Profitable Strategies to Control Salmonellosis in Dairy Cattle

[1]John K. House BVMS, PhD, Dip ACVIM and [2]Bradford P. Smith DVM, Dip ACVIM
[1]Sydney University Veterinary Center Camden NSW, Australia
[2]Department of Medicine and Epidemiology, School of Veterinary Medicine,
University of California Davis

Salmonella is endemic on many intensive dairy farms, however outbreaks of disease are relatively infrequent and typically reflect a combination of environmental conditions and management events that culminate in impaired host immunity and cattle exposure to large doses of salmonella. Simplistically, control and prevention of salmonellosis in dairy cattle can be achieved via minimizing the challenge dose (limiting exposure) and maximizing host resistance. Fortunately the implementation of management strategies to achieve these goals is compatible with profitable dairy operation. Comfortable well-fed cows are productive and inherently resistant to salmonella infection. Similarly, management strategies to reduce environmental Salmonella contamination and transmission also reduce transmission of other enteric and intra-mammary pathogens.

Sources of Infection, Minimizing the Challenge Dose

Feed – Adult Cattle: In the United States it has been estimated that 5 – 20% of feed commodities fed to dairy cattle and as much as 40 – 50% of protein supplements are contaminated with salmonella. Waste water and crop management may contribute to recycling of salmonella in forage crops grown on the dairy. Regional contamination of cattle feeds have previously been linked to human effluent and animal wastewater contamination of waterways. On large dairies it is possible to practice risk management by selective sourcing of forages and byproducts. Crops irrigated with well water are less likely to be contaminated with salmonella than crops grown with water contaminated with human or dairy effluent. Salmonella may be eliminated from contaminated forages by ensilage. For the ensilage process to effectively eliminate salmonella the pH needs to drop below 4.5. Corn silage typically achieves a pH below 4.5 whereas the pH of grass based silages and alfalfa haylage tends to be less consistent.

Feed – Calves: Colostrum and milk are common sources of infection for dairy calves. On a salmonella endemic farm aseptic collection of milk and colostrum from individual cows identified intra-mammary infections in 1% of cows. On the same farm salmonella contamination of pooled colostrum and milk varied from 0 – 20% of samples, with the high prevalence corresponding to warm moist conditions during the summer months. Contamination of milk and colostrum tend to increase through the processes of harvest, storage and delivery. High risk management practices for infecting calves include pooling colostrum and feeding waste milk from sick cows. Effective preventive strategies include implementation of good sanitary practices for collection, storage, and delivery of colostrum and milk. With good quality control, pasteurization of waste milk increases calf health and may be economically feasible.

Feeding utensils and personnel may play a significant role in transmitting salmonella between calves. During clinical illness, salmonella infects the salivary glands and is shed in saliva and nasal secretions. Adequate cleaning and disinfection of feeding utensils is necessary to remove salmonella contamination. Use of a common esophageal feeder to administer colostrum to newborn calves and fluids to sick calves is a very effective means of spreading disease. Salmonella is sensitive to most disinfectants, but removal of contaminating organic debris is imperative as the activity of disinfectants is reduced by the presence of organic matter.

***Environment* -** A feature of large intensive dairy farms is the close association of livestock with large volumes of manure. Fecal waste represents the largest reservoir of salmonella on dairy farms. This reservoir is very dynamic; provision of warmth and moisture may lead to the number of salmonella present in dry lots increasing from 10 salmonella per gram to 10^7 salmonella per gram of bedding within 24 hours. Good corral management that minimizes retention of water in corrals can mitigate the environmental multiplication of salmonella. Considering the high risk of disease during the transition period priority should be given to corral management of the close up and fresh cows.

Maternity pen and corral management are also important to minimize the exposure of calves to salmonella at birth. Up to 50 % of calves may be shedding salmonella in feces by 24 hours of age when left in a salmonella contaminated environment for the first 6 hours of life. Cows lying on salmonella contaminated bedding become coated with salmonella. Under wet conditions the fecal contamination of the teat and udder can become pronounced. Two possible consequences of this contamination are salmonella mastitis or salmonella contamination of milk derived from fecal contamination of the milk at milking time.

***Waste water* –** Conventional dairy lagoons function under anaerobic conditions. Pathogen reduction in anaerobic lagoons takes several months. Under field conditions the retention time is often insufficient for microbial killing due to heavy water usage for irrigation and flushing. The common practice of using waste water to flush alleys and irrigate forage crops inadvertently spreads salmonella within and between farms. Irrigation runoff into local waterways may further contribute to regional spread of salmonella. A number of studies have examined the survival of salmonella in liquid cattle waste maintained under anaerobic and aerobic conditions.[1] Survival times for salmonella range between 13 and 286 days. Discrepancies between studies have arisen due to differences in the original number of salmonella present, holding conditions, percent solids, temperature, oxidation-reduction potential, and serotype of salmonella. Survival of salmonella in slurry is enhanced by a reduction in temperature and by an increase in solids content. Survival is greatest at temperatures below 10 C and in slurries containing more than 5 % solids.[2] In comparative studies the survival of salmonella is reduced by aeration compared to static anaerobic storage systems.[3]

Acutely infected stock **-** Clinical outbreaks of disease in livestock amplify environmental salmonella contamination. During an outbreak and even on farms with endemic salmonella infections the prevalence of salmonella fecal shedding may approach 90%. In diarrheic animals, up to 10^8 salmonella may be shed in each gram of feces. Treatment of salmonellosis is aimed at controlling bacteremia through judicious use of effective antimicrobial drugs, limiting inflammatory cascades through use of non-steroidal anti-inflammatory drugs, replacing fluid and electrolyte losses, and meeting the nutritional demands of the patient. In neonatal salmonellosis antimicrobial therapy attenuates disease severity and may reduce mortality and salmonella fecal shedding.[4,5] There are no studies of rational antimicrobial therapy for salmonellosis in adult cattle. In a production system antimicrobial therapy should be used for severely ill cows and based on the antimicrobial sensitivity of salmonella isolated from organs at necropsy.

Chronically infected stock **–** *Salmonella Dublin* is host adapted to cattle capable of maintaining chronic infections or "carriers". Intra-mammary inoculation of adult cows with *S. Dublin* induced a chronic carrier state whereas oral challenge did not.[6] Conversely, chronic enteric and mammary *S. Dublin* infections have been observed following acute *S. Dublin* neonatal infections.[7] Serologic identification and removal of cattle chronically infected with *S. Dublin* is a logical control strategy following implementation of appropriate control strategies to limit environmental, water, and feed related pathogen spread. Serology is available in the USA from the Livestock Salmonella Research Laboratory, Tupper Hall, Room 2108, Univ. of California, Davis, CA 95616 (contact bpsmith@ucdavis.edu for more info).

Maximizing Host Immunity

Adult cow transition diet management **-** 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. In adult cattle salmonellosis commonly occurs close to parturition and may be associated with inter-current disease. The growth of salmonella in the rumen following ingestion is influenced by dietary intake before and after the salmonella is ingested. Dry matter intake may be depressed as much as 50 % for the four days prior to parturition. 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 starvation is associated with multiplication of salmonella. Disruption of normal fermentation with production of lactate favors the less fastidious salmonella, which multiplies rapidly using the available substrate. Qualitative dietary stress and dietary changes have been implicated as a predisposing risk factor in salmonella outbreaks in dairy cattle.[8] Reduction in the prevalence of salmonella may be observed following manipulation of the ration formulation and adjustment of feeding practices.[9] Nutritional indices appropriate for monitoring the performance of the transition ration (dry matter intake, milk production, milk components, incidence of LDA's, retained fetal membranes, milk fever, urine pH in close-up cows, change in body condition, and incidence of subclinical ruminal acidosis and ketosis) are all relevant to the prevention of salmonellosis.

Neonatal Immunity **-** The susceptibility of calves to salmonella infection changes during the first 3 months of life. Administration of equivalent doses of salmonella to 2 day and 14-21 day old calves produces more severe disease and greater shedding for a longer duration in the younger age group. Administering salmonella contaminated colostrum to newborn calves will produce disease in calves within a few days if the dose is high. Failure of passive transfer and poor nutrition also contribute to the risk of salmonellosis.

Environmental management **-** A seasonal pattern to salmonella outbreaks is often observed within regions. The specific conditions within a given area that contribute to disease outbreaks are variable. The consequences of environmental stress can usually be translated into variables that compromise host immunity (e.g. heat stress) or promote environmental contamination (e.g. humidity). Management practices that promote cow comfort and maintenance of a dry clean environment therefore reduce the risk of salmonellosis.

Vaccination **-** Most of the commercial salmonella vaccines licensed around the world are killed bacterins. The reported efficacy of salmonella bacterins in calves ranges from good to ineffective.[10,11] The consensus of all reports is that vaccination of calves with salmonella bacterins provides partial protection against salmonella challenge. No controlled vaccine studies for cows could be found. Adverse reactions to LPS in the form of anaphylactoid reactions are occasionally reported in cattle vaccinated with salmonella bacterins. Following sub lethal salmonella infections the sensitivity of animals to the lethal activity of LPS increases exponentially.[12]

There are a number of attenuated salmonella strains that have been used to immunize cattle against salmonellosis. The most widely tested gene deleted salmonella vaccines in cattle are the auxotrophic strains. Aromatic amino acid (aro) and purine (pur) auxotrophs of salmonella are attenuated and stimulate protective immunity.[13] Calves immunized with modified live salmonella vaccines are protected from homologous and heterologous salmonella serotypes when challenged within 3 weeks of vaccination.[14,15] Thereafter, protection to oral challenge is serotype specific with recall of immunity presumably involving specific antigen recognition.[16] Neonatal calves are often infected with salmonella during the first 24 hours of age. Administering a vaccine at 14 days of age is consequently ineffective. While it is impossible to make a generic recommendation to vaccinate calves at birth, in the authors experience extra label use of a modified live salmonella vaccine administered to calves at birth has been effective at reducing neonatal mortality.

Passive protection **-** The level of passive protection of calves achieved via feeding colostrum from vaccinated cows is questionable. A number of reports suggest immune colostrum provides passive protection and others report no protective effect. In a controlled clinical trial conducted on a commercial dairy colostrum from cows vaccinated with a modified live salmonella vaccine provided some protection to calves reducing salmonella fecal shedding whereas no effect on salmonella fecal shedding was observed when calves were administered colostrum from cows vaccinated with an autogenous salmonella bacterin.[17] In other studies, cows vaccinated twice with killed bacterins prior to parturition pass IgG antibodies to calves through colostrum, and this protection appears to be partial until the calf reaches 3 weeks of age, after which it wanes rapidly.

Abstract

Salmonelle est endémique dans plusieurs fermes laitières de grandes envergures. Cependant, les signes cliniques associés à la présence de salmonelle sont relativement peu fréquents et sont souvent le reflet d'une combinaison de facteurs environnementaux et de régie qui viennent perturber l'équilibre naturel et l'immunité. Le contrôle et la prévention de la salmonellose chez les bovins laitiers peuvent se faire en diminuant l'exposition et aussi en maximisant la résistance de l'hôte. Heureusement, les stratégies de régie pour prévenir cette maladie ne sont pas dispendieuses. Des vaches confortables et bien alimentées sont plus productives et résistent bien à une infection à *Salmonella*.

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