Salmonella in Cattle

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It is estimated that 16 to 73% of U.S. dairy farms and 38% of feedlots are infected with Salmonella. There are over 2,200 reported serotypes of Salmonella yet fewer than 2% of these account for approximately 80% of the disease reported in livestock, poultry, and humans. There is significant homology between the serotypes isolated from livestock, poultry, and humans suggesting that all species are exposed to a common pool of Salmonella. Epidemiological studies indicate significant transmission of Salmonella between species. Human salmonellosis is commonly linked to the consumption of Salmonella contaminated poultry, beef, and occasionally dairy products. Human Salmonella outbreaks usually reflect errors in food processing and or food handling that promote growth of Salmonella in contaminated food products. The high prevalence of antimicrobial resistance in zoonotic Salmonella isolates is of particular concern to public health authorities. Human transmission of Salmonella to livestock occurs sporadically when Salmonella infected individuals work with livestock and extensively when Salmonella contaminated human effluent is released into waterways and is used to irrigate livestock forage crops. Clinical outbreaks of disease in livestock amplify environmental Salmonella contamination. Irrigation of crops with Salmonella contaminated livestock effluent contaminates forages and watersheds, thus maintaining the Salmonella challenge to livestock and disseminating Salmonella throughout the region. Mammals, reptiles, birds, and insects also disseminate Salmonella within and between production units. Cattle dying of salmonellosis are commonly rendered along with other by-products from the livestock and poultry industries, and converted into animal feed. Although rendering is effective at killing Salmonella, post process contamination often leads to significant (50% of lots tested) Salmonella adulteration of rendered feed products.

It is estimated that between 5 and 20% of commodity feeds fed to dairy cows in the U.S.A. are contaminated with Salmonella. Healthy adult cattle normally tolerate small numbers of Salmonella in feed and do not develop clinical disease. However, if the organism multiplies in moist feed, clinical disease may occur. Salmonella outbreaks in cattle often reflect a series of events that culminate in a large challenge dose and impaired host immunity. The dynamics of disease in herds varies. The whole herd may be affected or just a specific age or production

group. Clinically affected animals may excrete 10^8 to 10^{10} Salmonella per gram of feces, or a total of 10^{14} per day. Cattle infected with Salmonella may shed Salmonella in feces and milk for 4 - 8 weeks following resolution of clinical signs of disease. A small proportion of cattle infected with Salmonella remain chronically infected. Chronic Salmonella infections in cattle are most commonly observed with *Salmonella dublin,* which is host adapted to cattle. Chronic intramammary infections with other Salmonella serotypes including *S. typhimurium* (B), *S. ohio* (C), *S. enteritidis* (D), and *S. muenster* (E) have been reported but appear less common. The prevalence of longterm Salmonella carriers in cattle populations is unknown. In one study 5 of 200 neonatal calves infected with *S. dublin* maintained persistent infections for a year. In a herd infected with *S. ohio* (Group C) chronic Salmonella shedding was documented in 7% of the herd. Herd outbreaks of salmonellosis typically resolve after a couple of months, however, despite resolution of clinical disease Salmonella may continue to cycle through the herd and persist in the environment for months or years. Salmonella contamination of dairy and beef products often continues following resolution of clinical disease.

Salmonella infections are most commonly acquired through fecal oral and oral oral contamination via the environment or fomites. Intranasal, conjunctival, and aerosol transmission may also occur infrequently. The number of Salmonella required to produce clinical disease is dependent on the virulence of the serotype and immunity of the host. The infectious dose for healthy adult cattle is approximately 10^9-10^{11} Salmonella. Immunity to Salmonella is age dependent with rapid changes occurring in the first 3 months of life. At 2 weeks of age the LD_{50} for some virulent strains is 10^5, at 6-7 weeks 10^7, and at 12-14 weeks 10^{10}. In contrast, administration of 10^{10} Salmonella to 24-28 week old calves failed to induce clinical signs of disease. Different age predilections, manifestations of disease, and virulence are observed between Salmonella serotypes and between different strains of the same serotype.

Calves on endemically infected farms are commonly exposed to Salmonella in the first few days of life. Salmonella exposure may occur via Salmonella contaminated colostrum or milk, surface contamination of teats and udder, personnel, equipment, or the environment. In adult cattle salmonellosis commonly occurs close to parturition and may be associated with inter-current disease. Depressed immunity during pregnancy and the postpartum period is associated with decreased T cytotoxic cell function, increased suppressor cell function and altered B cell function. The periparturient period is also a time of significant dietary change. The growth of Salmonella

in the rumen following ingestion is influenced by dietary intake before and after the organisms are ingested. Dry matter intake may be depressed as much as 50 % for the four days prior to parturition. The growth of Salmonella in the rumen is inhibited by high concentrations of volatile fatty acids and a low rumen pH (normal is 5.5-6.5). Anorexia is associated with low concentrations of volatile fatty acids and a high rumen pH (approaching pH 7.5). Salmonella disappear rapidly from the rumen of regularly fed cows, but maintain or increase their numbers when feed intake is decreased or interrupted for one or more days. Feeding after a period of anorexia is associated with multiplication of Salmonella. Following parturition dairy cattle are fed a high energy production ration. Clinical and subclinical lactic acidosis are common at this time. Disruption of normal fermentation with production of lactate favors the less fastidious Salmonella, which multiplies rapidly using the available substrate.

The keys to successful treatment of invasive Salmonella infections in cattle are; Controlling bacteremia and focal sites of infection through judicious use of effective antimicrobial drugs, limiting inflammatory cascades to prevent septic (endotoxic) shock through use of non-steroidal anti-inflammatory drugs, replacing fluid and electrolyte losses and meeting ongoing requirements, and meeting the nutritional demands of the patient. In a production system antimicrobial therapy should be based on the antimicrobial sensitivity of Salmonella isolated from organs at necropsy. While fecal cultures may reveal multiple Salmonella serotypes, necropsy organ cultures select for the invasive strains. A number of experimental studies have evaluated the efficacy of antimicrobial agents used at therapeutic doses including amoxycillin, trimethoprim sulfa, chloramphenicol, furazolidine, neomycin, and ampicillin. Use of chloramphenicol and furazolidine in food producing animals is now illegal in the United States. In a comparative trial of amoxycillin, trimethoprim sulfur, and chloramphenicol the drugs were found to have equal efficacy in reducing adverse clinical signs of disease when dosage regimens were based on MIC values and blood levels. In contrast, antimicrobial treatment of *S. dublin* carrier cows with gentamicin failed to eliminate Salmonella shedding despite invitro susceptibility of the organism. Experimental studies of subtherapeutic use of antimicrobials have had mixed results. Feeding chlortetracycline in milk replacer increased the severity of disease and the rate and duration of Salmonella shedding in one study, had no effect on the number of organisms excreted in another, and was associated with a reduced the risk of Salmonella shedding in a recent NAHMS study. There are many reports that describe the antimicrobial resistance profiles of Salmonella isolates

from different animal and human sources, but there is a paucity of prospective studies looking at drug use and antimicrobial resistance.

Successful reduction of Salmonella prevalence in livestock on a national level in the former German Democratic Republic (GDR; East Germany) via implementation of a Salmonella control program emphasizing immunoprophylaxis with modified live and killed Salmonella vaccines, indicates the potential benefits that can be derived from the application of effective Salmonella vaccines. Salmonella vaccine studies in cattle have focused on Salmonella bacterins and attenuated modified live Salmonella. Comparative trials indicate modified live attenuated Salmonella vaccines provide greater protection against virulent Salmonella challenge than Salmonella bacterins.