Final report

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Prepared by: Andrew Pointon[1], Jan Jackowiak[1], Jo Slade[1] and Michael Paton[2]
[1] South Australian Research and Development Institute
[2] Western Australian Department of Agriculture and Food

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Meat & Livestock Australia Limited
Locked Bag 991
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Review of surveillance data capture systems in abattoirs

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Executive summary

Terms of Reference

Review the capture of animal health surveillance data in abattoirs for the extensive sheep and beef industries in Australia and internationally, and identify lessons learned from similar schemes in the pig industry. Evaluate the possible application of such information systems in the sheep and beef industries. Identify the current situation in processors, including the systems available to processors, type of information collected and the level to which this information is currently used by stakeholders and government systems. Make recommendations on options for investment in research and/or the development of a pilot project to evaluate the usefulness of such information systems in Australian abattoirs.

International review

The results of a literature review and contact with international animal health disease surveillance experts, found only limited application of the the E-Surveillance approach. Apart from New Zealand, the largest sheep meat exporter, there are only pilot programs to evaluate this approach. In New Zealand the capture and reporting of production and abattoir post-mortem inspection information to producers is routinely combined with the payment details.

Most of the development work is reported from pilot projects in Scotland, South Australia, Western Australia and the Australian Enhanced Surveillance project. The profile of conditions monitored and reported to producers varies between countries and regions within countries.

Currently in Australia, the Export Production and Condemnation Statistics (EPACS) database is able to maintain partial surveillance data relating to animals and carcases condemned at export abattoirs. However, differences in alignment between these data sets and those collected in pilot performance surveillance projects are attributable to different conditions/criteria being recorded for different purposes (safety, wholesomeness, production efficiency).

Nonetheless, of particular interest in the AQIS data is the inclusion of conditions, identified by the E-Surveillance Coordinating group, that cause wastage (e.g. emaciation) across the supply chain. While the approach has been extensively utilised for eradication of bovine tuberculosis the application to Ovine Johne’s Disease and footrot in Australia represents a recent innovation.

Utilization of Meat Inspection Findings to Improve Livestock Production in Western Australia: MLA Research Project DAW.034

This major project conducted in WA in the mid-1990s for sheep and beef:

- confirmed that implementation of slaughter surveillance for commonly found production-limiting sub-clinical conditions is practical in Australian abattoirs;
- identified risk factors for common conditions affecting profitability in the sheep industry;
- quantified improvement in the health of livestock at slaughter, and
- confirmed positive producer attitudes and actions in response to surveillance feedback.

Subsequent associated projects quantified the cost of commonly detected conditions on-farm and processing wastage at the abattoir. The study provides a comprehensive evaluation of the approach and some of the economic drivers. Surprisingly the substantial economic drivers did not see the approach adopted, despite processor support for the approach.

Review of the Australian Pig Health Monitoring Scheme (PHMS)

Monitoring of production-limiting diseases has been conducted nationally in Australia on a user-pays basis for over 20 years. The PHMS approach has been utilised internationally. It includes severity scoring of several diseases of sub-clinical importance that would otherwise go

undetected by routine post-mortem inspection procedures. Considerable work has confirmed the diagnostic accuracy of the data and the economic impact of the conditions monitored and reported; both critical aspects of successful implementation.

Individual graphed reports showing two years data and benchmarked against similar herds, provides important information to producers that motivates disease control and prevention. From the PHMS data it can be reliably inferred that the health status of the (monitored) growing-pig herd in Australia has continued to improve consistently and substantially over the past decade. These data provide an objective and detailed account of the status of production-limiting diseases of the Australian pig herd that might be considered to support market access negotiations.

The scheme has been integrally involved in defining industry problems, setting R&D priorities and supporting the evaluation of interventions to limit the impact of sub-clinical herd infections. While some sponsorship is provided by the pharmaceutical industry to support quality assurance overheads and project funding is provided by industry (APL) for software development, the bulk of the cost is borne by producers.

The present industry contraction and reducing number of herds will make it difficult to sustain PHMS as a stand-alone service. Integration with routine inspection services may assist as long as the specificity and sensitivity of condition classification and range of production-limiting conditions is maintained.

Processor reporting

While some processors report substantial carcase information for sheep and beef, reporting of animal health data is generally limited to condemnations and usually only upon request from producers. Some abattoirs provide animal health feedback when processing problems arise. There is no systematic reporting of commercially-useful animal health information, despite abattoirs having HACCP programs where specification of incoming product might be expected to minimise carcase non-compliance arising from endemic sub-clinical disease.

Evaluation of approaches

In summary, the E-Surveillance approach integrates animal health feedback from slaughter to improve production and processing efficiency and profitability, with provision of information for regulatory disease control and national and international trade access compliance.

Both commercial and regulatory outcomes are significant in the design of an E-Surveillance program and keeping this balance will be critical for successful implementation.

The abattoir surveillance approach provides a useful tool, apart from initial disease detection and severity, to quantify losses on-farm resulting from commonly detected sub-clinical conditions and wastage during carcase dressing. The herd and flock data also facilitates studies to determine contributing factors to disease that can inform on-farm and regional disease control and prevention strategies. These commercial-drivers in themselves facilitate a positive feedback loop, whereby fewer carcases are classified as non-complying within the abattoir HACCP program. The current sheep Enhanced Disease Surveillance program under development builds on previous pilot projects in SA and WA and provides a useful platform on which to base further development of the E-Surveillance approach.

The Australian red meat industry has, under SafeMeat and AQIS, led the application of HACCP food safety programs. More recently the HACCP-based Livestock Production Assurance Scheme extends the approved arrangements on-farm. In conjunction with these programs, the National Animal Health Central Database operated by Animal Health Australia provides timely and accurate summary information on Australia's animal health status to support trade in animal commodities and meet Australia's international reporting obligations.

The feedback to producers of carcase and offal animal health data links abattoir (Australian Standard; Export Meat Orders) with on-farm (Livestock Production Assurance) food safety programs within the SafeMeat framework.

Specific market access requirements of AQIS include:

- Data management in an independently controlled database to meet OIE and importing country requirements.
- Inclusion of partial condemnation data in the Export Production and Condemnations Statistics (EPACS) database.
- Inclusion of ante-mortem condemnation data and causes (in EPACS).
- Implementation of a multi-species approach to underpin overall surveillance outcomes for market access.

The E-Surveillance approach at slaughter also services regulatory disease control programs. Examples include the successful national Bovine Tuberculosis eradication program and application within the current Ovine Johne's Disease Management Plan. State animal health jurisdictions are evaluating the approach in pilot projects for ovine footrot, knackery disease surveillance and residues in dairy calves.

Recognising the limited nature of resources, taking a risk-based surveillance approach is recommended to ensure efficient use of resources. While continuous surveillance/monitoring is preferred, it is noted that some conditions of sheep that have regional or seasonal association (e.g. knotty gut, liver fluke, footrot) lend themselves to a more focused and efficient risk-based approach when national implementation is considered. A food safety risk-based assessment of current post-mortem inspection of ruminants to better focus resources on reducing risk should be considered to potentially free up resources for the incorporation of feedback of abattoir data within a wider HACCP-based framework e.g. expansion of work underway by AQIS on bovine TB and beef measles.

While far from comprehensive, assessments of the sensitivity and diagnostic specificity of conditions detected post-mortem have shown sufficient rigour to support disease control interventions, though for new or unexpected results, follow-up diagnosis is recommended. However, there is evidence from Australian beef abattoir studies that significant wastage during processing may arise from misclassification of (aesthetic) conditions of offal and that the process of detection may, for some conditions, introduce food safety hazards.

Options

The following options are recommended.

1. Evolve the organoleptic post-mortem inspection role to provide disease information that links on-farm and processor HACCP-based programs.
2. Consider conducting a risk assessment of organoleptic post-mortem inspection that may facilitate implementation of additional procedures required for endemic and regulatory disease surveillance.
3. Utilise progress with the sheep industry with the OJD/Enhanced Surveillance programs to lead development for 'small stock' over the next three years.

4. Explore potential to consolidate routine processor carcase data (including partial condemnation/trim and causes) and surveillance/monitoring data on the same system with quarantined access according to end-user needs.
5. Manage the data in an independently controlled database to meet OIE and importing country requirements.
6. Incorporate trim data and causes into processor reports to producers to inform producers of the direct impact of disease on returns.
7. Use graphic presentation of data in producer reports to effectively communicate disease trends, seasonal effects, response to interventions and benchmark regionally.
8. Collaborate with state animal health jurisdictions in the development and implementation of regional endemic disease control programs to underpin market access.
9. Take a risk-based surveillance approach to ensure efficient use of resources.
10. Consider beef abattoirs as a stage 2 option (based on success of a sheep system).
11. Consider implementing E-Surveillance in pig abattoirs using aspects of the PHMS approach to support productivity and market access.

The following table of conditions provides an overview of commonly occurring production-limiting and regulatory conditions of ruminants that should be considered for reporting to producers, processors and regulatory jurisdictions in an E-Surveillance program.

Producer, processor and regulatory reporting: Specification of commonly occurring production conditions and those from routine organoleptic inspection for beef, sheep and goats recommended for reporting in Australia.

	Cattle			Sheep		Goats
	Calves	Steer/Heifer	Cow/Bull	Lamb	Sheep	
Abscess carcase	✓	✓	✓			
Actinobacillosis/mycosis		✓	✓			
Anaemia					✓[2]	
Arthritis (poly)			✓	✓	✓	
Bladder worm *Cys. tenuicollis*				✓	✓	✓
Bruising		✓	✓	✓[2]	✓[2]	✓
Cancer (eye)		✓	✓		✓	
CLA				✓	✓	✓
Dog bites				✓[2]	✓[2]	
Emaciation			✓	✓	✓	
Footrot					✓[1]	
Granulomas TB*	✓	✓	✓			
Grass seed				✓	✓	
Gross hide contamination						✓
Hardware disease	✓	✓	✓			
Hydatids			✓	✓	✓	✓
Jaundice	✓	✓	✓	✓	✓	✓
Knotty gut (Nodule worm)				✓[1]	✓[1]	
Liver abscess	✓	✓	✓			
Liver fluke - Fascialiasis	✓	✓	✓	✓[1]	✓[1]	✓
Liver melanosis					✓[2]	
Lungworm				✓	✓	

	Cattle			Sheep		Goats
	Calves	Steer/Heifer	Cow/Bull	Lamb	Sheep	
Nephritis	✓	✓	✓	✓	✓	✓
OJD					✓	
Peritonitis	✓	✓	✓			
Pleurisy	✓	✓	✓	✓	✓	✓
Pneumonia	✓	✓	✓	✓	✓	✓
Rumen abscess (anthelmintic)	✓	✓[2]	✓			
Sarcocystis	✓	✓	✓	✓	✓	✓
Septicaemia/toxaemia/ fever	✓			✓	✓	
Sheep measles *C. ovis*				✓	✓	✓
Small fibrotic liver-Lupinosis				✓[1]	✓[1]	✓
Vaccination abscess	✓	✓	✓	✓	✓	✓
Worms general				✓	✓	
Navel ill Bobby calves	✓					
Facial eczema		✓[1]	✓[1]	✓[1]	✓[1]	
Contamination	✓	✓	✓	✓	✓	✓
White muscle disease				✓	✓	

[1] Examples of candidates for risk-based surveillance based on known regional differences
[2] Examples of candidates for risk-based surveillance based on low prevalence or economically unimportant (subject to refinement with processors and producers using initial abattoir baseline data)

Supporting R&D to Evaluate Usefulness
Given the information currently available on the economic value of a comprehensive feedback system and the failure of such a scheme to be taken up, it seems unlikely that further research demonstrating the value of decreasing the prevalence of individual conditions will lead to its adoption. The prevalence of a number of diseases (sheep measles) or conditions (grass seeds) have been or are, currently of high industry priority. In spite of the good intentions of some processors to implement feedback schemes that would significantly mitigate these problems, such schemes have not been implemented.

Therefore, it is likely that the most useful research project to assist in implementing a comprehensive feedback scheme would be to examine the barriers to implementing such a scheme in the Australian meat industries.

Pending the consideration of the E-Surveillance Coordinating Group a pilot trial is recommended to:

- Validate data integrity including:
  - adequacy of data capture on the slaughter floor – sensitivity and specificity of priority conditions
  - accuracy of data entry (suitability of hardware and software)
  - traceability of livestock to source.
- Determine whether additional efficiencies might be achieved with current post-mortem inspection procedures.
- Validate the approach for multiple species, in multiple abattoirs.
- Evaluate impact on processor efficiency (extra costs and savings).

Such a trial should be considered to enable refinements of methodologies prior to national roll-out and to ensure stakeholder confidence in the rigour of the data acquired and information generated for various purposes. For sheep and cattle it is recommended that underpinning research be undertaken to produce a risk-based (economic impact and market access) refinement of the list of conditions for monitoring and reporting.

Contents

1 Project Objectives

- Identify similar projects that may have been undertaken, both in Australia and internationally, to investigate the application of electronic information management to the capture of surveillance data in abattoirs for the extensive livestock species and the quantification of the benefits derived from these systems. This stage will involve a review of the Pig Health Monitoring Scheme which is a voluntary commercially-driven system which utilises commercial veterinarians and DPI extension officers to capture a significant proportion of the industry.
- Evaluate the possible application of such information systems in the Australian context for the beef and sheep industries.
- Identify the current situation in processors, including the systems available to processors, type of information collected and the level to which this information is currently used by stakeholders and government systems.
- Make recommendations on options for investment in research and/or the development of a pilot project to evaluate the usefulness of such information systems in Australian abattoirs.

2 Methodology

Part 1 of the report provides synthesis and recommendations from the supporting material. International colleagues were contacted to update activities in this area and to obtain details of pilot programs and schemes in a standardised manner. A literature review was conducted for abattoir surveillance publications for beef, sheep and goats. Previous related Australian projects were reviewed. A comprehensive review of the Pig Health Monitoring Scheme was produced.

Existing networks (AQIS, abattoir, RDCs, overseas) were used to examine and assess current data capture systems, the type of information collected, the means of storage and capacity to interrogate data and the suitability of data outputs for the intended purposes. As part of this objective, results from MLA Project V.MSL.0001, Sheep Feedback Systems (Goers & Craig) were evaluated.

Opportunities for use of the system for inclusion in regulatory disease control programs in Australia and overseas were identified. Information on processor reporting to producers has been summarised from the companion Meat Standards Australia project for sheep and beef abattoirs. In examining the uses of surveillance data, particular attention was given to documenting associated reporting and extension activities undertaken in Australia by animal health professionals.

AQIS total carcase condemnation data, reported and evaluated in MLA's Through Chain Risk Profile for the Australian Red Meat Industry (Meat & Livestock Australia, 2003), was utilised to provide background on the incidence and proportional occurrence of 'pathology' (including foodborne zoonoses) occurring nationally in beef, sheep and lambs. Other projects/agency programs (e.g. National Granuloma Program, OJD, Sheep Enhanced Surveillance, Footrot etc.) were examined to identify opportunities and minimise duplication with current effort.

3 Review of Ruminant Health Monitoring/Surveillance Schemes

Management decisions affecting animal health and productivity are becoming increasingly complex, regardless of whether the decision is made at the farm, regional or national level. Consequently, decision makers such as producers, veterinary practitioners or regulators require quantitative information about the health and productivity of livestock in their care.

In recent reviews from Ireland and the US (van der Venter, 2000; More, 2008; DeHaven & Goldberg, 2006) there is recognition of the increasing importance of the quality and safety of agricultural products to remain competitive in a global trading environment. In this context, animal health is an important contributor to on-farm profitability, as well as food safety and quality and the international competitiveness of livestock and livestock products.

The Australian red meat industry has, under SafeMeat (http://www.safemeat.com.au/) and AQIS (http://www.daffa.gov.au/aqis), led the application of HACCP food safety programs. In 1994 AQIS first introduced the concept of a Meat Safety Quality Assurance (MSQA) system, requiring the full incorporation of HACCP as the basis for process control at export registered establishments. The legislative framework for MSQA at export establishments was introduced on 1 September 1994. Since that time, all export abattoirs have developed and implemented HACCP-based quality assurance programs for hygienic production and transport of meat and meat products. Such quality systems, now known as Approved Arrangements, are required under the *Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption* (AS4696-2002 based on ISO 9002-1994) and the *Export Control (Meat and Meat Products) Orders 2005*, and underpin red meat production in Australia.

More recently the HACCP-based Livestock Production Assurance Scheme (Horchner *et al*., 2006) extends the approved arrangements on-farm. In conjunction with these programs, the National Animal Health Information System (NAHIS) operated by Animal Health Australia (http://www.animalhealthaustralia.com.au/status/nahis.cfm) provides timely and accurate summary information on Australia's animal health status to support trade in animal commodities and meet Australia's international reporting obligations. Surveillance data collected from abattoir programs reported by NAHIS include Ovine Johne's Disease Management Plan, National Residue Survey and the National Granuloma Program.

The terms disease monitoring and surveillance are defined by OIE (Anon., 2008):
Monitoring means the continuous investigation of a given population or subpopulation, and its environment, to detect changes in the prevalence of a disease or characteristics of a pathogenic agent.

Surveillance means the investigation of a given population or subpopulation to detect the presence of a pathogenic agent or disease; the frequency and type of surveillance will be determined by the epidemiology of the pathogenic agent or disease, and the desired outputs.
Baldock and Cameron (pers. comm.) have provided a more succinct definition:

- Monitoring is concerned with understanding changes in endemic disease levels and their distribution in populations of animals.
- Surveillance can be interpreted to mean the detection of new or exotic diseases.

Surveillance systems comprise collection, analysis and interpretation of disease data, coupled with dissemination of information to decision-makers responsible for implementing appropriate actions (Davies & Stärk, 2006).

3.1 Reasons for conducting monitoring and surveillance

The reasons for conducting monitoring and surveillance of health and production in livestock populations are diverse and are summarised in Table 1.

Table 1. Levels and objectives of surveillance systems (Davies & Stärk, 2006)

Level	Objective	Purpose
National (State)	Demonstrate freedom from disease	Maintain trade access
	Outbreak detection	Facilitate response capability for exotic and novel diseases
	Disease control and eradication	Optimise operational efficiency of regulatory programs
	Monitor notifiable diseases	Gather epidemiological intelligence to support regulatory policy
	Monitor zoonotic and food-borne pathogens	Protect public health, maintain trade access
	Monitor emerging diseases	Early detection of novel pathogens or changing pathogenicity of organisms
Industry/ Corporate	Assure freedom from disease	Breeding stock suppliers – boar stud, protect production pyramids
	Outbreak detection	Protect production pyramids
	Define herd/flock disease status	Inform animal flow decisions
	Monitor endemic production diseases	Epidemiological intelligence to support health management decisions
	Monitor zoonotic and food-borne pathogens	Public health and trade access; quality assurance and product differentiation
	Indexes of animal welfare	Address consumer concerns – quality assurance
Commercial production	Monitor endemic production diseases	Support health management decisions
	Outbreak detection	Early response to minimise disease impact

3.1.1 Official trade access

At the international trade access level, the Codex Code of Practice for Meat (2005) advocates that disease information from ante- and post-mortem inspection should be reported *to the primary producer so as to seek continuous improvement in the safety and suitability status of animals presented for slaughter*. This is best achieved through the application of HACCP principles on a whole of chain basis, such as required by EC Regulation No 852 (2004) that requires food producers *to take remedial action when informed of problems identified during official controls*. This approach is consistent with the principles used to develop the Livestock Production Assurance scheme in Australia (Horchner *et al*., 2006).

Specific requirements of AQIS for the E-Surveillance project include:

- Data management in an independently controlled database to meet OIE and importing country requirements.
- Inclusion of partial condemnation data in Export Production and Condemnations Statistics (EPACS) database.
- Inclusion of ante-mortem condemnation data and causes (in EPACS).

- Implementation of a multi-species approach to underpin overall surveillance outcomes for market access.

3.1.2 Industry efficiency

In addition to safeguarding meat safety, the implementation of a whole of chain HACCP approach also facilitates potential:

- improvement in production efficiency;
- decreased inspection requirement;
- enhanced product quality, processing efficiency, and
- enables price-signals to motivate actions on prevention of these conditions.

Projects related to these production and processing drivers undertaken in Australia include:

a. Paton *et al.*, (1996) found that CLA causes an annual loss of $17M annually to the Australian wool industry and that flock infection is readily detected at slaughter (Paton, 1994).

b. A survey of eight processors in Australia recovering offal co-products found losses of $9M overall annually (Paton & Dowling, 2001).

c. The SA Lamb Development Team conducted a survey of SA processors and retailers in 1998. They found that grass seeds were costing at least $2 per lamb per year. A pilot preventative project based on inspection feedback from the abattoir was trialled but not implemented nationally.

Consequently, both the production and processing industry can reduce substantial losses in meat and wool. One way of achieving this is to provide processors with a risk mitigation tool that provides feedback that alerts, but does not alarm.

3.1.3 Regulatory programs

From a national animal health and market access perspective the surveillance of bovine tuberculosis at slaughter inspection represents a key component of a risk management system that provides a high level of assurance of eradication of *Mycobacterium bovis* (Radunz, 2006). The Ovine Johne's Disease Management Plan (OJDMP) is a significant component of the National Johne's Disease Control Program (NJDCP). The program is coordinated by Animal Health Australia to ensure the response to Johne's disease by jurisdictions and industries, continues to protect Australia's favourable Johne's disease status and reduce the impact of disease and control measures on the affected industries (Animal Health Australia, 2008). An important strategy is to utilise abattoir monitoring of sheep to minimise the risk to properties and geographic regions which currently appear disease free, and actively manage incursions when they occur.

A recent driver not canvassed by the E-Surveillance Steering Group includes footrot surveillance in Western Australia where the aim is to maintain a low prevalence to provide benefits to all of industry; and industry pays for the surveillance. This represents an example of risk-based surveillance as advocated by Stärk *et al.* (2006). *This term conveys the economic axiom that limited surveillance resources need to be applied where risk is greatest and so that the greatest economic return will be realised*.

3.1.4 E-Surveillance Coordinating Group

In the Australian context the benefits identified by the E-Surveillance Coordinating Group include:

- Productivity improvements for producers through the management of production diseases and other conditions causing wastage and loss in the supply chain e.g. grass seed and emaciation.
- Efficiency for abattoirs including staffing levels, chain speed, product loss as well as recalls and rejections at port-of-entry.
- Demonstrated disease status to aid maintaining/accessing new markets for AQIS.

3.2 Attributes of abattoir surveillance/monitoring

In part, this review of abattoir monitoring/surveillance is an extension of a previous report: *Surveillance Techniques for Food-Borne Pathogens in Livestock and Livestock Products* (Jordan, 2002). While Jordan's review lists the criteria for inclusion in food-borne surveillance this report examines the wider application to conditions that impact on productivity. Inspecting carcases and offal for conditions (grossly detectable abnormalities e.g. disease, contamination) at slaughter can fulfil both monitoring and surveillance functions provided:

- conditions result from infection
- these persist sufficiently to enable a useful quantification of extent within the population at the normal slaughter age
- they are exposed as a result of standard carcase dressing procedures making detection feasible
- that lesions for specific zoonotic infections are relatively pathognomonic.

Jordan (2002) cited attributes outlined by the United States Centre for Disease Control by which surveillance activities can be judged. The adequacy of abattoir surveillance for each of these is:

Sensitivity: Not all events of interest may be detected, due to mild infection or resolution of conditions prior to slaughter.

Timeliness: With electronic reporting systems, abattoir monitoring can supply real-time information to decision makers.

Representativeness: Limited to conditions of the population leading up to slaughter, unless conditions persist for extended periods.

Predictive value: Determined by specificity of conditions and likelihood of persistence to time of slaughter. Examination of all animals in a consignment increases reliability of the data in determining presence or absence of a condition when present at a low prevalence.

Accuracy and completeness of descriptive information: Chain speed, low prevalence of many conditions and boredom (if inspectors are not rotated regularly) will increase the number of missing detections.

Simplicity: Relatively easy and rapid in comparison with most other methods.

Flexibility: New conditions easily added to the framework.

Acceptability: Depends on sensitivity and specificity when dealing with diseases of regulatory concern.

Passive or active: Considered active surveillance due to coordinated collection and analysis of data despite the uncontrolled submission of lots for slaughter. The process in planning what to include in abattoir monitoring/surveillance using these attributes should be a key consideration in committing resources.

3.3 Abattoir surveillance/monitoring schemes for ruminants

A literature search demonstrated a paucity of abattoir-based programs that target production-related conditions for ruminants. Apart from reports of the use of routine inspection of cattle as a successful part of the eradication programs for tuberculosis (Kaneene *et al*., 2006; Radunz, 2006) these is little information for other species.

This is in contrast to the pork industry where slaughter monitoring has been used in many countries for decades (Section 5). Possible differences include:

- more diseases affecting intensively reared pigs evident at slaughter
- the demand for more immediate interventions to minimise losses
- established relationships between prevalence and severity and reduced productivity
- a more regular supply of slaughter stock to assess impact of interventions
- fewer diseases and conditions causing loss in the supply-chain in large stock (e.g. grass-fed beef)
- the ability to exert greater management control over contributing risk factors. The approach may be equally relevant for lot-fed beef where production is continuous and abattoir feedback can assist fine-tuning animal health programs and feeding regimes.

Consequently, much of the material reviewed in this section is taken from agency reports of pilot schemes and newly introduced programs, including:

- A pilot study of a Sheep Health Monitoring Scheme (Bejnarowicz, 1990)
- Utilization of Meat Inspection Findings to Improve Livestock Production in Western Australia Research Project DAW.034 (Paton, 1994)
- Monitoring ovine disease on the slaughter line in Scotland (Adams *et al*., 2005)
- Enhanced abattoir surveillance scheme for Ovine Johne's Disease and Other Conditions (Ian Links pers. comm.)
- New Zealand integrated organoleptic inspection with production-condition monitoring and reporting.

Only one of these pilot projects (Paton, 1994) evaluated the approach in beef in conjunction with sheep.

3.4 Existing systems in Australia and what they show

In the context of food safety and wholesomeness, surveillance of a broad range of conditions of carcases at the abattoir is conducted by AQIS (Meat & Livestock Australia, 2003). Conditions detected at post-mortem inspection listed by the OIE (www.oie.int) and the Australian Meat Standard (Anon., 1997, 2007) include Category B diseases BSE, acute brucellosis, anthrax, and hydatids, and Group C diseases acute salmonellosis, melioidosis and listeriosis (Table 2).

Table 2. Conditions detected at abattoir inspection listed by the OIE (www.oie.int) and the Australian Meat Standard (Meat & Livestock Australia, 2003)

Condition	**OIE List Category (A, B or C)**
BSE	B
Acute Salmonellosis (non-typhoidal)	C
Acute leptospirosis (*Leptospira* spp.)	
Acute brucellosis (*Bacillus abortus*)	B
Melioidosis (*Burkholderia pseudomallei*)	C
Glanders (*Actinobacillus mallei*)	
Anthrax (*Bacillus anthracis*)	B
Q fever (*Coxiella burnetii*)	
Black Leg (*Cl. chauvoei*)	
Braxy (*Cl. septicum*)	
Lamb dysentery (*Cl. Perfringens*)	
Acute erysipelas	
Toxoplasmosis	
Listeriosis (see micro hazards)	C
Cysticercus ovis (Sheep Measles)	
Cysticercus bovis (Beef Measles)	
Hydatids (*Echinococcus granulosus*)	B
Sarcocystis (*Sarcocystis* spp.)	
Lungworm	
Liver fluke (*Onchocericasis*)	
Generalised infections - tetanus, botulism, rabies, bovine leucosis, caseous lymphadenitis, tuberculosis (TB), actinobacillosis, actinomycosis, pyometra, lymphadenitis, fever, septicaemia, gangrene	
CLA (*Corynebacterium paratuberculosis*)	
Chronic suppurative conditions - pleurisy, peritonitis, (*Pasteurella multocida*) Pericarditis, hepatitis, nephritis, cystitis, retained placenta, abscess, pyaemia	
Generalised intoxication – toxic plants	
Generalised intoxication – heavy metals	
Generalised intoxication – mycotoxins	
Malignant and benign tumours	
Generalised conditions that render parts inedible – icterus, ascites, oedema, uraemia, toxaemia	
Multiple or serious injuries	
Pigmentation (abnormal)	
Dressing defects – machinery damage	
Insufficient bleeding – clots, ecchymoses	
Gross contamination – dirt, grease, ingesta/faeces	
Localised pathological lesions – skin lesions, arthritis, mastitis, fly strike etc	
Cysts and malformations	
Physical hazards – gun shot and related wounds,	
Physical hazards – injection sites and broken needles	
Physical hazards – bone fragments, bruising	
Physical hazards – other physical hazards – blades, packaging	

Condition	OIE List Category (A, B or C)
CNS tissue emboli	
Wool, grass seeds	
Insects and vermin	
Emaciation	

With regard to conditions detected at inspection that result from non-zoonotic infections, several studies suggest that disease itself is a stressor and may lead to additional contamination with hazards. Physiological responses to stress induce shedding in *Salmonella* carriers (Williams & Newell, 1967; 1970; Edwards *et al.*, 1997) and increase susceptibility to infection (Gronstol *et al*., 1974; reviewed by Jackowiak, 2000). It is believed that because suspects detected at ante-mortem inspection are sick, they are more likely to be shedding *Salmonella* and other significant food-borne organisms (Wray & Sojka, 1977). Radan (1964) isolated *Salmonella* from 9.2% of emergency-slaughtered cows and found that muscle tissue (meat) contained *Salmonella* only if other viscera were also infected. Mousing *et al.* (1997) found that 16% of pigs with pneumonia also harboured bacteria in a joint or in the liver, compared to 2% in pigs without pneumonia. In contrast, Robinson (1965) found *Salmonella* in 6% of suspect calves, which was comparable to 5.5% found in normal calves.

An examination of ‘suspect’ animals (diseased pigs) submitted for slaughter found the isolation rate of *Salmonella* species from the caecal contents was not significantly different between pigs classified as suspect or normal at ante-mortem inspection. However, this study did not investigate whether there is any association between suspect pigs and gut spillage due to processing difficulties or an increased prevalence of *Salmonella* in edible tissues of suspect pigs (Jackowiak *et al*., 2000).

Proposed opportunities for improvement of effectiveness and efficiency of traditional organoleptic inspection (i.e. visual, palpation, incision procedures to detect pathological conditions) in recent years are based on the concept that routine organoleptic inspection is likely to be counter-productive to achieving food safety objectives. The risk-based approach to meat inspection provides a scientific basis for the allocation of limited resources to maximise meat hygiene (Hathaway *et al.,* 1988; Hathaway & McKenzie, 1997; Mousing *et al*., 1997; Anon 1998).

These authors reported that some mandatory procedures (e.g. incision of the heart) have been shown to cause cross-contamination in field studies, as does examination of subsequent body sites following head inspection, when conducted by the same inspector (Preben Willeberg, pers. comm.). These observations led to a risk-based assessment of traditional post-mortem inspection where Pointon *et al.* (2000) demonstrated that the level of exposure of consumers to microbiological hazards in fresh pork is unlikely to be reduced significantly by the detection and removal of conditions. When traditional (incision) and risk-based (visual) post-mortem inspection procedures were compared it was demonstrated both were likely to result in a similar level of consumer protection (Hamilton *et al*., 2002).

Accordingly, efficiency changes were made to the *Australian Meat Standard and Export (Meat) Orders* to allow the use of the risk-based procedures i.e. visual inspection without routine lymph node incision. As a consequence, one industry response was not to reduce inspection staff due to elimination of the requirement to routinely incise lymph nodes of the head, but to increase line speed with the same number of inspectors or increased numbers.

Parallel assessments of organoleptic inspection have not been conducted for beef, sheep or goats to determine if similar efficiencies can be identified, in this case, enabling alternative 'inspector' monitoring and surveillance functions to be considered.

3.4.1 Current abattoir post-mortem and production condition data

Currently the Export Production and Condemnation Statistics (EPACS) database is able to maintain partial surveillance data relating to animals condemned at the abattoir. While condemnation data is available (Table 3; reviewed by Meat & Livestock Australia, 2003) background epidemiological information is unavailable, preventing interpretation in all but very general terms at the broad slaughter age/class of livestock level. Furthermore, data on partial condemnations is not continually recorded. For sheep this omits a major cause of partial condemnation (*C. ovis* – sheep measles) and is one of increasing market access concern (Carol Sheridan, AQIS, pers. comm.).

The main reasons for total carcase condemnation in Australia (Meat & Livestock Australia, 2003) are:
Calves **–** fever (28 condemned/10,000 carcases) and jaundice (11/10,000)
Steer/heifers – malignancy/cancer eye (0.56/10,000), septicaemia (0.45/10,000) and septic pneumonia (0.42/10,000)
Cow/bull – malignancy (including cancer eye) (18/10,000), fever (3.29/10,000), emaciation (2.37/10,000) and septicaemia (2.29/10,000)
Lambs **–** polyarthritis (2/10,000), sheep measles (1/10,000) and fever (1/10,000)
Sheep – emaciation (28/10,000), CLA (10/10,000) and fever (7/10,000)
Goats (skin off) – fever (35/10,000), emaciation (23/10,000) and gross contamination (10/10,000)
Goats (skin on) – gross contamination (31/10,000), fever (25/10,000) and emaciation (10/10/000).
More recent EPACS data for 2007 provided by AQIS in most part reflects the major causes of condemnation cited above (P. Smith, AQIS, pers. comm.). Additional common causes of condemnations are:
Steer/heifers **–** polyarthritis
Lambs **–** jaundice
Sheep – malignancy and sheep measles
Goats **–** CLA.

The degree to which these grossly detectable abnormalities (referred to as conditions) are associated with food-borne hazards have not been determined (Pointon *et al*., 2000).

The main reasons for partial condemnations reported by Paton (1994) from WA are:

Calves (up to one year) **–** pleurisy/pneumonia (3.3%), liver abscess (1.3%) and nephritis (0.9%)
Steers – liver abscess (1.3%), rumen (anthelmintic) injection abscess (0.4%) and traumatic reticulitis (0.4%)
Cows – pregnancy (3.2%), liver abscess (2.0%) and pneumonia/pleurisy (1.3%)
Lambs **–** pleurisy/pneumonia (5.6%), *C. tenuicollis* (3.9%) and arthritis (1.4%)
Sheep – CLA (22% of all stock monitored), by *C. tenuicollis* (bladder worm) (6.8%) and pleurisy/pneumonia (4.7%)

Differences in alignment between these data sets are attributable to emaciation and fever not being reported by Paton (1994), condemnations representing severe cases only (may be the 'tip of iceberg') and different conditions/criteria being recorded for a different purpose (safety, wholesomeness, production efficiency). These disparities in data collected exemplify the differences in purpose between inspection systems. However, of particular interest in the AQIS data is the inclusion of conditions that cause wastage across the supply chain identified by the E-Surveillance coordinating group (e.g. emaciation).

The domestic abattoir sector is not represented in these data. However, as a considerable proportion of product for the domestic market is produced at export abattoirs, it is likely that these causes of total condemnation would feature predominantly also.

In terms of monitoring for conditions at slaughter, the greatest focus is on the detection of granulomas in cattle as part of ongoing surveillance for tuberculosis under the Tuberculosis Freedom Assurance Program. During 2001/2, TB was detected on two separate occasions in lymph nodes submitted under the national surveillance program. One was in the bronchial lymph node of an aged buffalo cow from the Northern Territory and the other was from an aged cow from southern Queensland.

Infection with *Corynebacterium pseudotuberculosis,* which causes Caseous Lymphadenitis (CLA) in sheep, has been extensive in Australia. CLA results in product loss and increased inspection costs. In the 1980s the prevalence of CLA in West Australian adult ewes was estimated to be 54% with few flocks being free of this disease (reviewed by Paton *et al*., 1996). Recent data on the prevalence of CLA abscesses detected at slaughter in 223 sheep flocks in NSW, Victoria and WA found an average of 26% of sheep affected (Paton *et al*., 2003). CLA spreads mainly from sheep with discharging abscesses to sheep with cuts immediately post-shearing. An effective vaccine is now available for use (Paton *et al*., 1995).

Data on dressing faults and injection sites/broken needles is unavailable. While a pilot project has been undertaken to control grass seed damage, it has not been implemented as a national program, despite trade access issues arising due to affected shipments.

Further data may become available from a knackery study in Victoria that aims to define causes of wastage of cattle and assure the EU that fallen animals are being monitored. Another pilot project that may potentially interface with the E-Surveillance project is the Victorian DPI/Dairy Australia Calf Residues Project.

Table 3. Summary of carcase condemnations for cattle, sheep and goats from Australian export abattoirs (1/7/00 – 30/9/02)

	Total condemnations/10,000 carcases						
	Cattle			**Sheep**		**Goats**	
	Calves	**Steer/Heifer**	**Cow/Bull**	**Lamb**	**Sheep**	**Skin off**	**Skin on**
Abscess		0.07	0.32				
Actino Lumpy jaw		0.01	0.07				
Anaemia			0.10		0.17		
Arthritis			0.11				
At antemortem	0.26	0.35	1.41	0.42	2.49	1.95	1.28
Bruising	1.94	0.07	1.19	0.04	1.04	0.17	1.14
Cancer eye		0.22	10.56				
Chemical residue		0.02	0.02				
CLA				0.20	9.59	7.77	3.29
Company condemn	7.45			1.09	5.24	38.43	3.21
Cys. bovis Beef measles			0.01				
Cys. ovis Sheep measles				1.35	1.81	0.17	0.14
Ecchymosis	0.05		0.01	0.01	0.15	0.27	0.07
Emaciation	1.56	0.03	2.37	0.51	27.82	22.76	9.95
Eosinophils myositis		0.06	0.32				
Fever	28.19	0.27	3.29	1.27	7.17	35.02	25.47
Gangrene	0.09	0.13	1.29	0.02	0.14	0.56	0.25
Gross contamination	2.76		0.05	0.54	6.52	10.48	30.55
Hydatids			0.01*		0.01		
Immaturity	1.58						
Jaundice	11.01	0.08	0.34	1.98	3.89	2.38	1.31
Malignancy	0.27	0.34	7.31	0.16	7.39	1.01	0.72
Metritis		0.02	0.43			0.14	0.15
Muscle conditions					0.02		
Navel ill	0.18						
Neurofibroma			0.35				
Other causes	6.79	0.25	1.33	0.43	2.84	3.80	3.65
Peritonitis		0.02	0.18		0.06		
Polyarthritis	1.58	0.07	0.10	2.08	2.19	0.89	0.91
Pyaemia		0.01	0.95		0.08	0.09	
Sarcosporidia				0.03	2.33		
Septicaemia	0.55	0.45	2.29	0.31	2.65	2.40	3.74
Septic pneumonia		0.42	0.23	0.07	1.34	0.27	0.27
Tuberculosis			0.01				
Uraemia		0.06	0.38				
Wounds			0.01		0.03	0.10	
Xanthosis			0.12				
Total Condemnations	64.41 (0.64%)	2.75 (0.03%)	35.20 (0.35%)	10.48 (0.10%)	84.96 (0.85%)	128.65 (1.29%)	86.12 (0.86%)

3.4.2 Processor reports to producers

In summary, while processors report substantial carcase information for sheep and beef, reporting of animal health data is generally limited to condemnations and usually only upon request from producers. Some abattoirs provide animal health feedback when processing problems arise.

There is no systematic reporting of commercially useful animal health information. This is despite abattoirs having HACCP programs where specification of incoming product might be expected to minimise carcase non-compliance arising from endemic sub-clinical disease.

3.4.2.1 Sheep abattoirs

The following text (in italic) has been sourced from MLA Project V.MSL.0001 for sheep.
Data collection, management and feedback varied considerably between the plants visited. A summary of current data collected and feedback for each processing plant is provided below. Apart form the Enhanced Surveillance Program in SA, feedback of animal health data is limited to condemnations (Meat & Livestock Australia, 2008).

Plant	***Current data collected***	***Current feedback to producers***
1	*Weights and fat Yield % over whole carcase Condemnations (AQIS) Extensive skin data (by skin department) Age*	*Weight and Yield grid Fat Animals per 2 kg wt range Price category and weight grid Individual wt data if requested Number and % of animals per 1% yield range Health problems affecting >5% Number of condemns and deaths Key lamb performance indicators Skins - % per wool length range, % per specified fault Stock class (Lamb, hogget, mutton)*
2	*Weights & Fat Disease information through PIRSA AHS program Condemnations (AQIS) Seeds On back skin assessment Offal condemnation Age Wool roll test where >2 inches*	*Animals per 1 kg weight range by fat score Health report generated through PIRSA program Photo if seeds severe Stock class (lamb v mutton)*
3	*Weights & Fat Seeds (type, number, location) Condemnations (AQIS) On back skin description*	*Animals per 2 kg wt range Weight and fat grid Separate seed report Number of condemnations and deaths Number dirty*
4	*Weights & Fat Condemns Trim Age*	*Weight and fat grid Animals per 2 kg wt range > 12 kg and <28 kg Number condemned Reason for trim where affecting 20 + Stock class (lamb, hogget, mutton)*

Plant	***Current data collected***	***Current feedback to producers***
5	*Weight & Fat* *Offal problems (AQIS)* *Every animal aged*	*Individual weights (by animal ID if available)* *Weight, fat score, price grid* *Individual fat depth* *Number condemned and reason* *Number of teeth*
6	*Weight & Fat* *Bruising* *Contamination* *Trimming information* *Age* *Sex*	*Individual weights* *Individual fat scores* *Bruising* *Number of teeth* *Sex*
7	*Weight & Fat* *Number condemned (full and partial)* *Seed* *Skin wool length*	*Individual weight* *Individual Fat score and depth* *Full condemns - separate sheet* *Partial condemns reference to body part condemned* *Number of teeth* *NLIS if available* *MSA if make grade*
8	*Weight & fat* *Condemns (AQIS)* *Dog bite* *Grass seeds (photo sent to buyer)* *Skins*	*Individual weights* *Fat score 1-5 and fat depth* *Condemns* *Stock type*

Trim and health status *– Trim and health information varies significantly between plants and feedback to producers is minimal (generally numbers but not reasons). Often reasons will only be feedback to producers if a significant number of animals are affected. AQIS inspectors identify carcases (generally through a tagging system) for trimming and condemnations however carcases are only generally recorded as damaged and the reason for damage is not specified. The tags used by AQIS would have to follow the carcase to the scales (currently removed after trimming) to be recorded and even then the reason would only be categorised, not specific.*

Information collected by AQIS should be fed into the processor system, and then included in producer feedback. *In doing this there would be a standard format for animal health information. It is recommended that this occurs in conjunction with AQIS to develop something that works for all parties and include the required interfaces at plant and AQIS work stations. The opportunity to gather additional data if required should also be explored with AQIS.*
A number of processors are concerned that recording more health information will slow the chain speed or require additional labour, as it is anticipated that an additional recording station would be required:

It is considered important to minimise unnecessary trim. The issue of standard trim was highlighted following concerns regarding the variation in the amount of carcase removed with the secondary neck cut, when only a small amount needs to be removed. The need to develop a gauge or something similar, on the tool used to do the secondary neck cut was identified.
Ability to achieve critical feedback requirements for trim

- *Number of animals trimmed, part of carcase and reason – The key issue that will need to be overcome is slowing of the chain and increasing labour requirements in order to provide this* *additional information to the vendor. The most likely approach is through the AQIS inspectors*

- *Number of condemnations and reasons – as for point above*
- *Is damage at the fat score site – this information is not currently recorded and the likelihood of recording it in the future is low.*

Offal – *There are only two sites which provide details regarding offal. AQIS record if there is a problem with offal but it is not linked to individual lots.*

Ability to achieve critical feedback requirements for offal

- *Health status – Carcase trim and health are considered higher importance to offal feedback. AQIS are probably in the best position to be able to collect this information. It is recommended to explore the option of providing this feedback with AQIS.*

3.4.2.2 Beef abattoirs

Six beef abattoirs were contacted, some elected not to provide access to what was considered company IP. Three abattoirs had touch screens installed, one was operated by company employees, one by AQIS inspectors and the other had fallen into disuse.
Reporting of production information (e.g. hot carcase weight and P8 fat measurement) is combined with payment details, but the only health data provided are AQIS condemn certificates and only if requested by the vendor.

The best example of E-surveillance seen in a beef abattoir was a large processor killing stock from its own feedlots. The company had paid SASTEK to develop a touch screen system, with interlinked screens installed at various locations throughout the plant as follows:

- Sticking area – the NLIS data is scanned in and the carcases weighed immediately after sticking. Carcase numbers and live weights are entered into the system automatically. Data about hide quality and (sometimes) dentition is entered manually.
- Animal health station (located at viscera table, adjacent to AQIS inspection area) – the AQIS inspector marks affected offal and a works employee manually enters the findings on the touch screen. There is a button for each organ which, when pressed, opens a submenu listing common conditions occurring in that organ. Thus, any defect can be recorded against the carcase number.
- Head station – (located on the head chain) – dentition and any rejection data for tongue/cheek meat is entered here manually.
- Grading Station (located at the scales) – a fat probe is inserted at the P8 site and each side is weighed. Fat depth, fat class and hot standard carcase weights are entered into the system automatically. Market codes, AUS-MEAT bruising and other carcase defects are entered manually. The computer then generates a tag to be attached to each side.
- Carton scales – three screens where weights are entered into the system automatically and product ID entered manually. The computer generates a sticker to be attached to each carton. The first screen is alongside the offal carton conveyor, the second alongside the chilled primals conveyor and the third alongside the frozen trim conveyor. The frozen trim is scanned in an MQ (Lean Content Analysis system) machine, to measure the lean yield of the trim and this data is entered into the system automatically.

- Boning room input station – carcase tag barcodes are scanned and the tags removed. Data on the screen is compared to the product and if unsuitable, sides can be diverted off the rail, or manually downgraded on the touch screen.
- Coding station – displays progress on boning production – no data input.
- Rework stations (2) – used only by boning supervisors to record any losses/downgrades of primals for any reason (eg. pathology, dropped meat).

There are three other computer stations (boneless re-inspection, kill floor and load out) not linked to the touch screen system. QA personnel enter their own data into I-Leader at these stations. Feedback to the vendors (farmers selling yearlings to a feedlot) consists of data for each animal killed as follows:

- NLIS ID, Induction weight (weight of yearling when it entered the feedlot), induction dentition, induction lot number, number of days in the feedlot, live weight at slaughter, average daily gain (in the feedlot), dentition at slaughter, hot carcase weight and yield, fat depth, muscle score and colour, fat colour and marble and eye muscle area (cm^2). All the individual data is tallied together into a data summary of induction details, slaughter details and statistics for dentition, fat colour and depth, marble score, meat colour and eye muscle area. Company wide statistics for a three-month period are also provided as a point for comparison.
- No health data is included, although it was in the system. When this was discussed with a company official, he said the company collected the health data for its own purposes, to keep track of how much offal was being condemned and for what reason. The value of the data to the original vendor was questionable after the animals had been in a feedlot for up to 120 days prior to slaughter. If the company was interested in providing such data, it would first seek to improve the data integrity by checking the reliability of the carcase correlation, introduce severity scoring of defects and training of staff.

3.4.3 Information Leader

Information Leader is the most widely used quality assurance software in the Australian red meat industry. It is installed in nearly 100 sites throughout Australia and New Zealand and boasts a market penetration of nearly 85% of Australian export abattoirs.

Information Leader replicates any paper-based system into an electronic format. With all quality forms being completed in real time direct onto a desktop PC or via a tablet PC, connected to a wireless network, data is accessible instantly to anyone with a password. The system has been developed to support compliance systems required by many countries. The information collected can be used to make informed decisions, reduce duplication and increase the responsiveness of the QA system. The flexibility of Information Leader can be used to collect and report on almost any information. Because of its web-centric design Information Leader can instantly alert problems to chosen members within a system by sending emails or text messages. Changes to documents, procedures, forms and specifications can also be automatically communicated to all staff.

The need for accountability, traceability and documented evidence underpins any quality management system. Information Leader uniquely references all data and records changes and deletions. It provides a complete audit trail where the date, time and operator name can be determined for all entries.

Information Leader also has the ability to schedule tasks and jobs. For example, a weekly site hygiene audit request could be sent to a particular QA on Monday to be completed by the end of the day or a reminder could be sent to an operator to check the chlorine levels ten minutes past every hour or for product samples to be taken every other day for micro testing. Should these actions not be signed off within a specific time frame the system will automatically inform another chosen individual. Non-conformances from first, second and third party audits can be delegated to specific individuals and their progress monitored step by step.

The system provides a replacement for hardcopy auditing data and sits on company computing hardware. However, it allows AQIS officers limited access to certain files behind the company firewall and monitoring in real-time. This shared (company and AQIS) system is not used for disease data recording (i.e. EPACS).

3.4.4 AUS-MEAT

AUS-MEAT Limited ensures that mandatory feedback is supplied to the vendor or an authorised person on behalf of the vendor by AUS-MEAT accredited abattoirs. Feedback information is generally in the form of feedback sheets, but can also be a data file (including NLIS data) and is provided to the vendor or an authorised person/company on behalf of the vendor.

All export abattoirs are AUS-MEAT accredited. Domestic abattoirs are accredited if required by their customers e.g. Coles, Woolworths and the Australian Air Force.

The Over The Hooks Guide (http://www.ausmeat.com.au/Sales/pdf/OTH-A4.pdf) states that all AUS-MEAT accredited abattoirs provide the following feedback information on carcase performance based on objective measurements:

- For all cattle other than cows and bulls, individual carcase data recording hot carcase weight, P8 fat measurement (mm), dentition and bruise score.
- For cows and bulls, individual carcase data recording hot carcase weight, bruise score and where P8 fat measurement is used to determine price, P8 fat measurement (mm). Where dentition is used to determine the alternative category Young Bull *BYG*, dentition.
- For lambs and goats (skin-off) either individual carcase details or group data (where a ‘group’ is defined as the total number of lambs or goats in a fat class) recording number of lambs or goats average hot carcase weight, fat class.
- For other sheep, group data recording number of sheep, average hot carcase weight.
- For pigs, individual carcase data recording hot carcase weight, P2 fat measurement (mm), and sex.
- For goats (skin on) number of goats, average hot carcase weight.

3.5 Sheep health monitoring programs

3.5.1 Overview of schemes, pilot studies and surveys

Apart from abattoir programs for pigs, most effort has been focused on the sheep industry. However, most of these are unpublished in the peer review literature and have been pilot projects to establish the feasibility of the programs and evaluate the potential for producers to gain a worthwhile benefit:cost.

In this context, Paton (1994) was the only study that evaluated the responses of producers in terms of reducing the prevalence of significant infections and their attitude to receiving this type of data routinely (Section 4). In both counts the results were positive and encourage further consideration of such a program.

The Australian Enhanced Surveillance scheme and Scottish projects are modelled on similar pig health monitoring initiatives at the same locations. In Scotland the sheep project used modified data handling and reporting software used for the pig scheme. The Scottish sheep project found that whilst it was technically feasible to operate as an industry scheme, it was not cost effective, because:

- Individual lambs were worth about 50% less than pigs
- The range of conditions that could be monitored was more limited (e.g. no skin or head information).
- The information provided was of less use to farmers as the predominant system was based upon seasonal batches - what could a farmer do if he found out that his lambs had liver fluke after he had already dispatched half of them? The remainder were probably too old for any treatment to be cost effective.
- The identification system relied on ear tags and they were not much use after the head had been cut off. Most plants did not have a market requirement to have individual animal traceability after slaughter so they did not have the systems in place. This made it difficult for the vet to quickly identify which farm had sent in the batch.
- Veterinary inspector time was expensive.

3.5.2 Gross abnormalities (conditions)

A summary of conditions for lambs and sheep are provided in Table 4. Many of these potentially production-limiting diseases are sub-clinical in nature, narrowing their detection to post-mortem inspection at routine slaughter.

These indicate the occurrence of regional differences related to agent:environment interactions and biosecurity history. A further regional difference is highlighted by slaughter surveillance for footrot in WA. There is a general lack of alignment between the prevalence of conditions monitored in the WA project and that recorded by AQIS for condemnations (Table 3). This arises from a combination of recording different conditions and condemnation data reflecting only the severe cases.

The evaluation of the sensitivity and specificity of diagnosis of regulatory and important production-related infections is limited to ovine fascioliasis and Ovine Johne's Disease. In the case of fascioliasis of lambs and sheep in New Zealand, Hathaway *et al.* (1988) report the sensitivity of observation and palpation as 90% and specificity of 99.5%. With incision of the gastric surface, as required in the EU, the sensitivity was only marginally improved. As a result, non-detection rates are low and proportionally few livers are falsely down-graded. As little improvement of the overall performance of inspection is achieved by incision and incision and handling may introduce food-borne hazards, this risk assessment exemplifies the collection of adequate diagnostic information without compromising the safety of the product for consumption.
The surveillance for OJD in Australia appears to be a recent innovation and represents the flexibility of the approach and its additional use for regulatory purposes. This use has been critically underpinned by an evaluation of the sensitivity (53-87%) and specificity (97-100%) supporting the use of abattoir surveillance as a very economical and rapid ancillary method for assessing the OJD status of sheep (Bradley & Cannon, 2005) as part of industry assurance programs. No other evaluations of the sensitivity and specificity of conditions were found.

3.5.3 Integrated routine organoleptic and production-condition monitoring

Work by Bejnarowicz (1990) combining routine organoleptic inspection criteria with production-limiting diseases, as well as severity criteria, constitutes the most developed integration of routine monitoring/surveillance with organoleptic inspection services under the Controlling Authority. Whether this severity information for ruminants is relevant is highly questionable. What the project lacked was the transferable electronic carcase identification system capable of capturing both production and disease data information for multiple users as advocated by Hurnik (1991).

This severity classification of Bejnarowicz (1990) combines data for producers and with condemnation data, captures information required for meat inspection and payment purposes. It is noted by Adams *et al.* (2005) that in Scotland greater attention is needed to standardise the implementation of condemnation criteria within meat inspection staff. There has been no evaluation of the severity scores proposed by Bejnarowicz (1990) and the usefulness of these to producers and their advisors to guide cost-effective interventions. This scheme did not include any conditions of regulatory significance.

In New Zealand, the world's largest sheep meat exporter, a broad range of conditions of regulatory and production significance (Table 4) are recorded at routine inspection using a touch screen system. In large part, the system trialled by Bejnarowicz (1990) in SA reflects the system in New Zealand performed by routine inspectors, but with severity classifications.

The system in routine use in New Zealand is identified by this review as the international 'gold-standard' system. In summary its key features include:

- integrated organoleptic:production:regulatory condition recording
- inspectors recording information as part of routine duties
- laboratory support for validation of diagnosis
- touch-screen recording of conditions linked to carcase ID
- data on trim recorded for lines
- all condition and trim data integrated with carcase data
- producer reports containing carcase and payment details and condition prevalence
- controlled data access to producers, processors and regulatory/animal health bodies.

Table 4. Summary of conditions monitored in sheep at slaughter

Condition	AHA[1]	SA Dept Agric[2]	WA Dept Agric[3]	Scotland[4]	New Zealand[5]	Nigeria[6]
Knotty gut (Nodule worm)	✓				✓	
Liver fluke (*Fascialiasis*)	✓*	✓*		✓	✓	
Hydatids (*Echinococcus granulosa*)	✓	✓			✓	✓
Sheep measles (*Cysticercus ovis*)	✓	✓*	✓		✓	
CLA (*Coryne. paratuberculosis*)	✓	✓*	✓	✓	✓	
Pleurisy	✓	✓	✓	✓	✓	
Pneumonia	✓		✓	✓	✓	✓
Lungworm	✓	✓			✓	
Sarcocystis (*Sarcocystis* spp.)	✓	✓*			✓	
Bladder worm (*Cysticercus tenuicollis*)	✓	✓	✓		✓	
Cancer	(✓)	✓			✓	
Anaemia	(✓)					
Emaciation	(✓)	✓*			✓	
Jaundice	(✓)	✓*			✓	
Arthritis/Polyarthritis	(✓)	✓*	✓		✓	
Septicaemia/Toxaemia	(✓)	✓*			✓	
Grass seeds	(✓)	✓*	✓		✓	
Vaccination abscess, OJD and other	(✓)	✓	✓		✓	
Abscessation				✓	✓	✓
Pericarditis				✓		
OPA (Jaagsiekte)				✓		
TB						✓
Nephritis			✓			✓
Dermatitis						✓
OJD	✓					
Small fibrotic liver (Lupinosis)			✓			
Melanosis of liver	(✓)				✓	
Worms general e.g. tapeworms	(✓)				✓	✓
Bruising	(✓)	✓				
Dog bites	(✓)				✓	
Contamination					✓	
Facial eczema					✓	
White muscle disease					✓	

* Severity scores

( ) Conditions reported by other inspectors (may be underestimated)

[1] Animal Health Australia (2008) (Ian Links pers. comm.)

[2] Bejnarowicz, L. (1990) A pilot study of a sheep health monitoring scheme. DPIE/SA Dept of Agriculture.

[3] Paton, M. (1994) Utilization of Meat Inspection Findings to Improve Livestock Production. Research Project DAW.034. Report to the Meat Research Corporation.

[4] Adams, C., Varo, A., Stevenson, H., Hall, M., Brough, H., Strachan, D. & Gunn, G. (2005) Monitoring of ovine disease on the slaughter line. Report for Quality Meat Scotland.

[5] New Zealand Food Safety Authority

[6] Kudi, A.C., Kalla, D.J.U., Alkali, Y., Ladan, S.M., Kudi, M.C. & Mai, H. (1997) Abattoir survey of small ruminant diseases in Bauchi, Nigeria. Revue Elev Med vet Pays trop, 50, 281-284.

3.5.4 Methodologies

In the South Australian programs managed by Bejnarowicz (1990) and Whyte in 2006 and in Scotland (Adams *et al.,* 2005), inspection staff, additional to those conducting routine inspection, were employed. In the latter SA scheme, the sheep industry provides financial support for the enhanced surveillance program.
Elsewhere across Australia, AQIS inspection personnel conduct both the OJD surveillance and the enhanced surveillance for production-related conditions.

Severity scoring was only implemented by the pilot scheme evaluated by Bejnarowicz (1990) but there was no systematic evaluation of the usefulness to producers and the Controlling Authority.
Various methodologies for data recording on the slaughter floor have been implemented. In Scotland a PDA was used. This required training of inspection staff and location of common conditions for ease of entry on the keypad. In WA a customised keypad was developed for data entry.

3.5.5 Assessment of impacts

The only project that evaluated time-series data and the impact of the scheme was conducted by Paton (1994; Section 4). There is a paucity of reports establishing the relationship between abattoir data and production effects. Paton *et al.* (1996) demonstrated the worth of knowing CLA infection, through detection at the abattoir, with flock performance (wool production).

3.5.6 Reporting formats

Customised data handling software was developed during the WA project (Paton, 1994). In Scotland, software developed to provide producer reports for the pig industry was modified for reporting sheep data to producers (Adam *et al.,* 2005). In the present Australian pilot enhanced surveillance program, data is reported centrally on a lot basis for the abattoir to use however they wish. Aggregated data is supplied to each state, other than SA where industry has provided additional funds to support provision of reports to individual producers.

The Scottish system of percentages and graphs provides easy access to data. The supplementary data comparing individual consignments/farms with the area average provides a useful benchmarking perspective as done for the pork industry in Australia (Section 5.3).

Use of aggregated flock data for epidemiological purposes (area status, disease trends, risk factor associations etc.) as implemented in the Pig Health Monitoring Scheme represents a powerful secondary use of the data. Such information can be used for market access purposes and inform the need for and design of endemic disease control and prevention programs. This is particularly helpful for sub-clinical conditions e.g. sheep measles.

3.5.7 Support programs

A considerable amount of customised extension information for producers has been generated in conjunction with the SA and WA programs. The Livestock Production Assurance Scheme (LPA – Level 1) (http://www.safemeat.com.au/English/Meat_Safety/On_farm_feedlot_saleyard/Livestock+Production+Assurance+%28LPA%29/LPA+Level+1/LPA+Level+1.htm) is being developed to verify the declarations made in the National Vendor Declaration (NVD). This system will be independently audited and is underpinned by HACCP principles (Horchner *et al.,* 2006). The LPA-NVD require records of animal health treatments to be recorded to meet market access specifications. In this way data feedback of condition presence and prevalence (critical limits) from (abattoir) E-Surveillance programs provides a further opportunity to refine endemic disease control and prevention. Subsequent post-mortem inspections of carcases and offals serve to verify the efficacy of interventions. In this way abattoir surveillance data, when utilised by producers to minimise the occurrence of non-complying carcases, provides a direct link between abattoir HACCP compliance (Australian Standard; Export Meat Orders) and on-farm food safety QA (LPA; NVD).

3.5.8 Constraints

There are several potential causes of reduced sensitivity of detection of conditions. These include:

- where the inspection system runs in conjunction routine organoleptic inspection the transfer of findings is incomplete (Adams *et al*., 2005).
- inconsistency between classification of conditions when carcase condemnation is the final disposition (Adams *et al*., 2005).
- when condition prevalence is low, sensitivity suffers (Adams *et al*., 2005; Berends, 1993).
- boredom - if the key data recording position is not changed regularly. There is a need for regular 30 minute rotations to offset this constraint (Adams *et al*., 2005).

Boxing lines of sheep (Adams *et al.,* 2005) make trace-back more difficult for notifiable conditions and reporting of production-limiting diseases where there is no linked identification system from individual animal to carcase.

Layout of the slaughter line (Adams *et al.,* 2005) may not allow room for addition inspectors if used.

Constraints observed by Bejnarowicz (1990) included:

- Lack of validated diagnostic specificity
- Cost of lab confirmation neither practical or cost-effective
- Undefined biases in the population monitored at abattoir
- Long-term benefits need to be defined.

3.6 Beef health monitoring programs

A review of the literature failed to find any systematic program of slaughter monitoring for beef other than that evaluated for calves, steers and cows in WA by Paton (1994; Section 4) and as part of bovine TB eradication programs (Kaneene *et al*., 2006; Radunz, 2006).

Conditions resulting in carcase condemnation of beef vary from those of small stock (Table 5). From this limited perspective it is difficult to comment on whether the prevalence of conditions observed at slaughter for large stock is less than small stock and consequently of less potential benefit to producers and processors.

Conditions (gross abnormalities) monitored in calves, steers and cows at slaughter in WA and New Zealand are presented in Table 5.

Table 5. Summary of conditions monitored in cattle at slaughter

Condition	**WA Dept Agric**[1]	**NZ**[2]
Abscess		✓

Condition	**WA Dept Agric**[1]	**NZ**[2]
Nephritis	✓	✓
Beef measles *C. bovis*		✓
Pneumonia	✓	✓
Pleurisy	✓	✓
Liver abscess	✓	
Rumen abscess		
Pregnancy	✓	
Metritis		
Carcase abscess		
Peritonitis	✓	
Emaciation		✓
Fractures		
Fatty liver		
Septicaemia/toxaemia		✓
Actinobacillosis/mycosis	✓	✓
Granulomas/Tuberculosis		✓
Cancer eye		✓
Arthritis	✓	✓
Hydatids	✓	✓
Sarcocystis		
Jaundice		✓
Hardware disease (Traumatic reticulitis)	✓	✓
Bites/wounds	✓	✓
Bruising		✓
Xanthosis		✓
Contamination		✓
Facial eczema		✓
Navel ill – bobby calves		✓

[1] Paton, M. (1994) Utilization of Meat Inspection Findings to Improve Livestock Production. Research Project DAW.034. Report to the Meat Research Corporation.

[2] New Zealand Food Safety Authority

One study reports an assessment of the sensitivity and specificity of organoleptic inspection techniques for bovine offal from a major beef abattoir in Australia (Uzal *et al.,* 2002). The sensitivity and specificity of AQIS inspectors to classify bovine livers according to suitability for human consumption, pet food and condemnation was 73%, 87%, 72% and 93%, 75%, 96%, respectively. Classification sensitivity and specificity for bovine kidneys for human consumption was 66% and 69%.

The main reasons for downgrading livers to pet food, in decreasing importance, were hydatids, fibrotic adhesions and liver fluke. For kidneys the main causes were chronic focal interstitial nephritis and congenital cysts.

As for sheep an evaluation of the sensitivity and specificity of abattoir detection of gross pathology for Bovine Johne's Disease (BJD) has been conducted (Badman reviewed by Roe *et al*., 2001). Depending on the gold-standard, ELISA or histopathology, the apparent sensitivity of gross pathology is 55% and 64%, respectively. However, the kappa value (concordance) for gross pathology and histopathology conducted on the same samples was 0.1114, indicating little agreement between the two tests i.e. the two tests are detecting different cohorts of ELISA positive reactors. As the study showed a high level of false positive animals and there is little space and time available for a thorough examination of cattle intestine for BJD at the abattoir, surveillance has not been implemented.

The integrated system in routine use for beef in New Zealand is identified by this review as the international 'gold-standard' system (Table 5). In New Zealand as in Australia (Radunz, 2006) granulomas are submitted for examination for TB. In New Zealand beef measles (*C. bovis*) is also a regulatory disease with detection having laboratory follow-up for confirmation.

Uzal *et al.,* (2002) conclude there is a moderate level of misclassification of livers by AQIS inspectors and kidneys were relatively more difficult to correctly classify than livers. In terms of impact of bovine livers downgraded from human consumption, Uzal *et al*., (2002) found 52% classified as pet food and 5% condemned. For kidneys the downgrading rates were 64% classified as pet food and 0.3% condemned.

Due to misclassification alone, understandably, consequent financial loss is substantial. For livers acceptable for human consumption 27.1% were incorrectly downgraded costing an estimated loss to industry of A$373 (representing 22.3% of potential returns) for every 1000 human consumption livers. For kidneys a total of 33.6% of all human consumption product were incorrectly downgraded costing an estimated loss to industry of A$288 for every 1000 human consumption kidneys processed at this abattoir.

In terms of food safety Uzal *et al.,* (2002) demonstrate that although incorrect upgrading of livers might pose a risk to public health few, if any, of the livers incorrectly classified as fit for human consumption could have been considered a food safety risk to consumers. The value of beef surveillance for regulatory purposes is exemplified by the Tuberculosis Freedom Assurance Program (http://www.animalhealthaustralia.com.au/aahc/index.cfm?F23D800A-AA1B-D0EE-1FA2-7204FC59EB5A).

The standard surveillance activity for the next three years will be standard meat inspection of cattle at abattoirs, primarily for stock over two years; and example of risk-based surveillance (Stärk *et al.,* 2006). The last tuberculosis (TB) case (outbreak) was detected in January 2002 in a buffalo and was resolved that year. The National Granuloma Submission Program has been the major surveillance tool for TB since 1991. This data is held within the National Animal Health Information System (NAHIS) and is reported quarterly by Animal Health Australia (http://www.animalhealthaustralia.com.au).

The Australian cattle industry has developed systems to verify and ensure food safety status and other quality attributes of livestock. The Livestock Production Assurance scheme (LPA – Level 1 http://www.safemeat.com.au/English/Meat_Safety/On_farm_feedlot_saleyard/Livestock+Production+Assurance+%28LPA%29/LPA+Level+1/LPA+Level+1.htm) was developed to verify the declarations made in the National Vendor Declaration (NVD). This system is independently audited and is underpinned by HACCP principles (Horchner *et al.,* 2006) to ensure the integrity of the program is maintained. The LPA-NVD require records of animal health treatments to be recorded to meet market access specifications. In this way data feedback of condition presence and prevalence (critical limits) from post-mortem surveillance provides a further opportunity to refine endemic disease control and prevention. Subsequent post-mortem inspections serve to verify the efficacy of interventions. Thus, abattoir surveillance data, when utilised by producers to minimise the occurrence of non-complying carcases, provides a direct link between abattoir

HACCP compliance (Australian Standard; Export Meat Orders) and on-farm food safety QA (LPA; NVD).

3.7 Goat health monitoring surveys

One-off surveys for conditions of goats have mainly been reported, with only New Zealand integrating routine organoleptic inspection for meat hygiene and production conditions (NZFSA pers. comm.). One survey of feral goats in Australia (Hein & Cargill, 1981) identified CLA as the most prevalent condition ranging from 0.3-19% of goats in consignments.

The studies 1-5, described in Table 6, represent targeted surveys providing a profile of commonly occurring conditions and the presence of specific infections. The integrated system in routine use for goats (and deer) in New Zealand is identified by this review as the international 'gold-standard' system.

For some studies the full list of conditions examined is not listed comprehensively in the methods section.

Table 6. Summary of conditions monitored in goats at slaughter

Condition	**SA Dept Agric[1]**	**Nigeria[2]**	**Qld[3]**	**WA Agric[4]**	**NZ[5]**	**NZ[6]**
Arthritis						✓
CLA (*Corynebacterium paratuberculosis*)	✓		✓	✓		✓
Pneumonia	✓	✓	✓			✓
Pneumonia *(Mycoplasma)*					✓	
Sheep measles (*Cysticercus ovis*)	✓					✓
Mites	✓					
Sarcocystis (*Sarcocystis* spp.)	✓					✓
Hydatids						✓
Pleurisy	✓					✓
Pericarditis	✓	✓				
Nephritis	✓		✓			
Septicaemia/toxaemia						✓
Cirrhosis	✓					
Hepatitis	✓	✓				
Tapeworms		✓				
Abscess		✓				✓
Vaccination abscess						✓
Liver fluke (*Onchocericasis*)		✓				
Mange		✓				
Orchitis		✓				
Bladder worm (*Cysticercus tenuicollis*)	✓		✓			
Mastitis (*Mycoplasma* spp.)					✓	
Emaciation						✓
Cancer						✓
Bites and wounds						✓
Contamination						✓
Facial eczema						✓

1 Hein, W.R. & Cargill, C.F. (1981) An abattoir survey of diseases of feral goats. *Australian Veterinary Journal,* 57, 498-503.
2 Kudi, A.C., Kalla, D.J.U., Alkali, Y., Ladan, S.M., Kudi, M.C. & Mai, H. (1997) Abattoir survey of small ruminant diseases in Bauchi, Nigeria. *Revue Elev Med vet Pays trop,* 50, 281-284.
3 McKenzie, R.A., Green, P.E., Thornton, A.M. & Blackall, P.J. (1979) Feral goats and infectious disease: an abattoir survey. *Australian Veterinary Journal,* 55, 441-442. (NB not all GDAs listed in methods but included serology for *Brucella* and chlamydia)
4 Anderson and Nairn (1985) An abattoir survey of the prevalence of caseous lymphadenitis in feral goats in Western Australia. Aust. Vet. J. 62: 385-386.
5 Belton, D. (1996) Abattoir surveillance of mycoplasmas in the lungs and udders of New Zealand goats. *Surveillance (Wellington),* 23.
6 New Zealand Food Safety Authority

4 Summary of Utilization of Meat Inspection Findings to Improve Livestock Production in Western Australia

The MLA pilot study of slaughter surveillance of sheep and beef in Western Australia (Research Project DAW.034) represents the most extensive evaluation of the approach found in this review. Key findings are provided in this section.

The project provides an evaluation of:
- implementation of slaughter surveillance for commonly found conditions in sheep and beef in Australian abattoirs
- identification of risk factors for common conditions affecting profitability
- on-farm costs associated with conditions found
- quantification of improvements in the health of livestock at slaughter, and
- producers attitudes to surveillance feedback.

Advances in disease control and eradication programmes have reduced the impact of acute diseases on animal production systems. However, the effects of chronic diseases that cause few deaths, have few clinical signs but affect large numbers of farms are potentially significant. These conditions also often affect the quality and value of animal products and decrease abattoir productivity. The inability of abattoirs and animal production industries to reduce or even effectively define the impact of chronic disease is a serious impediment to efficiently producing a quality product in the meat industries.

4.1 Effects of health reports on condition prevalence

The effects of Health Reports and their messages were only examined in lambs because one year was not sufficient time to have any realistic effect on the chronic disease levels in adult sheep. Many conditions in adult sheep at abattoirs were likely to be more than two to three years old. The effects of messages were examined in cattle in 1993.

For the nine most common conditions recorded in lambs, eight conditions had significantly lower prevalences ($P<0.05$) in lines from farms receiving reports in 1991. In the remaining condition the prevalence was not different ($P>0.05$).

The prevalences in lines in 1992 were compared, for each condition, to lines that received extension messages about that condition in 1991. CLA, small fibrotic liver and *Cysticercus tenuicollis* had lower prevalences ($P<0.05$) in lines that received extension messages about that condition in 1991, than in lines that received no extension messages about that condition.
The observed prevalences in lines from farms that received extension messages about that condition in 1991 were 23% to 84% (an average of 67%) lower than the expected values if extension messages had had no effect.

Producers receiving Health Reports in 1991 sent lambs with approximately 22% less chronic conditions to the same abattoir in the year following reports. Producers who received an extension message about a particular condition in Health Reports, sent lambs with 67% less of that condition in the following year.

Of the 689 farms that received Health Reports on lambs slaughtered in 1993, 194 or 28% had received Health Reports in each of the three years of this study. Farms receiving at least one Health Report in both 1991 and 1992 had on average, 38% less chronic disease in 1993 than

farms that received no Health Reports in these years. Farms receiving Health Reports in 1992 had 26% less disease and in 1991 had 37% less chronic disease. This compares to an average 22% less disease in lambs slaughtered in 1992 from farms receiving Health Reports in 1991.
The effects of extension messages in Health Reports on the prevalence of chronic diseases were also examined. On average for the nine main conditions in lambs, the observed prevalences were 68% lower than the expected prevalences. This compares to an average 67% lower observed prevalences in 1992 compared to expected prevalences if messages had had no effect.

Providing lamb producers with Health Reports giving the prevalences of a number of chronic conditions and messages about controlling them, results in 20 to 40% less chronic disease in stock from these farms in subsequent years. Sending these producers messages about particular diseases resulted in 68% lower chronic disease prevalences in the following years.

4.2 Producer utilisation

Telephone interviews were conducted to evaluate how sheep and cattle producers reacted to information contained in Health Reports. Producers with moderate disease prevalences for three sheep and three cattle diseases were selected to be interviewed and half of these producers were sent Health Reports as usually happened (cases) and half had Health Reports withheld (controls). One hundred and sixty-seven producers were interviewed, 87 cattle and 80 sheep producers. Of these 83 were sent Health Reports and 84 reports were withheld.

The evidence collected from these producers, half of whom received Health Reports, supports evidence collected on changes in disease prevalence from abattoirs that producers were motivated by these reports to control chronic diseases.

The project sent over 20,000 Health Reports on more than 1.2 million stock in 2½ years of operation. In the circumstances of the industrial, technical, logistical and operational challenges of this project, this must be seen as a considerable achievement.

4.3 Risk factors and economic impact

Risk factor studies of arthritis and pneumonia/pleurisy in lambs, pneumonia/pleurisy and nephritis in cattle and an economic study of CLA in abattoirs were conducted. Shearing lambs increased the risk of having a high arthritis prevalence by approximately 11 times. Mulesing lambs increased the risk of high arthritis prevalence by approximately 6 times. The average growth rates of non-merino lambs from control farms was 249 gms/day which was higher (P=0.0032) than the 144 gms/day from case farms. Of the 57 joints identified as affected by arthritis all lesions where bacteria were isolated (37% of joints) were infected with *Erysipelothrix rhusiopathiae*.

The economic cost of arthritis could be significant as growth rates for high arthritis flocks were 42% lower than low arthritis flocks. The lost grazing opportunity of lambs not growing at the higher rate could cost $1.50 per ewe or $1.12 per lamb. This equates to a loss of approximately $160,000 in the WA lamb industry. Since approximately 1% of lambs have arthritis and the cost of downgrading due to arthritis is $7.75 per lamb, the cost in the abattoir is likely to be $109,000. This would equate to a total cost of $269,000 to the WA lamb industry.

Every increase of one winter dry standard ewe (DSE) in whole farm stocking rate increased the likelihood of lambs having a high pneumonia/pleurisy prevalence by 2.4 times. While lines of lambs slaughtered between September and November were 22.4 times more likely to have high pneumonia/pleurisy levels. Lambs that walked back more than 0.5 km to paddocks after marking or mulesing had 12.7 times more chance of having high pneumonia/pleurisy. Lambs that were drenched were 6.4 times less likely to have high pneumonia/pleurisy prevalence but this variable was not significant in the model and did not significantly improve the model (P>0.05).

The effects of management and the environment on the prevalence of pneumonia/pleurisy in cattle were investigated. Herds drenching calves were 4.9 times more likely to be in the case group, having a high pneumonia/pleurisy prevalence; while cattle slaughtered between July and November were 5.4 times more likely to have high pneumonia/pleurisy levels. Cattle grazing pasture containing double-gee for more than three months in the year before slaughter had 5.8 times more chance of having high pneumonia/pleurisy.

The effects of management and the environment on the prevalence of nephritis in cattle were investigated. Herds drenching calves were 7.5 times more likely to be in the case group having a high nephritis prevalence. While cattle that were home bred were 4.2 times more likely to have high nephritis levels. It is possible that assembling young cattle for drenching when they may be more susceptible to leptospirosis potentiates spread leading to higher rates of lung infection. This data also suggests that buying cattle in may cause higher infection rates.

The effects of caseous lymphadenitis (CLA) on productivity in a commercial abattoir were investigated. Tissue loss from trimming due to CLA amounted to 0.6 kg per sheep or approximately $0.12 per sheep (at $2.00/kg for mutton in the abattoir) or $2.2million per annum. The rate of condemnation due to CLA was 0.43% averaging $0.08 per sheep or $1.6million annually. This estimated cost of $3.8million is near the figure estimated by Paton (1989) which was made assuming a higher average CLA prevalence. The CLA average prevalence in this study is near the estimate for WA of 25% made by Paton (1993). In spite of the falling CLA prevalences in WA, this disease causes significant economic losses in abattoirs throughout Australia. The average prevalence throughout Australia is probably higher than in WA as evidence from a NSW abattoir that actively seeks low CLA sheep suggests that in 50 lines of cull for age ewes the CLA prevalence was approximately 30% (R. Fletcher pers. comm.). This prevalence was confirmed in a later study (Paton *et al.,* 2003).

4.4 Recommendations

From the findings of this very broad project, recommendations can be made about the progress of adoption of this system by the Australian meat and livestock industries and further research to be undertaken.

- That the feed-back system developed by this project should be incorporated into the E-Surveillance Program to demonstrate its benefits to the meat production industry.
- That the effects of providing Health Reports on disease prevalences in the feedlot and grass fed beef industries be evaluated in the E-Surveillance Program.
- That the effects of different management practices around shearing and mulesing on arthritis be examined in farms chosen for the occurrence of these factors.
- That the results of other risk factor studies from this project be examined with a view to conducting further research on the conditions that may need to be redefined into clear disease entities.

5 Review of the Australian Pig Health Monitoring Scheme

The review of the Pig Health Monitoring Scheme (PHMS) provides an assessment of its advantages, constraints, ease of implementation, applications and supporting studies to underpin successful utilisation by industry.
Recording disease data at slaughter defines herd health status for eleven sub-clinical conditions, enabling veterinarians to link disease prevalence associated with certain environmental conditions and husbandry practices with biological and financial performance. The health status of pigs can be quantified during their most costly phase of production, the grower/finisher phase, by monitoring a range of organ systems from a representative sample of pigs taken from the grower/finisher population. The approach includes severity scoring of several diseases of sub-clinical importance that would otherwise go undetected by routine post-mortem inspection procedures.

5.1 Objectives and methods

Inspection of gross lesions in slaughtered pigs may be used for many purposes including diagnosis of disease problems in herds, estimated prevalence of disease, surveillance of herds with high health status, decision support models and quality assurance programs, and to help communicate with and motivate producers. Secondary use of the data is made through the compilation of regional, state and national disease reports to inform industry programs and support R&D priorities.

5.2 Australian Pig Health Monitoring Schemes

PHMS as an industry based program was first established in South Australia and Western Australia in the mid-1980s. The user-pays scheme was then progressively implemented in Queensland, New South Wales and Victoria on a coordinated basis with assistance from the Pig Research and Development Corporation and Australian Pork Limited. On an annual basis approximately 390 herds, representing a total of 50% of the national sow herd are monitored at least once annually. Inspections are usually conducted on a seasonal basis.

Early uptake depended on the ability of field veterinarians to interpret and apply the data accurately for producers. The enhanced graphics in producer reports and peer group comparisons of herd data, features of PIGMON3.0™, provide easily interpreted herd data benchmarked against similar herds.

With the current industry contraction, many services are now integrated with other activities due to insufficient revenue to maintain stand-alone providers. This contraction is also impacting on capacity to maintain a central data management and reporting system and provision of a national lesion classification and detection quality assurance program.

There are several features of the Australian PHMS approach that increases its utility in comparison with the Scandinavian approaches (continuous recording by meat inspectors):

- In the Australian PHMS greater emphasis is placed on recording production limiting conditions compared to the European schemes, in which meat inspection staff predominantly record lesions related to carcase wholesomeness.
- The service has been underpinned by a quality assurance program, whereby inspectors participate in an annual exercise and data on their performance is statistically analysed relative to a 'gold standard' inspector.

- The sample size is based on sound statistics to provide acceptable levels of disease detection and estimates of prevalence.
- The diagnostic utility of gross classification has been extensively studied and provides veterinarians with reliable predictive information. The specificity and sensitivity of diagnoses of enzootic pneumonia, ileitis, nephritis and papular dermatitis based on gross lesions at slaughter has been determined (Table 7).

Table 7. Results of attempts to estimate the sensitivity (SE) and specificity (SP) of gross lesions observed at slaughter

Lesion	SE	SP	Reference Standard	Country (Reference)
Enzootic pneumonia	76%	71%	Histopathology	Canada (Hurnik *et al.,* 1993)
Papular dermatitis				
Grade 1	78%[a]	78%	Mange-free pigs	Australia (Davies *et al.,* 1991a)
Grade 1		>98%		
Grade 3		>99%		
Nephritis				
Mild	59%	74%	Culture	Australia (Chappel *et al.,* 1992)
Severe	42%	93%		
Ileitis				
Thickening	100%	58%	Histopathology & intracellular organisms	Minnesota, USA (Jones *et al.,* 1993)
Thickening & inflammation	100%	89%		
Ascariasis	91%	22%	Intestinal ascarid worms	Canada (Bernardo *et al.,* 1990b)
	96%	24%	Lifetime faecal +'ve[b]	

[a] Sensitivity for grades 1, 2 and 3 combined
[b] Faecal egg counts (5 samples/animal)

The use of PHMS internationally has been reported from the US, New Zealand, South Africa and the UK. In general, additional inspectors attend participating abattoirs to examine participating herds. The aims of the program are to improve health and welfare of pigs and their productivity. The use of techniques for monitoring sarcoptic mange developed in PHMS have been reported in Canada, Mexico, Spain, Italy and the UK.

5.3 Interpreting herd reports

Slaughter reports provide both an assessment of the sub-clinical health status of the finisher pig herd and an indirect assessment of the suitability of the environmental and management conditions over preceding months. In this regard the prevalence is the product of two sets of risk factors: those determining the incidence of infection (commonly commencing in the weaner accommodation) and those affecting the duration of lesions during the grower/finisher phase (Table 8).

The interpretation of PHMS reports also requires consideration of the statistical accuracy: the level of confidence of the data; the clinical history of the slaughtered stock, including duration of lesions; the growth performance of the group; the age of stock; and the environment/management conditions to which stock were exposed during growth.

Table 8. Guidelines for defining populations to which slaughter lesions can be reliably related

Condition	Time of Resolution	Reference
Enzootic pneumonia	8-16 weeks	Backstrom & Bremer, 1976; Wallgren *et al*., 1990; Noyes *et al.,* 1990
Pleurisy	8-12 weeks	Martinsson & Lundeheim, 1985; Mousing 1988b
Ascarid liver lesions		
Mild: first exposure	3 weeks	Copeman & Gaafar, 1972; Jorgensen *et al.,* 1975
Moderate to severe: reinfection	6-12 weeks	Eriksen, 1982; Bernardo *et al.,* 1990a
Atrophic rhinitis	4-5 months	Straw *et al.,* 1986a; Scheidt *et al.,* 1990
Pleuropneumonia	10-12 weeks	B. Thacker & L.K. Clark, pers comm. 1990
Ileitis – proliferative enteropathy	4-6 weeks	Rowland & Lawson, 1986
Necrotic enteritis	> 4 weeks?	Emsbo, 1951; Rowland & Hutchings, 1978
Regional ileitis	> 4 weeks?	
Mange – high average score	5 weeks	Cargill *et al.,* 1996
Leptospirosis: nephritis	4 months	Jones *et al.,* 1987

5.4 Quality assurance and validation

Quality assurance exercises have been designed and conducted with the aim of standardising techniques of inspection and regulating the qualitative and quantitative observation of lesions. This facilitates:

- compilation of a national pig disease database
- definition of national and regional problems
- development of collaborative research and extension projects across the national pig industry.

To standardise the implementation of PHMS internationally, training and quality assurance (QA) exercises are conducted with inspectors from each mainland Australian state and with the PHMS coordinator/reference inspector of the US pig industry. A manual describing the QA exercises and statistical methods is available from the authors.

5.5 Producer evaluation

Producer surveys to evaluate the usefulness of slaughter monitoring programs have generally indicated a high level of satisfaction. Most found the system useful in diagnosing sub-clinical disease problems and a high proportion had taken action to modify disease control procedures. Producers require lesion diagnosis to be as detailed as possible and the severity of lesions should be reported. While veterinary services are regularly used by producers, concern was expressed in a Canadian survey regarding the level of veterinary expertise in the interpretation of findings. While producers felt that they should contribute the majority of funds, support from national or state producer bodies is warranted.

5.6 Alignment with industry disease status

Because PHMS inspections and reports are provided only to producers requesting the service, summary reports are likely to be biased towards larger herds, breeding stock suppliers, producers who are interested in optimising health and to those with current herd health problems.

A systematic survey of slaughtered stock in Minnesota has been performed to determine if data collected from farms voluntarily participating in PHMS slaughter monitoring are representative of the industry in general. Parasitic infestation and respiratory diseases appear to be common among upper Midwest US pigs.

In summary, despite the above biases the study demonstrated that PHMS gave a reliable estimate of the respiratory disease status of industry in the mid-1990s. However, PHMS data is a substantial underestimate of the prevalence of liver spots and papular dermatitis across the wider industry.

A similar unpublished comparison was conducted in SA in 2005. Bias similar to that found in the US was observed in a comparison 24,910 pigs inspected from 77 herds subscribing to PHMS and 30,464 pigs inspected from 263 herds not subscribing to PHMS.

5.7 Support services required for Pig Health Monitoring Schemes

When the original PHMS was initiated in SA, only those producers willing to nominate a veterinary service to assist in the interpretation of reports were admitted as members. This policy was adopted to provide uniformity in the epidemiological interpretation of the reports. Veterinarians were provided with training seminars and publications aimed at enhancing their interpretation of the reports. Subsequently some producers requested that membership not be restricted only to producers with nominated veterinarians. When nomination of a veterinary service was made optional 70% of producers still requested that their inspection reports be sent direct to their preferred veterinarian as well as receiving a copy themselves.

Veterinary laboratories provide an important backup service to PHMS. This is especially the case during implementation to check the specificity of classifications made by staff conducting inspections, especially for new infections. Providing diagnoses without appropriate confirmatory testing can quickly erode client confidence.

5.8 Establishing Pig Health Monitoring Schemes

A range of models have been used for the implementation of PHMS. Across Australia, each state-based PHMS adapted the scheme to suit its particular existing resources and abattoir location. Implementation of the standardised monitoring protocols and a Quality Assurance (QA) program to monitor the accuracy of inspectors are, however, fundamental. Initially, inspections were conducted by trained technical officers in SA, clinical veterinarians in WA and NSW, veterinarians and technical officers in Victoria and state employed meat inspectors in Queensland. Each state had a data bureau coordinator who generated producer and summary reports from PIGMON™ which had been collated centrally by the SA PHMS, which also coordinated the QA program with corporate sponsorship. For the last decade, a veterinarian has been conducting inspections in SA, receiving and collating the national data directly from each user and conducting the QA exercises in each state.

The preferred model is where the inspection service provider understands pig production, how producers intend to use results and is the first point of contact for receiving feedback from users of the information to underpin improvements.

5.9 Defining problems

PHMS information at the regional, state and national level has been used by departmental health services for leptospirosis and nationally to establish research priorities for respiratory disease, specifically pleuropneumonia.

The trends and impacts of disease mitigation procedures, identified by this secondary use of data, validate the efficacy of therapeutic and husbandry practices introduced over the past decade at the industry level.

- There is a consistent decline in both prevalence and severity of pneumonia lesions across monitored herds, particularly in the past four years.
- There has been a progressive decline (50% reduction) in pleurisy in all herds over the past 10 years. This decline is due to a reduced prevalence of mild pleurisy i.e. fibrous adhesions between lobes. Severe Score 2 pleurisy (adhesions to the rib wall which necessitate stripping of the pleura/trimming) has not declined. A new Score 3, where the pleurisy impacts on processing efficiency, has just been introduced.
- Pleurisy does not appear to be reducing in the commonly inspected herds – improvement is still a challenge. There has been a dramatic reduction of pleurisy in herds that have introduced all-in/all-out production.
- Disease impact studies for enzootic pneumonia and sarcoptic mange have been conducted relating severity of lesions to performance reductions.
- Analysis of herd incidence of ileitis might be informative (i.e. number of herds positive per season and relation to herd growth rate and feed conversion ratio).
- To clarify the extent of herds remaining infected with Leptospirosis, herds with nephritis lesions should be followed-up with laboratory testing.
- Association of arthritis with degree of trim may be informative – quantification may assist.
- A new range of management/production descriptors have been included in PIGMON3.O™ to enable evaluation of new production systems (multi-site, slatted flooring, bedding-rearing systems etc).

PHMS has only been used in a limited manner for detection of new (exotic) disease and regulatory purposes. Examples include: detection and trace-forward of Atrophic Rhinitis nationally from a pig stud that had introduced animals from Canada and use of the PHMS network to establish successive national serum banks.

5.10 Monitoring lesions affecting carcase ‘safety and wholesomeness’

While lesions related to herd growth performance are given priority in PHMS, carcase lesions reported include pleurisy, arthritis and abscess (primarily from sites other than the head) which comprise the majority of causes for condemnation by meat inspection authorities (Pointon & Arthur, 1995). However, these conditions rarely contain food-borne hazards (e.g. *Salmonella*; Pointon *et al*., 2000) and therefore are of aesthetic/wholesomeness significance.

5.11 Data management and reporting: PIGMON3.O™

Data from all herds is stored in PIGMON3.O™, a specially tailored software program. PIGMON3.O™ enables historical analysis of health trends and allows investigation of interactions between disease levels and a broad range of potential contributing factors such as production systems, pig flow, herd size, geographic location, inspectors and abattoirs.

Producer reports from PIGMON3.O™ provide the previous 24 months data for every disease in an easy to understand graphical format. For each disease there are comparative animal prevalence figures for those herds of the same size category and health status in the state. This feature provides comparison of each herd’s health status relative to its peer group. This gives a sense of perspective on the relative health status for each particular herd and provides motivation for producers and consultants to address problems.

The standard epidemiological report in PIGMON3.O™ lists animal and herd disease prevalence for the last 10 years, however, a variety of other time periods and options are also available. Using the data analysis and SQL query by example capabilities of Access, a vast capacity to ask specific questions on the disease and prevalence data in PIGMON3.O™ is also available. Some examples include herd size, health status, pig flow (batch farrowing/ conventional); progeny housing (traditional/bedding systems), herd type, sow/progeny segregation, type of stock (e.g. porker/baconer); and regional analysis. Such reports enable producers and industry support services to target resources on better defined problems and identify emerging problems requiring formulation of new approaches.

Individual abattoir reports can be scheduled to evaluate the impact on processing efficiency and likely causes of product wastage.

5.12 Successful application of Pig Health Monitoring Scheme

The education of pig health service providers is pivotal to the application and reputation of the PHMS. Overstatement of the significance of results and inaccurate diagnoses must be guarded against through the education of field veterinarians, actively encouraging use of laboratory support and regular contact between the inspection service and field veterinarians.

Equally the reliability of data from one inspection to the next is pivotal, as is the specificity of the condition classification. Graphs of prevalence data over 24 months and against like-herds is paramount for effective communication with producers and their health advisors.

5.13 Conclusions

From the PHMS data it can be reliably inferred that the health status of the (monitored) growing-pig herd in Australia has continued to improve consistently and substantially over the past decade.

These data provide an objective and detailed account of the status of production-limiting diseases of the Australian pig herd that might be considered to support market access negotiations.

The scheme has been integrally involved with defining industry problems and assisting the evaluation of interventions to limit the impact of sub-clinical herd infections.

While some sponsorship support is provided by the pharmaceutical industry to support quality assurance overheads and project funding is provided by industry (APL) for software development, the bulk of cost is borne by producers.

The present industry contraction and reducing number of herds will make it difficult to sustain PHMS as a stand-alone service. Integration with routine inspection services may assist as long as the specificity and sensitivity of condition classification is maintained.

Should new export markets seek clarification of specific disease status, PHMS provides a sound platform for providing a national industry response.

6 Evaluation of Approaches

In summary, the E-Surveillance approach integrates animal health feedback from slaughter to improve production and processing efficiency and profitability, with provision of information for regulatory disease control and national and international trade access compliance. Both the commercial and regulatory outcomes are significant in the design of an E-Surveillance program and keeping this balance will be critical for successful implementation.

The following specific observations are drawn from material reviewed in the previous sections. A summary of the rationale for each key assessment is provided.

1. Integration of abattoir surveillance/monitoring with routine organoleptic inspection and data feedback to producers is consistent with the application of HACCP-based approaches on a through-chain basis.
Rationale

- Provision of post-mortem information reflects Codex Standards and legislation in our trading markets that call for through-chain control of hazards.
- Feedback of information from carcases/lines at slaughter represents an extension of the application of HACCP on-farm and at processing in the Australian red meat industry (detailed as SafeMeat Approved Arrangements).
- The approach provides an information loop to assist incoming product to be presented to meet processor carcase compliance specifications, in contrast to current carcase inspection information used as part of abattoir process control (for safety and suitability) with little or no feedback to producers.
- In this way feedback of carcase data to producers links abattoir (Australian Standard; Export Meat Orders) and on-farm (LPA:NVD) food safety programs.
- It capitalises on the activity of a trained inspection workforce whose surveillance encompass many OIE List B and C diseases.
- The adoption of a multi-species approach adds to the overall scientific confidence in Australia’s surveillance programs sought by trading partner reviewers.
- The list of possible conditions to be recorded (and reported to various stakeholders) will depend on a range of factors including economic impact on-farm and at processing, regulatory requirements and market access criteria (reporting specifications are provided in the following Options section).
- Although the identification of conditions for organoleptic purposes differ in part from those for boarder producer and industry uses, they should be contained within a common classification and disposition language to simplify their collection by the same inspectors.
- Training to harmonise classification and disposition judgements with the identification of higher frequency findings is likely to be necessary.
- Although extra resources are used in many schemes/pilot studies, the expertise to identify most conditions of interest already exists within current organoleptic inspection services and a practical, real-time and time efficient recording system is lacking.
- A food safety risk-based assessment of current organoleptic inspection of ruminants to better focus resources on reducing risk should be considered to potentially free up resources for the incorporation of abattoir data feedback within a wider HACCP-based framework e.g. continuation of work underway by AQIS on bovine TB and beef measles.

- Establishment of such an integrated system enables a rapid response for the detection and risk management for new or emerging conditions of industry significance.
- Such a system is feasible and achievable as demonstrated by the recording/reporting system operating for the majority of slaughtered stock in New Zealand, though enhancements are recommended.

2. Broad based continuous surveillance is useful in identifying both herd and flock infection and the extent of conditions especially when inherently sub-clinical in nature.
Rationale

- While far from comprehensive, assessments of the sensitivity and diagnostic specificity of conditions detected post-mortem have shown sufficient rigour to support disease control interventions, though for new or unexpected results, follow-up diagnosis is recommended.
- Pilot schemes have been shown to be effective in identifying and quantifying conditions that warrant the implementation of cost-effective control/preventative strategies by producers.
- Continuous monitoring provides information to assess response to interventions, seasonal patterns and regional status (freedom/specific infection).
- Monitoring constantly, as opposed to a sample (as for pigs), overcomes some of the seasonal biases and problems with sensitivity especially when regulatory conditions that occur at low prevalence are concerned.
- The wider scope of this type of monitoring focuses inspector attention on a more prevalent range of conditions which may increase the detectability of conditions by the food inspection service.
- Constant monitoring identifies farm and regional problems which informs processor purchasing policy and producer disease management strategies to optimise returns.
- Constant monitoring quantifies wastage and processing inefficiencies.
- Once the trade risk of a condition has been determined and an acceptable prevalence decided, such information can be incorporated into feedback messages to reflect the level of action required to achieve a target prevalence of a condition e.g. grass seeds, hydatids, sheep measles.
- The approach informs government policy for control of endemic diseases.
- Similar systems could be used by the processing sector in price signals to reflect market risks.
- Associated technical and extension support will depend on regional differences.

3. Any enhanced surveillance procedure should not be counter-productive to food safety outcomes.
Rationale

- Risk assessment studies of organoleptic inspection procedures have, in some instances, identified procedures (e.g. incision and palpation of specific offal to marginally improve sensitivity and specificity) that introduce additional pathways for food-borne contamination.
- Any additional procedures required for endemic disease surveillance should be evaluated in this context. Thus, a risk assessment of organoleptic post-mortem inspection procedures for beef and sheep (as conducted for pigs) should be considered to identify opportunity for improvements in the efficiency and effectiveness of current procedures.

4. Effective through-chain identification systems to support trace-back functions are a prerequisite.

Rationale

- If lines cannot be kept separate there is a need for individual animal identification for boxed lines.
- Opportunity for combining carcase details for payment with inspection results on an individual animal basis should be examined as part of ongoing development of recording systems i.e. one software system with partitioned access for various users as in New Zealand.

5. The fundamental objective of the systems in abattoirs must be to provide customised reports back to stakeholders and agreement on disclosure policy.

Rationale

- Reports should be provided to individual producers. This observation is based on research that a major motivator for action by producers to control conditions is information on prevalence of those conditions found in their own animals.
- While various producer reporting systems were identified, graphics provide easy identification of key results and facilitate easy identification of individual farm trends and regional comparisons.
- Benchmarking condition prevalence against regional averages and industry targets can assist prioritising producer responses, industry policy, buyer policy and relevant research.
- The database should facilitate the easy production of abattoir and regional reports to assist evaluation of the impact of various conditions.
- From experience with the pork industry there needs to be clear understanding how aggregated data might be used e.g. pleuritis as an indicator of animal welfare.

A summary of opportunities for improvement identified in the various pilot studies are summarised in Table 9.

Table 9. Opportunities for improvement identified in the studies reviewed (✓ recommended).

Opportunity for improvement	SA[1] 1990	WA[2] 1994	Scotland[3] 2000
• Conduct a cost evaluation of the impact on-farm of significant conditions detected at slaughter	✓	Conducted	
• An assessment of measuring long-term disease trends	✓	Conducted	
• Use the system for zoonotic diseases	✓		
• Conuct a long-term trial on cost-effectiveness of impacts	✓	✓	
• Consider implementing on a fee-for-service basis	✓		
• Utilise the WA software for multi-disease recording	✓		
• There needs to be an effective identification to support trace-back functions	✓		✓
• Apply to grass-fed and lot-fed beef industries		✓	
• End-user/beneficiary will determine disease list/score			✓
• Link production data systems to routine organoleptic inspection findings	✓		✓
• Training to harmonise classification and disposition judgements	✓		✓

1 Bejnarowicz, L. (1990) A pilot study of a sheep health monitoring scheme. DPIE/SA Dept of Agriculture.
2 Paton, M. (1994) Utilization of Meat Inspection Findings to Improve Livestock Production. Research Project DAW.034. Report to the Meat Research Corporation.
3 Adams, C., Varo, A., Stevenson, H., Hall, M., Brough, H., Strachan, D. & Gunn, G. (2005) Monitoring of ovine disease on the slaughter line. Report for Quality Meat Scotland.

7 Options

From the foregoing assessment the following options are recommended.

1. Evolve the organoleptic post-mortem inspection role to provide disease information that links on-farm and processor HACCP-based programs.
2. Consider conducting a risk assessment of organoleptic post-mortem inspection procedures for beef and sheep (as conducted for pigs). This will identify opportunities for improvements in the efficiency and effectiveness of current procedures that may facilitate implementation of additional procedures required for endemic and regulatory disease surveillance. (Note – this process has already been initiated by AQIS for bovine TB and beef measles).
3. Utilise progress with the sheep industry with the OJD/Enhanced Surveillance programs to lead development for ‘small stock’ over the next three years.
4. Explore potential to consolidate routine processor carcase data (including partial condemnation/trim and causes) and surveillance/monitoring data on the same system with quarantined access according to end-user needs.
5. Establish a process to manage data disclosure to meet all stakeholder needs (producers, processors, exporters, state and federal animal health and federal safety jurisdictions). This includes managing the data in an independently controlled database to meet OIE and importing country requirements.
6. Utilise the National Animal Health Control database (previously NAHIS) that interfaces with existing systems (e.g. AQIS, EPACS) to capture and manage data with SQL functionality (as in NAHIS and PIGMON3.0™) to enable desk-top epidemiological interrogation of data and customisation of reports to stakeholders.
7. Incorporate trim data and causes into processor reports to producers to inform producers of the direct impact of disease on returns.
8. Use graphic presentation of data in producer reports (as in PHMS and the Scottish sheep surveillance program) as enhancements of the New Zealand approach to effectively communicate disease trends, seasonal effects, response to interventions and benchmark regionally.
9. Collaborate with state animal health agencies and rural practitioners in the provision of endemic disease control and prevention information to individual producers with flock/herd animal health problems.
10. Collaborate with state animal health jurisdictions in the development and implementation of regional endemic disease control programs to underpin market access.
11. Recognise the limited nature of resources and take a risk-based surveillance approach to ensure efficient use of resources (Stärk *et al.,* 2006). While continuous surveillance/monitoring is preferred, it is noted that some conditions of sheep that have regional or seasonal association (e.g. knotty gut, liver fluke/fascialiasis, footrot) lend themselves to a more focused risk-based approach when national implementation is considered.
12. For validation of post-mortem observations of regulatory significance, laboratory testing for confirmation of diagnosis is essential to maximise specificity and utility of the information (e.g. OJD, beef measles and footrot).
13. Consider beef abattoirs as a stage 2 option (based on success of a sheep system) as companies have a variety of confidential customised reporting systems that can incorporate disease feedback when problems arise.

14. Consider implementing E-Surveillance in pig abattoirs using aspects of the PHMS approach to support productivity and market access.
15. Access on-going specialist epidemiological advice to characterise biases to ensure correct interpretation of the data (eg farm and region level free from disease).

Condition specification and reporting
The foregoing routine organoleptic inspection carcase condemnation data (for safety and wholesomeness), conditions reported in surveillance/monitoring programs for production and regulatory purposes serve to identify the breadth of conditions that should be considered for inspection and reporting (i.e. for development of software capabilities).

Those recommended for routine recording and reporting from an integration of organoleptic inspection, regulatory and production surveillance/monitoring are listed in Table 10.
This list is based on the relative occurrence of the conditions in Australia, their impact on farm productivity, regulatory and trade significance, wastage post-slaughter and impact on abattoir efficiency.

Reporting systems should present data in simple tables and/or graphs of prevalence over three years to show seasonal trends and improvements, perhaps on an annual basis coinciding with major stock sales. These graphs should also benchmark the prevalence of the specific conditions on a regional basis to provide producers with an assessment of their livestock health management. Data management systems should enable further examination of data to identify regional and seasonal associations and enable selection of properties for further risk factor and economic impact studies.

Table 10. Producer, processor and regulatory reporting: Specification of commonly occurring production conditions and those from routine organoleptic inspection for beef, sheep and goats recommended for reporting in Australia.

	Cattle			Sheep		Goats
	Calves	Steer/Heifer	Cow/Bull	Lamb	Sheep	
Abscess carcase	✓	✓	✓			
Actinobacillosis/mycosis		✓	✓			
Anaemia					✓[2]	
Arthritis (poly)			✓	✓	✓	
Bladder worm *Cys. tenuicollis*				✓	✓	✓
Bruising		✓	✓	✓[2]	✓[2]	✓
Cancer (eye)		✓	✓		✓	
CLA				✓	✓	✓
Dog bites				✓[2]	✓[2]	
Emaciation			✓	✓	✓	
Footrot					✓[1]	
Granulomas TB*	✓	✓	✓			
Grass seed				✓	✓	
Gross hide contamination						✓
Hardware disease	✓	✓	✓			
Hydatids			✓	✓	✓	✓
Jaundice	✓	✓	✓	✓	✓	✓
Knotty gut (Nodule worm)				✓[1]	✓[1]	
Liver abscess	✓	✓	✓			
Liver fluke/Fascialiasis	✓	✓	✓	✓[1]	✓[1]	✓
Liver melanosis					✓[2]	
Lungworm				✓	✓	
Nephritis	✓	✓	✓	✓	✓	✓
OJD					✓	
Peritonitis	✓	✓	✓			
Pleurisy	✓	✓	✓	✓	✓	✓
Pneumonia	✓	✓	✓	✓	✓	✓
Rumen abscess (anthelmintic)	✓	✓[2]	✓			
Sarcocystis	✓	✓	✓	✓	✓	✓
Septicaemia/toxaemia/fever	✓			✓	✓	
Sheep measles C. ovis				✓	✓	✓
Small fibrotic liver-Lupinosis				✓[1]	✓[1]	✓
Vacc abscess	✓	✓	✓	✓	✓	✓
Worms general				✓	✓	
Navel ill Bobby calves	✓					
Facial eczema		✓[1]	✓[1]	✓[1]	✓[1]	
Contamination	✓	✓	✓	✓	✓	✓
White muscle disease				✓	✓	

[1] Examples of candidates for risk-based surveillance based on known regional differences
[2] Examples of candidates for risk-based surveillance based on low prevalence or economically unimportant (subject to refinement with processors and producers using initial abattoir baseline data)

8 Supporting R&D to Evaluate Usefulness

Several studies have contributed data estimating the impact of endemic disease across the value chain. The costs of CLA (Paton, 1994) and arthritis (Paton *et al.,* 2003) on loss of product have been assessed at different times. The value of rejected and downgraded offal has also been estimated (Paton & Dowling, 2001; Uzal *et al.,* 2002).

The Meat Inspection Findings study (Paton, 1994) clearly demonstrated the success of providing producers with information on the health quality defects detected in their animals.

The prevalence of a number of diseases (sheep measles) or conditions (grass seeds) have been, or are, currently of high industry priority. In spite of the good intentions of some processors to implement feedback schemes that would significantly mitigate these problems, such schemes have not been instigated. Therefore, it is likely that the most useful research project to assist in implementing a comprehensive feedback scheme would be to examine the barriers to such a scheme in the Australian meat industries.

Such a project should examine:

- the effect of sectional interests that narrow their responsibilities to exclude participation in such a scheme.
- information and infrastructure ownership issues that preclude productive sharing and collection of information.
- policy development which threatens the future role of staff skilled in the collection of data useful to the value chain.

Given the information currently available on the economic value of a comprehensive feedback system and the failure of such a scheme to be taken up, it seems unlikely that further research demonstrating the value of decreasing the prevalence of individual conditions will lead to its adoption. However, some further research/modelling may assist in identifying future extra benefits of this system.

This research could include:

- Evaluating the impact on processing efficiency and potential savings e.g. reduced line speed/increased staffing.
- The economic benefits of the consolidation of processor carcase quality data and surveillance/monitoring data on the same system. Evaluating the capacity to relate disease effects to quality and cost impact.
- Examining the integration of risk-based surveillance (Stärk *et al*., 2006) for selected conditions where extra resources are required for data collection into a comprehensive feedback system including regional issues such as intestinal nodules (knotty gut) in wet areas of northern NSW (loss of runners) or footrot in WA.

Cost impact projects described above should be a part of any pilot project if such projects are the outcome of this review. A pilot project will also create an opportunity to update simple messages to producers about detected conditions with the latest available science.

These studies may also form an opportunity to re-examine the epidemiology of some conditions where science needs updating so that messages in the future can be more effective.

Pending the consideration of the E-Surveillance Coordinating Group, a pilot trial is recommended to:

- Validate data integrity including:
    - adequacy of data capture on the slaughter floor – sensitivity and specificity of priority conditions
    - accuracy of data entry (suitability of hardware and software)
    - traceability of livestock to source.
- Determine whether additional efficiencies might be achieved with current post-mortem inspection procedures.
- Validate the approach for multiple species, in multiple abattoirs.
- Evaluate impact on processor efficiency (extra costs and savings).

Such a trial should be considered to enable refinements of methodologies prior to national roll-out and to ensure stakeholder confidence in the data acquired and information generated for various purposes.

For sheep and cattle it is recommended that underpinning research be undertaken to produce a risk-based (economic impact and market access) refinement of the list of conditions for monitoring and reporting. As risks change the current (one touch) list could be refined while other lower priority of lower prevalence conditions may require to 'go behind' the one touch list requiring perhaps three touches to record.

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