



Scientific Evaluation of Bovine Post Mortem Examination Procedures in New Zealand

Part C

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1. Executive Summary	1
2. Introduction	3
3. Methods	4
3.1. Scientific information	4
3.2. Procedures for evaluation	4
3.3. Hazard identification	5
3.4. Food safety evaluation	6
3.5. Suitability evaluation	6
3.6. Animal health considerations	6
4. Biological hazards in slaughter cattle	7
4.1. Possible systemic or generalised conditions of public health importance due to biological hazards in slaughter cattle	7
4.2. Localised conditions of possible public health importance due to biological hazards in slaughter cattle	11
5. Physical hazards in slaughter cattle	12
6. Chemical hazards in slaughter cattle	13
7. Suitability conditions in slaughter cattle	14
7.1. Abscessation	14
7.2. Arthritis	14
7.3. Bruises	15
7.4. Gangrene	15
7.5. Icterus	15
7.6. Neoplasms	16
7.7. Sarcocysts	17
7.8. <i>Taenia saginata</i>	17
7.9. <i>Toxoplasma</i>	17
7.10. Pigmentation	18
7.11. Pleurisy	18
7.12. Uraemia	19
8. Animal health surveillance	20
9. Scientific evaluation of post mortem examination procedures	21
9.1. Carcass	21
9.2. Diaphragm	23
9.3. Gastrointestinal tract	25
9.4. Head	27
9.5. Heart	31
9.6. Kidneys	34
9.7. Liver	36
9.8. Bile ducts	39
9.9. Hepatic lymph nodes	42
9.10. Lungs	43
9.11. Oesophagus	47

9.12. Pancreas	48
9.13. Rumino-reticular junction	49
9.14. Spinal column	50
9.16. Spleen	51
9.17. Testicles	53
9.18. Thymus	54
9.19. Tongue	55
9.20. Trachea	57
9.21. Uterus	59
10. References	61
11. Appendices	71
Appendix 1	71
Appendix 2	72
Appendix 3	74
Appendix 4	76

1. Executive Summary

This document describes Part C a scientific evaluation of the likely contribution of routine post mortem examination of tissues of the bovine carcass and viscera. Other tissues have been evaluated in two separate reports (MAF Anon a and b, 2011) Scientific “modernization” of post mortem examination procedures in domestic slaughter species has involved competent authorities in a number of countries including New Zealand for the last decade. As a result of detailed comparative scientific evaluation, field trials and risk assessment, a considerable number of changes to routine procedures have been made. Such changes have led to more cost-effective examination on the slaughter line, less wastage and less cross-contamination of product, and provision of more flexibility in how food safety and food suitability requirements are met.

The examination procedures evaluated in this report, apart from those applying to very young calves, have remained largely as established in the mid -1970s.

This study is based on: review of the scientific literature, unpublished MAF reports on meat hygiene, comparison with regulatory requirements in other countries, and expert opinion. In this sense, it utilizes empirical scientific knowledge rather than risk assessment. While quantitative data on actual changes in levels of hazards consequential to different post mortem procedures is not available, there is clear scientific evidence of the likely value of different procedures relative to overall food safety and suitability outcomes achieved by post mortem meat inspection.

The study clearly indicates that the current intensity of routine examination for some of the tissues of cattle is not scientifically justified. Recommendations for change include the alignment of some highly intensive examination procedures carried out exclusively in New Zealand with the less intensive procedures of our trading partners.

Table 1. A summary of procedures carried out in New Zealand and other countries and recommendations for change to the New Zealand procedures (V - view, P - palpate, I - incise, * - edible only)

Tissue	NZ	NZ Proposed	AUS	CAN	US	EU
Carcass (external & internal surfaces)	V	V	V	V	V	V
Diaphragm - thick skirt	VP	V	V	V	V	V
thin skirt	VP	V	V	V	VP	V
Gastrointestinal tract						
Intestines	V	V	V	V	V	V
Oesophagus	VP*	V*	V*	V	V	V
Reticulum	V	V	V	V	V	V
Rumen	V	V	V	V	V	V
Rumino-reticular junction	VP	V	V	VP	VP	V
Head (including oral cavity)	V	V	V (none)	V	V	V
Masseter	IV	IV	IV	IV	IV	IV
Pterygoid	IV	IV	IV	IV	IV	IV
Tongue	VP	VP	VP	VP	VP	VP
Heart	VPI	VPI	VPI	VI	VI	V
Kidneys	VP	V	VP	V	VP	V
Liver	VP	VP	VP	VP	VP	VP
Bile ducts	IV	IV	IV	IV	IV	IV

Hepatic lymph node	IV	VP	VP	IV	IV	VP
Lungs	VP	VP	VP	VP	VP	VP
Bronchial & mediastinal Inn	I	I	I (V)	I	I	I
Trachea	V (VI*)	VI*	V*	V*		V (VI*)
Pancreas	V*	V*	V*			
Spinal column	V	V	V	V	V	V
Spleen	VP	V	V	VP	V	V
Testicles	VP*	V*	V*	V*		V*
Thymus	V	V*	V*			
Uterus	V	V	V*			V

2. Introduction

The procedures for the post mortem examination of bovines in New Zealand have largely not been scientifically evaluated since their inception. An exception has been specific evaluation of procedures for the head and tongue for detection of *Cysticercus bovis*.

MPI and the meat industry have an agreed programme to carry out the evaluation of post mortem examination procedures for cattle in three stages:

- Some procedures only applied in New Zealand (Stage 1)
- Carcass and viscera lymph nodes that provide little contribution to the detection of bovine tuberculosis (Part B)
- Tissues not already covered by the first two stages (Part C).

This report presents a scientific review of the post mortem examination procedures comprising Part C. The study is based on: review of the scientific literature, unpublished MAF reports on meat hygiene, comparison with regulatory requirements in other countries, and expert opinion. In this sense, it utilizes empirical scientific knowledge rather than risk assessment to generate clear scientific evidence of the likely value of different procedures relative to overall food safety and suitability outcomes achieved by post mortem meat inspection.

3. Methods

3.1. SCIENTIFIC INFORMATION

The scientific information generated for this study was derived from:

- Review of the scientific literature
- Unpublished MAF reports
- AsureQuality post mortem examination databases
- Comparison with regulatory requirements in other countries
- Expert opinion

3.2. PROCEDURES FOR EVALUATION

The current procedures for selected organs and tissues of cattle slaughtered in New Zealand are shown in detail in Table 2.

For reporting of results, current procedures were compared with procedures applied in other countries, as detailed in Appendix 1.

Table 2. Post mortem examination procedures for selected tissues and organs of cattle slaughtered in New Zealand

Tissue / Organ	Procedure	Comment
Abdominal cavity	View	
Anterior mediastinal ln.	Incise	For reactor cattle incise lymph nodes thinly (approximately 2-3mm) and carefully examine cortex for tuberculous lesions.
Bile duct (e)	View & Incise	Incise major ducts anterior and posterior to the cystic duct.
Bile duct (i)	see edible	
Caul Fat	View	Lift and turn to view both sides
Diaphragm	View & Palpate	Lift to view the pleural cover.
External masseter	Incise	Two incisions for EU market
External surfaces carcass	View	
Eyes	View	
Head (e)	View	
Head (i)	see edible	
Heart (e)	View, Palpate & Incise	Opening of heart, then through septum, then additional incisions.
Heart (i)	see edible	
Hepatic ln.	Incise	
Internal pterygoid	Incise	
Internal surfaces carcass	View	
Intestines	View	
Kidneys (e)	View & Palpate	
Kidneys (i)	see edible	
Left bronchial ln.	Incise	
Limb joints	View	
Liver (e)	View & Palpate	The parietal and visceral surfaces

Liver (i)	see edible	
Lungs (e)	View & Palpate	Inspect trachea and main branches of bronchi to edible standard.
Lungs (i)	View & Palpate	
Middle mediastinal In.	Incise	
Neural canal	View	
Oesophagus (e)	View & Palpate	
Oral Cavity	View	
Pancreas (e)	View	
Parotid In.	Incise	
Peritoneum	View	
Pleura	View	
Posterior mediastinal In.	Incise	
Reticulum	View	
Retropharyngeal In.	Incise	
Right apical In.	Incise	
Right bronchial In.	Incise	
Rumen	View	
Rumino-reticular junction	View & Palpate	
Spinal column	View	
Spleen (e)	View & Palpate	Both sides
Spleen (i)	see edible	
Submaxillary In.	I	
Testicles (e)	View & Palpate	Including the epididymis
Testicles (i)	None	
Thoracic cavity	View	
Thymus (e)	View	Young cattle
Tongue (e)	View & Palpate	
Tongue (i)	see edible	
Tonsils	View	As part of viewing the mucous membranes, pharyngeal cavity and associated areas of the head
Trachea (e)	View & Incise	Open trachea and main braches of the bronchi. Inspect the lungs to edible standard.
Trachea (i)	View	
Udder (e)	View, Palpate & Incise	
Udder(i)	None	
Uterus	View	

3.3. HAZARD IDENTIFICATION

All hazards (biological, chemical and physical) that might be present in the carcass and viscera of cattle slaughtered in New Zealand were considered in this study.

Hazards that may be present in cattle tissues on a global basis (Table 3) were compiled from a variety of sources as well as from published scientific literature (Untermann, 1998; Schlundt, 2004; Goldsmid, 2005; Alonso *et al.*, 2010). Hazards not present in New Zealand were then excluded from further consideration. These included agents never reported in New Zealand (bovine spongiform encephalopathy, *Sarcocystis hominis*) and those that have been eradicated from the country (*Brucella abortus*, *Echinococcus granulosus*).

Following initial compilation, the list was differentiated relative to hazards that may cause grossly-detectable abnormalities (Tauxe, 2002; Dorny *et al.*, 2009; Hugas and Liebana, 2009; Alonso *et al.*, 2010).

Evaluation of the contribution to food safety and suitability involved each hazard that was capable of causing a grossly-detectable condition was assessed in terms of:

- Systemic / generalised food safety conditions
- Localised food safety conditions
- Indicator value of the grossly-detectable abnormality for other tissues.

3.4. FOOD SAFETY EVALUATION

Food safety considerations were evaluated relative to viewing, palpation and incision of the tissue in which the hazard could generate grossly-detectable abnormalities.

The indicator function of any grossly-detectable abnormalities was evaluated in terms of possible assistance to the meat inspector when making a disposition for other tissues. A commentary was also provided on the possibility of the hazard being present in the tissue or organ in the absence of grossly-detectable abnormalities.

3.5. SUITABILITY EVALUATION

A separate evaluation was undertaken for abnormalities that might be of value in the judgement of suitability, using the above approach.

3.6. ANIMAL HEALTH CONSIDERATIONS

The value of routine post mortem examination of selected tissues for animal health surveillance was taken into account in the study.

4. Biological hazards in slaughter cattle

A recently published report into the outcomes and values of current ante- and post-mortem meat inspection tasks in the UK (Alonso *et al.*, 2010) included a comprehensive list of hazards from a variety of sources. This was used as an up-to-date baseline for this study, together with consideration of other scientific literature and reports. A condensed list of biological foodborne hazards that were considered of likely public health significance was then compiled.

For this review, this list of biological foodborne hazards was further shortened on the basis of the hazardous agent either being absent from New Zealand (e.g. BSE, *Brucella abortus*, *Echinococcus granulosus*) or absent from cattle (e.g. *Trichinella* spp). The biological hazards that might be detected at post mortem examination were separated into those that may present a public health risk as a systemic infection and those that may present as an abnormality that warrants removal on the grounds of suitability (wholesomeness).

4.1. POSSIBLE SYSTEMIC OR GENERALISED CONDITIONS OF PUBLIC HEALTH IMPORTANCE DUE TO BIOLOGICAL HAZARDS IN SLAUGHTER CATTLE

4.1.1. *Salmonella* spp.

Salmonella has been reported in New Zealand cattle since 1948 (Josland, 1950). Two decades later, the predominant *Salmonella* serovars in New Zealand cattle were reviewed (Robinson, 1970) and found to be *S. Typhimurium* and *S. Bovismorbificans*, which were considered important and common causes of enteritis in New Zealand cattle. Since then, many serovars of this bacteria have been isolated from cattle including; Agona, Albany, Anatum, Bovismorbificans, Brandenburg, Bredeney, Choleraesuis, Enteritis, Hadar, Havana, Hafia, Heidelberg, Hindmarsh, Infantis, Johannesburg, Kentucky, Kiambu, Lexington, London, Orion, Saintpaul, Senftenberg, Typhimurium and Uganda (Clark *et al.*, 2002). Many serovars have also been isolated from humans although the epidemiological links between human foodborne outbreaks and serovars present in domestic animals have been difficult to quantify. The passage of *Salmonella* from enteric organisms to being detected within mesenteric lymph nodes in cattle without clinical symptoms or gross pathology has long been recognised (Moo *et al.*, 1980, Samuel *et al.*, 1981) along with the potential for these lymph nodes to be a significant reservoir of *Salmonella* to be transferred to meat and meat products.

S. Brandenburg has become an occupational hazard for farmers and veterinarians but has not yet been established as a foodborne pathogen, although the potential exists. Zoonotic pathogenic bacteria, such as *S. enterica* are known to be present in the lower gastro-intestinal tract of cattle and cause human illnesses through carcass contamination (Dowd *et al.*, 2008). Overseas there have been a number of highly publicized salmonellosis outbreaks in humans following ingestion of contaminated food (Lynch *et al.*, 2006) and among the outbreaks, for which the aetiology was determined, bacterial pathogens caused the largest percentage (55%). Of the bacterial pathogens, *Salmonella* serotype Enteritidis accounted for the largest number of outbreaks and outbreak-related cases.

Within New Zealand, recent studies have indicated the predominance of food pathways as a source of infection and disease for only one serovar, *S. Typhimurium* DT156, where there was no obvious seasonal pattern or any association with environmental factors (French *et al.*, 2011). The National Microbiological Database (NMD) has been compiled in New Zealand

since 1997 and shows the prevalence of *Salmonella* detected in beef to be extremely low, at 0.01% of sampled carcasses. The prevalence of septicaemic-like conditions detected by meat inspectors in New Zealand cattle is around 0.04% over the last decade and the condemnation rate for these cases is 100% (AsureQuality database).

Gross pathology associated with salmonellosis is typical of acute muco-necrotic enteritis and occurs especially in the ileum and large intestine. The disease is more commonly seen in calves rather than adult cattle. The intestinal wall may be thickened, oedematous and covered with yellow-grey necrotic material overlying a hyperaemic, granular surface. The spleen may be enlarged and congested, soon replaced by an acute splenitis with miliary foci of necrosis or reactive nodules (Jubb *et al.*, 1993) while the mesenteric lymph nodes are characterised by being enlarged and oedematous (Wray and Wray, 2000; Thompson, 2004). The liver is often pale and presents with many pin head sized necrotic foci while in chronic cases of salmonellosis, there is almost always an anterior bronchopneumonia, usually with adhesions and small abscesses (Jubb *et al.*, 1993)

It is evident that routine post mortem examination of the carcass and viscera of slaughter cattle is important to detect acute systemic / generalised salmonellosis. Such cases are extremely rare and are much more likely to be identified at ante mortem cf. post mortem examination. However, if such an animal is presented for post mortem inspection, gross pathology is present in many organs and tissues and readily apparent by viewing.

4.1.2. *Campylobacter* spp.

Campylobacter species are commonly reported as zoonoses with *C.jejuni* the most common cause of human foodborne illness. (MAF *Campylobacter* Risk Management Strategy 2010-2013). These organisms generally cause subclinical intestinal infections in a variety of ruminants and human infection may occur by oral transmission with an infective dose that is relatively low. Human infection in New Zealand has shown an association with dairy cattle, however spatial and temporal patterns suggest that many rural cases are associated with environmental rather than food pathways (French *et al.*, 2011). Although consumption of poultry is considered the major contributor to human infection by *Campylobacter* species, current attribution studies (MAF *Campylobacter* Risk Management Strategy 2010-2013) are evaluating other potential exposure pathways for humans and the relative importance of cattle as a source of foodborne infection with this organism.

The lack of gross pathology associated with this disease in cattle makes the detection of infected animals by organoleptic examination highly unlikely.

4.1.3. Pathogenic *Escherichia coli* (STEC, VTEC)

Escherichia coli species are part of the normal gut microflora in healthy animals although some cattle are known to carry more pathogenic strains such as *E. coli* O157:H7 without exhibiting any clinical signs. The bacterial and host factors influencing colonisation and pathogenicity in cattle and humans remain poorly defined and, although human infections may arise through a variety of routes; since the organism has been frequently isolated from cattle, this species is considered a primary reservoir of infection.

E. coli O157:H7 has been isolated from the mesenteric lymph nodes from a position close to the anterior root of the mesentery, the middle of the small intestine, and the ilealcaecal colic node with no obvious gross pathological lesions (Cray and Moon, 1995). Ruminants are also believed to be the major reservoir of *E. coli* O157:H7 in New Zealand (Buncic and Avery,

1997; Cookson *et al.*, 2006), but very little information is available about the epidemiology of carriage of STEC in animal reservoirs in this country (French *et al.*, 2011). Recent genotyping studies have indicated that only a clinical subset of STEC O157:H7 are important for human infection and that while clinical types 1 and 3 were predominant in both human cases and ground beef, types 5 and 6 were common in cattle faeces but relatively uncommon in human cases and ground beef (Whitworth *et al.*, 2008).

Human infection with this organism in New Zealand is strongly associated with the density of dairy cattle (Thorburn, 2010) and this is consistent with environmental rather than food pathways of transmission. Given the strong association with food pathways in other countries, a competent authority must consider the implication of any post mortem examination procedure in the transmission of this organism.

There is no opportunity for detection by organoleptic examination of carcasses and viscera. The possible presence of pathogenic *Escherichia coli* (STEC, VTEC) in any faecal contamination is vindication for the minimisation of any unnecessary handling, including post mortem examination procedures, along with effective routine examination for any faecal contamination of the carcass and viscera.

The lack of gross pathology associated with this disease in cattle makes the detection of infected animals by organoleptic examination highly unlikely.

4.1.4. *Listeria monocytogenes*

L. monocytogenes is a facultative intracellular pathogen that is responsible for severe foodborne infections in humans and can also cause invasive disease in many different animal species, including cattle.

In ruminants, *L. monocytogenes* primarily causes meningoencephalitis and uterine infections (Nightingale *et al.*, 2004) and the uterine infections are characterized by late-term abortions or septicemia in neonates while the meningoencephalitic form of animal listeriosis is characterized by neurological signs, including circling, excessive salivation, and unilateral facial paralysis (Vermunt and Parkinson, 2000). An acute septicaemic form of listeriosis can cause anorexia, emaciation and diarrhoea in animals; however these cases are unlikely to be presented for slaughter.

Human listeriosis remains an uncommon infection since. *L. monocytogenes* present in raw material is effectively inactivated by the cooking of meat and pasteurisation of milk. In general *L. monocytogenes* contamination of processed ready-to-eat food products occurs by cross-contamination of the finished product from the food processing plant environment (Schlech and Acheson, 2000) since this psychrotrophic organism is able to proliferate at refrigerator temperatures which provides a unique advantage over other pathogenic foodborne bacterial species in this environment, whose proliferation is inhibited by refrigeration.

In contrast with *Salmonella* and *E. coli* O157:H7 infections, raw animal-derived food products are rarely a direct source of human listeriosis (Nightingale *et al.*, 2004).

<i>The lack of gross pathology associated with this disease in adult cattle makes the detection of infected animals by organoleptic examination highly unlikely.</i>
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4.1.5. *Cryptosporidium parvum*

C. parvum is the only zoonotic species of *Cryptosporidia* and is a common enteropathogen of cattle globally. It is generally associated with diarrhoea in calves of less than one month of age, and is most often found in the distal small intestine accompanied by atrophy and fusion of villi, metaplasia of the surface epithelium, degeneration or sloughing of enterocytes, and shortening of microvilli (Heine *et al.*, 1984). It is rarely found in adult cattle and if infected the clinical signs are mild, inapparent gross pathology, with histopathological findings in the small intestine generally characterized by villous atrophy and the presence of various developmental forms of *Cryptosporidia* in the microvillous border of the epithelium.

Consumption of meat as a vehicle for foodborne infection by *Cryptosporidia* of humans has not been identified in a recent study (Smith *et al.*, 2007) with the use of contaminated water and poor food handling practices contributing most to human infection.

The lack of gross pathology for this parasite in adult cattle means that infected cattle are highly unlikely to be detected irrespective of the intensity of organoleptic examination.

4.1.6. *Clostridia* spp.

Clostridium difficile can be found in the intestinal tracts of a variety of animal species, including food animals, such as cattle and pigs (Weese *et al.*, 2009) but without any accompanying clinical signs. *C. difficile* has also been found in retail meat and is an important cause of enteric disease in humans. Other clostridia that have been isolated from the bovine intestinal tract contents include *C. perfringens*, *C. tetani*, and *C. botulinum*. Conversely commensal species of *Clostridia* make up 20% of the gut microflora in healthy cattle (Dowd *et al.* 2008) and were the most common and diverse species identified.

C. perfringens is the predominant cause of gas gangrene-like traumatic and wound infection, especially when localised in muscle tissue. It is also believed to play an auxiliary role in enteric conditions (Niilo, 1980).

With the exception of gangrene, the carriage of Clostridia spp. in cattle is asymptomatic and organoleptic examination has no value in mitigating any potential foodborne risks.

4.1.7. *Yersinia* spp.

Yersinia species are ubiquitous organisms known to be isolated from soil, water and the gastrointestinal tracts of many animals. The species most associated with disease in humans is *Y. enterocolitica*, a heterogeneous species that is divided phenotypically into five biotypes and numerous serotypes, many of which are considered environmental and non pathogenic. Clinical disease of animals by *Yersinia* spp. is generally in young animals and almost all adult animals from which the organism can be isolated will be asymptomatic. An early European study isolated *Y. enterocolitica* from the mesenteric lymph nodes of cattle but many more from faecal samples (Wauters *et al.*, 1971). A later New Zealand study had demonstrated that *Y. pseudotuberculosis* was commonly found in the faeces of clinically healthy cattle (Hodges, 1985) although a following study carried out to investigate the presence of *Yersinia* spp. in the rectal contents of adult cattle in New Zealand (Bullians, 1987) was not able to isolate *Y. enterocolitica* and only 2 out of 330 cull cows were positive for other *Yersinia* spp. (*Y. pseudotuberculosis* and *Y. intermedia*). The latter study concluded the low prevalence rate of this organism in adult cattle indicated that this class of animals represented little risk to

human health however a more recent study in New Zealand (Fenwick, 1997) has isolated potentially pathogenic strains of *Y. enterocolitica* from asymptomatic animals, which reinforces the importance of preventing faecal contamination of product during dressing.

The lack of gross pathology associated with this disease in cattle makes the detection of infected animals by organoleptic examination highly unlikely.

4.2. LOCALISED CONDITIONS OF POSSIBLE PUBLIC HEALTH IMPORTANCE DUE TO BIOLOGICAL HAZARDS IN SLAUGHTER CATTLE

4.2.1. *Mycobacterium bovis*

Mycobacterium bovis has been traditionally regarded as a food borne zoonosis. While it is accepted that unpasteurised milk from infected cows presents a credible risk to human health, there is no published scientific evidence of meat itself being a transmission vehicle.

Previously in New Zealand, bovine tuberculosis was a common cause of chronic granulomatous lesions in both carcass and visceral lymph nodes and routine organoleptic examination of readily available carcass and mesenteric lymph nodes of slaughtered cattle has been routinely employed to detect this disease. Caseation and calcification were common features of those lesions with liquefaction observed less frequently (Collins, 1970), and aggregations of tubercles resulting in the formation of large masses of tuberculous tissue. However, the very low number of cattle confirmed as infected with *M. bovis* presented for slaughter in New Zealand now (80 animals for year ending June 2011 excluding reactors, AHB Annual Report 2010/2011), active surveillance programme, and Good Hygienic Practice on the slaughterfloor ensures that the likelihood of infected milk remaining on the carcass, or an infected lymph node reaching the consumer is close to negligible.

Inspection of lymph nodes and other tissues for *M. bovis* lesions in New Zealand is now considered to be an activity of negligible public health value.

4.2.2. Peritonitis

Acute fibrinous or fibrinopurulent peritonitis is common in cattle and usually the result of a perforated uterus or reticulum (Jubb *et al.*, 1993). Both may result with local acute, and then chronic, peritonitis with adhesions. Cattle appear to have a propensity to localise and wall off septic foci within the peritoneal cavity, and these foci may develop into abscesses. Perforation of the abomasum or intestine is more likely to give diffuse fibrinous or fibrinohaemorrhagic peritonitis. The latter occurs in most cases of clostridial haemoglobinuria and in some cases of blackleg and septicæmic pasteurellosis. A more localised peritonitis of this type occurs in some cases of clostridial enterotoxaemia caused by *Clostridium perfringens* type B & C. (Jubb *et al.*, 1993).

It is possible that peritonitis may include biological hazards present in gastrointestinal tract.

Rarely actinobacillosis produces heavily scarified granulomas, especially about the peritoneum of the forestomachs.

5. Physical hazards in slaughter cattle

A review of literature on food borne hazards concluded that the risk of physical hazards related to the meat production is much less relevant for public health compared to the risk from biological and chemical hazards (Alonso *et al.*, 2010).

The existing literature on physical hazards is very limited and the only physical hazards identified through literature that can originate in animals are a) broken needles, or fragments of needles that are used for veterinary purposes, such as vaccinations and injections and b) fragments of bullets and pellets (Horchner, 2006). Broken or fragmented needles embedded in the tissues of the animals can cause a variety of reactions in the body, especially in the muscle tissue. These reactions are usually inflammatory and either due to introduced bacteria or the nature of the introduced material itself. The reactions are usually abscessation, scar tissue formation, callus formation or cyst formation (Beechinor *et al.*, 2001).

In New Zealand slaughter cattle, injection site lesions are not uncommon (around 2% of the kill in 2010) but due to lack of evidence to indicate otherwise, almost all injection-site lesions are considered the reaction of the body to the injection itself, rather than including a section of hypodermic needle. This view is also supported by others (George *et al.*, 1995) where, during an extensive histological examination of over 15,000 injection-site lesions in beef muscle at boning room level, not one broken needle or fragment was detected.

The value of post-mortem meat inspection in the detection of broken needles is hard to quantify and under routine examination parameters of chain speed and lighting levels, it would be highly unlikely for a needle to be detected during visual inspection. It is very likely that any needle fragment within an injection site lesion will be removed when the defect is trimmed from the carcass.

6. Chemical hazards in slaughter cattle

Compared to the detection of microbiological agents, chemical contaminants are far more difficult to detect by gross examination post mortem. Chemical contaminants in food can arise from a large range from substances that are normally in use e.g. veterinary medicines and feed additives, pesticides (insecticides, rodenticides and herbicides), chemicals used in the maintenance of agricultural equipment and buildings (engine oils and fuels, wood treatment preparations etc.). Contaminants can also arise from substances not in normal or authorised use (Waltner-Toews and McEwen 1994). The latter group includes environmental contaminants, like heavy metals (Sharpe and Livesey 2006; Andree *et al.*, 2010) and unlicensed veterinary preparations (Reig and Toldra 2008), but also substances found normally in some soils (such as cadmium). A recent study carried out in the UK concluded that although residues of veterinary drugs in food of animal origin carry a potential public health risk if the MRL is exceeded, it is extremely unlikely that minor non-compliances have any significant public health implications (Woodward, 2009).

Potential risks from these hazards are addressed through a residues monitoring program and specific investigations of non-compliant products.

7. Suitability conditions in slaughter cattle

There are a number of grossly observable defects that affect the standard of suitability or wholesomeness of the carcass. All are subject to post mortem examination and disposition judgements.

7.1. ABSCESSATION

Septicaemia and haematogenous spread of organisms may produce foci of inflammation throughout the skeletal musculature (Jubb *et al.*, 1993). Abscessation from distal limb inoculation and infection may progress to regional lymph node abnormalities with reactive lymph nodes being the normal response to the presence of antigen from a variety of sources with the variations in level of reactive activity being characteristic of nodes from differing anatomical sites.

Infection by *Actinobacillus lignieresii* gives rise to discrete granulomatous lesions of the oral cavity and tongue, known as “woody tongue”, but very rarely cutaneous abscesses in other areas have been reported such as on the lower hind limb (Aslani *et al.*, 1995). Small lesions occasionally are detected in and generally restricted to the tongue although rarely a primary infection of the oral cavity and tongue may give rise to involvement of the efferent lymph nodes, in particular the parotid, retropharyngeal and bronchial lymph nodes (Hungerford, 1975). This organism is now regarded as belonging to the *Mannheimia* species (Blackall *et al.*, 2002)

Fusobacterium necrophorum is generally associated with hepatic abscesses and enlargement in cattle but may also be one of the contributing pathogens to foot rot. It is a normal inhabitant of the bovine rumen and hepatic abscessation is associated with a high grain diet. Secondary serofibrinous peritonitis can occur although it has not been reported as a cause of regional lymph node abscessation nor is regarded as a foodborne zoonosis. Other pathogens that may give rise to abscessation in cattle include *Arcanobacterium pyogenes*, *Staphylococcus* spp. and *Pseudomonas* spp. A necrotising fasciitis in a bull due to infection with *Arcanobacterium haemolyticum* has been recently reported in New Zealand (Bancroft *et al.*, 2010).

Corynebacterium pseudotuberculosis has occasionally been recorded as causing cutaneous abscessation in dairy cows which led to regional lymph node involvement (Yeruham *et al.*, 1997). The condition did not progress to a generalised lymphadenitis and lymphangitis was not observed. Other pathogenic bacteria isolated from cutaneous abscesses in this report included *C. pyogenes*, *Staphylococcus aureus* and *Micrococcus* species.

7.2. ARTHRITIS

Diseases of the joints may be degenerative and/or infective. Degenerative arthropathy is more frequently seen in older cattle and is reported from a number of joints. Arthropathy of the tarsus (bone spavin) is occasionally reported in ox (Jubb *et al.*, 1993) although lameness sufficient to prevent weight bearing will preclude these animals being presented for slaughter. The tarsus is not presented for post mortem examination. Ankylosing spondylosis of the vertebrae is reported in older bulls; especially those kept for artificial breeding purposes, but the condition has no food safety significance.

Inflammatory joint disease (arthritis) may be either infectious or non-infectious with the former being the most common. Infections tend to cause simultaneous arthritis and

tendovaginitis with each being primarily a synovitis (Jubb *et al.*, 1993) incurred by haematogenous spread of pathogens. Fibrinous arthritis is known to result from infections of *Arcanobacter* spp., *Erysipelothrix rhusiopathiae*, *Staphylococci* spp and *Streptococci* spp. while purulent arthritis or chronic suppurative arthritis has been reported in cattle as the outcome of infection by *Arcanobacter pyogenes*, although it is very unlikely that these animals will be presented for slaughter.

Other reported causes of bovine arthritis include *E. coli*, *Salmonella* spp., *Mycoplasma bovis* and *Haemophilus somnus* (Jubb *et al.*, 1993) although these organisms are thought to be opportunistic rather than showing predilection for joints. *Mycoplasma* spp. bovine group 7 has been suggested as causing arthritis in cattle in Australia (Hum *et al.*, 2000) however neither *H. somnus* nor *M. bovis* is currently reported in New Zealand.

7.3. BRUISES

These defects are commonly reported on cattle and most are acquired by the animal between the farm and slaughter. Generally these will be less than one to two days in age and of no consequence to the consumer. Provided there is no necrotic or gangrenous involvement to the bruise, their removal is a matter of wholesomeness and suitability.

7.4. GANGRENE

C. perfringens is the predominant cause of gas gangrene-like traumatic and wound infection, especially when localised in muscle tissue. It is also believed to play an auxiliary role in enteric conditions (Niilo, 1980).

7.5. ICTERUS

Icterus or jaundice is the discolouration of tissue and body fluids by an excess of bile pigments, caused by either an overproduction or impaired excretion of bilirubin. The latter, known as cholestasis may either result from a failure of uptake or conjugation of unconjugated bilirubin, or an inability to excrete conjugated bilirubin (Jubb *et al.*, 1993).

The most common cause of biliary obstruction within New Zealand cattle is infestation by *Fasciola hepatica*. Hepatocellular injury from a range of plant toxins such as in *Lantana* and *Senecio* species and some metal poisoning, such as copper, can lead to a failure of bile excretion while extrahepatic biliary obstruction ultimately leads to an accumulation of pigment within the parenchyma. Icterus has also been occasionally reported in cattle being poisoned by ingestion of blue-green algae (Gussman *et al.*, 1985) and in cases of bovine haemolytic anaemia caused by *Theileria orientalis* (McFadden *et al.*, 2011).

Rarely, icterus may be due to congenital incompetence of hepatocellular uptake or transport of bile pigment and very rarely cases of occlusion of the bile ducts in aged cattle by cholangiocarcinoma leading to icterus have been reported (Yusuke *et al.*, 2003). The discolouration is most obvious in white tissue, such as fat, white fibrous tissue and to a lesser degree cartilage and must be distinguished from those animals that naturally accumulate carotenoid pigments such as in Channel Island breeds of cattle (such as the Jersey).

7.6. NEOPLASMS

The prevalence of neoplasms detected at post mortem examination of cattle in New Zealand averaged just under 0.08% in 2010 (AsureQuality data base). Neoplasms within the carcass are generally restricted to the lymph nodes and include lymphosarcoma and metastases of primary tumours. Tumours of bones are rarely reported in cattle (Jubb *et al.*, 1993). These include fibrosarcoma, which are usually found in the head rather than the carcass, and chondroma. The latter is a benign tumour characterized by the formation of mature cartilage that is firm to hard, smooth or nodular, roughly spherical masses with a thin fibrous capsule. Osteoma are benign tumours consisting of well differentiated bone and are uncommon lesions that usually affect the bones of the head, and have been reported in cattle (Jubb *et al.*, 1993). Osteosarcoma are very rare malignant tumours with most arising in the metaphyseal region of long bones but usually reported in dogs and rare in other species. Another very rare neoplasm that has been recorded in cattle is the giant-cell tumour of bone, characterised as expansile osteolytic masses in the ends of long bones. They tend to be locally aggressive but usually do not metastasise.

None of these conditions have been shown to present a food borne risk to the consumer.

Neoplasms that may progress to lymph node involvement include squamous cell carcinoma; the most common neoplasm detected in New Zealand cattle. Primary sites are poorly pigmented mucocutaneous junctions of the body; usually adjacent to the eye and very rarely the vulva. Gross appearance depends not only on the anatomical tumour site, but also the stage of malignancy. In general, pre-malignant lesions are small, greyish-white, elevated, hyperplastic plaques or papilloma-like structures. Malignant tumours are more irregular, nodular, pink, erosive, and necrotic in nature and such tumours may metastasize along draining lymphatics to regional lymph nodes such as the parotid, retropharyngeal and submaxillary lymph nodes in cases of ocular squamous cell carcinoma (Vermunt, 2002) and the internal iliac lymph node in cases of squamous cell carcinoma of the vulva. Any metastatic spread of this neoplasm is considered grounds for total condemnation of the carcass and all parts for wholesomeness purposes (around 51% of such cases in 2010, AsureQuality database).

Lymphosarcoma is detected mainly in young cattle of less than two year of age according to Shortridge and Cordes (1971) and predominantly occurs as a single case within a herd. The thymic and multicentric forms are the most common. The initial lesion in a lymph node may be large with the capsule usually permeated and obliterated with infiltration to adjacent tissue (Jubb *et al.*, 1993). The condition is generally extensive and obvious upon observation. Unlike adenocarcinoma in sheep, this neoplasm in cattle has not been associated with the small intestine. It is known to be associated with bovine leukaemia virus and transmission requires prolonged and close contact with infected animals or the inoculation of infected lymphocytes. Prevailing husbandry practices and lack of widespread winter housing are likely to account for the current low prevalence of this disease in New Zealand.

Mesotheliomas are rare tumours that arise from cells of the serous linings of the pericardial, pleural and peritoneal cavities, frequently involving all these locations. The tumour occurs most commonly as a congenital neoplasm in foetal or young cattle, although there are a few reports of acquired mesothelioma in adult cattle (Girard and Cécyre, 1995). These cases have included metastatic involvement with the tracheobronchial lymph node.

Cutaneous lymphomas have been reported in cattle and all cases have progressed to multiple lymphadenopathy (Schweizer *et al.*, 2003) with detectable lesions in regional lymph nodes. This condition should be readily apparent by visual examination.

7.7. SARCOCYSTS

Globally there is only one species of sarcocysts relevant to public health with respect to the consumption of infected beef and that is *S. hominis* (syn. *S. fusiformis*, *S. bovi homini*). It has not been reported in New Zealand (Mitchell, 1988, Hill, 1994) and will not be considered in this review. Occasionally other species of sarcocystis are detected upon examination of the bovine carcass (such as *S. cruzi* and *S. hirsuta*) but neither involve man in their lifecycle or have any relevance to human health.

7.8. TAENIA SAGINATA

The cestode of *T. saginata* (syn. *Cysticercus bovis*) is very rarely detected within New Zealand cattle and, of the individual tissue submissions that have been made since 2000 none have been made from carcass skeletal muscle. Almost all submissions have been detected within the heart, masseter or pterygoid muscles. Measurements of the volume and surface area of beef carcasses demonstrate that the effective volume of the carcass that can be examined by observation is less than 3%, assuming that a cyst has to be within 2.5 mm of the surface to be seen (van der Logt *et al.*, 1997).

Despite the low sensitivity of organoleptic examination for *T. saginata*, visual examination of the cut muscle surfaces for such cysts should continue although there has been no indicator function of the diaphragm demonstrated in the New Zealand disease profile. Almost all positive identifications of the parasite in New Zealand arise from examination of either the heart or cheek musculature (Appendix 4).

7.9. TOXOPLASMA

The protozoan parasite *Toxoplasma gondii*, is one of the most common parasitic infections of man and other warm-blooded animals. It has been found world-wide and nearly one-third of humanity has been exposed to this parasite. In most adults it does not cause serious illness, but it can cause blindness and mental retardation in congenitally infected children and disease in immuno-compromised individuals (Sibley *et al.*, 2009).

Although toxoplasmosis is acknowledged to be a zoonosis that occurs in livestock, natural toxoplasma infection appears to be rare in cattle (Hall *et al.*, 2001) with older serological tests to detect *T. gondii* antibodies in bovines giving false positives and greatly overestimating its incidence. Humans become infected by ingesting tissue cysts in undercooked or uncooked meat or by ingesting food and water contaminated with oocysts from infected cat faeces. Oocyst-transmitted infections may be more severe than tissue cyst-induced infections (Hill and Dubey, 2002) Cattle are not believed to remain persistently infected as long as sheep do, and epidemiological studies points to consumption of raw or undercooked mutton and pork to be an important risk factor for infection during pregnancy (Kapperud *et al.*, 1996; Tenter *et al.*, 2000) rather than consumption of beef.

Moreover the infrequent prevalence, generally microscopic pathology and very rare abnormalities associated with lymph nodes indicate that this disease is unlikely to be detected by organoleptic examination.

7.10. PIGMENTATION

Carotene pigmentation is confined solely to fat and is usually observed in cattle of the Jersey and Guernsey breeds. The fat has a distinct yellow appearance although this has no relevance to food safety.

Eosinophilic myositis is a rare condition of cattle that is thought to be a reaction to degenerating sarcocysts. It is found in cattle of all ages and is characterized by gross lesions that are well-demarcated, greenish focal stripes which fade to off white when exposed to air. Some lesions have a brown-green or grey-green colour.

Lipofuscinosis is a rarely recorded condition of stock in Australia and South Africa associated with prolonged ingestion of *Trachyandra divaricata* or *T. laxa* and intense lipofuscin storage in all central and peripheral neurons. Poisoning by *Phalaris* spp. in New Zealand has been known to cause a similar condition where indolic metabolites have been stored in lysosomes, and with intense storage may give rise to greenish discolouration of the kidneys (Jubb *et al.*, 1993). Ceroid lipofuscinosis is recognised as an inherited condition of Devon cattle in New Zealand (Hill and Johnstone, 1993) although this results in profound blindness at around 14 months of age and are unlikely to be presented for slaughter.

Melanosis is an uncommon condition is an abnormal accumulation of melanin, a sulphur containing protein based pigment, found in the lungs, liver, brain and spinal cord where it usually involves the pia mater or more rarely the dura mater. Frequently the condition is also found on the pleura or peritoneum or in the fascia between muscles. There is no recorded food safety consequence of the condition.

Ochronosis is a rare condition is caused by an accumulation of a yellowish brown or chocolate coloured pigment in cartilage, tendon sheaths and joints and sometimes is generalised.

White muscle disease is rarely seen in cattle and is usually presented as bilaterally symmetrical pale areas of musculature. The cause is due to a deficiency of vitamin E and/or selenium and is a matter of suitability rather than food safety.

Xanthosis is a hereditary condition that causes a dark brown colouration of muscle due to the accumulation of xanthine. It is most common in the Ayrshire breed and the condition is usually detected in the heart, diaphragm, tongue and masseter muscles although any muscle may be affected.

7.11. PLEURISY

Lung pathology involving the pleura is not uncommon in New Zealand cattle. Pleurisy is not considered an entity in itself but is usually a pathological consequence of pneumonia. The prevalence of pleurisy that requires the carcass to be retained for trimming in New Zealand slaughter cattle is 4.5% with a small peak in autumn and a trough in spring (ASUREQuality database, 2012). This prevalence and periodicity has remained constant over the last decade.

7.12. URAEMIA

It may result from gross pathology of one or both kidneys as in hydronephrosis, pyelonephritis, and renal calculi or from obstruction to the flow of urine from the bladder by urethritis or ureteroliths. An increase in urinary pressure may lead to rupture of the bladder with consequent infiltration of urine into abdominal tissues, eventual reabsorption of urine into the blood, with production of an uraemic odour of the carcass and viscera. Olfactory examination of boiled tissue 24 hours post slaughter should distinguish uraemia from urine spillage.

8. Animal health surveillance

The monitoring of bovine tuberculosis will continue until the disease has been eradicated from New Zealand and examination of the carcass will play a part in that. Almost all reported sites of infection that are confirmed as *M. bovis* are restricted to lymph nodes from the head, thoracic viscera and mesentery (MAF Anon. c, 2011). However a very small proportion (0.18%) of infected animals had infections confirmed in the internal iliac, superficial inguinal or supramammary lymph nodes over the last two decades. With only 80 confirmed cases detected in slaughter cattle in the year ending June 2011, it is unlikely that the disease will be discovered within any of these three lymph nodes, however examination of them will continue.

Routine examination of the bovine carcass has little relevance to monitoring of Johnes disease and *T. saginata* infection with the very infrequent prevalence of the latter in New Zealand slaughter cattle. A programme to screen more than 50% of dairy herds within New Zealand for Enzootic Bovine Leucosis is operated by LIC and the year 2010/11 is the third consecutive year that the country has remained free of any evidence of EBL. There is no indication of re-emergence of EBL due to residual pockets or by reintroduction from the beef industry (NZ Dairy Statistics, 2010/11). The disease is of interest to New Zealand as it has been recognised as a cause of lymphatic neoplasia and should be eliminated by an effective monitoring scheme (Reichel *et al.*, 1998).

9. Scientific evaluation of post mortem examination procedures

9.1. CARCASS

The carcass will continue to be examined for food safety and suitability purposes. Irrespective of this, the likelihood of detecting biological hazards of potential public health importance is low (see previous section),

Acute infection by *Salmonella* species is usually apparent upon observation due to a hyperaemic response by the animal that may be visible on the peritoneal surface of the abdominal cavity and viscera, especially in calves. Pathology associated with salmonellosis is typical of acute muco-necrotic enteritis and occurs especially in the ileum and large intestine, and gross pathology of acute salmonellosis detectable on the carcass may include hyperaemia of the peritoneum with pleural adhesions in chronic cases (Jubb *et al.*, 1993).

Faecal contamination could contain any of the enteric organisms known to inhabit the bovine gastrointestinal tract such as *Salmonella* spp., *Campylobacter* spp., *Clostridia* spp., *Cryptosporidium parvum*, STEC / VTEC, and *Yersinia* spp.. Hygienic processing will include taking all practical steps to minimise the contamination of carcasses during dressing followed by careful examination to identify and remove all grossly visible contamination.

9.1.1. Current procedures

Examination of the carcass by viewing is generally standard routine procedure throughout the major cattle exporting countries with differences being restricted to procedures for the kidneys, diaphragm and two carcass lymph nodes.

New Zealand requires the carcass to be examined by viewing internal and external surfaces. These include the abdominal cavity, limb joints, neural canal, peritoneum, pleura, spinal column, tail (if present), thoracic cavity and, depending on presentation, to view and palpate kidneys, diaphragm and diaphragmatic pillars if present; and testicles if saved for human consumption. The internal iliac, superficial inguinal or supramammary lymph nodes are to be examined by incision and viewing.

Australia requires the internal and external surfaces of the carcass/side to be examined by observation, including the tail, musculature, serous membranes, diaphragm, joints and exposed bone and, depending on presentation, to view and palpate the enucleated kidneys and thick skirt. The internal iliac, superficial inguinal or supramammary lymph nodes are to be examined by observation, or by palpation in mature bulls and cows (full mouth).

Canada requires the internal and external surfaces to be examined by viewing. These are described as the joints, outer muscular surfaces, the body cavities, the diaphragm and its pillars, the peritoneum, the pleura, the neck and, depending on presentation, the kidneys if present. There are no specific carcass lymph nodes to be examined.

The EU requires examination of the carcass and specifies visual inspection of the diaphragm, kidneys, pleura and peritoneum. There are no specific carcass lymph nodes to be examined. The US requires inspection programme personnel to observe the cut surfaces of muscles and bones, lumbar region, pillars of the diaphragm, peritoneum, pleura, neck, carcass exterior, lumbar region, and, depending on presentation, the tail and to observe and palpate the

kidneys and diaphragm. The internal iliac, superficial inguinal or supramammary lymph nodes are to be examined by palpation.

9.1.2. Scientific evaluation

The New Zealand requirements for examination of carcass lymph nodes have been previously reviewed (MAF anon b, 2011) and it was recommended that the requirement to examine the subiliac, lumbar chain, renal, superficial cervical and atlantal (if present) lymph nodes be removed. This aligns examination procedures in New Zealand with the requirements of our major trading partners and in the case of the atlantal lymph node, reflects what has been occurring in practice in most countries for many years.

9.1.3. Recommendations for examination of the carcass

There is no risk to public health in New Zealand slaughter cattle that warrants any deviation from the international standard post mortem procedure for carcass examination which is by viewing of all exposed internal and external surfaces.

The internal iliac, superficial inguinal and supramammary lymph nodes should continue to be examined by incision and viewing, and further investigation and field studies are required to determine what intensity of examination is justified in New Zealand slaughter cattle for these lymph nodes. There are differences in the method of examination proscribed by overseas regulatory authorities, with palpation required of the two sets of carcass lymph nodes by some, despite the impediment to detection of abnormalities that result from the fat cover of such lymph nodes in prime animals. Similarly, examination by viewing as required by others is unlikely to be effective in those carcasses with lymph nodes covered by fat.

9.1.4. Carcass splitting

The value of examination of the exposed spinal column after carcass splitting is currently under consideration. This procedure was not introduced to facilitate meat inspection but rather to increase the number of carcasses that could be placed in a chiller as well as to facilitate the chilling process by increasing air flow over the internal surfaces of the abdominal and thoracic cavities. In the spinal columns of carcasses of other species that are not split prior to chilling, such as ovines and cervines, there are no reported diseases or abnormalities that present a risk to human health and an extensive literature search has not identified any such abnormalities liable to occur in New Zealand cattle. A small number of abnormalities have been observed in the bovine spinal column, but none with any food safety significance. The most commonly encountered include fractures, diskospondylitis, spondylosis, abscesses, tumours, myelitis and degenerative diseases (Braun *et al.*, 2003, Frederick *et al.*, 2009). Of the few spinal cord tumours that have been described in cattle, most are oligodendroglioma, schwannoma, melanoma or ganglioglioma (Roth *et al.*, 1987; Braun and Ehrensperger, 2006; Uchida *et al.*, 1999).

The one condition that is relevant to food safety and found within the spinal cord is bovine spongiform encephalopathy, which has never been reported in New Zealand.

The risks to human health that may be undetected by the non-splitting of bovine carcasses in New Zealand slaughter cattle are most likely to be those that arise from contamination by zoonotic enteric microflora that is not observed by examiners due to reduced visual access of the abdominal and thoracic cavities. It is also possible that some pleurisy lesions may remain undetected. Any reduction of visual access will be a function of chain speed, abdominal wall

opening cuts, lighting direction and intensity, and stand height. It is recommended that any establishment considering bovine processing without carcass splitting should demonstrate that the internal surfaces can still be adequately examined.

9.2. DIAPHRAGM

9.2.1. Food safety

Food safety conditions are essentially limited to *T. saginata*. However the parasite is rarely detected in the diaphragm in New Zealand (Appendix 4), compared to the heart and cheek muscles and has negligible value as an indicator tissue.

9.2.2. Suitability

The most commonly detected abnormality in the bovine diaphragm in New Zealand slaughter cattle is pleurisy as a consequence of pulmonary infection and these infections almost always represent a matter of suitability for the consumer rather than a risk to human health.

Adhesions from either peritonitis or pleurisy may be observed on the respective surfaces of the diaphragm and these may range from acute to chronic in nature. Such abnormalities are unlikely to be restricted to the diaphragm and should be apparent by observation of the abdominal or thoracic cavities or their contents.

Eosinophilic myositis is relatively rare in cattle and some evidence exists to suggest that this condition is evidence of degenerated sarcocysts (Jubb *et al.*, 1993). The gross lesions in cattle are characteristic green, focal stripes or patches that fade to off-white when exposed to air. Some lesions are either brown-green or grey-green and the condition may be restricted to single muscles or widespread through all including the heart. Individual lesions may be 2-3 mm in diameter and over time may take on granulomatous characteristics as muscle fibres undergo degeneration.

The only sarcocyst species that has relevance to human health (*S. hominis*) has not been recorded in New Zealand, thus any finding of this abnormality will have no consequence to the health of the consumer but present as a condition of suitability. In one study carried out in a New Zealand slaughterhouse (Mitchell, 1988), almost two thirds of the 100 carcasses tested had macroscopically identifiable macrocysts present with the rectus abdominus and psoas muscles most commonly affected. The author considered the actual prevalence to be higher since many of the cysts detected in the study were less than 4mm in length and only found after several minutes of intense observation. Of the two species of sarcocyst found in the study (*S. hirsuta* – transmitted by cats and *S. cruzi* – transmitted by canids) almost all of the sarcocysts were judged to be *S. hirsuta* by the thickness of the cyst wall.

Muscle conditions include atrophy or hypertrophy, neither of which have any relevance to public health. Muscular dystrophy has been described in the Meuse-Rhine-Yssel breed of cattle in the Netherlands with signs primarily in the diaphragm and intercostal muscles. The disease is regional, familial and affects cows from 2 – 10 years of age. The most severe changes are in the diaphragm which is swollen, pale and inflexible (Jubb *et al.*, 1993). This condition has no relevance to public health

9.2.3. Current procedures

The New Zealand post mortem requirements for the diaphragm (thin skirt) and diaphragmatic pillars (thick skirt) are to examine by viewing and palpation including the lifting of the thin skirt to view the pleural cover. This examination may be carried out either on the carcass or viscera table as determined by the dressing procedures.

The routine post mortem requirements of the bovine diaphragm for Australia, Canada and the EU are restricted to viewing while the US requires the diaphragmatic pillars to be examined by viewing and the thin skirt by viewing and palpation on the carcass.

9.2.4. Scientific evaluation

The sensitivity of post mortem meat inspection for detecting cysts of *T. saginata* is very low. Where animals are lightly infested, as in New Zealand, the sensitivity of inspection has been estimated to be around 4% (van der Logt *et al.*, 1997). Risk assessment models have demonstrated that in countries with a very low prevalence of *T. saginata* there is virtually no difference in the level of consumer protection achieved by intensive compared with reduced inspection to detect cysticercosis.

Of all single case submissions made from slaughtered cattle of lesions suspected to be *T. saginata* between 2000 and 2010, where the tissue was identified; only one submission included a section of diaphragm and in that instance, the cestode was identified by histopathology in the accompanying heart and forequarter muscles sections but not the diaphragm and masseter muscles (appendix 4). There have been only four other submissions, over the same period where the tissue was identified, that included a section of diaphragm and each came from a line of cattle that involved more widespread infection. In each case, the parasite was either confirmed in other tissues (such as masseter or heart) as well as the diaphragm (1) or not confirmed (3). These findings would suggest a very low indicator value for examination of the diaphragm in New Zealand for *T. saginata*.

These findings concur with others (Minozzo *et al.*, 2002, Scandrett *et al.*, 2009) who demonstrated in artificially infected animals the diaphragm had a lower cyst density than the musculature of the heart and head including the tongue. The latter indicated that the thin skirt had a lower cyst density than did the diaphragmatic pillars. In naturally infected cattle the a number of studies have indicated that the diaphragm has a significantly lower cyst density than head and heart musculature (Opara *et al.*, 2006; Pearse *et al.*, 2010; Lopes *et al.*, 2010; Eichenberger *et al.*, 2011)

Cestode infections most relevant to public health are the viable cysts which are soft and less liable to be detected by palpation as opposed to the more easily detected aged non viable calcified cysts. It is in extensively infested carcasses that the cestode is likely to be detected in the diaphragm as well as in the other more frequently affected tissues and organs such as the heart and masseter muscles.

Any pleurisy or peritonitis is also likely to be apparent on the surface of the respective cavities as well as the surface of the diaphragm.

9.2.5. Recommendations for examination of the carcass

For those thin skirts that are presented for examination on the carcass, in order to examine the thoracic surface of the diaphragm, it is necessary to lift the tissue. Similarly when presented on the viscera table, both sides should be viewed to establish freedom from abnormality.

It is recommended that the diaphragm (thick and thin skirt) be examined by viewing both sides of the thin skirt and exposed surfaces of the pillars.

9.3. GASTROINTESTINAL TRACT

9.3.1. Food safety

The primary reservoir of the major zoonotic risks to human health from the consumption of meat and meat products is the gastro-intestinal tract. These include *Campylobacter* spp., *Clostridia* spp., *Cryptosporidium parvum*, pathogenic *Escherichia coli*. (STEC, VTEC), *Listeria monocytogenes*, *Salmonella* spp. and *Yersinia* spp. The only organism of this group of enteric pathogens that is characterized by gross pathology is *Salmonella* and although an acute septicaemic form of listeriosis can cause anorexia, emaciation and diarrhoea in animals, these cases are unlikely to be presented for slaughter.

Gross pathology associated with salmonellosis is typical of acute muco-necrotic enteritis and occurs especially in the ileum and large intestine. The intestinal wall may be thickened, oedematous and covered with yellow-grey necrotic material overlying a hyperaemic, granular surface. The mesenteric lymph nodes are characterised by being enlarged and oedematous (Wray and Wray, 2000; Thompson, 2004).

The lack of gross pathology associated with infections by other organisms in cattle makes the detection of such animals unlikely by post mortem examination irrespective of intensity.

Infection by *Mycobacterium bovis* is usually by inhalation or ingestion of the organism and so a small proportion of cases occur in which the mesenteric lymph nodes are affected. Post mortem examination of these lymph nodes has been addressed in a previous report (MAF Anon b, 2011)

9.3.2. Suitability

Certain conditions that occur in the gastro-intestinal tract of cattle have no consequence for public health but do affect wholesomeness of the product.

The bovine stomach is comprised of four chambers, the rumen, reticulum, omasum and abomasum. Actinobacillosis occasionally occurs in the wall of the bovine rumen or reticulum and the gross pathology includes a nodular or ulcerative lesion with marked development of fibrous tissue in the wall of the organ. Any generalised peritonitis will be apparent by inflammation and adhesions over the surface of the organs and often to the posterior aspect of the diaphragm.

Johne's disease is characterised by chronic, granulomatous degenerative enteritis that causes intermittent but persistent diarrhoea, progressive weight loss, and eventual death. Animals presented for slaughter with long standing Johne's disease are often detected by examination of the gastrointestinal tract, mesentery and mesenteric lymph nodes with thickening and

corrugation of the jejunal wall a feature of this disease (Thompson, 2004). In less advanced cases, lesions are generally confined to small areas of the intestine and individual lymph nodes and may only be diagnosed by histopathology (Worthington, 2004). Johne's disease mainly affects dairy cattle in New Zealand (Vermunt and Parkinson, 2000).

Small intestinal carcinomas have very rarely been reported in New Zealand cattle (Johnstone *et al.*, 1983) with gross pathology including thickening and proliferation of the mucosa to form nodular or polypoid masses, which were often associated with areas ulceration and necrosis. Where partial obstruction to the flow of ingesta was present, the thickness of the intestine was increased by dilatation or muscular hypertrophy. The mesenterys and omentum were thickened and nodular while the mesenteric lymph nodes were swollen and nodular. Organs that contained focal nodular metastatic lesions included the liver, kidneys, lungs, ovaries and uterus.

9.3.3. Current procedures

The New Zealand post mortem requirements for the gastro-intestinal tract include examination of the rumen, reticulum, omasum, abomasum, intestines and omental fat by viewing.

Australia requires the gastro-intestinal tract to be examined by viewing with the exception of the oesophagus which is only required to be examined by viewing when saved for human consumption.

The US requires the abdominal viscera and oesophagus to be examined by viewing and the rumino-reticular junction to be examined by viewing and palpation.

Canada requires the oesophagus, rumen, rumino-reticular junction, reticulum, omasum and abomasum to be examined by viewing and does not describe examination procedures for the intestines or omental fat apart from examination of omental and mesenteric fat if saved for human consumption to ensure freedom from contamination.

The EU requires examination by viewing of the oesophagus, the gastro-intestinal tract, the mesentery and the gastric lymph nodes; and by palpation and, if necessary, incision of the gastric lymph nodes. Examination of omental fat is not described.

9.3.4. Scientific evaluation

There is consensus amongst regulatory authorities that the gastro-intestinal tract requires no more intensive examination than that provided by viewing. The requirement to view the mesenteric lymph nodes ensures that on occasions the examiner will need to reposition the gastro-intestinal tract but otherwise refrain from handling the material.

There is no reported condition that provides any indicator value for the routine examination of the omental (caul) fat. If the tissue is saved for human consumption, then it should be examined on both sides, primarily to ensure freedom from contamination.

The gastro-intestinal tract, including the mesenteric lymph nodes, is significant with respect to the animal health surveillance programmes for both bovine tuberculosis and Johne's disease.

9.3.5. Recommendation for examination of the gastrointestinal tract

The gastro-intestinal tract should be examined by viewing.

9.4. HEAD

9.4.1. Food safety

The only condition that could be considered as posing a risk to public health that may be detected in the bovine head is *T. saginata*.. Probabilistic risk modelling has indicated that the risk to consumer infection by *T. saginata* by consumption of New Zealand's export beef is around 0.50 infections per year and increasing to 0.61 infections per year if there were no specific procedures to detect *T. saginata* (van der Logt *et al.*, 1997). New Zealand is regarded as having a very low prevalence of *T. saginata* with all human infection acquired overseas and no established endemic life cycle of the parasite.

Another zoonotic condition that may be present in the bovine head is *T. gondii*, however this is not detectable by organoleptic post mortem examination..

The possibility of meat borne transmission of *Mycobacterium bovis* to humans has been discussed in previous sections. A recent study has shown that infection of bovine head lymph nodes occurs in a third of all cases submitted for laboratory confirmation and the head remains an important area for examination to detect this disease. (MAF Anon c, 2011). The parotid, medial retropharyngeal and submaxillary lymph nodes are required to be examined by incision and it is in the interest of New Zealand's livestock industry for this level of examination intensity to continue.

9.4.2. Suitability

Conditions that affect suitability that may be encountered in the head include squamous cell carcinoma, bovine tuberculosis, actinobacillosis and actinomycosis. Other infectious agents such as *Moraxella bovis* (pink eye) and parapox virus infection (pseudocowpox) may be restricted to the cornea, conjunctiva and skin, and have no relevance to the consumer.

Actinobacillus lignieresii is a commensal of the oropharynx and rumen in cattle and occasionally the organism may cause pyogranulomatous inflammation, especially of the upper alimentary tract. This organism can give rise to discrete granulomatous lesions of the oral cavity and tongue, known as "woody tongue". Small lesions occasionally are detected in and generally restricted to the tongue although rarely a primary infection of the oral cavity and tongue may give rise to involvement of the efferent lymph nodes, in particular the parotid, retropharyngeal and bronchial lymph nodes (Hungerford, 1975). This organism is now regarded as belonging to the Mannheimia species (Blackall *et.al.*, 2002)

Infection of cattle by *Actinomyces bovis* is usually manifested as mandibular osteomyelitis (Jubb *et al.*, 1993) and should be distinguished from chronic granulomatous infections caused by *Actinobacillus lignieresii*, *Arcanobacterium pyogenes*, *Staphylococcus aureus*, *Nocardia* spp and *Aspergillus fumigatus* that generally do not infect bone. The mandibular enlargement is usually obvious upon viewing and there may be accompanying fistula into overlying soft tissue that discharge through skin or mucous membranes.

Eosinophilic myositis may occur in head muscles.

Infectious keratoconjunctivitis in cattle is associated with infection by *Moraxella bovis*. The condition is usually seen in late spring and summer in young animals and it has been suggested that the condition is initiated by *M. bovis* before other agents, including mycoplasma and rickettsia, invade causing a more serious keratitis (Rosenbusch and Ostle, 1986). This condition is considered the most common disease of the bovine eye in New Zealand (Vermunt, 2000) and in cases of severe purulent keratoconjunctivitis is thought to also involve the bacterium *Branhamella ovis*, which is closely related to *M. bovis*, but of low pathogenicity.

There is no evidence of a zoonotic pathway from this condition.

Skin diseases include papillomatosis, dermatophytosis, dermatophilosis, spring eczema, and photosensitisation due to sporidesmin toxicity. Less common diseases of skin include autoimmune disease, lymphosarcoma, granulomatous dermatitis (e.g. due to *Nocardia* or *Mycobacterium* spp), chronic mucosal disease, and malignant catarrhal fever where crusting and alopecia may involve the neck and face of cattle without ocular or nasal discharge (Munday *et al.*, 2008). Papular stomatitis lesions may be found on the mouth, muzzle and nares of affected cattle. The infection is caused by a parapox virus that is not transmissible to humans.

Ocular squamous cell carcinoma is a common abnormality of the head of slaughter cattle in many countries (Carvalho *et al.*, 2005; [Tsujita and Plummer](#), 2010). Although an association between squamous cell carcinoma and the bovine papilloma virus has been described (Newton, 1996); ultraviolet light is considered the most important aetiological agent with potential risk factors including diminished circumocular and corneoscleral pigmentation, breed differences, age and level of nutrition (Vermunt, 2002). If there is any invasion of the osseous structures of the head or metastatic spread to the lymph nodes, most regulatory authorities including New Zealand requires condemnation of the carcass and viscera.

In general, pre-malignant lesions are small, greyish-white, elevated, hyperplastic plaques or papilloma-like structures. Malignant tumours are more irregular, nodular, pink, erosive, and necrotic in nature and such tumours may metastasize along draining lymphatics to regional lymph nodes such as the parotid, retropharyngeal and submaxillary lymph nodes in cases of ocular squamous cell carcinoma (Vermunt, 2002). Any metastatic spread of this neoplasm is considered grounds for total condemnation of the carcass and all parts for wholesomeness purposes. Most affected animals presented for slaughter are identified at ante mortem inspection and closely examined post mortem.

9.4.3. Current procedures

The New Zealand requirement for post mortem examination of the head of adult cattle is for all surfaces to be viewed after removal of the skin, hair and any loose material in the buccal cavity. This standard is irrespective of whether head tissue, including the tongue, is recovered for human consumption. The parotid, medial retropharyngeal, submaxillary lymph nodes are required to be examined by incision and viewing. The masseter muscle is required to be incised twice and viewed for product going to the EU, and incised once and viewed for all other markets. The pterygoid muscle is required to be incised once and viewed. New Zealand processors have the option of training their staff in boning and offal rooms in the detection of *T. saginata* and dispensing with incision and examination of masseter and pterygoid muscles on the slaughterfloor (TD 03/165). This option is being used in some bovine export premises.

Australia requires either the head to be examined by observing the external surfaces and the oral, buccal and nasal cavities or the head may be removed and discarded without inspection where tissues, including tongue, are not recovered for human consumption. That country considers that the head has no indicator value towards disposition of the carcass and viscera and the latter option applies to animals other than those subject to conditional slaughter or emergency slaughter in an area in relation to which the relevant authority requires minimal risk inspection for tuberculosis and is considered an equivalent procedure. For these animals, the parotid, retropharyngeal and submaxillary lymph nodes are required to be either examined by viewing or they may be excised and discarded without inspection. Australia requires the masseter muscle to be incised twice and viewed for product going to the EU, and incised once and viewed for all other markets. The pterygoid muscle is required to be incised once and viewed.

Canada requires that the head must be examined before the carcass passes the final inspection station. Head inspection shall not commence until the head is clean and properly prepared and presented. This includes being free of hair, pieces of skin, contamination, horns and the palatine tonsils removed. The head is to be visually examined, including the eyes and tongue, to detect any dressing fault and abnormality. The medial and lateral retropharyngeal, parotid and mandibular (syn. submaxillary) lymph nodes are required to be exposed, examined visually and carefully incised. Both the masseter and pterygoid muscles are to be incised once and examined by viewing.

The US require the head surfaces and eyes to be observed and examined for sanitary dressing defects as including hair, hide, ear canals, lips or horns, ingesta and bruises. The extent of the head surfaces to be examined is not described nor whether the oral, buccal and nasal cavities are to be examined. The mandibular, parotid, medial and lateral retropharyngeal lymph nodes are to be incised and observed. Both the masseter and pterygoid muscles are to be incised once and examined by viewing.

The EC requires visual inspection of the head and throat and the tongue must be freed to permit a detailed visual inspection of the mouth and fauces. The tonsils are to be removed. The sub-maxillary, retropharyngeal and parotid lymph nodes are to be excised and examined. The masseter muscle is to be incised twice and examined by viewing and the pterygoid muscle examined by one incision and viewing.

9.4.3.1. Tonsils

Both Canada and the EU require the palatine tonsils to be removed, to expose the retropharyngeal lymph nodes, before examination of the head takes place while neither Australia nor the US have any requirement to examine or remove the tonsils. There has been no demonstrated reason from within New Zealand for their continued examination, nor has there been any demonstrated rationale for their removal prior to presentation to the inspector.

9.4.3.2. Head skinning

The current standard of presentation require the bovine head to be completely skinned and washed free of all ingesta and loose material irrespective of the eventual destination of the head and tongue. However the possibility of presenting the head with sufficient skinning to allow for relevant examination of those sections of the head that may be recovered for human consumption, such as the masseter and pterygoid muscles, should be considered.

The examination of the eye and surrounding tissues along with the external rim of the orbit is required to establish that the head is free of squamous cell carcinoma and any local metastatic spread. For this to occur, the head must be skinned sufficiently to expose the mandible, eyes and orbits. There are no reported conditions restricted to the underlying cranium dorsal to the eyes and mandible that have any bearing on the suitability or wholesomeness of the remainder of the carcass or head meat.

If the head is to be partially skinned and washed, the likelihood of contamination of exposed masseter muscles must be considered and avoided. The tongue should be presented dropped and free of contamination so that adequate examination can occur.

9.4.4. Scientific evaluation

A risk assessment of post mortem inspection procedures for the heads and tongues of adult cattle and very young calves slaughtered in New Zealand was carried out in 1999 (MAF Regulatory Authority) and concluded that none of the current routine post mortem examination procedures for the external masseter and pterygoid muscles provided any indicator function to assist in the disposition of the tongue, carcass or viscera for public health reasons apart from the very few animals in which *T. saginata* may be detected. The severity of adverse effects in cases of human infection is usually mild compared to those of many other food borne diseases.

The study indicated that xanthosis was the only abnormality that was occasionally detected by viewing however in these cases the condition also involved the heart and diaphragm and was likely to be detected in those tissues. The study also showed that there were no abnormalities of the masseter and pterygoid muscles that assisted with disposition of the tongue, and that there was a negligible contribution to be made to public health by viewing the external surfaces of the head or the nasal cavities. Similarly, there was nothing to be gained in terms of protection for the consumer from examination of the skinned head apart from the eyes, associated orbits and mastication muscles.

Furthermore, the same study demonstrated that application of targeted intensive post mortem examination procedures for *T. saginata* in New Zealand have no benefits in terms of reducing risks to human health, with the risk of human infection remaining at extremely low levels irrespective of targeted examination procedures. The only value for continued examination of the masseter and pterygoid muscles in New Zealand slaughter cattle is to assist detection of sporadic outbreaks.

Of laboratory submissions that have been made for *T. saginata* since 2000 in which the tissue was identified, approximately a third included cheek musculature and in those animals in which the parasite was confirmed by histopathology, almost a quarter had the parasite detected within the cheek muscles. This ratio is in contrast to European establishments in which almost all infected animals are found to have the parasite in cheek muscles; however it is probable that lack of incision of the heart required by the EU is a factor in this disparity. The sensitivity of routine post mortem meat inspection for *T. saginata* is very low, particularly in lightly infested animals, and this means a significant proportion of individual carcasses containing cysts will pass undetected. The important parameter of carcass and viscera examination for *T. saginata* is the total volume of muscle examined in those sites that have been shown to have the highest cyst density such as heart and masseter muscles. In comparison to other countries, New Zealand examines more tissue for *T. saginata* by viewing, palpation and incision than does Australia, the US, Canada or the EU despite having an extremely low prevalence of the parasite.

Given New Zealand's extremely low prevalence of this parasite and lack of endemic cycling, a high intensity of examination is not justified. The overriding reason for bovine post mortem examination procedures directed towards the detection of *T. saginata* in New Zealand should be to increase the likelihood of the detection of a more than an isolated infection; either a cluster or an outbreak. An examination procedure that continues to provide adequate sensitivity would be one incision of both the masseter and pterygoid muscles along with the existing number of incisions into the heart since these two tissue sets provide almost all of the positive submissions for New Zealand cattle. This would align the examination procedures of New Zealand with those of Australia, Canada and the US for the bovine head.

9.4.5. Recommendations for examination of the head

The head should be examined by viewing and the masseter and pterygoid muscles should be incised once and examined by viewing.

The parotid, medial retropharyngeal, submaxillary lymph nodes should be examined by incision and viewing while the tonsils should not be required to be examined

The head should be sufficiently skinned to allow for examination of the eyes and surrounding orbits along with the masseter muscles and should be sufficiently clean to allow for the tongue and oral mucosa to be examined.

9.4.6. Animal health surveillance

The bovine head, being the portal to both the alimentary and respiratory tracts, is one of the main sites for the detection of bovine tuberculosis. With a third of all confirmed cases of bovine tuberculosis having affected head lymph nodes (MAF Anon c., 2011), the need for continued intense examination of the submaxillary, parotid and medial retropharyngeal lymph nodes is indicated. As the number of cases of bovine tuberculosis diminishes, the necessity of such infections being detected increases.

Examination of the oral mucosa is necessary to detect diseases that manifest as lesions of the tongue and buccal mucosa. These include mucosal disease as well as some exotic diseases, such as foot and mouth disease and vesicular stomatitis. Should any exotic disease enter New Zealand, it is highly unlikely that it will remain undetected until affected cattle carcasses are presented for post mortem inspection, however any vesicles observed on the tongue or oral mucosa should be drawn to the attention of the MPI veterinarian.

9.5. HEART

9.5.1. Food safety

Of the known food borne pathogens that present a public health risk to the consumer, *Salmonella* spp. have been reported as producing gross pathology in the bovine heart including subserosal petechial haemorrhages (Wray and Wray, 2000). However, these changes are in young animals that are dying of acute salmonellosis and very unlikely to be presented for slaughter.

Generalised conditions such as septicaemia and toxæmia frequently result in gross pathological changes in the heart (Jubb *et al.*, 1993) which include cloudy swelling, fatty degeneration, petechial haemorrhages and blood stained fluid in the pericardial sac. The

nature and severity of these conditions means that most septicaemic or toxæmic animals will not be presented for slaughter.

The heart is considered a site of predilection for *T. saginata* and Canadian studies have shown the heart to have the highest density of cysts in trials carried out with experimentally infected cattle (Scandrett *et al.*, 2009) with the masseter and pterygoid muscles being the second most densely infected tissues. Many other studies of both naturally and experimentally infected cattle have confirmed the heart as a site of predilection for this parasite (Minozzo *et al.*, 2002; Wanzala *et al.*, 2003; Lopes *et al.*, 2010).

9.5.2. Suitability

Most infectious febrile conditions and toxicities result in some degenerative change to the myocardium or myocarditis and primary disease confined to the pericardium is rare (Jubb *et al.*, 1993) Fibrinous pericarditis usually results from haematogenous infections while purulent pericarditis occurs almost solely in cattle as a result of traumatic penetration by a foreign body originating in the reticulum. Infectious agents that have been reported as infecting the bovine heart include *Arcanobacterium* spp., *Clostridia* spp., *Haemophilus somnus*, *Pasteurella* spp., and *Salmonella* spp. (Braun, 2009).

In some prolonged debilitating diseases in cattle, subendocardial mineralisation in the atria and left ventricle may accompany endocardial fibrosis when these cavities are acutely dilated. Many bacteria are capable of causing acute valvular endocarditis and in cattle *Actinomyces pyogenes* is probably the most common pathogen with the primary site of infection found at another site, such as a traumatic peritoneal abscess, hepatic abscess, mastitis or metritis (Jubb *et al.*, 1993). Other causal organisms include *Streptococci* spp..

Other localised conditions include abscesses and infarcts. Abscesses resulting from a bacteraemia may be at any stage of pathogenesis, including chronic mineralisation. Other miscellaneous conditions of the heart include hypertrophy, physiological dilatation, agonal haemorrhages resulting from electrical stunning, melanosis and imperfect bleeding with congestion and a left ventricle full of blood.

Neoplasms of the bovine heart are infrequently detected and whereas primary neoplastic disease of the heart is rare, metastases in the myocardium from primary tumours in other organs are more common (Jubb *et al.*, 1993) especially haemangiosarcoma and lymphoma. Haemangiosarcoma may be primary or secondary tumours in the myocardium, most commonly around the right auricle while lymphoma may be nodular or diffuse.

Rhabdomyoma are anomalous formations of myocardial fibres detectable as one or more discrete but non encapsulated nodules. These are rare lesions and seen as grey nodules anywhere in the heart. Neurofibroma (or schwannoma) are isolated or multiple benign neoplasms of peripheral nerves and when the heart is involved, the tumours are single or multiple, round or nodular masses, either on the epithelial surface or within the myocardium (Jubb *et al.*, 1993).

9.5.3. Current procedures

The New Zealand post mortem requirements for the heart are; to observe and palpate all external surfaces of the heart, to incise the left ventricle from apex to base and through the interventricular septum and the atrioventricular orifices, to observe the internal surface and muscular surfaces exposed by incisions and then incise both parallel to and within both cut

surfaces of the interventricular septum and examine by observation and palpation. These procedures proscribe four incisions within the myocardium as well as dividing the interventricular septum.

Australia requires the external & internal surfaces of the heart to be palpated after being opened by the company. The examiner is to make three or four incisions into internal musculature and observe.

Canada requires the heart of all cattle and calves over the age of six weeks to be visually examined by one of two procedures; either by making one incision in the musculature that passes through the interventricular septum from base to apex in order to open the heart and expose both ventricles or by everting the heart and making three shallow incisions in the heart musculature.

The US requires the heart to be examined by observing the cut and inner surfaces, after incising the heart from base to apex or vice versa, through the interventricular septum.

The EU requires visual inspection of the pericardium and heart, the latter being incised lengthways so as to open the ventricles and cut through the interventricular septum. In practice, the company may remove the pericardium, trim the atria, incise the left ventricle and present the opened heart to the inspector for viewing.

It is noteworthy that Canada, the US and the EU do not require the heart to be routinely examined by palpation and allow the heart to be visually examined after opening the left ventricle and interventricular septum. Only Australia and New Zealand routinely incise the internal musculature in addition to palpation and opening.

9.5.4. Scientific evaluation

New Zealand requires more intense examination of the bovine heart than do any major trading partners and this is specific to the detection of *T. saginata*.

In contrast to the proportion of cases of *T. saginata* that are identified in New Zealand from lesions in the heart (around 60%), almost all cases identified in the EU are from incision in the cheek musculature. Since carcass distribution of the cysts is likely to be similar worldwide, it could be argued that viewing of the trimmed and opened heart is considerably less sensitive than incision, viewing and palpation of the heart.

In those countries that incise both masseter muscles and the heart (ie non EU countries) most studies have found more lesions located in the heart than masseter muscles (Wanzala *et al.*, 2003; Scandrett *et al.*, 2009; Pearse *et al.*, 2010). The ratio of cysts between the heart and head in these studies ranged from 5.8:1 to 3:1 although recent work in Australia has suggested a much higher ratio for lightly infected animals (Pearse *et al.*, 2010). Canadian studies showed that for the animals in which additional non-traditional sites were evaluated, none yielded higher cyst densities than those traditionally inspected (Scandrett *et al.*, 2009). When only traditional sites (for all animals) were compared, the heart ranked highest overall, although it was not significantly different from the masseter muscle, and was the most frequently affected site. The traditional site of oesophagus was one of the least rewarding of all sites for detection of cysticerci while the heart was confirmed as the preferred site for detection of bovine cysticercosis based on high cyst density and frequency of infection, and greater visibility of gross lesions due to the early inflammatory response in cardiac muscle (Scandrett *et al.*, 2009).

Examination of the heart appears to be the most effective use of post mortem examination effort in the detection of lightly infested animals and should continue with the current number of incisions and intensity of examination.

All other conditions involving gross pathology of the heart should be apparent upon observation.

9.5.5. Recommendations for examination of the heart

The heart should be examined by visual examination of the external surfaces, palpation and incision. The incisions shall be made to firstly open the left ventricle from apex to base and through the interventricular septum and the atrioventricular orifices, and then to incise the myocardium both parallel to and within both cut surfaces of the interventricular septum.

9.6. KIDNEYS

9.6.1. Food safety

Some renal conditions indicate the possibility of zoonotic infections and sequelae of these include nephritis, enterotoxaemia and septicaemia.

Of the common zoonotic organisms that may infect cattle in New Zealand, those most likely to be found within the kidney are leptospires. Leptospiral infection of cattle is not uncommon in New Zealand and most infection of adult cattle is subclinical (Jubb *et al.*, 1993). Cattle have been reported as maintenance hosts for the serovars *L. borgpetersenii* sv hardjo and ballum, and *L. interrogans* sv Pomona (Baker and Lopez, 2004; Rennie, 2005; Heuer *et al.*, 2008).

However, despite the zoonotic potential of these organisms, they have not been implicated as food-borne zoonoses.

9.6.2. Food suitability

The kidney is often involved in generalised pathological conditions and examination of the parenchymous organ may assist in the disposition of the viscera and carcass. In cases of suspected toxaemia or septicaemia, specific bilateral changes in the kidney that are identifiable on organoleptic examination include cloudy swelling, fatty degeneration and petechial haemorrhages.

Nephritis caused by zoonotic pathogens includes infections by leptospires. Gross pathology seen in cattle with acute leptospirosis includes mild icterus, severe anaemia with swollen kidneys that are initially dark but progressing to numerous haemorrhages. As cattle recover, the kidneys present with many small grey interstitial areas of necrosis (Jubb *et al.*, 1993).

The kidney is often involved in generalised pathological conditions and examination may assist in the disposition of the viscera and carcass. In the case of a suspected toxaemia or septicaemia, specific bilateral changes that are detectable by organoleptic examination include cloudy swelling, fatty degeneration and petechial haemorrhages.

Conditions that may be detected in the bovine kidney include infarcts, which are pathology resulting from occlusion of blood supply, Areas of necrosis are replaced by connective tissue

giving rise to a scar. Kidney infarcts can occasionally arise from a pyogenic ulcerative endocarditis or from a pyaemia, with lodgement of septic emboli in the kidney and formation of numerous abscesses in the kidney cortex.

Pyelonephritis is occasionally seen in cattle, particularly cows following parturition and especially where foetal membranes have been retained. The condition is essentially an infection of the renal pelvis with a mixed flora of pathogens including streptococci, coliforms and *Corynebacterium renale*. Since the infection is ascending, the condition may be unilateral or bilateral and if associated with oedema and emaciation or evidence of uraemia, toxemia or pyaemia, warrants total condemnation.

Multiple cysts are occasionally seen in the kidney, are usually congenital and do not present any risk to the consumer. Hydronephrosis is caused by mechanical obstruction to urine flow and similarly presents only as a suitability defect.

Leptospiral infections were once not uncommon in New Zealand cattle although vaccination against three common serovars (Copenhageni, Hardjo and Pomona) is now widespread and the incidence of nephritis seen in slaughter cattle is extremely low. These serovars can be zoonotic although there is no evidence that they can be food-borne. Since the development of effective vaccines, now up to 90% of dairy herds are vaccinated against leptospire serovars (Cranefield, 2000).

Before the eradication of *Brucella abortus* and widespread use of vaccines against leptospiral infections, the main cause of bovine kidneys being rejected was for focal interstitial nephritis. Other reasons included cysts, pigmentation, pyelonephritis, amyloidosis, glomerulonephritis, renal atrophy and agonal haemorrhage. The condition of white spotted kidneys is more commonly seen in young cattle and almost never in adult cattle.

Tumours are rare in the bovine kidney although in leukaemia, the kidneys are enlarged and mottled grey due to lymphatic infiltration. Embryonal nephroma is occasionally seen in cattle situated at the anterior end of the kidney in contact with the adrenal body.

Bovine tuberculosis is very rarely seen in the kidney and this organ has not been submitted as a possible infection site in the last three decades in New Zealand (MAF Anon c, 2011).

Neospora caninum has been recognised as causing abortions and renal pathology in the kidneys of aborted calves with gross pathology including focal nonsuppurative nephritis (Thilsted and Dubey, 1989) however this has not been reported in adult cattle.

9.6.3. Current procedures

The New Zealand post mortem examination requirements are for examination by viewing and palpation of the enucleated kidneys.

Australia requires the enucleated kidneys to be examined by observation and palpation. The US requires the kidneys to be observed and palpated on the carcass without specifying that they be enucleated. Canada requires that the enucleated kidneys are examined either on the carcass or on the viscera table by observation and the EU requires the kidneys to be examined by observation, and, if necessary, by incision.

It is noteworthy that palpation of the kidneys is not required in Canada or the EU and that observation provides sufficient examination intensity for those two competent authorities.

9.6.4. Scientific evaluation

The reported prevalence of deep seated abscesses that are detected upon palpation within the bovine kidney is very rare and almost all defects are discovered by observation. The kidney does have some indicator value towards the disposition of other conditions within the carcass and viscera but in general these will be through the detection of such gross observable pathology as cloudy swelling and nephritis. Anecdotal evidence from meat inspectors suggests that palpation of bovine kidneys does not contribute to information gained by observation with regard to determination of the disposition of carcass or viscera.

There are no reported abnormalities of bovine kidneys of significance to public health that warrant the continued palpation of the kidneys although it is recognised that the organs will need to be handled to observe both sides.

9.6.5. Recommendation for examination of the kidneys

The kidneys should be viewed. The level of examination intensity afforded by viewing of both sides of the bovine kidney should be sufficient to allow for the correct disposition to be made by the examiner of the carcass and remaining viscera.

9.7. LIVER

9.7.1. Food safety

Salmonellosis is one zoonotic infection of cattle that may be evident in the liver as focal necrosis. Infective bovine liver has been reported as the dominant source of human infection for *Salmonella* Dublin (Lester *et al.*, 1995) while others have shown that *S. enteritica* is readily translocated via efferent lymphatics in cattle and may be recovered from liver tissue (Pullinger *et al.*, 2007) shortly after the organisms reach the mesenteric lymph nodes.

Other researchers have isolated STEC from the liver of healthy cattle (Keen *et al.*, 2010). There have been reported cases of people infected by STEC through the consumption of raw beef liver although it was not apparent whether the liver was contaminated post slaughter with enteric contents or was infective preslaughter (Widiasih *et al.*, 2003).

The same authors reported studies of *Yersinia pseudotuberculosis* in mice that showed the translocation of the organism from the intestine to the liver by a route that bypassed Peyer's patches and replication in intestinal lymph nodes although this may not be relevant to bovine yersiniosis.

Studies have shown that *Campylobacter* species can be recovered from bile in many healthy slaughter cattle and from the livers of some of these animals (Enokimoto *et al.*, 2007; Matsumoto *et al.*, 2008) which indicates that both livers and bile could be an important source of contamination of *Campylobacter* species. The species identified were *C. coli*, *C. fetus* and *C. jejuni*. The capacity to withstand the biliary environment by *C. jejuni* has been demonstrated by others (Fox *et al.*, 2007).

Several studies from countries with high prevalence rates of *T. saginata* in cattle and humans have reported greater numbers of cysts within the parenchyma of bovine liver than the heart (Wanzala *et al.*, 2003) and head (Adewole, 2010) although this has not been a feature of experimentally infected cattle in a Canadian study where no cystercerci were recovered from

the liver (Scandrett *et al.*, 2009). In such countries with a culture of consumption of raw beef liver, this means of human infection would be important.

9.7.2. Suitability

A literature search indicates that the bovine liver is one of the most important tissues to be examined with respect to appropriate dispositions being made on viscera and carcasses. The liver is central to the processes of detoxification and biotransformation of substances absorbed from the gastro-intestinal tract, in addition to its role of excretion and synthesis. Changes in colour, consistency, size and structure of the liver are all important indicators when differentiating between localised and systemic conditions. The gross pathological lesions in some cases may be pathognomonic for specific diseases although liver lesions are common and indicate the presence and causes of diseases in other organs and systems (Jubb *et al.*, 1993).

Bacterial hepatitis is common, but, with a few important exceptions, is usually focally distributed and of little clinical significance. Bacteria may gain entrance to the liver by direct implantation (such as via a foreign body); by invasions through the capsule from an adjacent suppurative peritonitis; haematogenously via the hepatic artery or portal vein; or via the bile ducts (Jubb *et al.*, 1993). Localised abscessation is relatively common in cattle and is thought to be caused by pathogens reaching the liver from the gastrointestinal tract via the portal vein. Hepatic abscesses are a feature of feedlot cattle which is usually a sequel to rumenitis (Jubb *et al.*, 1993).

Inflammation of the liver can lead to a wide range of gross pathological changes with hepatitis that may be acute, subacute or chronic; suppurative or non-suppurative; focal or diffuse. Agents capable of causing hepatitis include *Salmonella* spp., *Pasteurella* spp., *Leptospira* spp. and *Fusobacterium necrophorum*, viruses, bacteria, spirochetes, fungi and helminths. *Clostridia* spp., especially *C. novyi*, may occasionally infect cattle and cause an infectious necrotic hepatitis known as Black disease and there may be an association with concurrent infestation by *Fasciola hepatica*.

Hepatocellular adenomas are rarely reported in cattle and are usually single and up to 15cm in diameter. Smaller ones project as smooth nodes while larger specimens may be lobate and pedunculated. They are soft and light brown or yellowish and may include haematopoietic foci (Jubb *et al.*, 1993).

Very rarely adenomas are reported from bovine livers as a result of chronic pyrrolizidine poisoning (Fu *et al.*, 2004) with cattle being more susceptible than sheep. Metastatic tumours of the liver are of a wide variety and some of the carcinomas and sarcomas arrive via the lungs and hepatic artery. These may be multiple but are seldom numerous. Metastases arriving via the portal vein such as pancreatic carcinoma, may almost replace the liver before producing clinical signs, such as icterus, caused by either extrahepatic bile duct obstruction or by intrahepatic cholestasis, or both (Jubb *et al.*, 1993).

Hydropic degeneration and cloudy swelling where the liver is enlarged and pale tan, with scattered hyperplastic nodules in long standing cases, may result from hypoxia, ketosis, damage by a wide range of toxins and overload by bile pigment (Jubb *et al.*, 1993). These changes should not be confused with fatty infiltration, which is a normal physiological change that may occur in late pregnancy or heavy lactation.

Livers may exhibit grossly detectable signs of toxicosis. Sporidesmin is rapidly absorbed from the intestine and concentrated within the liver and hepatic bile where the molecule undergoes a glutathione-linked, copper catalysed cycle of oxidation and reduction to produce a toxic free radical superoxide. The resulting liver injury blocks the secretion of phylloerythrin, the breakdown product of chlorophyll, to permit the accumulation of endogenous porphyrins (e.g. haemoglobin and myoglobin) which give rise to jaundice and chronic cirrhosis. Compared to sheep which graze much closer to ground level and more liable to ingest sporidesmin, cattle are much less frequently affected.

A number of plants if ingested may be hepatotoxigenic. In New Zealand, this may include *Solanaceae* spp (nightshade), *Compositae* spp. (rangiora, ragwort), *Leguminosae* (lupins) *Myoporaceae laetum* (ngaio), *Verbenaceae* (lantana) (Connor, 1977). Symptoms vary from cirrhosis (lupinosis, ragwort poisoning) to hepatocellular swelling, hydropic degeneration and apoptosis or shrinkage necrosis (lantana). Pyrrolizidine (as may occur in *Boraginaceae*) poisoning and aflatoxins, from mouldy feedstuff, are liable to produce megalocytosis.

Copper poisoning is rarely reported and usually accidental in cases such as cattle being fed poultry waste that contained copper sulphate used to treat birds for aspergillosis (Tokrinia *et al.*, 2000).

Infection of cattle by *Fasciola hepatica* is considered under bile ducts below.

Pigmentation occurs relatively often. Congenital melanosis may be observable as numerous deposits from flecks to larger bluish-black areas 2 cm or more in diameter (Jubb *et al.*, 1993) Acquired melanosis has been reported in cattle grazing extensive unimproved pasture in certain areas of the world but rarely in New Zealand. Haemochromatosis has been observed in cattle exposed to high levels of iron in pasture and /or water and presents as an enlarged brownish liver with darkened hepatic lymph nodes. Congenital protoporphyria has been reported in Limousin cattle in which the liver exhibits a dark golden brown pigment in the portal areas.

Hepatocellular atrophy can occur as a result of severe malnutrition such as in aged cattle with poor teeth. The liver will appear dark and small with wrinkling of the capsule (Jubb *et al.*, 1993) and may appear firmer than normal. Atrophy of the liver can result from reduced blood or bile flow adjacent to space occupying lesions in the liver or chronic pressure from a distended rumen.

Developmental abnormalities include; intrahepatic congenital cysts which contain clear, serous fluid of no consequence to human health, and congenital vascular shunts which rarely allow for the animal to be presented for slaughter.

Telangiectasis is a cavernous ectasia of groups of sinusoids seen occasionally in cattle. These lesions have no functional significance and may be seen throughout the liver parenchyma as dark red areas, irregular in shape, well circumscribed and ranging from 1 mm to several cm in diameter (Jubb *et al.*, 1993) The absence of clinical symptoms of related liver dysfunction indicates that this condition has no relevance to human health.

9.7.3. Current procedures

The New Zealand post mortem examination procedures require the liver to be examined by viewing and palpation of both the parietal and visceral surfaces. These procedures are

required irrespective of whether the liver is saved for human consumption. Australia, Canada, the EU and the US all require the liver to be examined by viewing and palpation.

9.7.4. Scientific evaluation

It is recognised that the liver is one of the most important organs to be examined during slaughter and has a high indicator function towards disposition of the carcass and other viscera since it acts as a filter interposed between the portal and systemic circulatory systems.

This importance is also recognised by other competent authorities and there is no indication that the level of examination intensity should be reduced for the bovine liver within New Zealand slaughter cattle.

9.7.5. Recommendations for examination of the liver

The liver should be examined by viewing and palpation

9.7.6. Animal health surveillance

The bovine liver has some relevance to the current animal health surveillance programmes in New Zealand with respect to bovine tuberculosis. Although the detection of tubercular lesions within the liver is rare now with almost all lesions detected with lymph nodes of the head, thoracic cavity and mesentery, approximately 1.5% of all single lesion submissions over the past two decades have been from the liver (MAF Anon c, 2011).

In advanced cases of Johne's disease in cattle, multiple focal granulomas have been described in the liver, hepatic lymph nodes and very rarely the kidneys and lungs (Jubb *et al.*, 1993). In New Zealand, the liver is not considered of significance in monitoring the prevalence of *T. saginata*.

9.8. BILE DUCTS

9.8.1. Food safety

The possibility of the meatborne zoonotic potential of *F. hepatica* has been suggested based on the successful oral inoculation of mice and piglets with metacercariae and immature flukes (Taira, 1991). Although the results of the experiments suggest that humans consuming raw dishes, such as pâté, prepared from raw fresh bovine livers infected with immature *Fasciola* spp. could become infected with liver fluke, the most common food borne transmission route of *Fasciola* spp. to humans is via the ingestion of watercress contaminated with encysted cercariae (Slifko, 2000).

However, the indicator function of organoleptic examination of either bile ducts or the liver will be negligible since any metacercariae or immature flukes small enough to survive comminution during pâté production will not be detectable by organoleptic examination. Grossly observable pathology of bovine bile ducts will indicate that mature flukes are or have been present in the bovine liver but not necessarily the presence of metacercariae. It is clear that application of targeted intensive post mortem examination procedures for *F. hepatica* have no benefits in reducing risks to human health.

There is some recent debate over the role of the bovine gall bladder and bile as a focus of STEC O157 colonization in cattle (Stoffregen *et al.*, 2004; Jeong *et al.*, 2006; Reinstein *et al.*, 2007) with the latter study indicating that *E. coli* O157:H7 in the gallbladders of naturally shedding cattle is a rare occurrence and concluding that the gallbladder of cattle is not a common site of prevalence of *E. coli* O157:H7 and therefore is not likely to serve as a source for faecal shedding or contamination of meat during processing.

A number of studies indicate that bile may contain *Campylobacter* species in healthy slaughter cattle (Enokimoto *et al.*, 2007; Matsumoto *et al.*, 2008).

9.8.2. Suitability

The predominant feature of abnormal bile ducts in New Zealand cattle is the presence of *F. hepatica*, a worldwide parasite. Various stages of the trematode's life cycle may be present in the bovine liver at slaughter from the migrating metacercariae (diameter < 0.5 mm) to immature flukes to sexually mature flukes (length 2.5 – 3.0 cm) approximately three months after infection. Adult flukes may survive for many years. The gross pathology in bovine bile ducts begins with desquamative and ulcerative lesions within the large bile ducts and progresses to thickened bile duct walls lined with granulation tissue which may be mineralized (Jubb *et al.*, 1993).

Adenomas of the gall bladder have been rarely reported in cattle (Jubb *et al.*, 1993) as cholangiocellular adenoma but not involving the bile ducts.

Within domestic animals, there is a lack of association between viruses, chemical carcinogens, mycotoxins and drugs with hepatobiliary neoplasms as is known to occur in humans with the rare exception of localised, polypoid foci of cystic hyperplasia being specific changes in cattle poisoned by highly chlorinated naphthalene (Jubb *et al.*, 1993). Such cattle are extremely unlikely to be presented for slaughter in New Zealand.

Biliary hyperplasia is a characteristic reaction of the liver to particular insults such as the toxicoses of phomopsin (from lupins), pyrrolizidine alkaloids (from *Heliotropium* or *Echium* spp.) and aflatoxin. However, residual levels of these toxins in otherwise healthy cattle presented for slaughter will have no significance for the consumer.

9.8.3. Current procedures

The New Zealand post mortem examination procedures require the major bile ducts anterior and posterior to the cystic duct to be opened by incision and the contents viewed. The bile ducts in the renal impression are to be incised and the contents viewed. These procedures are required irrespective of whether the liver is saved for human consumption.

Australia requires the main bile ducts to be incised transversely and contents observed. However, these procedures for the incision of the main bile ducts and observation of contents may not be required at a meat business by the controlling authority.

Both Canada and the US requires the bile ducts to be opened longitudinally and inspected for the presence of liver flukes while the EU requires incision of the gastric surface of the liver and at the base of the caudate lobe to examine the bile ducts.

9.8.4. Scientific evaluation

The New Zealand requirements for examination of the bile ducts for liver flukes have been drawn up to include both the US and the EU requirements so that the major bile ducts are opened longitudinally followed by a transverse incision across the base of the caudate lobe. Although one study carried out in the US (Ciolfi, 1985) concluded that longitudinal incisions had a greater sensitivity for the detection of distomiasis (liver fluke) than did transverse incision, New Zealand has persisted with both areas of incision to meet the requirements of both competent authorities.

The disposition judgement relating to the detection of liver fluke in the bile ducts is for severely affected livers to be condemned while livers not severely affected may be saved for pet food. These judgements have little scientific basis as livers that are severely affected by liver fluke will not present any more risk to pets (cats and dogs) than those less affected; the difference being in the degree of pathological change, not the presence or absence of a microbial threat to the health of the pet. The only possible risk is through the consumption of metacercariae as outlined above and the presence of these is unrelated to any detectable gross pathology.

Post mortem examination of the bile ducts should be restricted to the production of wholesome livers and to provide important animal health information to the producer. The sensitivity of the post mortem procedure should be sufficient to provide the most information with the least effort and the US data suggests that transverse incision of the base of the caudate lobe does not add to the information gained by longitudinal incision of the major bile ducts.

There is also unlikely to be any increase in risk to the consumer if the bile ducts were incised by the processor prior to viscera examination as the disposition of affected livers being consigned to pet food or condemned will still be available from the gross pathology after duct incision. This task is one that could easily be carried out in association with the separation of the organ from the GIT and presentation to the examiner. Unlike the advantage of the person incising the organ/tissue being the examiner when inspecting for *T.saginata* when the sensation of incising a partially calcified cyst is an integral part of the sensitivity of detection; with fascioliasis the identification of the condition is achieved by viewing the thickness of the biliary ducts and observation of their contents.

9.8.5. Recommendations for examination of the bile ducts

It is recommended that examination of the bile ducts is required on the grounds of wholesomeness and not food safety. The major bile ducts should be opened longitudinally and the contents inspected.

Incision of the major bile ducts prior to examination by the inspector should have no relevance to the disposition of the organ being determined by the examiner.

9.8.6. Animal health surveillance

F. hepatica can be a serious impediment to stock health if suppliers are unaware of its presence in their herds. Many commonly used anthelmintics are either not effective against *F. hepatica* or only against adults rather than immature flukes. Seasonal variability in pasture supply and extent of habitat for the intermediate host give rise to an intermittent problem for

many cattle breeders, who rely on detection at slaughter to confirm if selective treatment is required.

This function of post mortem examination of the bovine liver is important to the New Zealand meat industry.

9.9. HEPATIC LYMPH NODES

9.9.1. Food safety

Any potential zoonotic pathogen present in the liver could be present in the hepatic lymph nodes however, despite this possible haematogenous source of infection, very little pathology is detected within these lymph nodes in slaughter cattle. *Salmonella* spp. have been recovered from the bovine hepatic lymph node (Hathaway *et al.*, 1993) but this was from a very young calf for which the mode of infection was most likely via the umbilicus.

The prevalence of lesions caused by *Mycobacterium bovis* in the hepatic lymph node is very low (Corner, 1994; Whipple *et al.*, 1996; Barthel, 2000; MAF Anon. c, 2011)

9.9.2. Suitability

In one study of fifty one cattle infected with Johne's disease, it was reported that fourteen animals had some liver pathology, and of these only four animals had slight infiltration of the hepatic lymph nodes with Langhans' giant cells (Buergelt *et al.*, 1978). The significance of the infiltration was limited since it was not obvious grossly and acid fast stains were negative for *M. paratuberculosis*.

9.9.3. Current procedures

The New Zealand post mortem examination procedures require the hepatic lymph nodes to be examined by incision and viewing. These procedures are required irrespective of whether the liver is saved for human consumption.

Canada and the US require the hepatic lymph nodes to be examined by incision and viewing while Australia and the EU require examination of the portal lymph nodes by observation and palpation.

9.9.4. Scientific evaluation

Anatomically the hepatic lymph nodes (Sisson and Grossman, 1975) are described as being situated in and ventral to the portal fissure, with most grouped around the portal vein, hepatic artery and bile duct; and covered by the pancreas. Some may be ventral to the pancreas. Their length varies from 1 to 7 cm with afferent vessels coming from the liver, pancreas, duodenum and ventral abomasal lymph nodes.

A wide range of pathological conditions affect the liver and an abnormal hepatic lymph node in the absence of gross liver pathology could be indicative of a localised pathology that is not detectable by routine organoleptic examination. However, it is noteworthy that one previous study of very young cattle in New Zealand indicated that the hepatic lymph nodes were poor gross indicators of a possible septicaemia (Hathaway *et al.*, 1993).

The rationale and primary purpose given by the US for examination of the hepatic lymph nodes is to detect septicaemia, pigmentary changes associated with liver flukes and carotenosis which is a yellow-orange discoloration of the liver; and neoplasia, with a secondary purpose in the detection of bovine tuberculosis. However, when comparing the traditional procedures including incision of the hepatic lymph nodes with those for high speed lines where the hepatic lymph node is required to be examined by observation only, the US task force agreed that “the test data confirmed that the new procedure for steers and heifers was as effective as the traditional procedure and more effective for liver inspection” (Wesson, 1983).

Gross pathology with respect to septicaemia will not be restricted to the hepatic lymph node and the indicator value of examination of this lymph node for this condition will be minimal. Bovine fascioliasis has no public health significance and will be detected by examination of the bile ducts rather than the hepatic lymph nodes.

With respect to the detection of bovine tuberculosis in New Zealand, a recent study has indicated that the sensitivity of examination and likelihood of detection of tuberculosis in New Zealand will have a negligible reduction, if incision of the hepatic lymph nodes is removed from the list of routine bovine post mortem examination procedures. Corner (1994) concluded that careful examination of six pairs of lymph nodes along with the lungs and mesenteric lymph nodes would identify at least 95% of infected animals which concurs with the later work done in New Zealand (MAF Anon c, 2011). These did not include the hepatic lymph nodes.

9.9.5. Recommendations for examination of the hepatic nodes

Since there is no condition reported to be restricted to the hepatic lymph node that may only be detected by incision, there is no demonstrated need within New Zealand cattle to continue with incision of the hepatic lymph nodes and they should be examined by viewing and palpation.

9.9.6. Animal health surveillance

Examination of this lymph node for bovine tuberculosis has little relevance to the Animal Health Board programme. Over the past two decades, bovine tuberculosis has been detected within the hepatic lymph nodes in 0.31% of all submissions and it has been estimated that the effectiveness of detecting an infective line of tubercular cattle without any examination of the hepatic lymph node would be more than 99.8% of the likelihood if examination of this lymph node was retained (MAF Anon. c, 2011).

In advanced cases of Johne’s disease in cattle, multiple focal granulomas have been described hepatic lymph nodes (Jubb *et al.*, 1993) but given that it is generally restricted to the gastro-intestinal tract, mesenteric lymph nodes and mesentery; examination of the hepatic lymph nodes has no significant role to play in the detection of this disease for animal disease surveillance purposes.

9.10. LUNGS

9.10.1. Food safety

Of the several enteric zoonotic pathogens that present a risk to public health, *Salmonella* species and *E.coli* can give rise to an acute interstitial pneumonia which arises from the associated endotoxaemia and septicaemia (Pohl *et al.*, 1993; Watson *et al.*; 1998, Geue *et al.*,

2002). The alveolar septal lesions are distributed widely throughout the lungs with great distribution of lesions in infectious lobar and bronchopneumonia (Jubb *et al.*, 1993). It is very unlikely that gross pathology will be restricted to the lungs.

Several serotypes of *Salmonella* are involved in enteric disease of cattle in New Zealand (Vermunt and Parkinson, 2000), although the predominant pathogenic serotype is *S. Typhimurium*.

Bovine tuberculosis has been rarely detected within the lung parenchyma in New Zealand over the previous two decades with only 1.51% of single lesion submission coming from lungs in that time (MAF Anon c, 2011). However the prevalence of confirmed lesions detected the lungs rises markedly in those animals with two (10.82%) or more lesions (33.3%), which reflects the importance mode of infection by pathogens that invade the lung tissue. It also probably demonstrates the low sensitivity of examination of the lungs, even by palpation and observation, since most primary lesions in the pulmonary parenchyma can be very small and difficult to detect (Jubb *et al.*, 1993). Primary lesions are regarded as occurring predominantly in the dorsocaudal portions of the caudal lobes.

In comparison to lesions within lung parenchyma, bovine tuberculosis was confirmed in thoracic lymph nodes in over 50% of cases in the study. For these reasons, examination of the thoracic lymph nodes is of critical importance in assisting the bovine tuberculosis eradication programme

9.10.2. Suitability

Lung pathology is a common post mortem finding in adult cattle although most pathology is restricted to small discrete areas of the lung parenchyma. Pneumonia may range from simple lobar or bronchopneumonia to extensive generalised sero-fibrinous pneumonia.

Abscesses within the lungs may develop from any suppurative pneumonia and bacteria that can give rise to pulmonary pathology include *Arcanobacter* spp., *Haemophilus somnus*, *Klebsiella pneumoniae*, *Mannheimia haemolytica*, *Pasteurella* spp., *Pseudomonas aeruginosa*, *Staphylococcus* spp. and *Streptococcus* spp.. (Jubb *et al.*, 1993; Vermunt and Parkinson, 2000; Nicholas, 2004) Pneumonia caused by *Haemophilus* spp. is known to have a high mortality rate overseas, but has not been reported in New Zealand.

Pasteurellosis in cattle is characterised by either an acute or peracute septicaemia or as a secondary infection, especially following viral disease of the respiratory tract (Jubb *et al.*, 1993). The viruses that have been incriminated as predisposing cattle to severe pasteurella pneumonia include *parainfluenza* 3 virus, BHV -1 and bovine respiratory syncytial virus. A number of serotypes have been isolated with Type A1 being ubiquitous and usually isolated from cattle with pneumonia. This pneumonia has a broncho-pneumonia pattern or, in its most fulminating form, a lobar pattern. The affected lungs are characterised by extensive reddish-black regions of consolidation with prominent gelatinous thickening of interlobular septa and areas of coagulation necrosis (Jubb *et al.*, 1993).

Other viruses known to be present in New Zealand include bovine herpesvirus 1 (BHV-1) which mainly affects animals over 6 months of age. It is usually associated with upper respiratory tract disease and conjunctivitis. Surveys have demonstrated that the virus is widespread in New Zealand, with up to 100% prevalence in some areas (Neilson and Grace, 1988; Horner, 1990). Only one strain of the virus is thought to exist in New Zealand, and the BHV-1 strains that are responsible for producing severe respiratory disease in North America

and Europe are thought not to be present here. Thus, IBR in New Zealand is a mild disease from which recovery takes 7-14 days and for which deaths are rare (Vermunt and Parkinson, 2000)

Pulmonary mycoses have been recorded in cattle, especially from infections of *Aspergillus* spp. *Bordetella bronchiseptica* is an obligate parasite of the upper respiratory tract of a number of animals. *Rhodococcus equi* is a common inhabitant of the alimentary tract, but it occasionally produces lesions in the lungs and lymph nodes, particularly the mediastinal lymph nodes which may resemble lesions caused by *M. bovis*.

The organism that gives rise to contagious bovine pleuropneumonia, *Mycoplasma mycoides* subsp. *mycoides* is not present in New Zealand. Clinical signs include severe fibrinous pneumonia with partial or complete consolidation of one or both lungs. Local lymph nodes are enlarged, oedematous and may contain areas of necrosis. Any incursion of this mycoplasma is more likely to become apparent in a herd than in slaughter cattle.

Dictyocaulus viviparus is the only lungworm of cattle in New Zealand. Overseas, outbreaks in adult dairy cattle nearly always occur because either cattle have not been exposed to sufficient parasitic challenge in earlier life to provide adequate immunity, or immunity has been lost as a result of a lack of re-infestation. The significance of lungworm in adult cattle in New Zealand is debatable since infection with *D. viviparus* occurs primarily in calves below 10 months of age, but clinical lungworm disease is now seen much less commonly since the widespread use of anthelmintics. To date, only one account of a confirmed outbreak of lungworm infestation in a dairy herd has been published (Fairley, 1996).

Neoplasms have been very infrequently reported in the lungs of New Zealand cattle and to date have been restricted to fibroma (Shortridge and Cordes, 1971). Overseas, neoplasms in the lungs have been reported as metastases from primary haemangiosarcomas, which are highly malignant neoplasms that readily invade and metastasise (Scott and Anderson, 1992). Metastasis usually occurs early, since the tumour cells have ready access to blood vessels. The lung is the most common site for metastasis, but metastasis can be found in almost any tissue (Pulley and Stannard, 1990).

Numerous survey articles on bovine neoplasia have been published worldwide, and although the prevalence figures vary between countries, there is general agreement that the most common bovine neoplasms are located in the skin and soft tissues, and include fibropapilloma, fibroma, squamous cell carcinoma and melanoma (Vermunt and Thompson, 2001) but only very rarely, neoplasms of the bovine lungs.

9.10.3. Current procedures

The New Zealand requirements are for the lungs are to be examined by viewing and palpation. When saved for human consumption, the trachea and main branches of the bronchi are to be examined to edible standard by incision and viewing. The right bronchial, left bronchial, anterior mediastinal, middle mediastinal, posterior mediastinal and right apical lymph nodes are to be examined by incision.

Australia requires the lungs to be examined by palpation and when saved for human consumption, the bronchi are to be opened and the internal surfaces observed. The bronchial and mediastinal lymph nodes to be examined by incision or, for animals for which minimal risk inspection for tuberculosis is required (other than animals subject to conditional or emergency slaughter); an equivalent procedure is to observe the lymph nodes.

Canada requires the lungs to be examined by visual inspection and palpation. The right and left tracheobronchial, cranial and caudal mediastinal lymph nodes are to be incised and examined.

The EU requires visual examination and palpation of the lungs; incision and examination of the bronchial and mediastinal lymph nodes (*Lnn. bifurcationes, eparteriales and mediastinales*). The trachea and main branches of the bronchi must be opened lengthways and the lungs must be incised in their posterior third, perpendicular to their main axes; these incisions are not necessary where the lungs are excluded from human consumption.

The US require the lungs to be examined by observing both the costal and ventral surfaces and palpating the costal surfaces. The lymph nodes associated with the lungs are to be incised and observed, including the mediastinal (posterior, middle and anterior) and bronchial (right and left) lymph nodes.

There is variation in the names used in different countries for the thoracic lymph nodes in cattle with the nomenclature used in post mortem procedures reflecting the natural range in number, size and position of lymph nodes observed in thoracic viscera. Canada does not specify examination of the middle mediastinal lymph nodes which are often not clearly distinguishable from the cranial and caudal lymph nodes (Sisson and Grossman, 1975). A more pragmatic description for New Zealand to use in post mortem procedures would be the mediastinal lymph nodes. This will encompass all of those lymph nodes within the mediastinal lymphocentre.

Similarly both Canada and the US do not specify examination of the right apical lymph node although this is regarded as part of the bronchial lymphocentre by some (Sisson and Grossman, 1975). A more useful procedural description to use would be the bronchial lymph nodes to encompass all significant and easily located lymph nodes within the bronchial lymphocentre.

9.10.4. Scientific evaluation

The post mortem examination of the contents of the thoracic cavity is important in assessing the risk to public health. The lungs have a major indicator role to play with respect to such conditions as septicaemia and toxemia which should lead the inspector to condemn all parts of the carcass and viscera. For those reasons, the present procedures for the examination of the lung parenchyma and associated lymph nodes should continue.

The description of the lymph nodes to be incised should be amended to reflect the natural variability of size and location of lymph nodes, and changes in internationally recognised nomenclature, to mediastinal and bronchial lymph nodes.

9.10.5. Recommendations for examination of the lungs

The procedures for the examination of the lung parenchyma should be visual examination and palpation. The associated thoracic lymph nodes should be examined by incision.

The description of the lymph nodes to be incised should be amended to reflect the natural variability of size and location of lymph nodes, and changes in internationally recognised nomenclature, to mediastinal and bronchial lymph nodes.

9.10.6. Animal health surveillance

The main consideration of the lungs and associated tissue in relation to animal health surveillance is in the detection of bovine tuberculosis and of the thoracic contents, the disease is usually detected within the mediastinal and bronchial lymph nodes. In the recent study of bovine tuberculosis in New Zealand (MAF Anon c, 2011), lesions in the tracheobronchial and mediastinal lymph nodes comprised just over 67% of all submissions and along with the lymph nodes of the head, the intensity of examination of these tissues should be maintained.

9.11. OESOPHAGUS

9.11.1. Food safety

This organ is one of the less common sites for detection of *T. saginata* and there has not been one confirmed cestode detected in the oesophagus in laboratory submissions for *T. saginata* between January 2000 and May 2011 in New Zealand. There were six submissions that included tissue from the oesophagus over that period and five of them were shown to be a schwannoma or neurofibroma on histopathology.

This poor rate of detection of *T. saginata* in the oesophagus in New Zealand is matched by Canadian studies into experimentally infected cattle (Scandrett *et al.*, 2009) which confirmed that the traditional site of oesophagus was one of the least rewarding of all sites for detection of cysticerci, even when compared to non traditional sites such as other carcass muscle groups.

Inadvertent contamination with enteric pathogens with the risk of contamination by handling remains the greatest risk to public health from the oesophagus.

9.11.2. Suitability

Occasionally actinobacillosis of the stomach can extend to the lower portion of the oesophagus with grossly overt pathology. Sarcosporidiosis occasionally occurs in the striated muscle of bovines and is associated with eosinophilic myositis. This condition has no relevance to public health other than being mistaken for *T. saginata* by inspection staff.

Infestation by *Gongylonema pulchrum* has been reported in the bovine oesophagus of Europe, Asia, the US and Australia but has not been recorded in New Zealand.

Mucosal disease and malignant catarrhal fever have been reported as producing longitudinal epithelial defects in the bovine oesophagus (Jubb *et al.*, 1993) but neither have any public health significance.

9.11.3. Current procedures

The New Zealand post mortem procedures require that the oesophagus be examined by both viewing and palpation when saved for human consumption. Anatomically the oesophagus is a long flexible tube of a thickness that permits detection of any calcified cyst of a diameter greater than a few millimetres if it is palpated by sufficient pressure from both sides. The oesophagus is usually examined by viewing while running the tube between fingers and thumb from the proximal to the distal end.

Australia does not require routine examination of the oesophagus unless it is saved as an edible product (in which case observation is sufficient) while Canada, the US and the EU require routine examination of the organ by viewing.

9.11.4. Scientific evaluation

Palpation of the oesophagus was introduced to enable detection of *T. saginata* however the extremely rare occurrence of this parasite detected within the bovine oesophagus in New Zealand indicates that there is no demonstrated need to palpate this tissue. An analysis of the submissions made from slaughtered cattle of lesions suspected to be *T. saginata* made between 2000 and 2010 has shown that not one case of positive identification of the parasite has been made from the oesophagus over those years where abnormalities have been detected in one tissue. There have been three separate submissions made out of the total of 188 that have either been solely oesophagus (1), heart and oesophagus (1) and heart, skeletal muscle and oesophagus and in each case histopathology has shown the lesions to be other than from cestode infection.

It would appear that the oesophagus has little indicator function for the detection of *T. saginata* or any other disease in cattle of significance to public health and in the New Zealand situation, where almost all confirmed infections of *T. saginata* are light, any more intense examination of a suspect line should be redirected towards further incision and examination of the heart and masseters, rather than the oesophagus.

9.11.5. Recommendations for examination of the oesophagus

The oesophagus should be examined by viewing only when saved as an edible product.

9.12. PANCREAS

9.12.1. Food safety

The pancreas has not been reported as showing gross pathology in either the acute or chronic form of salmonellosis in an extensive review (Wray and Wray, 2000) or in any of the other potential zoonotic infections.

9.12.2. Suitability

Nodular hyperplasia is occasionally noted by inspection staff, particularly in older animals. In most cases, there is no sign of an antecedent injury while the hyperplasia usually involves only the endocrine tissue. The hyperplastic lobules project as flat, white elevations from the contour of the organ which are hard on palpation

Chronic interstitial pancreatitis very occasionally is reported in cattle (Jubb *et al.*, 1993). The inflamed ducts are a potential site for the development of pancreatic calculi which are small, seldom larger than 5 mm, white, hard and composed of carbonates and phosphates. This condition has no relevance to food safety

Neoplasms that have been reported from the bovine pancreas in one US study (Kelley, 1996) include islet cell tumours, pancreatic exocrine carcinoma, neurofibroma and neurofibrosarcoma. Most of the islet cell tumours had metastasised to the iliac, mediastinal, hepatic and mesenteric lymph nodes along with lesions in the peritoneum, mesentery and

liver, while all of the exocrine carcinoma metastasised widely. It is expected that all animals in which metastases are detected will be condemned. Other pancreatic defects found in the study included nodular hyperplasia, exocrine acinar hypoplasia and fibrosis, pancreatic lithiasis, pancreatitis, peripancreatic fibrosis, pancreatic steatosis and pancreatic haemorrhages.

Other diseases of the bovine pancreas include pancreatic lithiasis, pancreatic creatitis, pancreatic fluke infestation, pancreatic atrophy associated with nutritional deficiencies, and diabetes mellitus as a sequel to infection with the foot-and-mouth disease virus.

9.12.3. Current procedures

New Zealand and Australia require the organ to be examined by viewing only when saved for human consumption while Canada, the US and EU post mortem requirements do not include routine examination of the pancreas

9.12.4. Scientific evaluation

There has been no indicator value demonstrated to justify routine examination of the pancreas and it should continue to be restricted to examination by viewing of the organ only when saved for human consumption.

9.12.5. Recommendations for examination of the pancreas

Examination should be restricted to examination by viewing only when saved for human consumption
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9.13. RUMINO-RETICULAR JUNCTION

9.13.1. Food safety

There are no specific abnormalities of the rumino-reticular junction that have been reported as a risk to the consumer.

9.13.2. Suitability

The major imperative of examination of the rumino- reticular junction is to detect penetration of the region by foreign bodies. Occasionally these can give rise to chronic irritation of the mucous membrane of the anterior wall of the reticulum, ulceration and abscessation that may involve the reticulum, liver and diaphragm. In long standing cases with sharp foreign bodies the object may penetrate the diaphragm and the pericardium giving rise to traumatic pericarditis (Jubb *et al.*, 1993).

9.13.3. Current procedures

The New Zealand post mortem requirements include the examination of the rumeno-reticular junction by viewing and palpation.

Australia and the EU require this section of the gastro-intestinal tract to be examined by viewing, while Canada and the US require the junction to be examined by viewing and palpation.

9.13.4. Scientific evaluation

Any abscessation that has reached the exterior of the rumen or reticulum will be apparent upon viewing. Further extension of the injury to the diaphragm or heart will similarly be apparent and the only purpose of palpation of the rumeno-reticular junction would be to detect any initial pathology and possible a foreign object. Although these should be discarded on suitability grounds, any lesions undetected on the viscera table should be obvious upon opening the rumen and reticulum upon further processing.

9.13.5. Recommendations for examination of the rumino-reticular junction

The continuation of examination by palpation of the rumino-reticular junction in New Zealand for abnormalities is unwarranted and examination procedures should be limited to viewing.

9.14. SPINAL COLUMN

9.14.1. Food safety

The only consideration for food safety in the bovine spinal column would be remnants of spinal cord in cattle with bovine spongiform encephalopathy, which has not been recorded in New Zealand.

Tuberculous abscesses in the vertebrae have been recorded in the lumbar region of cattle when the disease was widespread (Thornton, 1962; Collins, 1965); however the successful control programme of bovine tuberculosis in New Zealand makes the possibility of an animal having an infection restricted to the vertebral column extremely low with no food safety consequence from consumption of the rest of the carcass (MAF Anon c, 2011).

9.14.2. Suitability

Melanosis is an uncommon condition is an abnormal accumulation of melanin which found in the lungs, liver, brain and spinal cord where it usually involves the pia mater or more rarely the dura mater. Frequently the condition is also found on the pleura or peritoneum or in the fascia between muscles. There is no recorded food safety consequence of the condition and if melanosis was confined to the spinal cord and remained undetected, this would have no significance. This is the most common condition reported by inspection staff in New Zealand in two thirds of the beef premises and the only spinal defect reported in half of those premises.

Neuroblastoma is a very rare condition characterized by progressive hind limb ataxia that would preclude presentation for slaughter (Steinberg *et al.*, 2006). This has not been reported in New Zealand beef premises.

Perosomus elumbis is a rare condition of unknown aetiology characterized by the aplasia of the lumbosacral spinal cord and vertebrae. The early onset of ataxia would make the animal very unlikely to be presented for slaughter. (Buck *et al.*, 2009) This has also not been reported in New Zealand beef premises.

Rhabdomyosarcoma is a very rare tumour in cattle that has been once reported to have infiltrated the spinal column from the thoracic cavity. It would be obvious on routine post

mortem examination of the thoracic cavity. (Kajiwara *et al.*, 2009). This condition has not been reported in New Zealand beef premises.

Schwannoma is an uncommon condition has been rarely reported as occurring in the spinal columns of cattle, and in almost all cases the associated ataxia and paresis ensures that the animals are not presented for slaughter (Murcia *et al.*, 2008). This abnormality is very rarely reported by inspection staff in New Zealand.

Spinal abscesses involving *Fusobacterium necrophorum* have been rarely recorded in a calf in New Zealand but the accompanying ataxia would have made the possibility of the affected animal being presented for slaughter remote (Surveillance, 1979). Spinal abscesses have been occasionally reported by inspection staff in New Zealand in a third of beef premises. Organisms that have been reported as isolated from the bovine central nervous system include *Haemophilus somnus*, *Listeria monocytogenes* (Jubb *et al.*, 1993) although neither has been associated with spinal abscesses.

Vertebral osteomyelitis with abscessation: The resultant abnormalities of gait and posterior paresis ensure that these animals would be most unlikely to be presented for slaughter. (Braun *et al.*, 2003; Braun and Ehrensperger, 2006).

Other conditions include broken vertebrae (that have no food safety implications), grease and ingesta inadvertently dispersed over the spinal column by the carcass splitting saw.

9.15.3. Current procedures

The New Zealand post mortem requirement for the spinal column is that it be examined by viewing. The spinal cord is treated as a specified risk material (SRM) and is removed before the carcass leaves the slaughter floor.

The indicator value of examination of the spinal column towards the detection of conditions that have public health significance is negligible within New Zealand slaughter cattle. Examination should be unnecessary apart from the verification that any market access requirement to remove SRMs has been complied with.

9.15.4. Scientific evaluation

There is no demonstrated need to examine the spinal column with regard to food safety

9.16. SPLEEN

9.16.1. Food safety

Although presentation of animals with acute salmonellosis for slaughter is extremely unlikely, the spleen of such animals is likely to be enlarged and congested, soon replaced by an acute splenitis with miliary foci of necrosis or reactive nodules (Jubb *et al.*, 1993). Chronic salmonellosis may also give rise to splenic enlargement and haemorrhagic infarcts may be the result of a pyaemia. One study has shown that enteric serovars of salmonella are quickly translocated from the lumen of the intestine via the lymphatic system to the spleen (Pullinger, 1997) and in these cases extensive gross pathology will be detectable in the gastrointestinal tract and mesentery. Very young calves have been reported dying from *Salmonella* Dublin with purulent inflammatory changes to the spleen but without gross pathology in the gastrointestinal tract, liver, heart, lungs, kidneys, lymph nodes or cerebral cortex (Wallis *et*

al., 1995) but these are not typical of *Salmonella* infections of adult cattle. *Salmonella* Dublin is still considered exotic to New Zealand (Bingham, 2010).

With regard to STEC, researchers who experimentally infected calves with STEC were not able to demonstrate the presence of the organism in the spleen up to four weeks post inoculation (Zhao *et al.*, 1998).

Yersinia spp. have been recorded as producing splenic hypertrophy and studies have shown after ingestion, the enteropathogenic *Y. pseudotuberculosis* and *Y. enterocolitica* pass into the small intestine (Marra and Isberg, 1997), where they translocate across the intestinal epithelium at sites of lymphoid tissue in the gut known as the Peyer's patches. Both enteropathogens then migrate to the mesenteric lymph nodes and are subsequently found in the liver and spleen, where they replicate extracellularly. Gross pathology includes whitish caseonecrotic foci (Jubb *et al.*, 1993) which may be enlarged by lymphoid and histiocytic hyperplasia.

Anthrax is a specific cause of splenic enlargement but has not been recorded in New Zealand since 1954 (Gill, 1993) and extremely unlikely to be detected in cattle presented for slaughter in this country. With anthrax the splenic enlargement is almost solely vascular (Jubb *et al.*, 1993) and frequently spontaneous rupture of the spleen is a feature of this disease.

9.16.2. Suitability

Abnormalities of this organ include acute enlargement in certain specific diseases (such as leptospirosis, anthrax and other septicaemias) and traumatic pericarditis. Active hyperaemia is common in acute systemic infections and also occurs in some acute bacterial infections such as clostridial enterotoxaemia of calves. Passive congestion of the spleen may arise as a result of disturbances in the systemic and portal circulation (Jubb *et al.*, 1993) and an acutely congested spleen is enlarged, moderately turgid, and cyanotic with the capsule bluish black. Thrombosis of the splenic vein has been observed in association with traumatic reticulitis and portal thrombosis in cattle (Jubb *et al.*, 1993) and purulent splenitis may develop by local extension from penetrating wounds in the reticulum.

Splenomegaly may also be due to lymphoma or leukaemia. Although the spleen is expected to be involved in systemic malignancies of the lymphoid system, this only occurs in about a third of cases in cattle (Jubb *et al.*, 1993) while metastatic carcinoma involving the spleen usually arises in the pancreas or reproduction system.

Abscesses of the bovine spleen may be either military or large and focal and may be due to organisms such as *Actinomyces pyogenes*.

Occasional encysted liver flukes have been detected in the spleen.

Nodular hyperplasia has been occasionally observed in the spleens of older bulls (Jubb *et al.*, 1993) with most nodules up to 2 cm in diameter that project hemispherically above the capsule.

Neurofibroma have occasionally been reported in the bovine spleen and the only significance is their confusion with *T. saginata* cysts by inspection staff (Bundza, 1988). A mast cell tumour in the spleen has been reported in New Zealand slaughter cattle (Hill *et al.*, 1991).

9.16.3. Current procedures

The New Zealand post mortem requirements include the examination of the spleen by viewing and palpation.

Australia, the US and the EU only require the spleen to be examined by viewing while Canada is the only other country, apart from New Zealand, that requires the spleen to be palpated and viewed.

9.16.4. Scientific evaluation

A review of the scientific literature has not indicated any abnormality that presents a risk to the consumer that requires palpation of the spleen for its detection. The possibility of enlargement and abscessation can be detected by viewing and the thickness of the organ ensures that any substantial swelling should be readily apparent.

9.16.5. Recommendations for examination of the spleen

The spleen should be visually examined on both sides.

9.17. TESTICLES

9.17.1. Food safety

Bovine brucellosis is a highly contagious disease caused by *Brucella abortus*. The dominant feature is late-term abortion and infertility in cattle, while in humans the disease is a serious zoonosis causing undulant fever. The disease has been eradicated from New Zealand.

9.17.2. Suitability

Both interstitial and intratubular orchitis has been recorded in bulls (Jubb *et al.*, 1993) but these conditions usually do not present with grossly visible pathology. Such conditions may have either an infectious or an immune origin.

Necrotising orchitis is a characteristic feature of brucellosis but may also arise from other infections, or conditions causing severe trauma or ischaemia of the testicles. Occasionally chronic periorchitis may obliterate blood supply to the testis, which will become necrotic and surrounded by a markedly thickened tunic. When incised, the necrotic area will be dry, yellow, often laminated and only slightly calcified. Organisms that are implicated in the pathogenesis of orchitis in bulls, sometimes in association with overt abscessation, include *Brucella abortus*, *Mycobacterium bovis*, *Arcanobacter pyogenes*, *Escherichia coli*, *Haemophilus* species, *Salmonella* species, *Actinobacillus* species, *Nocardia farcinica*, *Staphylococcus* species and *Streptococcus* species (Jubb *et al.*, 1993)

Primary epididymal neoplasms are extremely rare in domestic animals (Jubb *et al.*, 1993) although primary testicular tumours are occasionally reported from older bulls. The most common type is the Sertoli cell tumour which causes enlargement of affected testes. Other types include the interstitial (Leydig) cell tumour, found mainly in older bulls of the Guernsey breed (Jubb *et al.*, 1993) and seminoma which have also been reported from older bulls, often with associated cryptorchidism. The latter are not malignant but tend to be locally invasive.

Infectious and immunological causes of epididymitis of bulls are largely the same as for orchitis. Epididymitis has been observed in bulls with seminal vesiculitis induced by inoculation of *Mycoplasma bovis*, but the roles of *Mycoplasma* and *Chlamydia psittaci* in causing epididymitis await clarification. The condition has also been reported as accompanying orchitis and testicular degeneration in bulls infected with *Trypanosoma brucei*, which has not been reported from New Zealand.

Primary epididymitis is not common in the bull. However, *Histophilus somni* infection has been associated with primary orchitis, although it is unclear whether this condition can be transmitted to bulls from infected rams. BHV-1 infection has been associated with infections of the epididymis and, in Africa the Epivag organism also causes primary epididymitis. There have been occasional reports of an animal with epididymal abscesses that proved to be an autoimmune response to sperm leakage within the epididymis rather than from an infectious cause (Parkinson and Bruere, 2007).

9.17.3. Current procedures

The New Zealand post mortem examination requirements for testicles are viewing and palpation only when saved for human consumption.

Australia and Canada require examination by viewing only when saved for human consumption while the EU requires routine examination by viewing.

The US do not describe any examination procedures for testicles.

9.17.4. Scientific evaluation

New Zealand has no diseases of the bovine testicles that would justify more intense examination of these tissues than that proscribed by our trading partners. One of the more common causes of bovine orchitis, *Brucella abortus*, has been eradicated from New Zealand (Sabirovic, 1997).

There is no indicator function towards disposition of the remainder of the carcass.

9.17.5. Recommendations for examination of the testes

The testicles should be examined by viewing only when saved for human consumption.

9.18. THYMUS

9.18.1. Suitability

Thymic hyperplasia has been recorded in calves where gross symptoms have included the thymus glands filling the anterior mediastinum and extending up the neck. The capsules remain thin and delicate while the lobulation is distinct (Jubb *et al.*, 1993).

Thymic lymphomas have been recorded in cattle and characteristically in yearlings of the beef breeds (Jubb *et al.*, 1993). These lymphomas are not associated with infections with bovine leukaemia virus. Typically there is swelling, sometimes massive, at the base of the neck and oedema of the brisket. The tumours may extend from the rami of the mandibles to the base of the heart, be poorly encapsulated and may infiltrate the surrounding tissue. On cut surfaces,

the tumours are grey with irregular yellow areas of infarction. These neoplasms are very obvious at post mortem examination by viewing and metastatic extension of the primary tumour will result in condemnation of the carcass and all parts. Lymphoid thymomas have been rarely reported in domestic animals but not in cattle (Jubb *et al.*, 1993).

Inflammation associated with some degree of atrophy of the thymus gland occurs frequently in infectious diseases (Jubb *et al.*, 1993). In calves affected by epizootic bovine abortion, the thymus exhibits both lymphocytolysis and infiltration with other inflammatory cells.

Thymic involution is part of the normal aging process and may be reduced by dietary restriction or accelerated by toxic insult.

9.18.2. Current procedures

The bovine thymus is required to be routinely examined by viewing in New Zealand slaughter cattle, although this is restricted to young cattle. Apart from very young calves, most slaughter cattle in New Zealand are two years old and greater and for most of these animals the thymus gland is vestigial.

Australia requires the thymus to be examined by viewing only when saved for human consumption while Canada, the EU and the US have no requirement for routine examination of the thymus.

9.18.3. Scientific evaluation

The thymus is an endocrine gland found within the anterior part of the thoracic cavity with two branches that extend up the neck adjacent to the trachea. This gland gradually atrophies as the animal matures so that by the time of sexual maturity, much of the gland has been converted into fibrous tissue and fat. It is not collected as an edible part of the carcass in adult cattle.

There is no reported condition of the thymus that would suggest it has an indicator function in mature cattle and consequently there can be little justification for the continuation of post mortem examination of this tissue.

9.18.4. Recommendations for examination of the thymus

It is recommended that the thymus be examined by viewing only when saved for human consumption.

9.19. TONGUE

9.19.1. Food safety

The tongue has traditionally been implicated as a site of predilection for *T.saginata*, although the work of Scandrett and others (2009) indicates that the cyst density found in the tongue of moderately to heavily infected cattle may approach that of the thin skirt but much less than found in the heart, masseters or thick skirt. In lightly infected animals it is to be expected that very few cysts will be detected within the tongue.

This is borne out by New Zealand data. Analysis of the *C. bovis* submission database from 2000 to 2011 indicates that the tongue has almost no indicator function with respect to the

detection of *C. bovis*. Of the 188 single case submissions made, 10 were from the tongue and all were shown to be negative for *T. saginata* by histopathology. Nine of the submissions were found to be actinobacillosis (“woody tongue”) and one was a schwannoma. Over this period, only one submission with tissue from the heart and tongue was made, which proved to be positive for *T. saginata*.

Examination of the tongue for *T. saginata* in lightly infected cattle would have a low indicator function and is a procedure that should be restricted to examination of suspect lines.

9.19.2. Suitability

Actinobacillosis or woody tongue is an occasional finding in the bovine tongue at post mortem examination. It is a disease of soft tissue caused by infection by *Actinobacillus ligniersii* which is considered a commensal organism within the oropharynx of cattle. Entry of the organism into soft tissue follows mucosal damage, usually by hard and/or sharp plant material in the diet. The condition presents as firm nodular lesions within the tongue which can be palpated. These may coalesce to form a large mass which may include a caseous centre. Actinobacillosis can also lead to regional lymphadenitis with incised lymph nodes revealing small, soft yellow or orange granulomatous masses (Jubb *et al.*, 1993). The retropharyngeal and submaxillary lymph nodes are most often affected.

Oral necrobacillosis or necrotic stomatitis in cattle is usually caused by *Fusobacterium necrophorum* as a secondary invader following mucosal damage (Jubb *et al.*, 1993). The early lesions are large yellowish grey, dry areas of necrosis on the sides or dorsal grooves of the tongue and other surfaces of the oropharynx, and are readily visible.

In cattle, oral squamous cell carcinomas are very rarely reported with the exception of a few geographic foci, where they are associated with oral papillomatosis and ingestion of bracken fern. In a review of neoplasms in New Zealand cattle, there was one reported case of carcinoma of the tongue in an adult bovine (Webster, 1966) and one of a mastocytoma in the tongue of a two week old calf (Shortridge and Cordes, 1971).

There is a report of a mast cell tumour being situated under the tongue of a bull (Hill *et al.*, 1991) in the US but this is an extremely rare neoplasm.

A number of viral diseases are known to produce ulcerative changes to the surface of the tongue. The tongue is a site of predilection for foot and mouth disease in which vesicles appear within days of infection, beginning as small hyperaemic foci which coalesce and finally rupture, leaving ulcers surrounded by ragged tags of necrotic epithelium. In severe cases, most of the mucosa of the dorsal surface of the tongue may slough.

Other diseases that may produce symptoms that are similar to FMD in cattle include: bovine papular stomatitis (circular raised papules, mucosal disease (persistently infected BVD cases which present erosive oral lesions), infectious bovine rhinotracheitis (oral mucosal lesions are uncommon), rinderpest (reported eradicated), and bluetongue (most infections in cattle is subclinical but rarely reported symptoms include mucosal erosion in the oral cavity).

9.19.3. Current procedures

The post mortem examination requirements for the bovine tongue in New Zealand match those required of other major beef exporting countries and all require examination of the tongue by viewing and palpation.

9.19.4. Scientific evaluation

The imperative for close examination of the tongue should be in the detection of any vesicular disease that may indicate an unwanted exotic disease. The likelihood of detection of *T. saginata* solely in tongue seems to be negligible within the New Zealand context as that parasite is more readily detected in the masseter muscles and myocardium.

Infections by *Arcanobacter* spp. and *Actinomyces lignieresii* are not uncommon in New Zealand cattle and their presence within the tongue constitutes an abnormality of suitability that should be removed from the food chain. For that reason the palpation of the tongue does have an indicator function toward the detection of “woody tongue” and other abscesses and close visual examination is required to detect vesicles that may indicate exotic diseases.

9.19.5. Recommendations for examination of the tongue

The tongue should be examined by viewing and palpation.

9.19.6. Animal health surveillance

Examination of the tongue does have an important role to play in the detection of a number of diseases exotic to New Zealand. These include any of the vesicular diseases that may affect cattle such as foot and mouth disease and vesicular stomatitis. Other diseases that may be confused with viral vesicular diseases that display lesions in the buccal cavity include bovine papular stomatitis, mucosal disease, infectious bovine rhinotracheitis and bluetongue.

Should any of these diseases enter New Zealand, it is highly unlikely that they will remain undetected until affected cattle carcasses are presented for post mortem inspection, however any detected superficial lesions of the tongue that are vesicular in nature should be brought to the attention of the premises veterinarian.

9.20. TRACHEA

9.20.1. Suitability

The trachea is frequently affected as an extension of inflammatory disease of either the upper or lower parts of the respiratory tract. Tracheitis frequently accompanies bronchitis and is sometimes a minor component of pneumonias that do not arise by extension of severe upper respiratory disease (Jubb *et al.*, 1993).

Many microflora have been isolated from the lungs of cattle and thus may be present in the lumen of the trachea at slaughter. In New Zealand, these include: *Fusobacterium necrophorum* (in calf diphtheria), *Pasteurella* spp, *Haemophilus somnus*, *Arcanobacter pyogenes*, infectious bovine rhinotracheitis (IBR) viruses. *A. pyogenes* has been reported as a zoonosis (Goldsmid, 2005) but not as food borne.

Enzootic pneumonia is an infectious disease primarily of housed calves. It is probably caused by a combination of one or more respiratory viruses (PI-3, IBR and BRS) complicated by secondary bacterial invasion with *Pasteurella haemolytica*, *P. multocida* or *Haemophilus somnus*. BVD virus may also contribute because of its immunosuppressive effects, thus increasing the susceptibility of the animal to the other respiratory pathogens. *Mycoplasma*

bovis is a major contributor to calf pneumonia in Europe but this organism is not present in New Zealand (Reichel *et al.*, 1999).

Infectious bovine rhinotracheitis is an infection with bovine herpes virus 1 (BHV-1) that mainly affects animals over 6 months of age. It is usually associated with upper respiratory tract disease and conjunctivitis. Surveys have demonstrated that the virus is widespread in New Zealand, with up to 100% prevalence in some areas (Horner, 1990). Only one strain of the virus is thought to exist in New Zealand, and the BHV-1 strains that are responsible for producing severe respiratory disease in North America and Europe are thought not to be present here. IBR in New Zealand is generally a mild disease from which recovery takes 7-14 days and for which deaths are rare. Most clinical cases occur during the warmer months of the year, particularly involving 2-year-old heifers after they have joined the milking herd.

Most cattle in New Zealand are seropositive for Parainfluenza virus 3. It is possible that PI-3, together with bacteria such as *H somnus* and *P multocida*, is responsible for some cases of calf pneumonia, as the virus has been recovered from cattle with acute non-fatal upper respiratory disease (Oliver *et al.*, 1976).

Serological evidence of bovine respiratory syncytial virus infection in New Zealand cattle was first reported in 1997 (Motha). Often herds infected with BRS virus are also simultaneously infected with IBR virus. Lesions of severe bovine respiratory disease due to BRSV infection have not been reported in New Zealand as they have in North America and Europe.

In cattle, malignant catarrhal fever (MCF) is an acute generalised, almost invariably fatal disease caused by ovine herpesvirus 2 (OHV-2). The disease may affect all categories of cattle but it is rare in calves. Cattle dying from MCF usually exhibit the 'head and eye' form of the disease, although the more acute intestinal form has been seen during outbreaks. Typical signs include corneal opacity, mucopurulent oculo-nasal discharge, lymphadenopathy, diarrhoea, and a high fever. Some animals show neurological signs. The disease occurs more commonly in the South Island, and this may reflect the higher sheep to cattle ratio supporting the notion that sheep are the carriers of the virus.

Primary neoplasms of the trachea of cattle are extremely rare (Brodey, 1973; Stevenson and Taylor, 1977; Jubb *et al.*, 1993). Congenital lipomas have been reported as causing impingement upon the trachea in calves (Sickinger *et al.*, 2009) but this condition is unlikely to reach the slaughter floor in adult cattle.

Haemorrhagic speckling of tracheal mucosa in slaughtered cattle has been reported as causing small extravasations in the submucosal lymphoid follicles (Jubb *et al.*, 1993). In feedlot cattle, severe mucosal and submucosal oedema of the dorsal region of the distal half of the trachea occasionally causes death by asphyxiation although this condition is unlikely to be reported in New Zealand.

Dictyocaulus viviparus is the only lungworm of cattle in New Zealand. Overseas, outbreaks in adult dairy cattle nearly always occur because either cattle have not been exposed to sufficient parasitic challenge in earlier life to provide adequate immunity, or immunity has been lost as a result of a lack of re-infestation. The significance of lungworm in adult cattle in New Zealand is debatable. Only one account of a confirmed outbreak of lungworm infestation in a dairy herd has been published (Fairley *et al.*, 1996). However it would be possible for lungworms to be inadvertently situated within the trachea.

This organ is not considered a common site of any parasitic infection and the only value in exposing the tracheal mucous membrane by means of a longitudinal incision through the tracheal cartilage is to detect aspirated stomach contents. There is no indicator value in these findings towards any consideration the examiner may have towards carcass and viscera disposition.

9.20.2. Current procedures

The New Zealand post mortem requirements for the trachea are for routine examination by viewing; while if saved as edible, the trachea is to be opened up by incision and both the outside and the lumen examined by viewing.

There is some divergence in the international post mortem examination requirements for the trachea. The EU requires the trachea to be routinely examined by viewing, and if the trachea is to be saved for human consumption, requires it to be examined by opening by incision and viewing. Canada and Australia have no specific requirements for the examination of the trachea, unless it is presented for human consumption in which case it should be examined by viewing without opening by incision.

The US does not consider the lungs or trachea suitable for human consumption and has no requirements for examination of the trachea.

9.20.3. Scientific evaluation

The likelihood of any abnormality being present in the bovine trachea that has any significance to food safety is negligible, apart from the possible incidence of aspirated rumenal contents. In the event of the trachea being saved for human consumption, there is a need to demonstrate suitability and freedom from contamination that can only be achieved by incision. If neither lungs nor trachea are saved for human consumption, the scientific literature does not demonstrate any indicator function for examination of the trachea.

9.20.4. Recommendations for examination of the trachea

There should be no requirement to routinely examine the trachea unless saved for human consumption, when it should be examined by incision and viewing.

9.21. UTERUS

9.21.1. Suitability

Diseases of the uterus are not uncommon in New Zealand slaughter cattle, especially aged cull breeding cows. Metritis is most commonly associated with pregnancy, especially if material is retained after parturition. Infectious agents reported in New Zealand that may give rise to endometritis include *Haemophilus somnus*, *Leptospira Pomona*, *Trichomonas foetus* and *Campylobacter fetus* subsp. *venerealis* (Vermunt and Parkinson, 2000). Sequelae of metritis include chronic endometritis, uterine abscess, parametritis, salpingitis, pyaemia, pyometra and occasionally pyelonephritis.

Other authors have reported that uterine infections with *Arcanobacter pyogenes* either alone or with one or both of the Gram-negative anaerobes, such as *Bacteroides* spp or *Fusobacterium necrophorum*, are often associated with histological or clinical evidence of

inflammation and fibrosis of the endometrium and are the most commonly isolated pathogenic bacteria associated with endometritis (Runciman *et al.*, 2008). Gross pathology indicative of septic metritis and sequelae include enlarged uterus, excessive fluid, thickened mucous membrane, often softened, oedematous and covered with exudate.

9.21.2. Current procedures

New Zealand requires the uterus to be routinely examined by viewing.

Australia only requires the non-gravid uterus to be examined by viewing when recovered for human consumption. Neither Canada nor the US requires the uterus to be routinely examined. However the EU does require the uterus to be examined routinely by viewing

9.21.3. Scientific evaluation

The uterus is not routinely collected for human consumption in New Zealand and any abnormality condition restricted to that organ is unlikely to present any risk to the consumer. In those animals in which the metritis has progressed beyond the uterus into a systemic condition, gross pathology will also be observable in the abdominal viscera and peritoneum that will enable the correct disposition to be made. All carcass and viscera from an animal with systemic involvement from metritis are condemned, while any metritis that is not acute without systemic involvement will result in condemnation of the organ itself.

9.21.4. Recommendations for examination of the uterus

Given the significant proportion of aged cows in New Zealand slaughter cattle, it is recommended that the uterus continues to be examined by viewing.

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11. Appendices

APPENDIX 1

Table 1. A summary of procedures carried out in New Zealand and other countries and recommendations for change. (V - view, P- palpate and I - incise)

Tissue	NZ	NZ Proposed	AUS	CAN	US	EU
Carcass (external & internal surfaces)	V	V	V	V	V	V
Diaphragm - thick skirt	VP	V	V	V	V	V
thin skirt	VP	V	V	V	VP	V
Gastrointestinal tract						
Intestines	V	V	V	V	V	V
Oesophagus	VP*	V*	V*	V	V	V
Reticulum	V	V	V	V	V	V
Rumen	V	V	V	V	V	V
Rumino-reticular junction	VP	V	V	V P	VP	V
Head (including oral cavity)	V	V	V‡	V	V	V
Masseter	IV (2)	IV (1)	IV (1-2)	IV (1)	IV (1)	IV (2)
Pterygoid	IV (1)	IV (1)	IV (1)	IV (1)	IV (1)	IV (1)
Tongue	VP	VP	VP	VP	VP	VP
Heart	VPI (4)	VPI (4)	VPI (3-4)	VI (1+)	VI (1)	V
Kidneys	VP	V	VP	V	VP	V
Liver	VP	VP	VP	VP	VP	VP
Bile ducts	IV	IV	IV#	IV	IV	IV
Hepatic lymph node	IV	V	VP	IV	IV	VP
Lungs	VP	VP	VP	VP	VP†	VP
Bronchial & mediastinal lnn	I	I	I (V)	I	I	I
Trachea	V (VI*)	VI*	V*	V*		V (VI*)
Pancreas*	V*	V*	V*			
Spinal column	V	V	V	V	V °	V
Spleen	VP	V	V	VP	V	V
Testicles	VP*	V*	V*	V*		V
Thymus	V	V*	V*			
Uterus	V	V	V*			V

‡ Head may be removed and discarded without inspection where tissues, including tongue, are not recovered for human consumption

*ylno elbide

#Procedures for the incision of main bile ducts and observation of contents may not be required at a meat business by the controlling authority

° Carcass inspection must be done after carcass splitting

† View ventral surface, view and palpate costal surface

(Number) Number of incisions to be made

APPENDIX 2

Table 2. Current New Zealand post mortem requirements: Appendix 3 Amendment 16 Dec.2011

Issue	Procedure	Notes
Abdominal cavity	V	
Anterior mediastinal ln	I	For reactor cattle incise lymph nodes thinly (approximately 2-3mm) and carefully examine cortex for tuberculous lesions.
Bile duct (e)	VI 2	Incise major ducts anterior and posterior to the cystic duct.
Bile duct (i)	see edible	Carcass alone edible
Caul Fat	V 1	Lift and turn to view both sides
Diaphragm	VP 1	Lift to view the pleural cover.
External masseter	I 1	Two incisions for EU market
External surfaces carcass	V	
Eyes	V	
Gastro-intestinal tract	V	
Head (e)	V	
Head (i)	see edible	
Heart (e)	VPI 1	Opening of heart, then through septum, then additional incisions.
Heart (i)	see edible	
Hepatic Inn	I	
Internal iliac Inn	I	
Internal pterygoid	I	
Internal surfaces carcass	V	
Intestines	V	
Kidneys (e)	VP	
Kidneys (i)	see edible	
Left bronchial ln	I	
Limb joints	V	
Liver (e)	VP 1	The parietal and visceral surfaces
Liver (i)	see edible	
Lungs (e)	VP 1	Inspect trachea and main branches of bronchi to edible standard.
Lungs (i)	VP	
Mesenteric Inn	V 1	The Inn should be sufficiently exposed prior to post mortem examination. Incise in cattle with lesions suspect of TB and those made SPVD
Middle mediastinal ln	I	
Neural canal	V	
Oesophagus (e)	VP	
Oral Cavity	V	
Pancreas (e)	V	
Parotid Inn	I	
Pericardium	V	

Peritoneum	V	
Pizzle (e)	V	
Pizzle (i)	V	
Pleura	V	
Posterior mediastinal In	I	
Precrural/Subiliac Inn	1 & 2	Incise in cattle with lesions suspect of TB, actiniform and/or those made SPVD
Prescapular/ Superficial cervical Inn	1 & 2	Incise in cattle with lesions suspect of TB, actiniform and/or those made SPVD
Reticulum	V	
Retropharyngeal Inn	I	
Right apical In	I	
Right bronchial In	I	
Rumen	V	
Rumino-reticular junction	VP	
Spinal column	V	
Spleen (e)	VP 1	Both sides
Spleen (i)	see edible	
Submaxillary Inn	I	
Superficial inguinal Inn	I	
Supramammary Inn	I	
Tail (e)		
Tail (i)		
Testicles (e)	VP 1	Including the epididymis
Testicles (i)	No	
Thoracic cavity	V	
Thymus (e)	V 1	Young cattle
Tongue (e)	VP	
Tongue (i)	see edible	
Tonsils	V 1	As part of viewing the mucous membranes pharyngeal cavity and associated areas of the head
Trachea (e)	VI 1	Open trachea and main branches of the bronchi. Inspect the lungs to edible standard.
Trachea (i)	V	
Udder (e)	VPI	
Udder(i)	No	
Uterus	V	

APPENDIX 3

Table 3. Working instructions for adult bovines to meat inspectors (AsureQuality)

Carcass Inspection
External Surfaces viewed
Internal surfaces and peritoneum viewed
Spinal column and neural canal viewed
Thoracic cavity viewed
Diaphragm and pillars viewed and palpated
Abdominal cavity viewed
Kidneys viewed and palpated if present
Tail viewed if present
Testicles viewed and palpated if for human consumption
Head Inspection
View head
Oral cavity and tonsils viewed
Eyes and surrounding tissue viewed
Parotid lymph nodes incised and viewed
Submaxillary lymph nodes incised and viewed
Retropharyngeal lymph nodes incised and viewed
Tongue viewed and palpated
External cheeks incised into two parts of equal thickness (flaps fold outward) and viewed
2nd incision into external cheeks, viewed if EU
Internal cheeks incised and viewed
Viscera Inspection
Pillars of diaphragm viewed and palpated on both sides if present
Outer heart surface viewed and palpated
Heart incised through left ventricle, the interventricular septum and the atrioventricular orifices
Cut surfaces of interventricular septum incised base to apex
Internal surface of left ventricle incised parallel to both cut surfaces of interventricular septum 75mm
Internal surfaces and cut surfaces of heart viewed and palpated
Liver parietal and visceral surfaces viewed and palpated prior to incisions
Hepatic lymph nodes incised and viewed
Hepatic bile ducts viewed
Bile ducts anterior and posterior to cystic bile duct opened and viewed
Renal impression incised if EU
Bile ducts in renal impression incision viewed if EU
Thymus viewed (young cattle)
Both sides of lungs viewed and palpated
Posterior mediastinal lymph node incised and viewed
Middle mediastinal lymph node incised and viewed
Anterior mediastinal lymph node incised and viewed
Left bronchial lymph node incised and viewed
Right apical lymph node incised and viewed
Right bronchial lymph node incised and viewed

Edible lungs - EU: Incise posterior third of diaphragmatic surfaces perpendicular to main axis, viewed
Trachea - edible. Incise and view trachea and left and right bronchi
Trachea - inedible. View
Diaphragmatic surface of lungs viewed
Both sides of spleen viewed and palpated
Oesophagus viewed and palpated
Rumen viewed
Rumino-reticular junction viewed and palpated
Pancreas viewed
Omental fat lifted and both sides viewed
Uterus viewed
Intestines viewed
Kidneys viewed and palpated if present
Udder viewed and palpated if saved for human consumption
Udder incised each quarter if saved for human consumption
Testicles and epididymis viewed and palpated if saved for human consumption
Tail viewed if present
Tendons viewed if present

APPENDIX 4

Table 4. Tissues submitted for suspect *T. saginata* from 2000 to 2010 from single case detections (where tissue is identified) and histopathology.

Tissue	Positive <i>T. saginata</i>	Possible <i>T. saginata</i>	Negative <i>T.</i> <i>saginata</i>	Total
Brain			1	1
Fat			1	1
Heart	23	24	55	102
Heart & muscle	1		1	2
Heart & oesophagus			1	1
Heart & tongue	1			1
Heart, masseter & muscle		1		1
Heart, oesophagus & muscle			1	1
Heart, masseter, diaphragm & muscle	1			1
Lymph node			1	1
Masseter and pterygoid muscle	7	21	31	59
Muscle (not masseter)	1		5	6
Oesophagus			1	1
Tongue			10	10
Total	34	46	108	188