

Quantitative risk assessment of *Salmonella* in sheep meat produced in New Zealand – The Story So Far (July 2002)

The purpose of this three year research project, undertaken in conjunction with Meat New Zealand, is to develop a quantitative risk assessment of *Salmonella* in sheep meat. The project was initiated because of a *Salmonella* Brandenburg epidemic in the lower South Island and because the risks of *Salmonella* from red meat are largely unknown. This project will provide short and medium term risk management strategies. It will investigate the incidence of *Salmonella* in sheep meat through the food chain starting with animals on the farm, the processing and retailing stages and finally the consumer. This report presents information gathered during the first 18 months of the project. It is due to be completed by mid 2003.

Background

An epidemic of *Salmonella* Brandenburg abortions in sheep in the South Island, peaking in 2000, and consequential increase in human cases and detections on sheep meat resulted in a "Quantitative risk assessment of *Salmonella* in sheep meat produced in New Zealand (Sal-QRA)". The Sal-QRA programme has identified the prevalence and levels on carcass meat of *Salmonella* after slaughter, and demonstrated a significant decrease during processing. Similarly, the failure to identify any cases-control association with consumption of sheep meat suggests that a foodborne route of infection is not contributing significantly to the burden of *S. Brandenburg* cases.

What is *Salmonella* Brandenburg?

Salmonella Brandenburg is a member of the *Salmonella* family of bacterial pathogens. Like most *Salmonella*, it lives in the intestines of animals and people and is generally spread by contact with animals, contaminated environment, faecal contamination in food and water, or from person to person.

While *Salmonella* is a leading cause of food-borne illness in New Zealand, *S. Brandenburg* has, until recently, only infrequently caused human illness in New Zealand. Similarly, it was rarely isolated from farm animals despite being relatively common overseas, especially in pigs.

What's new about this bug?

In 1996, a subtype of *S. Brandenburg*, now known as the "South Island strain", was identified as the cause of abortions in sheep in mid-Canterbury. Stock movements through drought in that year introduced the organism to South Otago, and it rapidly spread to epidemic proportions in South Otago and Southland. Since then, the South Island strain of *S. Brandenburg* has also been associated with diarrhoea in cattle and, more importantly, in calves.

For reasons as yet unknown, the South Island strain has not been associated with sheep infections north of mid-Canterbury and in the North Island, although has been isolated in the North Island from a single pig and occasionally in poultry feed.

What about animals?

Like most *Salmonella*, *S. Brandenburg* lives in the intestines of animals, especially pigs, although prior to 1996 had rarely been isolated from New Zealand farm animals.

The South Island strain of *S. Brandenburg* has most frequently been detected in adult sheep where it causes abortion. There is one report of stillborn pups in a dog.

Most recently, the South Island strain of *S. Brandenburg* has been associated with diarrhoea in cattle and bobby calves, and domestic animals such as dogs and horses are susceptible to *S. Brandenburg*. Of note is that lambs are apparently not susceptible to *S. Brandenburg* infection, and do not exhibit symptoms of animal salmonellosis.

Contact with farm animals and the environment is, therefore, a major source of risk on the farm. This is especially so for children who by nature come into close contact with bobby calves.

Can people get *Salmonella* Brandenburg?

Like all *Salmonella*, *S. Brandenburg* causes gastrointestinal illness in humans. Prior to 1996, cases of human *S. Brandenburg* gastroenteritis were reported infrequently and sporadically. However, a commensurate increase in human cases was associated with the southern sheep epidemic. Indeed, the peak of human cases occurred at exactly the same time (2000) as the peak in the number of farms in Southland confirmed as having sheep abortions due to *S. Brandenburg*.

The majority of the human cases have been attributed to contact with infected farm animals, including veterinarians, veterinary workers, sheep and cattle farmers, farm workers, and skin handlers. Not one case was reportedly food-borne, and indeed an NZFSA commissioned case-control study recently completed by ESR could not ascribe a single case to the consumption of food.

All cases were associated with farms and/or animal contact.

The greatest risk is for children exposed to calf-rearing and lambing operations, the former being of greatest risk as scouring in bobby calves is a common occurrence.

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A quantitative risk assessment model for Salmonella in sheep meat produced in New Zealand (NZFSA, 2000-2003)

The outcomes of the research project “A quantitative risk assessment of *Salmonella* in sheep meat produced in New Zealand” are dependent on development of a quantitative risk assessment (QRA) model to estimate risks to human health under varying conditions. QRA models provide a description of all pathways for contamination of food from farm-to-plate, and allow risk management strategies to be put in place that are solidly backed by science. NZFSA (previously MAF Food) will develop a QRA model over a period of 3 years that provides the basis for effective risk management of *Salmonella* in sheep meat according to specific stakeholder goals. The project will:

- Compare the effectiveness of different sanitary measures applied at different steps in the food chain in negating market access / compliance problems and reducing risks to human health (including the value of microbiological monitoring programmes), and select optimal measures on this basis.
- Develop cases for judgement of the equivalence of sanitary measures applied in New Zealand that may be different to those that are applied in importing countries and that are a condition of market access.
- Provide information to assess the relative importance of sheep meat as a vehicle for food-borne salmonellosis compared with other foods.
- Provide a QRA platform for other microbial hazards transmitted by faecal contamination of fresh carcasses e.g. *S. Brandenburg* in bobbies, *E. coli* O157:H7 in adult cattle, and *Campylobacter*.

Retrospective case-control study of factors associated with outbreaks of Salmonella Brandenburg abortion (Massey University EpiCentre, 2000-2001)

There has not been any systematic epidemiological investigation of *S. Brandenburg* abortions on sheep farms. This project will provide the first information on factors associated with the occurrence of outbreaks on farms. The project will compare, on a flock, farm and regional basis, environmental, management and animal factors in clinically affected (*S. Brandenburg* outbreak during the 2000 season) and unaffected flocks. The results will be used to identify management interventions to reduce the risk of disease.

Pilot studies of Salmonella Brandenburg prevalence in lambs and ewes (Massey University EpiCentre, 2000-2001)

The project will compare the prevalence of *Salmonella* in groups of ewes and lambs on farms that experienced clinical outbreaks of *S. Brandenburg* abortion with that on farms in the same region that had no disease outbreak during the 2000 season. Faecal samples on-

farm and caecal samples after slaughter will be collected in order to evaluate the effect of pre-slaughter transportation and lairage on *Salmonella* carriage rates.

Retrospective case-control study of strip-grazing use in farms associated with outbreaks of Salmonella Brandenburg abortion (Massey University EpiCentre, 2001-2003)

The 2000 studies indicated that the practice of strip-grazing was the most important individual risk factor associated with the risk of disease outbreaks. However, the results also indicated that many flocks using strip grazing remained unaffected through the course of the regional epidemic. The project will compare on a flock, farm and regional basis, environmental, management and animal factors in clinically affected (*S. Brandenburg* outbreaks during the 1999 and 2000) and unaffected flocks (no outbreaks in 1999 and 2000) that practice strip grazing in order to identify additional factors that may explain the patterns of disease observed.

Association of severity of disease to carcass microbiology (Massey University EpiCentre, 2001-2003)

The 2000 “targeted” studies indicated that the occurrence of disease on farms was a determinant of risk of carcass contamination. Hence, the results of carcass sampling should be a reflection of disease status in the flocks from which the carcasses were derived. As the disease profile of supplying flocks is prone to variation over time, it is useful to retrospectively determine the prevalence and severity of clinical disease on farms supplying carcasses to the “random” carcass surveys in the 2001 and 2002 seasons.

Evaluation of a flock-screening test for confirming S. Brandenburg infection (Massey University EpiCentre, 2002-2003)

A flock-screening test based on bacteriological culture of vaginal swabs from aborted ewes is to be evaluated for confirming *S. Brandenburg* outbreaks in the wake of an outbreak of abortions. In addition, active surveillance, in collaboration with regional veterinary practices and LabNET, Invermay, is to be carried out to obtain improved data on the temporo-spatial pattern of the 2002 epidemic and to facilitate selection of study farms during 2003.

Enhancement of disease surveillance in collaboration with veterinary practices in the southern region (Massey University EpiCentre, 2002-2003)

Improved disease surveillance was identified as a necessary development in the original Gore meeting on the QRA project to facilitate diagnosis of affected flocks and gain insight into the nature of the epidemic. This project will encourage improvements in surveillance and reporting in the epidemic area through liaison with veterinary practices, laboratories and experts. Practices will be encouraged to maintain logs of clients reporting suspected outbreaks and funds budgeted for tests will be allocated to support laboratory diagnosis of suspected outbreaks.

Salmonella Brandenburg in sheep faeces (ESR Food, 2003-2004)

The goal of this project is to determine the prevalence and levels of *Salmonella* and *E. coli* (generic) in faecal pellets from clinically normal ovines from farms with S. Brandenburg abortions immediately prior to or after slaughter. The objectives of this project are to quantify the exposure of the ovine carcass to S. Brandenburg, and to determine if there is proportionality between *Salmonella* and *E. coli* levels in faeces such that the relative faecal contamination of different locations on the carcass, as judged by *E. coli* levels, can be used to predict the distribution of *Salmonella*.

Validation of methods for quantitative detection of Salmonella in Sheep Meat (AgResearch/MAF Food, 2000-2001)

The selection of standardised sample collection and analytical methods for the QRA programme has been rigorously and openly discussed through the TCG. A preliminary study to assess the effect of 72h refrigeration in pre-enrichment broth prior to quantitative analysis and the comparability of cultural and PCR-based methods is required. Similarly, it is necessary to perform an ongoing, although limited, validation study of the procedures for pre-enrichment of faecal/caecal samples.

Survey of premises processing characteristics (AgResearch, 2000-2002)

Industry will be surveyed and a database maintained of process characteristics of different sheep slaughter premises in New Zealand. Industry will be asked to make the information available to the QRA programme on a strictly confidential basis. A postal questionnaire will be utilised to document and categorise the process characteristics should this information not be made available, or if supplementary information is required.

Establishment of an estimate of the prevalence and concentration of Salmonella on freshly pelted carcasses and boned cuts on a national basis (AgResearch, 2000-2003)

A series of targeted and random carcass and cut sampling surveys for S. Brandenburg will be carried out on representative sample groups from (a) farms reporting abortions in the previous season (b) farms not reporting abortions in the previous season and (c) farms never reporting abortions. Samples will be collected at the start of the processing season (closest to the period of greatest number of abortions) and later in the processing season. Samples will be collected from animals from farms within the epidemic area (generally Southland) and outside the epidemic area (generally the North Island). A component of this study will be the determination of *Salmonella* contamination rates on associated pelts. These studies will be integrated with the on-farm, and other, *Salmonella* research projects and the National Microbiological Database.

Microbiological mapping of the surface of lamb carcasses (AgResearch, 2000-2001)

In order to model the numbers of *Salmonella* actually consumed on individual cuts of lamb, this project will map the distribution of *E. coli* (location and relative numbers) on lamb carcasses after processing using inverted dressing. Assuming that the sources of *Salmonella* and *E. coli* contamination are the same (i.e. indirect faecal via carcass/fleece contact) then

the distribution of the two organisms has a high probability of similarity and can therefore be inferred.

3-D Interactive display of microbial contamination (AgResearch, 2003-2004)

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Pelting aerosols as a cause of carcass and cross contamination (AgResearch, 2002-2003)

This project evaluates the contribution of aerosols generated during depelting to cross-contamination of carcasses with *S. Brandenburg*. Evidence points to the fleece as being a major immediate source of carcass *Salmonella* contamination. Direct fleece-carcass contact certainly occurs in the vicinity of opening cuts, and indirect contamination occurs through fleece-hand-carcass contact or carcass-hand-carcass redistribution. However, it does not explain contamination of carcass sites where such direct or indirect contact does not occur. Low levels of contamination of the carcass being "pelted" or neighbouring carcasses on the chain could result from aerosol formation and fallout. A knowledge gap presently surrounds the question of in-plant aerosols that may impact on both the Risk Assessment Model and the requirement, or otherwise, for antimicrobial interventions.

Effect of chilling on Salmonella viability and recoverability (AgResearch, 2001-2003)

This project examines the reduction of *Salmonella* numbers over the chilling process by experimental means, in particular, relative effect of the sampling methodology itself, temperature, drying and induction of the viable but non-culturable (VNC) state. Should the results point to a VNC concern, then that concern must be further evaluated and the relative risk to human health of infection by normal and VNC organisms investigated. Meat surface pH is but one of the variables of interest with respect to both pathogen survival and induction of the VNC state.

Water activity on the surface of lamb carcasses during chilling (AgResearch, 2003-2004)

The Sal-QRA programme has identified the prevalence and levels on carcass meat of *Salmonella* after slaughter, and demonstrated a significant decrease during processing, in particular during chilling. While, the reasons for this decrease are not fully understood, it is probable that drying on the carcass surface would not only prevent microbial growth but also cause microbial death. However, until recently, measurement of the water activity (A_w) on carcass surfaces has not been possible. The goal of this project is to use the method of Lovatt and Hill (1998) to measure the A_w of lamb carcasses during chilling. The apparatus designed for beef carcasses will be assembled, programmed for lamb chilling, calibrated using representative gels, and used to determine the A_w at sites of greatest microbial contamination on the carcass. The objective of this project is to measure the A_w of the surface of lamb carcasses during chilling to enable more accurate modelling of the growth and death of *S. Brandenburg* on the surface of lamb carcasses during chilling.

Consumer/health component of a quantitative risk assessment of *Salmonella* spp. in sheep meat produced in New Zealand (ESR Epidemiology, 2002-2003)

This project includes a detailed epidemiological description, using combined laboratory and notification data, of human salmonellosis in New Zealand for the period 1995-2002. Data on isolates referred to the enteric reference laboratory from animal health laboratories will also be analysed. A literature review will be carried out to estimate the degree of under-ascertainment of the *Salmonella* surveillance system. Finally a national case-control study will be carried out to estimate the contribution of food, water, environmental, animal and human exposures to the incidence of *S. Brandenburg*.

PFGE analyses of Salmonella Brandenburg isolates from non-epidemic regions (ESR Communicable Diseases, 2003-2004)

While the epidemic of *S. Brandenburg* has been restricted to the South Island, human cases of *S. Brandenburg* have occurred in the North Island. The pulsed field gel electrophoresis (PFGE) DNA profile of the South Island strain is distinctive, and it is not known if the North Island human cases are this PFGE sub-type or the more ubiquitous sub-types. This project will PFGE type a selection of isolates of *S. Brandenburg* from human cases (1996-2003) from geographic locations of New Zealand outside the epidemic area, PFGE type all isolates of *S. Brandenburg* from the ESR case/control study, and use the National Typing Database to identify clonal lineages of *S. Brandenburg*. The objective is to provide an authoritative overview of the population structure of the "South Island" clonal lineage *S. Brandenburg* in NZ, especially outside the epidemic region, and to identify possible epidemiological relationships and potential transmission routes given that sheep meat from the epidemic area is transported to, sold, and consumed in the North Island.

Salmonella under the Microscope

(Article in *Food New Zealand*, Oct/Nov 2002)

A major three-year research study examining the scope and spread of a strain of *Salmonella* in sheepmeat is underway and, it is hoped, will give a model for dealing with other food-borne pathogens in the future.

Expected to be completed later this year, the \$1.9 million *Salmonella* quantitative risk assessment (QRA) has been looking particularly at the Brandenburg strain of *Salmonella* which has been causing abortions in sheep in the lower South Island. *S. Brandenburg* can be transmitted to humans. Farmers and veterinarians who are in close contact with affected animals are particularly at risk and the study also aims to assess food-borne routes for human infection.

Coordinated by the New Zealand Food Safety Authority (NZFSA) with majority sponsorship from Meat New Zealand, researchers from the NZFSA, Massey University, AgResearch and the Institute of Environmental Science & Research Ltd (ESR) are working on the project which covers four points in the food chain: on-farm, processing, retail and consumer.

NZFSA project coordinator Dr Roger Cook explained that the project was kicked off in May 2000 with a meeting of all the stakeholders in Gore and research started in November 2000: "Results modelled in the QRA will establish the food-borne risk from the pathogen and also identify strategies for dealing with it," he said.

Early results show that environmental management factors on-farm may play an important role. In particular, strip-grazing with back-fencing is showing a possible contributory factor and – the most common infection method for sheep - inhalation of *Salmonella* bacterium, may lead to minimum yarding times being proposed. Improvements are already being seen in on-farm infection rates, possibly as a result of improved management information being fed back to farmers.

The good news for the meat industry is that initial results have shown a substantial decline in positives during processing, from slaughter through cooling to boning. This might be due to a redistribution effect during boning or the drying effect of the chillers, which either affects the viability of the pathogen or increases the adhesion of it, making it harder to remove for sampling. Further research is being done this year to clarify reasons for the observed decrease and to establish ways to reduce the prevalence and level of *Salmonella* even further.

"While the very low prevalence of positives found at retail (2.8%) in New Zealand suggests that the risk to the New Zealand consumer, and indeed those in our export markets, is low, especially since the sheepmeat will usually be cooked prior to consumption," Roger Cook said "confirmation of such awaits the results of analyses of product movement from the affected regions to the rest of New Zealand and ongoing human case control studies that identify, or not, any contribution from sheepmeat.