

Quantitative risk assessment model for *Salmonella* in sheep meat in New Zealand: Report of Gore Technical Meeting

Final Report

Steve Hathaway, MAF Food
Peter Davies, Massey University
Kelvin Ashby, Alliance Group

Introduction

Initiation of the research project “A quantitative risk assessment of *Salmonella* in sheep meat produced in New Zealand” follows two Steering Committee meetings and securing of majority sponsorship by Meat New Zealand (Appendix II). The research project has a three-year duration and will generate both short-term and medium-term risk management strategies for *Salmonella* in sheep meat, with a particular emphasis on *S. Brandenburg*. Development of the QRA model will also involve on-farm investigations to reduce both animal health losses and human occupational exposure.

Systematic application of a generic risk management framework is an essential component of the *Salmonella* QRA project and this represents a new approach to investigating a pathogen group of considerable public health importance in New Zealand. The rationale for development of this approach is presented in Appendix II (3). Given the potential for increased levels of *S. Brandenburg* in sheep in the next few years, development of a QRA model presents the best opportunity for identifying and implementing optimal controls.

Additionally, this approach will ensure that maximum short-term benefit is extracted from knowledge emerging during the development of the QRA. Short-term research will be focused on identifying measures for significantly reducing hazard levels contributing to occupational, consumer and “market access” risks. Medium-term research will be focused on generating more robust information for quantifying such reductions in risk and ensuring optimal control measures.

A technical meeting to initiate development of the *Salmonella* QRA project was held in Gore 26-28 July. The meeting was held over three days and was attended by representatives from most stakeholder groups participating in the QRA project i.e. primary producers, the meat processing industry, field veterinarians, MAF Food Assurance Authority (MAF FAA), Ministry of Health (MOH), science providers and the animal remedies industry (Appendix I). Before work on the technical agenda commenced, general discussions were held on the overall research strategy and the *Salmonella* QRA proposal originally presented to Meat New Zealand (Appendix II [3]). A summary of *Salmonella* in humans in Southland was presented by Dr. John Holmes of Public Health South.

The technical meeting included participation in a public meeting organised by the Gore City Council to present current information on *S. Brandenburg* in sheep.

The primary objectives of the technical meeting were to:

- Identify the risk management goals of all stakeholder groups
- Initiate a modular approach to identifying pathogen pathways in all sectors of the “farm-to-plate” chain
- Identify knowledge gaps and “short-term” research projects
- Make recommendations to the Technical Co-ordination Group (TCG) and Steering Committee for on-going development of the project.

A number of small research projects on various aspects of *S. Brandenburg* at the farm and processing level are currently underway, and it is hoped that the TCG will maintain a register of these projects and link their outcomes to the work of the wider *Salmonella* QRA project. Examples are recovery of *Salmonella* from the dust of sheep yards, surveys of wool from slaughter lambs, in-house monitoring of export product by processors, and vaccination.

Risk management goals

Clear identification of the risk management goals of different stakeholder groups has an important impact on the purpose and scope of a risk assessment. Risk management goals shared by most stakeholder groups involved in the *Salmonella* QRA project were identified as:

- Establish an estimate of occupational risk, and identify optimal risk reduction measures
- Establish an estimate of food-borne risk, and where appropriate, identify specific risk reduction measures that ensure an agreed level of consumer protection
- Provide strategies and interventions to reduce the potential for adverse market access events arising from the presence of *Salmonella* in fresh meat and meat products
- Provide a model for investigation of other food-borne pathogens.

Further risk management goals specific to individual stakeholder groups were identified as:

- For primary producers; utilise data generated from the on-farm module to prevent and reduce animal health problems in sheep and associated livestock groups
- For the processing industry; develop a case for the “equivalence” of sanitary measures applied to meat and meat products exported from New Zealand

- For the processing industry; investigate any animal welfare issues that may be associated with *Salmonella* infection in slaughter populations
- For the MOH; contribute to a risk profile for establishing broad food safety priorities for New Zealand consumers
- For the MAF Food:
 - ensure optimal market access for sheep meat exported from New Zealand, and develop a case for the “equivalence” of sanitary measures
 - utilise the QRA model to optimise existing generic HACCP plans for controlling faecal contamination of fresh meat (all slaughter species)
 - contribute to sustainable agricultural production systems in New Zealand.
- For field veterinarians and the animal remedies industry; develop cost-effective and efficient controls at the farm level, including vaccines
- For science providers; provide an effective scientific contribution to achieving all risk management goals and develop a generic risk assessment capability.

The above-mentioned risk management goals will be incorporated into the existing scope, purpose, and terms of reference of the *Salmonella* QRA project.

Further to these goals, the meeting supported the concept that industry develop codes of practice for primary production, transport, and slaughter and dressing of sheep. This work would be co-ordinated by the TCG.

Modular approach to identifying pathogen pathways

The Gore meeting adopted a modular approach to identifying pathogen pathways at the farm, processing, storage and distribution, and consumer handling sectors of the food chain. This “farm-to-plate” approach was recognised as an important precursor to developing a QRA model that will meet a range of risk management goals (Figure 1).

The primary focus of this meeting was on the farm and processing modules, with technical analysis of the remaining modules to be conducted as the *Salmonella* QRA project progresses. Technical experts assigned to each module provided information on the likely pathogen pathways, and the likely impact of current practices on the prevalence and concentration of *Salmonella*. Potential pathogen pathways other than those restricted to sheep were also noted, with particular reference to bobby calves sharing farms, transport and lairages at slaughterhouses. It is likely that post-slaughter pathogen contamination pathways for different animal populations share many common features.

On-farm module

The on-farm group concentrated on an epidemiological analysis of *S. Brandenburg* in sheep in the South Island. The recent emergence of this pathogen at the farm and

processing level in New Zealand adds considerable impetus to the *Salmonella* QRA project and implementation of cost-effective controls at the farm level are an important risk management goal. Occupational exposure to *S. Brandenburg* also has contributed to a marked increase in the overall number of human cases of *Salmonella* in New Zealand in the last few years. A detailed report of the work of this group is presented in Appendix III.

The occurrence of disease epidemics in pregnant ewes should be the focal point of research in this module as it directly or indirectly impacts on animal health, occupational, “market access” and food-borne risks.

Selection of farms and surveying of management factors for case-control and/or cohort studies will be an important activity. Although the time-frame for design and implementation of such studies is a factor limiting start-up in 2000, pilot studies could be feasible this year (see below).

General monitoring and surveillance of any *S. Brandenburg* epidemic that may occur in the South Island over the spring and summer of 2000/2001 would be an important input to the *Salmonella* QRA model. Integrated reporting of disease events from practising veterinarians, diagnostic laboratories, and other potential sources is required on an on-going basis. This would improve mapping of the temporo-spatial spread of any epidemic, allow better documentation of epidemic curves on farms, and assist identification of eligible case and control flocks for epidemiological studies.

Standardised monitoring through to the slaughterhouse of animals involved in any vaccination trials is also feasible this year.

Processing module

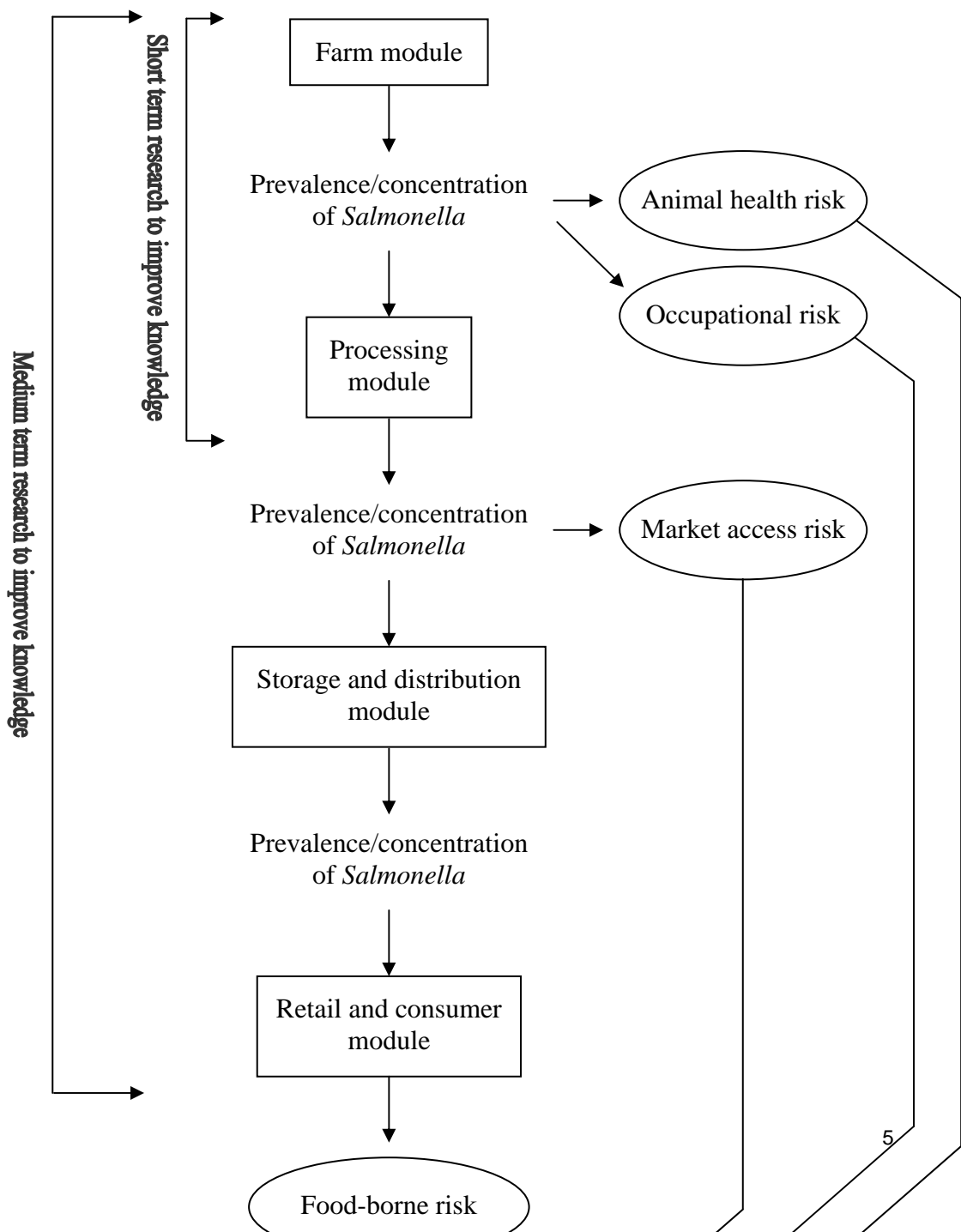
Control of cross-contamination of fresh meat with faecal pathogens remains a priority issue in the slaughterhouse environment. Although fresh meat produced in New Zealand has a low *Salmonella* contamination rate compared with other countries, the recent emergence of *S. Brandenburg* in sheep has created an increase in this baseline rate.

The chairman of the processing module (Kelvin Ashby) presented a typical process flow for sheep slaughter and dressing in New Zealand, with each step presented for detailed discussion as to the likely impact on *Salmonella* prevalence and concentration. All potential pathways for *Salmonella* at each step were presented as inputs. A detailed description of the work of this group is presented in Appendix IV.

It was recognised at an early stage that detailed information on the prevalence and concentration of *Salmonella* at the point of slaughter of different classes of sheep was a vital component of the QRA model, and this baseline would likely be used to “anchor” other modules. A subset of this would be detailed knowledge on the prevalence and concentration of *Salmonella* at the time of entry to the lairage for different classes of sheep. The level of *Salmonella* entering the process module would obviously change with different epidemiological factors on-farm, conditions of transport and lairage, season and other factors.

Current research has established that swim-washing and holding of sheep for variable times before slaughter can have a dramatic effect on growth rates of faecal contaminants on the fleece. Further, swim washes provide a vehicle for extensive cross-contamination between animals. This was seen as a high-priority area for short-term research to quantify the impact of this process step on *Salmonella* loads on the fleece, and subsequently on the carcass.

Figure 1: Project development for management of risks associated with *Salmonella* in sheep



Knowledge gaps and research requirements

An important goal of the meeting was to identify current gaps in knowledge and assign appropriate research projects to fill these gaps. Short-term problems currently affecting individual stakeholder groups were identified as a priority area, with much better knowledge on hazard control being required for “short-term” risk management.

Research relating to more detailed data for risk assessment and risk management will follow as medium-term projects.

The meeting recognised that systematic identification of all inputs to the QRA model, appropriate prioritisation of research projects, and consistent use of available methodologies were essential if the multiple risk management goals of the stakeholders are to be achieved.

To this end, harmonisation of microbiological sampling methods and culture is an immediate priority. Wherever possible, microbiological methodologies will be aligned to those used by the National Microbiological Database (NMD) as this will be used as an important research and monitoring tool throughout the *Salmonella* QRA project. Note: The NMD does not include methodology to quantify the number of *Salmonella* present in a positive sample, and this is an important part of the QRA project

Medium-term data needs

General monitoring and surveillance of *Salmonella* throughout all modules was seen as an on-going data requirement.

Case-control and cohort studies at the farm level were seen as being essential to measure the impact of different epidemiological factors on animal health, occupational exposure, and hazard levels entering the processing module. Such studies require considerable planning and resources, and were generally seen as medium-term rather than short-term research projects.

Gaining knowledge on the impact of transport and slaughterhouse lairage on *Salmonella*, including extrinsic contamination of live animals, is an important input to the QRA model. This should include quantification of *Salmonella* levels on wool at the farm, after transport, and after lairage.

Lack of information on the prevalence and concentration of *Salmonella* at the point of slaughter was identified as an essential data gap. (An important subset of this is the lack of information on the prevalence and concentration of *Salmonella* at the point of entry to the lairage). This would likely be regarded as the reference baseline for the QRA model. The meeting recognised that generation of this data had to take geographical, seasonal and slaughter-class factors into account, and would be cost-intensive. The impact of different lairage conditions would also have to be investigated.

Cross-contamination with *Salmonella* between livestock species is a likely to occur at a variable level on-farm, and during shared transport and lairage. It will be necessary to gain considerable information on *Salmonella* in slaughter populations other than sheep to assess this likelihood. Bobby calves are a particular cause of concern.

Although human surveillance data is available on a regional basis, development of a risk model depends on more detailed investigations. Both occupational and food-borne risks need to be quantified in terms of attack rates, and maximum information needs to be taken from food-borne disease investigations so as to anchor dose-response curves. Information gained from active surveillance will be used to validate the QRA model. It is important to note that without adequate human health data, the whole development of the QRA model would be jeopardised.

Establishing the survivability of *Salmonella* in meat and meat products held at temperatures of less than four degrees Centigrade is essential for completing the QRA model. Predictive microbiology relating to growth and survival of *Salmonella* in meat and meat products will be necessary for all but the on-farm modules.

Short-term data needs

Investigation of the *S. Brandenburg* status of ewes aborting in the 2000 lambing season in the south of the South Island was identified as a research priority that could reasonably be undertaken in the short-term.

Pilot case-control studies at the farm level that could be carried out in the short term if resources are available include:

- Retrospective mail survey (or personal interview) of selected farms to obtain data on farm, flock and management factors to evaluate associations with the occurrence of *S. Brandenburg* outbreaks
- Sampling of fleece and faeces from different groups of lambs at the time of initial drafting prior to slaughter
- Survey of “infected” and “non-infected” farms and their relative contribution to pathogen loads entering the slaughterhouse.

Research on the impact on hazard levels of different steps during processing was identified as a short-term priority. Particular steps identified for investigation are:

- Swim washing

- Final carcass washing
- Neck-stringing of carcasses (lower priority).

Monitoring of the impact of any interventions applied at the farm level in the short term should be co-ordinated between the farm module and the processing module.

Recommendations to the Technical Co-ordination Group (TCG) and Steering Committee

High-priority research projects

Farm module

1. Monitoring of ewes that have aborted during the 2000 lambing season.
2. Case-control studies to investigate epidemiological factors associated with on-farm transmission of *Salmonella* infection in sheep.
3. Survey of “infected” and “non-infected” farms and their relative contribution to pathogen loads entering the slaughterhouse.
4. Determination of occupational risks and the associated risk factors.
5. General monitoring and surveillance of *Salmonella* in sheep, including fleece contamination.

Processing module

1. Establishment of the prevalence and concentration of *Salmonella* (intrinsic and/or extrinsic) at the point of slaughter of sheep (reference baseline for the QRA model).
2. Establishment of the prevalence and concentration of *Salmonella* (intrinsic and/or extrinsic) at the point of entry of slaughter sheep to the lairage.
3. Survivability of *Salmonella* in meat and meat products held at temperatures of less than four degrees Centigrade.
4. Impact of swim washing, final carcass washing (and neck-stringing) on *Salmonella* loads on fresh sheep meat.

Storage and distribution module

Survivability of *Salmonella* in meat and meat products held at temperatures of less than four degrees Centigrade.

Retail and consumer module

Monitoring and surveillance of cases of food-borne salmonellosis on a regional and national basis.

Codes of practice

A short-term benefit from the QRA project would be the development of codes of practice for control of *Salmonella* at the level of each module. Considerable material already exists to support publication of generic codes by the TCG.

Project administration

The project title is “A quantitative risk assessment of *Salmonella* in sheep meat produced in New Zealand”. Following the Gore meeting, updated terms of reference will be circulated to all stakeholders.

Following the Gore meeting, some re-organisation of the technical sub-groups as presented in the project proposal of 30/5/000 (Appendix II [3]) is necessary. A Technical Co-ordination Group (TCG) for on-going development of the project and associated research should meet as soon as possible, and appropriate representation from each stakeholder group will be co-ordinated by MIA and Meat New Zealand.

The two technical sub-groups providing core input to the Gore meeting (on-farm and processing modules) will continue their work under the leadership of their elected chairmen. This will involve further pathway analysis and research co-ordination.

Overall development of the QRA model (QRA technical sub-group) will proceed under the guidance of the MAF Food Programme Development Group.

Action Plan

The Action Plan for further development of the project is:

1. Circulate report of Gore meeting to all stakeholder groups, with feedback to be discussed at the first meeting of the TCG. Encourage comment on all aspects of the report, and solicit further proposals for short-term (and medium-term) research related to identified risk management goals.
2. Retain responsibility for further pathway analysis and research co-ordination in each QRA module under current chairmen (Peter Davies and Kelvin Ashby).
3. Establish Technical Co-ordination Group (TCG) for on-going development of the project and associated research (meeting projected for the week beginning 4 September).
4. TCG to assist Meat New Zealand in allocation, specification and reporting on research projects.
5. MIA to continue assisting with maintenance of the project (Angus Davidson).
6. Harmonisation of microbiological methodologies to be managed informally by the MAF Food Programme Development Group as an immediate priority.

7. TCG to initiate new work on the storage / distribution and retail / consumer modules.

Appendix I: Participants in Gore Technical Meeting

Neil Armitage	MAF Food
Kelvin Ashby	Alliance Group
John Bassett	MAF Food
Graham Bell	AgResearch
Dennis Butler	Alliance Group
Gary Clark	Labnet Invermay
Roger Cook	MAF Food
Peter Davies	Massey University
Stan Fenwick	Massey University
Rosemary Hamilton	Federated Farmers
Steve Hathaway	MAF Food
John Holmes	Public Health South
Richard Hopkirk	MAF VA
Graemne Keeley	PPCS
Emma McBeth	Richmond Ltd.
Roger Marchant	Schering Plough Animal Health
Gerhard Nortje	ESR
Guill Le Roux	AgResearch
John Smart	Clutha Veterinarians

Appendix II: Research proposals and preliminary meetings

1. Provisional discussion paper to initiate research project: 31/3/00

Available from MAF Food Programme Development Group.

2. First meeting of the *Salmonella* QRA Research Project Steering Group: 11/5/00

3. Research proposal to Meat Industry Standards Council: 30/5/00

**Quantitative risk assessment model for *Salmonella* in red meat in New Zealand,
with a particular emphasis on sheep meat**

MAF Food Programme Development Group

Background

Risk management

Food safety world-wide is rapidly moving towards an environment based on the principles of food safety risk management. The risk-based approaches specified in the World Trade Organisation Sanitary and Phytosanitary (SPS) Agreement increasingly influence controls applied at the national level and bilateral equivalence agreements on sanitary measures are increasingly reliant on consistent risk management. MAF, FAA and MOH have now jointly developed a generic risk management framework for all aspects of food administration in New Zealand that is harmonised with the principles and practices adopted by international organisations.

Risk management provides the process whereby the results of risk assessment, and evaluation of other factors relevant to health protection of consumers and the promotion of fair trade practices, are used to choose and implement appropriate food safety controls. The four key steps in food safety risk management are risk evaluation (including quantitative risk assessment), assessment of risk management options, implementation of the risk management decision and monitoring and review (see Appendix I).

Risk management provides a sound scientific basis for challenging market access requirements that are not justified by genuine threats to human health. Further, risk models can be used to screen a number of different sanitary measures for their impact on reducing hazard levels at different points in the food chain, as well as scientifically establishing the probability of non-compliance with any importing country requirements.

The selection of preferred risk management options will primarily involve a systematic evaluation of the likely impact of different sanitary measures on reducing or eliminating risks to human health. Risk management allows decisions to be taken that are proportionate to the health risks involved, allows innovation and flexibility in application of sanitary measures, and allows due regard to be taken of costs as well as benefits.

“Farm-to-plate” approach

Regulatory and industry oversight of food safety must be broad enough to encompass all components of the food system from production to consumption, so as to ensure sanitary measures are applied where they will be most effective in reducing risks and ensuring compliance with importing country requirements. Inconsistent decisions on food safety and over-regulation can be avoided, and achievement of optimal food control necessitates appropriate interactions between government, industry, foreign governments, consumer groups and other stakeholders.

The sanitary measures that are developed to control particular food-borne hazards must be based on:

- Sound science and risk analysis
- Identification of required food safety outcomes that preferably are risk-based
- Establishment of performance/process criteria wherever appropriate, such as parameters for microbiological process control

- Application only to the extent necessary to protect human health, and be adapted to the health status of the areas of origin and destination of the food.
- HACCP, and flexibility in the design of specific controls
- Ensuring compliance with importing country requirements

An objective demonstration of equivalence of different sanitary measures applied in different countries requires application of a risk management framework utilising the above principles.

Quantitative risk assessment models

Effective risk management relies on quantitative risk assessment (QRA) models that generate estimates of risks to human health under a variety of conditions. QRA models provide a description of all pathways for contamination of food from farm-to-plate, and allow sanitary measures to be designed so that they are science- and risk-based, flexible, and allow due regard to be taken of costs as well as benefits. Further research needs to improve the outputs of the model can be identified in a systematic manner.

QRA modelling techniques for microbiological pathogens in foods are becoming increasingly common, but in the case of *Salmonella* contamination of red meat the impact of different sanitary measures (including microbiological monitoring programmes) on reducing risks to human health remains largely unknown. In the absence of a strategic risk management approach to investigating and answering questions about the effectiveness of different sanitary measures, short-term applied research results will continue to have only limited value.

Even more importantly, in the absence of QRA regulators have no sound basis for challenging market access requirements that are not scientifically justified by risk assessment.

A risk management approach to *Salmonella*

Salmonella are among the most important food-borne hazards in food on a world-wide basis. Others are *E. coli* O157:H7, *Campylobacter*, *Toxoplasma*, *Listeria*, and *Yersinia*. In the case of red meat, a risk management approach to controlling contamination with *Salmonella* is supported by a number of factors:

- *Salmonella* are among the food-borne hazards most commonly isolated from red meat
- These pathogens are the subject of increasing regulatory attention on a world-wide basis, and *Salmonella* performance criteria are increasingly being applied as import standards by different countries e.g. USA, Sweden
- New Zealand is likely to have continuing (and increasing?) market access problems and product wastage because of detection of *Salmonella*, especially in sheep meat and bobby veal

- **Actual** risks to human health from contamination of fresh red meat (particularly on a species-by-species basis) are largely unknown
- *Salmonella* are the object of a wide range of sanitary measures applied at various points in the food chain, but the relative value of these interventions is unknown
- Contamination rates for *Salmonella* are monitored at ever-increasing cost at various points in the food chain, but the statistical validity of different monitoring regimes relative to food safety goals is largely unknown
- Considerable scientific knowledge is available to support development of a quantitative risk assessment model, and identification of optimal sanitary measures
- *S. Brandenburg* appears to be an important (and unique?) contaminant of sheep meat produced in the South Island, with some suggestion of an early-phase epidemic at the farm level.
- The National Microbiological Database provides a representative and on-going source of data
- Current scientific research is piece-meal, ad hoc, and not subject to an overall risk management approach with strategic national goals
- Application of an overall risk management approach would not jeopardise short-term, applied research goals
- A QRA model for *Salmonella* would form a research platform for other microbial hazards transmitted by faecal contamination of fresh carcasses e.g. *S. Brandenburg* in bobby calves, *E. coli* O157:H7 in adult cattle.

Quantitative risk assessment model for *Salmonella* in red meat in New Zealand, with a particular emphasis on sheep meat

Goals

1. Provide a strategic risk management programme for control of *Salmonella* in red meat produced in New Zealand, with a particular emphasis on sheep meat.
2. Ensure optimal benefit from short-term applied research on hazard control at different points on the food chain.
3. Develop a farm-to-plate quantitative risk assessment model for *Salmonella* in sheep that will provide a sound scientific basis for optimal management of *Salmonella* contamination in the export and domestic food chains in the medium term.
4. Achieve favourable judgements of equivalence of sanitary measures applied in New Zealand in respect of current market access problems.

Objectives

1. Provide a National Steering Group to oversee applied research projects on *Salmonella* in the red meat food chain (and in particular sheep meat), so as to harmonise food safety outcomes from **short-term applied research** (pre-harvest and post-harvest) and ensure that they systematically contribute to developing a QRA model for an effective, national, risk-based management programme.
2. Provide technical sub-groups to co-ordinate technical aspects of *Salmonella* research in New Zealand.
3. 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.
4. Develop a QRA model **in the medium term** that provides the basis for effective risk management of *Salmonella* in red meat, with a particular emphasis on sheep meat.
5. Provide specific risk management advice for *S. Brandenburg* in the short and medium term to all interested stakeholders.
6. 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.
7. 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, *Campylobacter*.
8. Provide information to assess the relative importance of red meat as a vehicle for food-borne salmonellosis compared with other foods.

Response to MISC questions

Do we really need a QRA?

An important part of the project is the provision of a strategic risk management programme for control of *Salmonella* in red meat produced in New Zealand (with a particular emphasis on sheep meat), so as to ensure optimal benefit for all stakeholders. Systematic application of a risk management framework will achieve optimal benefit from short-term and medium-term applied research in negating on-farm, processing and occupational / consumer problems, irrespective of progression to a QRA model and the consolidated medium-term benefits that will flow from this.

The availability of a QRA in the medium term will provide a sound scientific basis for optimal management of *Salmonella* contamination in the export and domestic food chains. Benefits include genuine identification of cost-effective sanitary measures at points in the food chain where their food safety outcomes are maximised, provision of flexibility in choice of sanitary measures, scientific and statistical evaluation of all microbiological monitoring programmes (domestic and port-of-entry), development

of cases for judgement of equivalence where appropriate, and establishment of equity in risk management between different food sectors.

Further, current perceptions of *S. Brandenburg* (and other *Salmonella*) as important **food-borne** pathogens of red meat produced in New Zealand may be negated.

Is there any downside?

No downside can be identified by MAF FAA. (Even if the QRA model identifies a “significant” food-borne risk associated with *S. Brandenburg* in sheep meat, then it is in the industry’s best interest to design and implement sanitary measures that are cost-effective, and which minimise current market access problems).

What is the regulatory perspective / will a QRA be recognised in the marketplace?

Application of a risk management framework (including QRA) is now recognised world-wide as the most effective means of identifying appropriate sanitary measures for food in both domestic and export food chains. In the national situation, all stakeholders can be involved in establishing an “appropriate level of protection” and ensuring that optimal and cost-effective sanitary measures are put in place to achieve the appropriate level of protection in an equitable way across all food sectors.

A QRA model provides objective demonstration of how an exporting country meets the appropriate level of protection required by an importing country (WTO SPS Agreement), and unfavourable market access requirements can be challenged on a sound scientific basis.

People

The research project will involve multidisciplinary teams and co-ordination of applied research at several levels (Table 1):

- Steering Group
- Technical sub-groups: Technical management and co-ordination

Epidemiology / descriptive modelling

QRA modelling

Process

1. Approval of project proposal by MISC – 6 June 2000.
2. Establishment of Steering Group as agreed by MISC (initial co-ordination by FAA), and selection of chairman.
3. Initial meeting of Steering Group, and allocation of resources for meetings of sub-groups.

4. Initial meetings of technical sub-groups (including representation from the Steering Group).
 - Selection of group leaders
 - Review of current research programmes and likely outputs
 - Identification of short-term research and information needs, and resources required
 - Identification of medium term research and information needs, and resources required
 - Contracting of research
5. Scheduling of on-going meetings of Steering Group and Technical Sub-Groups, and formalisation of iterative links between groups.

Figure 1 describes functions and interactions between project teams.

Timelines

The duration of the overall project is envisaged to be from June 2000 to September 2003 (see Table 2). (Interim outputs are provisionally identified in Figure 1).

Table 1: Project teams

Group	Function	Composition
Steering Group	Overall management (RMF), and technical co-ordination	Meat New Zealand FAA/MOH Joint Food
Harmonisation	Funding “Risk manager” Reporting	Committee Industry / MISC AgResearch MIA MAF VA Federated Farmers Science providers Other stakeholders as appropriate
Sub-Groups		
1. Technical	Technical co-ordination of applied research	As agreed by Steering Group, and including FAA/MOH, industry,
MAF VA	Allocation of resources	AgResearch, Massey,
AgriQuality, field	Assessment of management	vets, ESR, LabNet Invermay etc

	Options Contract research	
2. “Epidemiology” Group	Preparation of descriptive pathogen pathway model Review current data Identify data gaps and Research needs	As agreed by Technical Sub-
3. QRA Massey, others	Modular development of risk model “Risk assessor”	FAA/MOH, AgResearch,

In order to gain the greatest benefit from microbiological monitoring, surveillance, and applied research projects in the short term, the Steering Group and the Technical Sub-Groups should meet well before the new lambing season (proposed timetable presented in Table 2).

The Steering Group should meet as soon as possible, so as to initiate the project and appoint members of the Technical Sub-Groups.

In this respect, the initial meeting of the Technical Sub-Group on Epidemiology should meet in late June for a two / three day workshop and:

- Develop a descriptive pathogen pathway model from farm-to-plate
- Review current literature and applied research projects in New Zealand, with a view to identifying data gaps and information needs, and making recommendations on further short-term and medium-term research projects
- Review current human surveillance data, and make recommendations as appropriate
- To the extent practicable, harmonise parameters for outcomes of current applied research so as to effectively serve the QRA model
- Contract research, in conjunction with Technical Management Sub-Group.

Short-term applied research projects will improve interim “risk management” decisions based on hazard control whereas medium-term applied research projects and QRA modelling will provide a sound scientific base for optimal risk management.

Funding

Likely funding needs and outputs covering the 2000 / 2001 slaughter season are presented as preliminary schedules in Table 2.

The primary funding agency will be Meat NZ.

The possibility of additional crown funding from MAF Policy Applied Research funding and MAF FAA / MOH Joint Food Harmonisation Committee funding to serve operational management needs on an on-going basis is being actively pursued. The tight time frame prevents application for such funding in the current year.

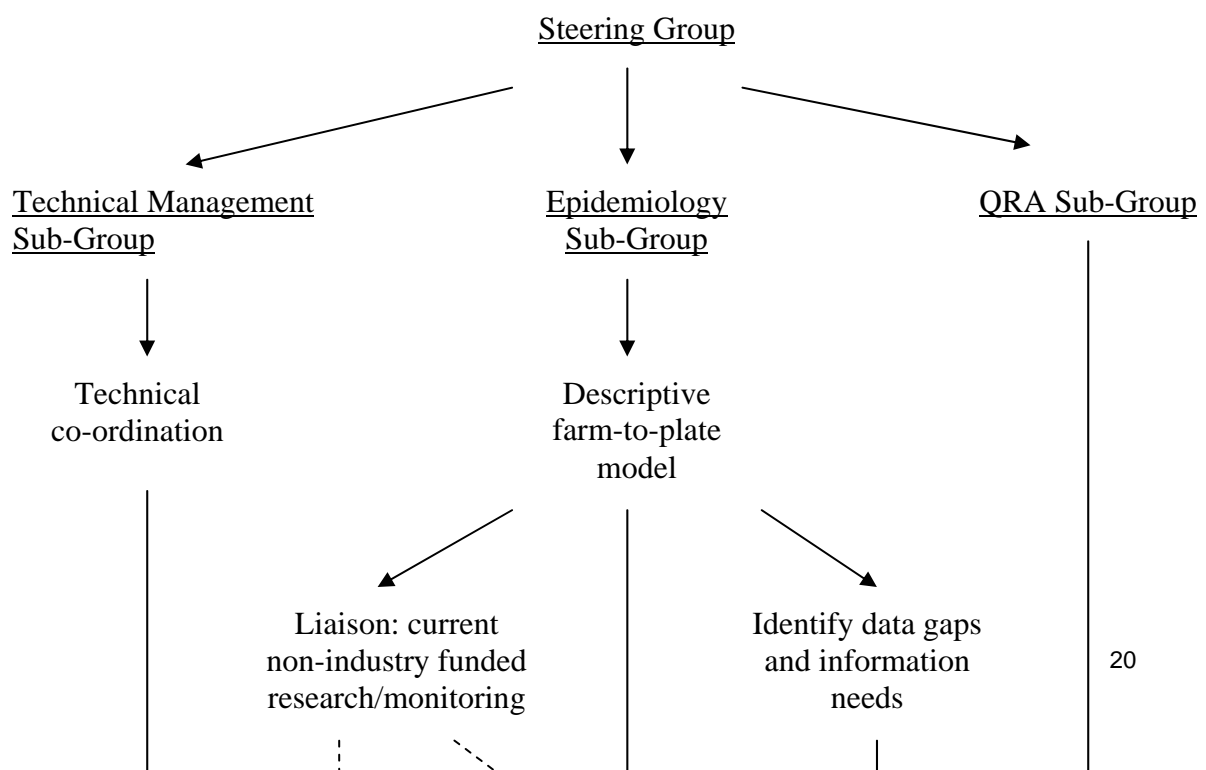
Preliminary schedules for funding, outputs and reporting will be revisited by the Steering Group and Technical Management Sub-Group in August 2000, and full schedules for the duration of the project will be drawn up.

Table 2: Preliminary schedules for funding and outputs

Date	Activity	Output	Funding
Mid-June 2000	Assemble Steering Group	Appoint Technical Sub-Groups	-
Late June 2000	Meeting of Epidemiology Sub-Group (3 days)	Preliminary descriptive model Identify 2000/2001 research needs	\$5000
Late July 2000	Meeting of Technical Management Sub-Group	Confirm research needs / allocate contracts	\$2000
		Research contracts for 2000/2001	\$100 000
Mid-August 2000	Meeting of QRA Sub-Group	Identify modules, allocate and begin work	\$13 000
Late August 2000	Meeting of Steering Group	Consolidate management programme	-

October 2000 to Sept. 2001	Meetings of Epidemiology Sub-Group as needed	Work programme Identify 2001/2002 research needs	\$8000
October 2000 to Sept. 2001	Meetings of Technical Management Sub-Group as needed	Work programme Confirm research needs / allocate 2001/2002 contracts	\$6000 \$100 000
October 2000 to Sept. 2001	Meetings of QRA Sub-Group as needed	Work programme to September 2001	\$80 000
October 2000 to Sept. 2001	Meetings of Steering Group as needed	Management programme	-
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Sept. 2001 to Sept 2002	Funding of meetings		\$10 000
	Funding of research	For 2002/2003	\$50 000
	Funding of QRA	For 2002/2003	\$80 000
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Sept. 2002 to Sept 2003	Funding of meetings	As allocated	\$10 000
	Funding of QRA		\$ 90 000
	Reporting		\$12 000
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Figure 1: Functions and interactions of project teams



3. Second meeting of *Salmonella* QRA Research Project Steering Group: 28/6/00

Meeting chaired by Dr. Neil Clarke, Meat New Zealand:

- Agreement on broad goals and objectives for the *Salmonella* QRA project
- Establishment of the stakeholder makeup of a *Salmonella* QRA Steering Committee, and the terms of reference
- Establishment of Technical Sub-Groups.

Appendix III

Report of the on-farm technical group

Peter Davies

Purpose

Initiate the development of a quantitative risk assessment for *S. Brandenburg* in sheep, including presentation of known data/research relating to the on-farm module, identification of data gaps that limit current knowledge on risks, and establishment of short-and medium-term research priorities.

Process

The occurrence of clinical disease in sheep due to *S. Brandenburg* infection was identified as the primary focus for discussion, as it represents the common factor linking the 3 stakeholder interests (animal disease, human disease, product safety) relevant to the production sector. A flowchart (Figure 1) was used to focus discussions on specific issues related to the occurrence of clinical disease in sheep due to *S. Brandenburg* infection. In addition, specific discussions addressed the issues of occupational health and recommendations for prevention and control of disease outbreaks in sheep. The following notes present the salient points of discussion of these issues, including principal data gaps and options for research.

Technical evaluation

Origin of the organism

- The clinical syndrome of abortion and ewe mortality due to *S. Brandenburg* infection was not recognised before 1996, when a single property was affected.
- *S. Brandenburg* isolates were previously uncommon among human and animal isolates in New Zealand and overseas.
- Molecular (PFGE) sub-typing of clinical isolates since then points to the involvement of a single clone of this serotype. This clone was not found among earlier isolates from humans in New Zealand
- The clinical disease has not been reported in other countries or the North Island of New Zealand. Other serotypes of *Salmonella* are recognised as causes of abortion outbreaks (particularly *S. Abortusovis*, *S. Montevideo*) although not in NZ.
- Because of the morbidity and mortality of the syndrome, it was considered unlikely that this was an existing problem that had gone unrecognised
- The origin of this clone is unknown. Possible origins include:
 - Mutation – genuinely new organism
 - Feed source (e.g. fishmeal in sheepnuts)
 - Wildlife
 - Humans

(* - sewage or discharge of wastes from fishing vessels has been considered a potential source of introducing *Salmonella* to an environment)

Given that the organism is now widespread in the lower South Island, it was considered that the original source of infection is likely to be of minor importance to the current epidemiology of the organism and disease, and therefore may not warrant significant resources for investigation. Two possible avenues for investigation were:

- 1) Retrospective PFGE typing of *S. Brandenburg* isolates from animals and animal feed prior to 1996
- 2) Closer scrutiny of 1996 human cases. Data from John Holmes indicated a possible increase in human cases of *S. Brandenburg* in Canterbury in 1996. The PFGE types, time and location of these cases should be verified.

The validity of assumptions about the apparent limited geographical distribution of the organism/disease (south of the South Island only) was questioned. Salmonellosis is notifiable in humans but not animals. Available data about animal disease are likely to underestimate the extent of the problem. Steps to improve the integration of passive surveillance data in both humans and animals should be considered. The reason for why the disease spread rapidly south from Canterbury, but not to the north has not been explained.

Mechanisms of introduction to farms and inter-farm spread

The subtle distinction between methods of introduction of *S. Brandenburg* onto farms and spread among farms was recognised, but both were considered together. Predominant mechanisms of long distance spread are likely to differ from mechanisms of spread among neighbouring properties. There is negligible hard data

on actual mechanisms of introduction onto SI sheep farms. The following factors were identified, based on empirical observations, published data in other species, or from first principles of disease transmission:

- Stock movements – including buying and selling of stock (sheep and other species), off-farm grazing of sheep and grazing of stock from other farms. Based on first principles, stock movement was considered to present the highest risk for introducing infection to farms (although no solid data exist). Spread of the disease from Canterbury to Otago and Southland is most likely the result of stock movement.
- Dealers – the likely high risk of purchasing via dealers was recognised
- Dogs/cats – Often asymptomatic carriers of *Salmonella*, and cases in dogs have been reported. Movement of dogs among farms is a potential means of transmission
- Wildlife – investigation has concentrated on gulls. Published literature indicates that birds are often transient carriers of *Salmonella*, but longer-term infection has been noted, particularly in gulls. High numbers of *S. Brandenburg* in the faeces of black-backed gulls have been reported in outbreak areas (G. Clark) and these birds may have an important role in the spread of the organism. Raptors (e.g. hawks) were also identified as potentially important (carriage of aborted fetuses etc across farm boundaries). Involvement of other species (e.g. ducks) is even more speculative. There is no information on occurrence in other wildlife such as rodents, ferrets, stoats, possums, rabbits, reptiles, and insects.
- Vehicles – stock and fertiliser trucks
- People – field visits, shearers, vets, scanners etc, (with dogs)
- Water – especially following local flooding
- Feed – hay, silage, root grazing, concentrates, grain, feed for other species on farms
- Wind/dust

Beyond stock movements, participants were not comfortable in trying to ‘rank’ these potential sources of introduction due to lack of hard data. Interpretation of results of sampling and testing potential sources is problematical, as it is likely that the organism is now widespread in the ecosystems of affected regions. Thus, although data gaps are numerous, targeted research of mechanisms of introduction of the organisms onto farms may not be rewarding. Published literature is consistent with the view that all the above constitute potential routes for introduction, and that their relative importance is likely to vary among farms and over time. Some of these routes may be amenable to management interventions, while others are not.

Reservoirs in the environment

It was noted that *Salmonella* are relatively resistant organisms capable of surviving for prolonged periods (months) under a range of conditions. Likely reservoirs include:

- Carrier stock – long term (months) asymptomatic carriage is well documented in several host species and for many *Salmonella* serovars. Available data indicate that the proportion of detectable faecal shedding by sheep in affected flocks declines considerably within 1-3 months after outbreaks. However, because of

the limitations of testing methods, one cannot rule out prolonged (year to year) carriage by infected sheep.

- Yards and ‘sheep camps’. Areas of concentration of stock are likely to become highly contaminated. Published literature, and data obtained by Gary Clark, confirms yards as a potentially important reservoir of *Salmonella*.
- Pasture and soil– survival for 3-4 months on pasture is reported, with survival being affected by conditions such as temperature, moisture, UV light, pasture length etc. Long-term residual contamination of pastures following outbreaks is feasible
- Water
- Vehicles and other fomites
- People (including clothing and boots)
- Wildlife
- Carcasses –disposal of dead animals, foetuses and membranes
- Residual contamination of trucks and lairages may be an important source for preslaughter infection of sheep after leaving farms.

As with mechanisms of spread, published literature is consistent with the view that all the above constitute potential reservoirs within the farm environment, and that their relative importance is likely to vary among and within farms, and over time.

Research opportunities include:

- 1) intensive longitudinal studies of the ecology and epidemiology of *S. Brandenburg* in the sheep farm environment.
- 2) Targeted study of specific areas, particularly yards; continuation or expansion of studies conducted by Gary Clark on yard dust.

Sources of exposure of sheep and outcomes

The range of outcomes of the exposure of sheep to *Salmonella* (including *S. Brandenburg*) can be categorised as:

- Transient: no colonisation of the animal
- Colonisation: the organisms become established in the host
- Shedding: the organisms multiply in the host and are shed (e.g. in faeces)
- Disease (enteritis, septicaemia, abortion)

The outcomes of exposure are likely to be determined by the route and dose of exposure. Established routes of exposure include:

- Oral – considered in published literature to be the most frequent route
- Respiratory (aerosol) – lower doses required than by oral route
- Conjunctival (dust) – demonstrated in sheep and potentially important in poultry
- Venereal – generally considered unimportant for *Salmonella*.

Duration of shedding following exposure is dose-dependent (higher exposures lead to prolonged shedding). Minimal data are available for *S. Brandenburg*. At Massey University last year, experimental infections using oral exposure were unsuccessful in reproducing disease but disease was successfully reproduced using I/V exposure.

A major issue was identified to be the relationship between exposure and the onset of disease. Available data suggest that *S. Brandenburg* may be widely distributed in the Southland and Otago environments, and hence exposure may be common. However, with one exception (8-10 month old lambs), disease has been limited to late pregnant ewes from July to September (it was noted that this differs from the seasonal pattern of enteric disease caused by other *Salmonella* serovars, where the incidence is highest in summer). Possible 'extreme' scenarios include:

- Asymptomatic carriers succumb to disease following 'stresses' associated with late pregnancy and winter (nutrition)
- Increased shedding from a minority of carrier animals, leading to a propagated epidemic of infection and disease among previously 'negative' animals
- Infection from environmental reservoirs leading to propagated epidemics in winter but not other times of the year.

The following factors were discussed as likely to affect outcomes of exposure

- Age – disease uncommon in young animals (< 2 tooth). Disease even appears less common in pregnant hoggets than older females.
- Pregnancy – disease generally confined to pregnant females. Data from John Smart and others indicate a higher risk in females carrying multiple foetuses, which implicates metabolic factors possibly related to nutritional stresses and the depression of the immune system in late pregnancy.
- Recent yarding, e.g. for crutching, shearing, drenching, vaccination etc.
- Total or partial feed deprivation – has an effect in reducing rumen antagonism to salmonellas
- Weather – recent winters have been mild. Potential for disturbances of feed intake with rain
- Strip grazing – John Smart reports that disease is largely confined to flocks that strip graze pregnant ewes in winter. This is considered a potentially key factor, with plausible mechanisms of increasing risk due to increased concentration of animals (established to be important with *Salmonella* in several species) and via nutritional effects (intermittent access to feed). It was acknowledged that management of grazing systems is highly variable among farms. It was noted that the disease syndrome had not occurred in regions of Otago and Southland where sheep are raised more extensively.
- Intercurrent disease – plausible, but no information available.
- Vaccination – Results using killed vaccine (without brandenburg antigens) in 1999 are equivocal, as were results from experimental challenge at Massey (Marchant). A new killed vaccine (with Brandenburg antigen) has been widely employed in Otago and Southland in 2000. Schering-Plough are collecting data from vaccinated properties again this year, and also conducting within-flock comparative studies on 6 farms.
- Breed – no information available

Better understanding of the factors predisposing to disease was considered critical to effective prevention of outbreaks. This is central to all 3 principal concerns at the production level. A case-control study (comparing characteristics of affected and unaffected flocks) was identified as the preferable approach for initial investigation.

Given the timing of the Gore meeting in relation to the lambing season, it is not possible to conduct an 'ideal' study in 2000, as the opportunity for collecting any data before the onset of disease has passed. However, a retrospective case-control study in 2000 is still considered to be worthwhile initiative, assuming resources can be in place by mid September. In addition to providing objective data on putative risk factors for disease, the design and implementation of data collection procedures would provide an invaluable foundation for a more intensive study in 2001 if warranted.

Other research options discussed included comparison, with respect to prevalence of *Salmonella*, of 1) strip-grazed and set stock farms, and comparison; or 2) vaccinated and unvaccinated flocks. Though both seen to be relevant lines of inquiry, it was considered that such focussed studies were not warranted when the existing data gaps are so broad. Because of the high cost of quantitative bacteriology, it was considered premature to attempt to estimate concentrations at the farm level until estimates of prevalence were available to guide more targeted studies in the future

Transmission (sheep-to-sheep) within flocks

Ram-to-ewe: Venereal spread considered unlikely, but sheep-to-sheep probable. Given the lag from mating to disease onset, and the small proportion of rams in flocks, the role of the ram is probably negligible. The possibility of increased shedding by carrier rams during the mating period, leading to exposure of females, was acknowledged.

Ewe-to-ewe: Direct transmission is likely to be aided by keeping stock at high density (strip grazing) and by yarding events. Considerable mixing of late-pregnant sheep occurs on some properties. There is limited information on the nature of epidemic curves, though John Smart and Andrew Roe reported varied observations including patterns consistent with both point-source (most cases over short time period) and propagated epidemics (lower and flatter curves, longer epidemics). Better information on the nature of epidemic curves among properties would be useful. Aborted fetuses and membranes contaminated with large numbers of organisms are considered to pose the highest risk for transmission of infection among sheep.

Ewe-to-lamb: Negligible information available, but potentially important for food safety. No evidence of perinatal disease in live-born lambs, but no hard data are available. Given the prolonged shedding likely by ewes in affected mobs, there is a high risk of exposure of lambs which may be important for food safety. Potential routes for transmission include: in utero, colostral, milk, saliva, faecal/oral, horizontal transmission (including skin/fleece contamination).

A cohort study of lambs reared in case and control flocks, comparing the prevalence of *Salmonella* at time of drafting, was considered the most valuable short-term research option. This would provide estimates of prevalence in lambs from these groups of farms, thus providing a measure by which to gauge the need for further research. Using case and control farms matched for vaccination status (vaccinated/unvaccinated) would both control for confounding by vaccination and provide preliminary information of the impact of vaccination in reducing the risk of infection in lambs. The data obtained would also provide a measure by which to gauge the need for further research. That is, if prevalence is low in lambs and similar

in case and control farms, this would indicate limited need for further investigation of this issue.

Risk status of sheep leaving farms and at point of slaughter

In the context of the overall QRA for *S. Brandenburg*, estimation of the prevalence and concentration of *Salmonella* in live animals leaving farms is highly relevant. This applies both for lambs and cull ewes. In the case of cull ewes (approximately 15% of animals leaving farms), the question of how long ewes should be retained on farms after outbreaks has practical importance. The current legal restriction on shipment is a minimum of 28 days after exposure to clinically-affected animals. Estimation of *Salmonella* prevalence in cull ewes in case and control flocks (as described above for lambs) should provide useful information about the relative risk presented by these different classes of stock (ewes vs. lambs) and farms (case vs. control), and thereby yield preliminary information on the contribution of *S. Brandenburg* outbreaks to overall *Salmonella* risk. This would be useful information to guide appropriate allocation for future research investments.

Animal management, including handling and hygiene, in the immediate pre-transport, transport, and lairage periods is likely to greatly impact the prevalence and concentration of *Salmonella* in sheep at the point of slaughter. This has been repeatedly observed in many species. These events typically include drafting, crutching, feed deprivation in yards pre-transport, duration and conditions of transport, and a range of lairage factors (hygiene, management, duration, water source, swim wash etc). Under New Zealand conditions there is an absence of data on these pre-transport, transport, and post-transport factors, although available literature in several species indicate that these effects are likely to be considerable.

Research opportunity: Pilot study to estimate the effect of the transport/lairage period under current commercial conditions on *Salmonella* prevalence.

Public Health Issues

In addition to the 'flowchart' discussions, Dr. John Holmes led a discussion of the human health impact of *S. Brandenburg*. The predominant impact has been via occupational exposure, and the role of *S. Brandenburg* as a foodborne pathogen in lamb is not clearly established. It is likely that many cases have involved high infectious doses associated with handling contaminated animal tissues (aborted foetuses etc). There has not been detailed follow up of cases to determine likely sources of infection. Factors considered to be of likely importance include:

- Exposure to aborted material, carcasses
- Personal hygiene, especially handwashing
- Oral infection – smoking, dog whistles
- Drinking water (contaminated by animals or birds)
- Clothing and boots
- Equipment and other fomites
- Pet lambs
- Dogs and cats
- Household dust

In addition to improved surveillance, more detailed follow up of cases should provide greater insight into the most important sources and risk factors for occupational infections.

Recommendations for prevention and control of S. Brandenburg

John Smart led a discussion of a document outlining options for farmers to prevent and control infection of their flocks and deal with outbreaks (see following section). These measures were generally seen as appropriate and practical. Disinfection of yards (e.g. with formaldehyde) may also have some value.

Summary

- The production sector is central to the *S. Brandenburg* problem, as the site of animal disease epidemics, the probable source of occupational exposure, and a source of potential foodborne disease risk associated with *S. Brandenburg* in sheep meat products
- The occurrence of disease epidemics in pregnant ewes should be the focal point of research in this sector as it directly or indirectly impacts all 3 major issues

The production module group spent most of the Friday morning session discussing the relative merits of the range of research options raised during the previous discussions.

Short-term research objectives (2000)

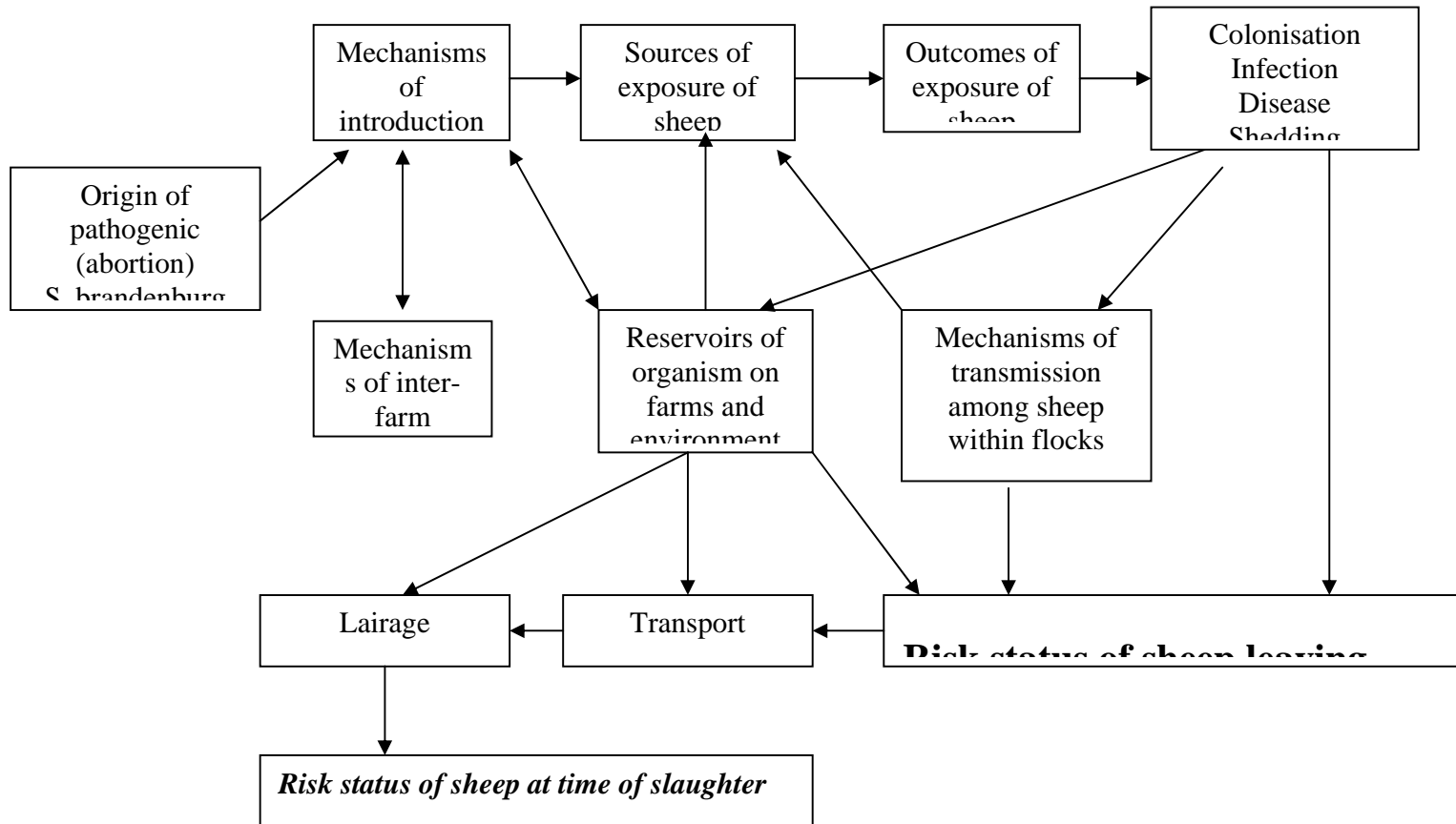
The following suite of studies is proposed for consideration. These studies are seen as complementary to each other, but each would independently provide needed information.

- More active disease surveillance and reporting through integrated reporting of disease events from practising veterinarians, diagnostic laboratories, and other potential sources. Better documentation of the anticipated epidemic will enable more precise mapping of the temporo-spatial spread of the epidemic, better documentation of epidemic curves on farms, and identification of eligible case and control flocks for epidemiological studies
- Pilot Case/control study: Identification of case and control flocks (as above). Mail survey (or personal interview) of selected farms to obtain data on farm, flock and management factors to evaluate associations with the occurrence of *S. brandenburg* outbreaks. These data would be collected retrospectively and would provide a foundation for a more intensive study (if warranted) in 2001. Alternatively, if indicated by the results, more targeted studies of specific putative risk factors may be preferred.
- Pilot cohort study of *Salmonella* prevalence in lambs. On a small number of case and control flocks, faecal and fleece samples will be collected from groups of lambs at the time of initial drafting prior to slaughter. Sampling of cull ewes on the same properties would also be conducted as discussed previously

- Pilot study of *Salmonella* prevalence in lambs before drafting and at the time of slaughter to ascertain the magnitude of the potential increment in prevalence between leaving the pasture and point of slaughter

We believe these pilot studies are relevant to all the major issues at the production level, and should provide a useful foundation for directing future research efforts in 2001 and beyond. The feasibility of conducting any or all of them this year will largely depend on the delay in resources becoming available. Available time did not permit specifics of logistics, study design, and cost to be considered by the group. The need for effective collaboration among different sectors is acknowledged. If time delays and funds preclude implementation of most of these proposed initiatives this year, it is important to establish the collaborative linkages and initiate selected projects in 2000

S. Brandenburg – Flow-chart for ‘On-farm’ module



Prevention and control recommendations for *S. Brandenburg*

John A Smart
Clutha Vets Animal Health Centre
P O Box 231
Balclutha

Gary Clark
Labnet Invermay
P O Box 371
Mosgiel

Salmonella Brandenburg has recently emerged as a devastating cause of abortion and deaths in ewes in many districts of Canterbury, Otago and Southland. Unfortunately we believe that further geographic spread of the disease including into the North Island is probably only a matter of time.

There are a number of management practices farmers can carry out which will reduce the chances of *Salmonella* Brandenburg occurring on their property. These include:

1. Vaccination - A vaccination programme using Salvexin +B (Schering Plough) can be set up. This involves vaccinating all breeding stock twice in the first year, the doses being given at 4 – 6 week intervals with the second dose occurring about two weeks prior to the main challenge period which appears to start about the end of June, i.e. the second dose should be given by mid June. In subsequent years all new stock will require two doses and all existing ewes will require one booster dose, again given by mid June.

The risk in pregnant hoggets appears much reduced so it is less important to vaccinate these.

Vaccination will result in:

- a reduction in abortions and ewe deaths.
 - a reduction in environmental contamination with the brandenburg organism resulting in less risk of spread to other properties and cross contamination occurring at freezing works.
2. Reduction in Stocking Density - Mob stocking systems, while they usually result in good nutrition for the ewes, do carry an increased risk if there is a contagious disease such as *Salmonella* Brandenburg going round. While not always desirable the more spread out you can graze your ewes the better from a contagious disease point of view.
 3. Maintain Adequate Nutrition - Ewes not under nutritional stress are more likely to withstand infectious challenge.
 4. Minimise the time ewes are in yards – bring smaller groups in at a time. This will also result in less risk of metabolic problems in pregnant ewes.
 5. Dampen down yards prior to yarding if they are dusty. *Salmonella* Brandenburg has been isolated from yard dust many months after an outbreak and has also been isolated from yard dust on farms where there has thought to be no cases of *S. Brandenburg*.

6. Avoid where possible the purchase and / or grazing of stock from known affected farms as there will almost certainly be a small percentage of the stock carrying the organism but not actually showing symptoms. However be aware that supposedly unaffected farms can harbour the bacteria.

An exception to the above is the purchase of rams – because of the numbers involved (usually 1 – 4 animals) and the timing (January – February period) the chances of importing *S. Brandenburg* while not absent are certainly extremely low.

7. Ensure all stock have access to a fresh clean source of drinking water.

If you are unfortunate enough to have an outbreak of *Salmonella* Brandenburg abortions and deaths occur on your farm the following measures should help to reduce the severity of the outbreak.

1. Rapid disposal of aborted fetuses and placenta by burial. This is most important as black backed gulls and hawks can accelerate the spread of the organism to other mobs and neighbouring farms.
2. Pour disinfectant over the exact area where aborted fetuses and placenta were lying. Note that not all disinfectants are equal – some are inactivated in the presence of organic matter, e.g. faeces, blood, dirt. The best general purpose farm disinfectants for this purpose are the quaternary ammonium compounds, examples of these are Stericide and Septex.
3. Rapid isolation of aborted ewes into a separate mob since these will be discharging millions of bacteria amongst other ewes.
4. Spread out affected mobs as far and wide as you can practically get away with.
5. Limit pre-lamb yardings to the absolute minimum in terms of number and length of time in the yards. One aborting ewe in a confined space has the potential to infect many others.
6. Control scavengers. These include black backed gulls, hawks and your own dogs. A dead gull or two left lying around often deters other gulls.
7. If only some mobs are affected go from unaffected to affected mobs on your daily rounds and then clean your vehicle tyres, wheel wells, farm bike trailer etc. Again use a disinfectant effective with high organic contamination as listed in 2 above.

Regarding antibiotic use to treat ewes suffering from *Salmonella* Brandenburg there are pros and cons associated with this. While antibiotic treatment if given in time will markedly increase the survival rate of affected ewes, this treatment:

1. Can result in an increase in the carrier state, i.e. ewes carrying and shedding the organism but not actually showing any symptoms.
2. Has the potential to result in an increased incidence of antibiotic resistance.

The use or otherwise of antibiotics should be discussed with your local veterinarian.

Salmonella Brandenburg (along with all *Salmonella*) have the potential to infect humans (i.e. they are a zoonosis) and cause a very nasty and debilitating illness. To reduce the chances of human infection if you have *S. Brandenburg* abortions occurring on your farm:

1. Use disposable gloves when handling any aborted material or lambing any suspect ewe. These are available at all vet clinics.
2. Avoid putting fingers, dog whistles etc. anywhere near your mouth until washed in disinfectant.
3. Wash hands in disinfectant prior to every meal.
4. Don't bring contaminated clothing / footwear indoors.
5. Clean and disinfect your boots.
6. No smoking (at least until your hands are clean but preferably never again – you should live longer as a result!)
6. Take care with young children with respect to exposing them to potentially contaminated material.

Salmonella Brandenburg has the potential to cause contamination problems at freezing works. If you have had the disease on your property then to reduce the chances of cross contamination at the works:

1. Dampen down dusty yards prior to yarding. *Salmonella* Brandenburg has been isolated from wool so dampening down will reduce wool contamination from *Salmonella* in shed dust.
2. Ensure stock are clean – crutch if necessary.
3. Again minimise time in yards as much as possible.
4. Keep yarding stress on stock as low as possible, i.e. reasonable handling, avoid excessive dog use etc. Any stress can result in increased shedding of *Salmonella* organisms by carrier animals.
5. When sending cull ewes to the works that have survived a bout of *S. Brandenburg* earlier on there are some precautions in addition to those already listed above.

These include:

- a. Keep these stock on the farm for as long as practically possible before sending to the works. Ideally these cull ewes should be kept until at least February. The longer the interval from disease occurrence to slaughter the less the chance of cross contamination. The meat regulations state that stock that has been in contact during the previous four weeks with stock affected with clinical salmonellosis shall not be sent to the works, however as stated above a longer interval is necessary to reduce the contamination problem and waiting until February of each year would be desirable.

- b. Shear surviving affected ewes prior to going to the works. This will reduce the potential for *Salmonella* contamination of the wool.
- c. Notify the works buyer of these ewes status so they can take appropriate measures at the slaughter premises.

Note that a, b and c above apply only to surviving ewes that were actually clinically affected by *Salmonella* Brandenburg themselves, not necessarily to other ewes from the mob being culled for other reasons, age etc.

For more information on *Salmonella* Brandenburg especially the incidence in your locality please contact your local Veterinary Clinic – they will be happy to provide advice on the problem.

Appendix IV

Report of the processing technical group

Kelvin Ashby and Steve Hathaway

Purpose

Initiate the development of a quantitative risk assessment for *S. Brandenburg* in sheep, including presentation of known data/research relating to the processing module, identification of data gaps that limit current knowledge on risks, and establishment of short- and medium-term research priorities.

Process

Control of cross-contamination of fresh meat with faecal pathogens remains a priority issue in the slaughterhouse environment. Although fresh meat produced in New Zealand has a low *Salmonella* contamination rate compared with other countries, the recent emergence of *S. Brandenburg* in sheep has created an increase in this baseline rate.

The presence of *Salmonella* in slaughtered sheep can result in “market access risk”, occupational and food-borne risks, and the extent of these risks will depend largely on the level of *Salmonella* brought in to the slaughterhouse environment.

The processing module represents a sequence of process steps that have a variable impact on the prevalence and concentration of *Salmonella* that initially enters the slaughterhouse environment via live sheep.

Technical evaluation

The chairman of the processing module (Kelvin Ashby) presented a typical process flow for sheep slaughter and dressing in New Zealand, with each step presented for detailed discussion as to the likely impact on *Salmonella* prevalence and concentration. All potential pathways for *Salmonella* at each step were presented as inputs. The approach taken has strong similarities to hazard analysis in the design of a HACCP plan.

This report only contains technical analysis of those steps considered to have significant potential for impacting on the prevalence and concentration of *Salmonella*.

Stock arrival/receipt

It was recognised at an early stage that detailed information on the prevalence and concentration of *Salmonella* at the point of slaughter of different classes of sheep was a vital component of the QRA model, and this baseline would likely be used to “anchor” other modules. A subset of this is the need for detailed knowledge on the prevalence and concentration of *Salmonella* at the time of entry to the lairage for different classes of sheep. The level of *Salmonella* entering the slaughter process module would obviously change with different epidemiological factors on-farm, conditions of transport and lairage, season, geography and other factors.

In the case of *S. Brandenburg*, the unknown status of sheep arriving at the slaughterhouse creates problems in applying more stringent sanitary measures. For a variety of reasons, it is

currently impracticable to separate lines of slaughter animals from “infected” versus “non-infected” farms. Further, a small number of sheep may be suffering actual infection with *Salmonella* rather than asymptomatic carriage at the time of slaughter. These animals may contribute a disproportionately large amount of contamination of the environment by faecal shedding.

Infected / contaminated sheep will cross-contaminate other sheep, the lairage, and drinking water containers. A pilot study has shown that 2% of drinkers in the slaughterhouses of one company contained *Salmonella*. People and dogs may also contribute to cross-contamination. The survival of *Salmonella* in the lairage environment is unknown, but may contribute to cross-species contamination. The role of bobby calves in the ecology of *Salmonella* in sheep, and subsequent contamination of sheep meat, is largely unknown.

Initial livestock assessment

Standard procedures for initial assessment of livestock include fleece status and levels of faecal contamination. Heavily soiled animals are likely to harbour higher prevalences / concentrations of *Salmonella*, and actions taken as a result of this process step are likely to have an important impact on subsequent contamination of the carcass at pelt removal. In this respect, there is considerable information available on the effect of fleece contamination and different washing regimes.

Establishing the proportion of animals that are washed, the variability in factors affecting this proportion, and the type of washes used will be important inputs to the QRA model.

Washing

A range of washing regimes are used, and they include swim wash, belly wash, and spray wash. Further, different pressures and wash times are used in different premises, some lines of sheep are washed twice, and the use of recycled water could be a factor in cross-contamination. All these factors will need to be considered at the wash step when building the QRA model.

Pilot studies have shown that swim wash water can be heavily contaminated with *Salmonella*. (10% in one sampling regime). Other studies conducted by AgResearch have identified the potential for excessive outgrowth of faecal microbes such as *E. coli* in wet fleeces given long lairage times. This data will provide an important input to the QRA model, and further studies are needed to quantify such effects on total fleece load at the time of slaughter and pelting. A key data requirement will be mapping the distribution of holding times in lairages given different washing regimes in different slaughterhouses.

Holding times in lairages

As well as impacting on growth rates of *Salmonella* in wet fleeces, long holding times may increase *Salmonella* shedding rates in faeces. Data from bobby calves and other classes of slaughtered livestock could be used as a surrogate when modelling this effect.

Slaughterhouses operating shifts may have considerably different lairage patterns to other premises. Also, different lairage patterns may apply to alternate shifts in the same premises.

Ante mortem inspection

Ante mortem inspection may provide a means of removing sheep clinically affected with *Salmonella*, although this was considered to be a low likelihood. Sheep with salmonellosis would most likely be exhibiting signs of septicaemia and be condemned at post-mortem inspection, however cross-contamination from such animals could be a significant problem up until that step in the processing module.

Rewashing

Rewashing of a small proportion of sheep will also impact on hazard loads entering the slaughter and dressing process. Rewashing usually consists of spray or belly washing, but in some situations may involve a second swim wash.

Stunning

Use of excessive water during stunning was identified as a possible source of cross-contamination of the fleece.

Location of weasand, rodding and bleeding, bunging

All these process steps were identified as possible sources of contamination of particular areas of the fleece / carcass with *Salmonella*. Quantification of such effects would be difficult, however some data on cross-contamination with surrogate microbes (*E. coli* and APCs) is available.

Anus trim

The influence of tail length, presence of dags and operator competency were recognised at this step. The margin for error in carrying out the anal trim is small, and the above-mentioned factors may have to be considered in the QRA model.

Empirical observations suggest that faecal smearing of the carcass can occur with incorrect anal trimming, and short-term research may be necessary to quantify such effects. Such research could also lead to improved good hygienic practice (GHP) in a general sense.

Y-cut

As in generic HACCP plans, the opening Y-cut was identified as a process step with considerable potential for cross-contamination of the carcass surface. Work by MAF Food has quantified this potential for *E. coli* and APCs. The NMD also monitors this site and this database will be of considerable importance in overall mapping of sheep carcasses for potential pathogen loads. Validation processes for HACCP plans in individual premises are a further source of surrogate data.

Shoulder flay

The possibility of review of current pelting practices was discussed, with attempts to prevent roll-back at this site (i.e. pelting of washed sheep) possibly being counter-productive in terms of subsequent carcass contamination.

Udder / cod removal

This is a compliance issue and non-compliance with current GHP has considerable potential to contaminate the carcass. In many cases, it appears that much more skin than is necessary is removed, and the fleece in this area is highly contaminated. Transfer of hazards to the carcass will create a further problem of redistribution at the pre-evisceration wash.

It may also be necessary to confirm that milk (and urine) do not contain *S. Brandenburg*.

Pre-evisceration wash

It was estimated that all premises carry out a pre-evisceration “shoulder” wash. This covers various areas of the carcass but does not include the hindquarters. MAF Food have conducted research on the impact of pre-evisceration washing on *E. coli* and APC concentrations and redistribution.

Aerosol of contamination may have an environmental effect at this step.

Post mortem inspection

Palpation by meat inspectors has shown to be a cause of cross-contamination and redistribution of microbes of faecal origin that have contaminated the carcass surface. Both New Zealand and international data is available to model this effect, however it is hoped that routine post mortem inspection will soon be “hands-off”.

Final carcass wash

All carcasses receive a final wash, but the systems used are of varying effectiveness. Most systems use flood washes at high pressure rather than low pressure, and this is likely to have a significant effect on carcass levels of *Salmonella*. Quantifying this impact was seen as an essential short-term research priority. A further potential benefit of such research would be to support equivalence arguments in respect of “pathogen reduction interventions”.

Product pathways

Detailed data is required on the proportion of carcasses that are hot- compared to cold-boned, as the potential for growth and survivability of *Salmonella* is likely to be considerably different through these different product pathways.

Detailed information is also needed on the proportion of carcasses chilled versus frozen, for the same reasons.

Neck stringing

Neck stringing before chilling creates the potential for growth of *Salmonella* on the occluded surfaces of the carcass (remain moist, and much slower cooling curves). This surface includes the “Y-cut” area. This potential effect was considered to be an important part of carcasses mapping, and the subject of short-term research (medium priority).

Marshalling / cooling floors

This step is subject to industry GHP standards but nevertheless has the potential to allow growth of *Salmonella* in situations of non-compliance. Mapping product flows is an essential model input.

Chilling

Re-defining the adequacy of the PHI model is currently under way, and this will be a critical modelling component of the QRA.

It will also be important to document levels of cooling compliance for including in the QRA model.

Cutting and boning

The technical group had insufficient time to explore the impact of different product flows and process steps in detail, and it is acknowledged that this is a critical area for inclusion in the QRA model. Surrogate data on this topic is available from a number of international studies, and medium-term research may be required under New Zealand conditions to validate model inputs.

Offals

Offals represent a particular product pathway that has a similar potential for contamination with *Salmonella* as fresh meat. Considerable data is available on microbiological contamination rates under New Zealand processing conditions, and further technical analysis is needed for modelling this pathogen pathway.

Summary

Technical analysis of the processing module is a very different exercise to that applied to the on-farm module, with industry GHP standards being applied at all process steps. Nevertheless, there is considerable potential for non-compliance at different steps, and this potential has to be built into the QRA model.

The technical analysis largely followed the hazard analysis / critical control point principles of HACCP, and considerable data defining GHP is available from previous work by MAF Food (design of generic HACCP plans) and Ag Research (effect of fleece contamination and carcass mapping). Although not quantifying *Salmonella* prevalence or concentration, this research will provide important surrogate data for inclusion in the QRA model.

A range of data gaps and research priorities were identified. It was also evident that detailed description of product treatments and flows will be necessary to complete the QRA model, and this will be achieved by field observations and questionnaires to industry.

Lack of information on the prevalence and concentration of *Salmonella* at the point of slaughter was identified as an essential data gap. This would likely be regarded as the reference baseline for the QRA model. The meeting recognised that generation of this data had to take geographical, seasonal and slaughter-class factors into account, and would be cost-intensive. The impact of different lairage conditions will also have to be investigated during the development of the QRA model.

Current research has established that swim-washing and holding of sheep for variable times before slaughter can have a dramatic effect on growth rates of faecal contaminants on the fleece. Further, swim washes provide a vehicle for extensive cross-contamination between

animals. This was seen as a high-priority area for short-term research to quantify the impact of this process step on *Salmonella* loads on the fleece, and subsequently on the carcass.

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