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# First Report of Anaerobic Isolation of *Salmonella enterica* from Liver Abscesses of Feedlot Cattle

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In feedlot cattle, the occurrence of liver abscesses is a complex interplay between an aggressive grain feeding program and a number of dietary and management factors. The incidence of liver abscesses ranges from 12 to 32% (1). *Fusobacterium necrophorum*, an anaerobic bacterium that originates from the rumen, is the primary etiologic agent (2, 3). The second most common bacterial species isolated is *Trueperella* (formerly *Arcanobacterium*) *pyogenes* (4). We analyzed liver abscess samples collected at slaughter from 10 feedlot cattle in the summer of 2013 to determine the dominant bacterial species involved. The 10 samples were collected randomly from a lot of Holstein steers that originated from the same feedlot in the Midwest. In addition to *F. necrophorum* (100%; 10/10) and *T. pyogenes* (40%; 4/10), for the first time, we isolated *Salmonella enterica* from all 10 samples that were plated on a blood agar plate and incubated for 24 h in an anaerobic glove box (Thermo Fisher Scientific, Waltham, MA). The species identification was confirmed by matrix-assisted laser desorption ionization–time of flight (MALDI-TOF) mass spectrometry (Bruker Daltonics Inc., Billerica, MA). Interestingly, on a blood agar plate incubated anaerobically, *Salmonella* appeared as whitish, large, round, and somewhat rough colonies (Fig. 1A). However, when the colony was picked and restreaked on a blood agar plate and incubated aerobically, colonies appeared small, round, smooth, and gray (Fig. 1B). All 10 isolates agglutinated with *Salmonella* polyvalent O antiserum but did not agglutinate with B, C1, C2, D1, D2, and E serogroup antisera. All isolates were PCR positive for the *invA* gene (5). The strains were submitted to the National Veterinary Services Laboratories (Ames, IA) for serotyping and were identified as 6,7:g,m,s:e,n,$z_{15}$, a novel serotype. The pulsed-field gel electrophoresis (PFGE) analysis, done per the CDC's PulseNet protocol (6), indicated that all 10 *Salmonella* isolates had 100% Dice similarity.

This is the first report of *Salmonella* isolation from liver abscesses of cattle. There are reports of *Salmonella* isolation from liver abscesses in humans (7, 8). It is not known whether *S. enterica* is one of the etiologic agents or whether it entered, via blood or lymph, into an abscess initiated by *F. necrophorum* in the liver and survived. It is possible that *Salmonella* present in the gut could cross the gut epithelial barrier, enter the portal circulation, and get trapped in the portal capillary system of the liver to initiate infection. The entry through the gut epithelium may be facilitated by inflammation of the ruminal epithelium, and possibly the mucous membrane of the hindgut, associated with ruminal and hindgut acidosis (1). *Salmonella* bacteria have been isolated from lymph nodes of healthy cattle at the time of slaughter (9). Recently, Bugarel et al. (10) have published draft genome sequences of two novel strains of *Salmonella*, isolated from lymph nodes of slaughtered cattle, which match the antigenic designation of our strains from liver abscesses, and have named the serotype Lubbock. Interestingly, the PFGE banding patterns of the two Lubbock strains from lymph nodes were 100% identical to the banding patterns of the 10 liver abscess strains (data not shown). However, the identical banding pattern may not necessarily mean strain relatedness. Although PFGE is routinely used to assess strain relatedness in outbreak investigations, in the case of *Salmonella*, XbaI restriction, at least with some serotypes, has proven to be serotype specific (11).

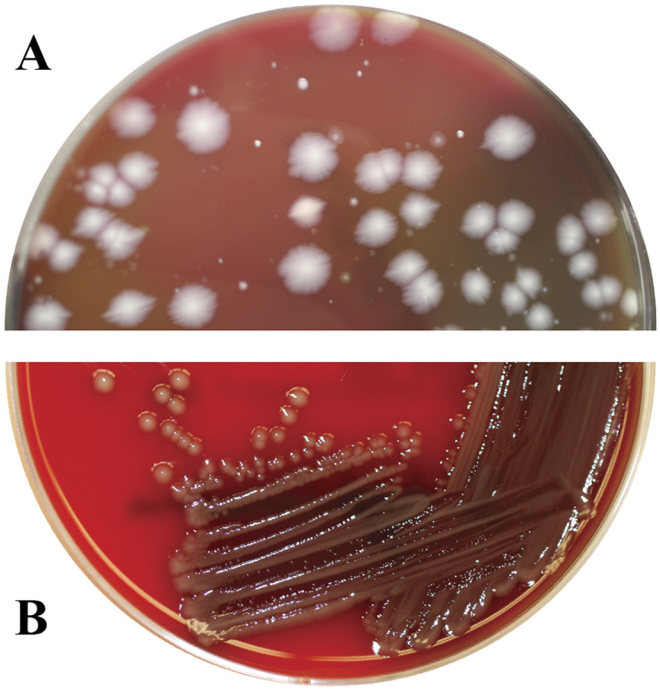


**FIG 1** Colony morphology of *Salmonella* on an anaerobic blood agar plate from initial inoculation of liver abscess sample (A) and on an aerobic-growth blood agar plate (B).

*Salmonella* bacteria are facultative intracellular pathogens that have the ability to adapt quickly to diverse environments, includ-

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ing fluctuations in oxygen concentrations. It is well known that *Salmonella* bacteria are capable of robust growth under anaerobic conditions (12). In fact, *Salmonella* bacteria grown under anaerobic conditions are more invasive and virulent and adhere better to mammalian cells than do aerobically grown cells (13, 14). Fink et al. (15) have demonstrated participation of the oxygen-sensing, global regulator Fnr in regulating anaerobic metabolism, flagellar biosynthesis, motility, chemotaxis, and virulence in *Salmonella enterica* serotype Typhimurium. Therefore, it is possible that *Salmonella* could be contributing to the formation of abscesses. However, further studies are needed to evaluate the prevalence and importance of *Salmonella* in liver abscesses of feedlot cattle.

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