, and host resistance factors. Host resistance to *Salmonella* in cats may be influenced by a number of variables, including age, immunocompetence, hospitalization, cage confinement, multicat environments (e.g., multicat households, animal shelters, catteries), medical or surgical procedures, chemotherapy, administration of exogenous glucocorticoid therapy, gestational status, prior or concurrent disease, and possibly prior immunization.<sup>3,6-9,11</sup> Both of these cases originated in the same multicat household, and the affected animals were either very young (10 weeks) or very old (14.7 years), suggesting possible environmental stress, altered immune status, or both. Additionally, case no. 2 had concurrent respiratory infection with *Bordetella bronchiseptica*, incurring additional immunological and physiological stress with compromise to local pulmonary defense mechanisms. A recent report described a possible association between an outbreak of fatal salmonellosis among cattery-raised kittens and their earlier vaccination with a high-titer modified-live panleukopenia vaccine.<sup>11</sup> Case no. 2 also had a history of recent vaccination for feline panleukopenia.

Clinical syndromes of feline salmonellosis include gastroenteritis, bacteremia/endotoxemia, localization to individual or multiple organs, chronic febrile disease with anorexia and lethargy, chronic subclinical infection, conjunctivitis, and abortion.<sup>1,7-9,17</sup> In case no. 1, the intestinal, hepatic, and pulmonary lesions, multiple organ isolation of *Salmonella*, and clinical history of anorexia were consistent with *Salmonella* gastroenteritis and bacteremia. Failure to isolate *Salmonella* from the alimentary tract in cats with multiorgan localization and septicemia, as in case no. 1, has been previously described.<sup>1,6,7</sup> Pneumonia associated with acute *Salmonella* gastroenteritis has also been previously described.<sup>1</sup> In case no. 2, the pneumonia was complicated by concurrent bordetellosis.

In both case nos. 1 and 2, cats were fed a home-formulated diet containing raw beef. Isolates of *Salmonella* recovered from two samples of beef fed to case no. 2 were identical to isolates cultured from this animal's intestine and lung. Contamination of diets after their preparation may occur through communal feeding practices in a multicat household or through the use of contaminated food dishes or utensils. In this case, the *Salmonella* isolates from the two meat specimens were obtained from samples that had not yet been incorporated into the diet, eliminating the possibility of sample contamination by organisms shed from other cats in the household. Bacterial contamination of meat and meat products during processing typically occurs after slaughter, when animal carcasses are contaminated by fecal material containing *Salmonella* during processing. *Salmonella* species are common isolates from beef contaminated during processing, but they are not considered ubiquitous organisms within the domestic household environment.<sup>2,12,17-19</sup> The Center for Disease Control reported that in human cases of food-borne salmonellosis between 1973 and 1984, contaminated beef accounted for the majority of reported cases at 19%, followed by turkey (9%), pork (7%), and poultry (5%).<sup>20</sup> Fecal shedding of *Salmonella* organisms from infected animals may continue for 3 to 6 weeks, and occasionally as long as 14 weeks in cats recovering from salmonellosis.<sup>1,12,17</sup> In both case nos. 1 and 2, these cats cohabitated with other cats in a multicat household environment, sharing food, water, and litter boxes; this provided numerous opportunities for exposure and possible infection of other cats in the environment. Additional information regarding the storage and preparation of the home-prepared diet would be of interest in these cases. Unfortunately, this information was unavailable.

Most human cases of salmonellosis involve direct exposure to contaminated foodstuffs, but cases of human salmonellosis due to direct and indirect contact with infected domestic animals are well documented.<sup>17,21-26</sup> Among human cases, individuals at highest risk of infection, invasive disease, and mortality include children <9 years of age (<1 year of age, >175 cases/100,000 persons; 1 to 9 years of age, 50 cases/100,000 persons; >9 years of age, 25 cases/100,000 persons) and the elderly (incidence of invasive disease, 18% versus general population at 10%).<sup>27,28</sup> The number of cat-owning households in the United States has been estimated between 27.3% and 28.6%.<sup>29,30</sup> Many domestic cats spend a significant amount of their lives in close proximity to humans, providing ample opportunity for direct and indirect human exposure to zoonotic organisms through contact interaction (e.g., stroking, grooming); maintenance of food, water bowls, and litter boxes; or surface contamination of human food preparation areas. As a result of these two cases, the client was advised by the referring veterinarian to discontinue the practice of feeding a raw beef-based diet to her cats; it is not known if the client implemented this recommendation.

## Conclusion

This report describes two cases of feline salmonellosis in cats from a multicat household fed a contaminated raw

beef-based homemade diet. In one case, the causative agent, *S. newport*, was recovered from both the clinically affected animal and the raw beef-based diet, which it was fed. Cats fed raw beef contaminated with *Salmonella* are at risk for development of salmonellosis and may constitute a zoonotic disease risk due to shedding of infectious organisms.

<sup>a</sup> SNAP FeLV Antigen Test; Idexx Laboratories, Inc., Westbrook, ME

<sup>b</sup> Sensititre Gram Negative Identification Plate; Trek Diagnostic Systems, Ltd., East Grinstead, West Sussex, United Kingdom

<sup>c</sup> Salmonella O Antiserum Poly A - I & Vi; DIFCO Laboratories, Detroit, MI

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