A qualitative risk and benefit assessment for visual-only post-mortem meat inspection of cattle, sheep, goats and farmed/wild deer

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In the context of modernising post-mortem meat inspection (PMMI) to make it truly risk-based and food chain-orientated, the European Food Safety Authority (EFSA) is currently assessing existing official EU meat inspection including PMMI procedures for a range of livestock species. EFSA’s scientific opinions on meat inspection of swine and poultry have already been published\(^1\), and those on meat inspection of ruminants, farmed game animals and solipeds are under development.

The UK Food Standards Agency is currently funding research to build the evidence base for the modernisation of PMMI, which includes an assessment of the risks and benefits of visual-only PMMI, where mandatory palpation and incision procedures are omitted. A recent risk and benefit assessment of visual-only PMMI for pigs (Hill, Donaldson et al. 2012) concluded that the risk to consumers of pig meat/products would be negligible moving from the current to visual-only inspection of all UK pigs, including those that are not eligible for visual-only PMMI according to current EC Regulation criteria\(^2\). In this report we present the results of a similar risk and benefit assessment for a change from current to visual-only PMMI for cattle, sheep/goats and farmed/wild deer.

The hazard/species pairings considered are listed in Appendix I; the hazard/species pairings that were shortlisted as vulnerable to a change in risk were *Mycobacterium avium* subsp. *paratuberculosis* (MAP) (all species), *M. bovis* (all species), *Fasciola hepatica* (all species), *Erysipelothrix rhusiopathiae* (cattle, deer), *Dictyocaulus viviparus* (cattle, deer), *Cysticercus bovis* (cattle), Caseous lymphadenitis (CLA) (sheep, goats), Jaagsiekte (Ovine Pulmonary Adenocarcinoma - OPA) (sheep, goats) and *Dictyocaulus filaria* (sheep, goats). The results of the public health risk assessment indicated that all hazard/species pairings were Negligible with the exception of *Cysticercus bovis* in cattle, which was judged to be of Low-Medium increased risk for non-conforming systems compared to systems that conform to


Regulations\(^3\) for visual-only PMMI. However, the absolute risk was judged to be Very Low - Low for all conforming and non-conforming systems under visual-only PMMI.

Most hazard/species pairings were concluded to pose a potential increased risk to animal health/welfare, including bovine TB (Very Low – Low increase in risk, but with considerable uncertainty), *Fasciola hepatica* (Negligible – Very Low) and *C. bovis* (Very Low - Low). Only for bovine TB is feedback to farmers relatively assured (because this is the only disease considered that requires mandatory follow-up by AHVLA). Hence as a result of low feedback rates, the feedback to farmers for *F. hepatica* and *C. bovis* is low enough that the real risk to animal health/welfare for these two diseases of including non-conforming systems under visual-only PMMI is probably negligible. That then leaves bovine TB as the only confirmed non-negligible animal health and welfare risk. However the judgement of Low is very uncertain, as it is unclear to what extent PMMI prevents the potential transmission of TB to other cattle, by removing cattle from infected herds earlier than the next planned tuberculin test. Further research is required in this area.

The benefit assessment identified the need for more research to quantify the exact extent to which the omission of certain palpation and incision procedures would reduce contamination of the edible carcase, and subsequently whether this would have any corresponding reduction in public health risk. An indirect benefit was identified in using the time saved from omitting mandatory palpations/incisions to record conditions found more accurately and in a way that is more amenable to further epidemiological analysis.

Further research is probably required before any policy decision can be made, but there is certainly a convincing reason to conduct this research, as there are avenues of enquiry, such as better data recording, which may make visual-only PMMI a compelling option. This should be balanced against the need to support the TB control programme.

1 Introduction

Official meat inspection is important for assuring the safety of meat and is also required to ensure access to international trade. Therefore, the aims of the current system of official meat inspection are to: 1) protect public health by ensuring that meat is safe to eat, 2) protect animal health and welfare, 3) maintain consumer confidence, and 4) facilitate national and international trade (Alban, Steenberg et al. 2011). However, the current *post-mortem* meat inspection (PMMI) that employs typical macroscopic inspection techniques, namely visual examination, palpation and incision, cannot detect the foodborne hazards that are of importance today, e.g. *Salmonella*, *Campylobacter* and *E. coli* O157 (EFSA 2009).

The European Commission (EC) has recognised a need to develop a more effective, risk-based approach to meat inspection (EC 2000). This would improve efficiency in controlling the most important public health hazards associated with meat at abattoirs whilst maintaining surveillance of animal health/welfare issues. The subsequent Food Hygiene Regulations (Regulations (EC) 852/2004, 853/2004 and 854/2004) enabled implementation of different approaches to PMMI for pigs, calves and lambs, provided certain criteria were met and that it was based on a sound risk assessment. These regulations included the requirements to supply Food Chain Information (FCI) (epidemiological data, heard health data, production data), from farmers to the slaughterhouse operator and Official Veterinarian (OV) at the slaughterhouse for animals before arrival at the slaughterhouse. EC Regulation 854/2004 allowed Official Auxillaries (colloquially known as meat inspectors in the UK) to conduct visual-only *post-mortem* inspection (i.e. without mandatory use of incision and/or palpation techniques in routine slaughter) of fattening pigs reared indoors from controlled housing conditions and integrated production systems. EC regulation 1244/2007 extended the principle of visual-only PMMI to cattle and sheep/goats, provided certain age and management conditions are met (including ‘all-in-all-out’ production and cattle/sheep being less than 8/12 months old respectively).

A previous risk assessment (Hill, Donaldson et al. 2012), addressing the risk arising from moving to visual-only PMMI of all pigs in the UK, concluded that the risk in
relation to all public health hazards detectable by current PMMI (including *Mycobacterium bovis*) would be negligible. It was also concluded that there would be a very low increased risk to animal health/welfare due to Tuberculosis (TB) lesions being missed by meat inspectors if they omitted incision of the head lymph nodes, because current PMMI is the only surveillance mechanism for identifying the presence of TB associated changes in pigs. As part of the UK Food Standards Agency’s (FSA’s) continuing process to modernise meat inspection a similar risk and benefit assessment has been conducted for other livestock species where visual-only meat inspection has been allowed by current legislation, specifically cattle, sheep/goats and, in addition, farmed/wild deer.

The specific risk question asked by the FSA was:

“What is the change in risk for i) public health and ii) animal health/welfare if the derogation for visual only *post-mortem* meat inspection, established in EC Regulation 1244/2007 for cattle and sheep/goats under certain age and management criteria, are extended to all animals of these species and farmed/wild deer in the UK?”

In addition the FSA requested an assessment of the benefits of visual-only PMMI of cattle, sheep/goats and farmed/wild deer. We do not consider the aspects of meat inspection not related to public or animal health/welfare i.e. consumer confidence and facilitating international trade, as they were determined to lie outwith the scope of the FSA’s research requirements.

### 2 Materials and methods

#### 2.1 Definitions

For clarity, we first define relevant terminology, concordant with the relevant EU legislation and risk analysis frameworks. To undergo visual-only PMMI there are several requirements as specified in Annex II of Regulation (EC) 1244/2007, including that animals are raised under “controlled and integrated production
systems”. An integrated system is defined as a herd that has detailed information available for all the animals from birth to slaughter and their management conditions. There are also several other criteria relating to ‘all-in-all-out’ systems, feed and bedding that make up the definition for a “controlled” system.

Expert opinion from the “English Beef and Lamb Executive” (EBLEX) suggests that all quality-assured farms in England and Wales, regardless of production type, would currently meet the criteria for a fully integrated system. This is due to meeting feed and management requirements, the traceability between farm and abattoir provided by FCI, and the various animal movement licence systems for cattle and sheep.

We define all production systems that meet the criteria as laid down by EC Regulation 1244/2007 as “conforming” systems and those that do not as “non-conforming” systems. For example, only those cattle slaughtered at an age of less than 8 months and produced in an integrated and controlled production system will be classed as “conforming”.

Another important clarification is that while a system may be conforming, not all batches/animals are able to be visually-inspected. Only non-suspect animals would be eligible for routine/normal slaughter and visual-only PMMI. These animals are: a) NOT considered as posing higher risk according to FCI, b) NOT showing relevant abnormalities at ante-mortem inspection and c) NOT showing relevant abnormalities at visual PMMI. Hence, if visual-only PMMI was implemented for all red meat animals slaughtered in the UK, then some animals will still be diverted to a category where carcases/organs would be palpated/incised in addition to visual-only PMMI.

Sensitivity of detection of infection is defined as the ability of PMMI to detect an infected animal, rather than the sensitivity of detecting visible lesions (in the context of TB, for example). That is, the sole concern is the ability to detect true infection of an animal.

Finally, for parsimony, all further references to animal health are taken to include both health and welfare issues.
2.2 Risk-benefit framework

The risk-benefit framework used in this assessment is identical to that carried out for the assessment of risk and benefit of the change from current to visual-only PMMI for pigs (Hill, Donaldson et al. 2012). Briefly, there are two main criteria that determine whether the risk will change: i) is the sensitivity of detecting a hazard affected as a consequence of switching from current to visual-only PMMI? And ii) is the hazard of concern more prevalent in non-conforming systems than conforming systems? If the answer to one or both of these questions is no, then non-conforming animals/systems pose no greater risk than conforming animals/systems. Where the relative risk is non-negligible, we also comment on the absolute risk to public/animal health. The relative risk can be defined as increased if the risk posed by visual-only PMMI of non-conforming systems is greater than the risk posed by conforming systems (conforming systems are assumed to be at an “acceptable” level of risk). The absolute risk to public health is determined by the relationship between the burden of undetected contaminated meat entering the food chain and the rates of human illness attributable to that contaminated meat. The absolute risk of a hazard will vary according to the prevalence of the disease it causes in the animal species, and, what proportion of those affected animals can be detected by the meat inspector through observation of related signs/lesions at PMMI. However, the sensitivity of detection of a given disease at PMMI varies with different stages of disease. Many diseases can go undetected at PMMI simply due to their low occurrence. Hence, while a specific risk may be judged to be increased under visual-only PMMI as compared to traditional PMMI, this increase in risk may not have significant effect on the total burden of disease in human and/or animal populations. This is especially true if the absolute risk for traditional PMMI is already very low-negligible and/or where alternative methods for the disease control are possible. The significance of any visual PMMI versus traditional PMMI increase in risk must be considered in context of the above mentioned aspects by the risk manager before taking appropriate action.

Disease within a herd or flock can be monitored and managed, if identified correctly and timely. The contribution of PMMI, being a part of the risk management activities of the national Competent Authority, to the control of animal health/welfare hazards
relies on the PMMI-derived information being fed back to the farmer. Hence, the absolute risk to animal health/welfare is assessed according to whether a potential decrease occurs in the feedback of meat inspection findings of relevant hazards to farmers of conforming and non-conforming systems. However, it is not clear how much information is being provided back to farmers on issues identified in the slaughterhouse, or if the farmer is actually interested in the feedback and/or willing to address the issues raised. This presumably depends on: the economics of the farm (such as the impact on productivity); legislation requirements followed up by relevant authorities (for example, the identification of TB-positive cattle); and the understanding and perception of Collection and Communication of Inspection Results (CCIR), which forms an important aspect of FCI\textsuperscript{4}. However, in this assessment we assume 100\% compliance with legislation and a 100\% reaction from farmers in order to address animal health and/or welfare issues. This is the only realistic way to make direct comparisons on the impact of the change from current to visual-only PMMI on animal health and welfare. The relevance and impact of this assumption is debated in the discussion.

The risk assessment framework, shown in Figure 1, largely follows the OIE guidelines for microbiological risk assessment (OIE 2004), with an additional Hazard Identification stage.

Figure 1: Risk and benefit assessment framework. At each stage specific decision criteria are used to assess the absolute/relative risk/benefit from the list of hazards specified in the appendix.

It is not feasible or necessary to assess the risk of all known hazards to public or animal health and welfare that may be found on cattle/sheep/goat/deer carcases and identified during meat inspection. During the Hazard Identification and Release Assessment stages of the framework a number of decision criteria are used to identify hazards where there may be a significant change in public/animal health risk between current and visual-only PMMI. Only those hazards which pose a potential risk are taken forward for a full risk assessment. More detail is given below.

Hazard Identification: Assessment of all relevant hazards under two criteria: i) is the hazard detectable only by palpation and/or incision? ii) does the hazard present a
significant public or animal health/welfare risk if not spotted at PMMI? Only those hazards meeting these two criteria are taken forward to Release Assessment.

Release Assessment: Assessment of whether non-conforming animals of each species considered would “release” relatively more of the hazard into the food chain than conforming animals. A measurable decision criterion was defined as: is the prevalence of the hazard higher in non-conforming animals than conforming animals?

Only those hazards where the prevalence is higher in non-conforming systems (or in the absence of relevant data unknown to be lower) are taken forward to the next stage.

Exposure and Consequence Assessment: All hazards remaining are assessed for i) the likelihood of human exposure, and the likely consequences of exposure, and ii) the likelihood of reduction in feedback from the Food Business operator (FBO) to the producer and the likely consequence of this reduction on animal health. The absolute risk to public/animal health from production of all species is assessed, to set in context the relative difference in risk between conforming and non-conforming systems.

Benefit Assessment: The possible benefits of removing palpation and incision from meat inspection procedures are discussed.

In this risk assessment, we define the following categories of risk, as modified from previous definitions (EFSA 2006).

Negligible – Risk or frequency/consequence is so low as to not merit consideration.

Very Low – Risk or frequency/consequence is almost negligible, but due to uncertainty or other extenuating circumstances cannot be excluded from consideration.

Low – Risk or frequency/consequence is small/infrequent, but still worth considering intervention/mitigation.

Medium – Occurs frequently, or event associated with a modest consequence.

High – Event occurs often, and/or is associated with a significant consequence.

Very High – Event occurs almost certainly, and/or is associated with a serious consequence.
Quantitative data in the published literature on benefits of visual-only PMMI are very limited, but it is widely considered that they relate primarily to i) a presumed reduction in microbiological cross-contamination of the carcase, and ii) a potential saving in time and resources (which could be channelled into other activities with human and/or animal health benefits). Both benefits were assessed, but due to large uncertainties we have not categorised the benefit by as many qualitative outcomes as for risks. Instead, we make only two distinctions – a “negligible benefit” (no detectable or perceived public/animal health benefit) and a “likely benefit” (evidence for improvement in public/animal health).

2.3 Hazard identification and release assessment

A comprehensive list of distinct infectious agents and post-mortem conditions was taken from the Animal Health and Veterinary Laboratories Agency’s (AHVLA’s) own protocol for post-mortem inspection of submitted cattle (78 hazards), sheep/goat (71) and deer (54) carcases. Using a combination of literature review and the expertise within the project team, hazards were shortlisted by considering those where there would be a decrease in sensitivity if visual-only inspection methods were employed, and in addition pose a potential threat to human and/or animal health. A summary of all hazards considered and identified is given in Appendix I. The hazards that were shortlisted as vulnerable to a change in risk were *Mycobacterium avium* subsp. *paratuberculosis* (MAP) (all species), *M. bovis/avium* (all species), *Fasciola hepatica* (all species), *Erysipelothrix rhusiopathiae* (cattle, sheep, deer), *Dictyocaulus spp.* (cattle, sheep, deer), *Cysticercus bovis* (cattle, deer), Caseous lymphadenitis (CLA) (sheep, goats), Jaagsiekte (Ovine Pulmonary Adenocarcinoma - OPA) (sheep, goats), *Dicrocoelium dendriticum* (liver fluke) (sheep) and *Dictyocaulus filaria* (sheep, goats). After further investigation, *Erysipelothrix rhusiopathiae* in sheep/goats, Bovine Leukosis Virus, *Echinococcus granulosus* (all species), *Cysticercus bovis* (deer) and *Dicrocoelium dendriticum* (sheep) were not pursued further, due to sufficient ability to detect these hazards visually at PMMI, and/or due to a current negligible incidence of detection at PMMI.
Due to a lack of relevant data to confidently categorise available datasets by whether the animals were from conforming or non-conforming systems, all hazards identified above were progressed to the exposure and consequence assessment stage.

### 2.4 Exposure and consequence assessments

#### 2.4.1 Assessment by decision criteria

The exposure and consequence assessments have been carried out for each of the hazard/species pairings identified in the previous section. The assessments follow the framework laid out in Figure 1, and are based on the decision criteria described within. Each assessment follows the same structure: a brief overview of the disease; a brief assessment of the difference in disease prevalence between conforming and non-conforming animals (where possible); an assessment of the difference in the sensitivity of current and visual-only PMMI of detecting disease associated abnormalities (where possible); and finally an assessment of the impact on public and/or animal health/welfare (i.e. the consequence assessment). Each section is concluded with a risk estimation stage, where the relative and absolute risk posed to public and/or animal health is given as appropriate.

The assessments of each hazard/disease pairing is summarised in Table 1. The final two columns give the overall relative risk estimate i.e. what is the risk posed by non-conforming systems relative to the risk posed by conforming systems? We make the a priori assumption that the risk from conforming systems is “acceptable”, hence by definition the risk posed by non-conforming systems can only be “unacceptable” if the relative risk is greater for non-conforming systems than conforming systems.

Only one non-negligible increase in relative public health risk could be identified by including both conforming and non-conforming systems in visual-only PMMI, which was *Cysticercus bovis* in cattle (low increase in risk). There were three increases in animal health and welfare risk identified: *C. bovis* in cattle, *Fasciola hepatica* in cattle/deer and *M. bovis* in cattle. For the sake of parsimony the exposure and
consequence assessments for the hazard/species pairing that were assigned a negligible increased risk for public and animal health are given in Appendix II.
Table 1: Summary of risk assessment for each hazard/species pairing identified for further assessment.

Each column represents one of the decision criteria in Table 1. The final two columns give the overall relative risk estimate: that is, what is the risk posed by non-conforming systems relative to the risk posed by conforming systems?

<table>
<thead>
<tr>
<th>Hazard/species pairing</th>
<th>Relative prevalence in NC** versus C*** systems</th>
<th>Relative sensitivity of VO versus T PMMI</th>
<th>Foodborne public health impact</th>
<th>Animal health or welfare impact</th>
<th>Overall relative risk to public health</th>
<th>Overall relative risk to animal health or welfare</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M. bovis</strong> in cattle</td>
<td>+*</td>
<td>--*</td>
<td>N</td>
<td>L – M</td>
<td>N</td>
<td>VL - L increase</td>
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<tr>
<td><strong>M. bovis</strong> in sheep/goats</td>
<td>+</td>
<td>--</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>M. bovis</strong> in deer</td>
<td>+</td>
<td>--</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>E. rhusiopathiae</strong> in all species</td>
<td>-</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>CLA</strong> in sheep/goats</td>
<td>+</td>
<td>-</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>F. hepatica</strong> in cattle/deer</td>
<td>++</td>
<td>-</td>
<td>N</td>
<td>N / VL increase</td>
<td>N</td>
<td>N / VL increase</td>
</tr>
<tr>
<td><strong>F. Hepatica</strong> in sheep/goats</td>
<td>+</td>
<td>-</td>
<td>N</td>
<td>N / VL increase</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>D. viviparus</strong> in cattle and deer</td>
<td>+</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>D. filaria</strong> in sheep/goats</td>
<td>N/A</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>C. bovis</strong> in cattle</td>
<td>++</td>
<td>-</td>
<td>L</td>
<td>VL - L</td>
<td>L-M</td>
<td>VL - L</td>
</tr>
<tr>
<td>Jaagsiekte in sheep/goats</td>
<td>-?</td>
<td>-</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td><strong>MAP</strong> in cattle</td>
<td>+</td>
<td>-</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Key: P – prevalence; NC – Non-conforming system; C – Conforming system; VO – Visual-only; T – Traditional; N – Negligible; VL – Very Low; L – Low; M – Medium.

*: +/- indicates increase/decrease in prevalence in non-conforming systems compared to conforming systems. Greater number of plus or minus signs indicates increasing scale, e.g. ++ – higher increase than +.

**: +/- indicates increase/decrease in sensitivity of visual-only versus traditional PMMI. Greater number of plus or minus signs indicates increasing scale, e.g. ++ – higher increase than +.
2.4.2 *Mycobacterium bovis* in cattle

**Overview**

A wealth of information on bovine TB is available in the scientific literature and government publications, and many of the significant factors regarding TB epidemiology have been discussed comprehensively elsewhere. Therefore, we have not replicated the authoritative reviews/risk assessments of human and animal TB epidemiology and surveillance, but simply refer to these assessments in our own brief summary (de la Rua-Domenech 2006; ACMSF 2010; ACMSF 2011).

TB in cattle was one of the most important zoonotic diseases during the first half of the last century until controls (e.g. milk pasteurisation, slaughter of infected cattle) brought the levels of infection in British cattle down from at least 40-50% of animals (Waddington 2004) to around 1-2% today (AHVLA 2011). Zoonotic transmission of *M. bovis*, which was primarily through raw milk consumption, is now considered extremely rare (de la Rua-Domenech 2006; HPA 2010). However, since the late 1990s there has been a marked increase in incidence of bovine TB in the southwest of England and Wales (subsequently spreading into the Midlands and Northern England), as recorded by the ongoing surveillance and control programmes in place across the UK (de la Rua-Domenech 2006; AHVLA 2011). There is still much debate over the relative contribution of the role of wildlife, especially badgers in the UK, as reservoirs of the disease and the related spill-over risk to bovines.

Surveillance for bovine TB is the most comprehensive among all animal diseases in the UK, and remains a high priority for the Department for Environment, Food and Rural Affairs (Defra) and Agricultural Departments in other countries within the UK, as part of an EU-approved and co-financed bTB eradication plan. It includes mandatory testing of herds using the tuberculin skin test every one or four years, depending on previous history of the herd and geographical location, supplemented with pre-movement skin testing, ad hoc testing and additional gamma interferon blood testing of some infected herds, depending on the location and epidemiological
situation of the breakdown. The testing regime is complemented by *post-mortem*
meat inspection (with back-tracing and tuberculin skin testing of affected herds),
where several mandatory procedures (e.g. the incision of certain lymph nodes) are
aimed at detecting localised TB associated lesions. A detailed flow diagram of the
process of tuberculin testing of cattle in Great Britain (GB) is given in de la Rua-

TB in cattle is typically characterised by small caseous nodules, primarily in the
mediastinal, retropharyngeal, tracheobronchial and mesenteric lymph nodes, which
are typically found by palpation and incision of the aforementioned organs at PMMI
(Liebana, Johnson et al. 2008).

*Difference in prevalence between conforming and non-conforming animals*

FSA meat inspection data categorise cattle into calves (< 8 months) and adults (> 8
months), hence we are able to broadly differentiate between the relative prevalence of
TB in non-conforming and conforming systems since calves slaughtered at <8 months
are usually reared indoors (Mary Vickers, EBLEX, personal communication). The
PMMI detection rate of *Mycobacterium* spp. in the UK during the period 2008-2011
was 0.27% in adult cattle (22,514 suspect lesions/8,484,371 cattle slaughtered) and
0.04% in calves (73/190,493), a statistically significant difference (p<0.05).

Considering the epidemiology of TB infection in cattle, this difference between age
groups is not unexpected, given that older cattle grazed outside will be far more likely
to be exposed to *M. bovis*, especially in high risk areas. Furthermore, it is known that
the sensitivity of detection at PMMI increases with age, as infected cattle have more
time to develop visible lesions, and so the data is likely to be confounded to some
degree.

*Sensitivity of detection*

The definition of the sensitivity of detection is the absolute ("true") sensitivity of
PMMI to detect infection of an animal, i.e. the number of animals detected by routine
PMMI divided by the number of animals *truly* infected, rather than the number of
animals with detectable lesions at routine PMMI divided by number of animals that
would test positive by a tuberculin test. While the former is practically very difficult to define this is the most appropriate definition of sensitivity of detection in the context of assessing public and animal health risk.

In a recent systematic review of the sensitivity of different tests for TB it was estimated that the sensitivity of PMMI (worldwide) was between 30-50% (Downs in prep.), although the sensitivity estimate is based on a comparison against a gold standard of culture, and so is not an estimate of the “true” sensitivity of detection, and will likely be biased upwards because of it. In a recent study of TB pathology in UK cattle the authors found that 55.5% (111/200) of skin-test positive animals (reactors) and 14% (28/200) of in-contact (skin-test negative) animals had macroscopically detectable lesions at post-mortem examination (Liebana, Johnson et al. 2008). The majority of these lesions were found within the lymph nodes. These examinations were carried out at several AHVLA laboratories, where a much more thorough examination than could be expected at PMMI took place. Hence we can conclude that even in the best case scenario (as skin-test positive animals and their contacts will be subject to a more thorough PMMI) at least around 1 in 2 TB-positive cattle are not spotted during routine PMMI inspection. These PMMI-undetected, false negative animals may not have any macroscopic lesions, or may have small, localised lesions that are undetectable by routine PMMI. The true sensitivity of traditional meat inspection for detection of TB-associated lesions is thought by some experts in the project team to be much lower than the 30% quoted by Downs et al.. Omitting incision of the lymph nodes and palpation will reduce the sensitivity of meat inspection, given that most animals are identified through lesions in the lymph nodes. For cattle with PMMI-detectable lesions, omitting incision could result in a large (almost 100%) reduction in sensitivity, whilst for all PMMI-examined cattle the actual reduction would be more likely to be between 5-30%.

We can therefore argue that PMMI is a very insensitive TB-detection test for the purposes of food safety. If we assess that the animal-level sensitivity of PMMI is around 20% (lower than that indicated in the quoted systematic review, but higher than the view of some of the project team experts of around 5%), four out of every five TB-infected cattle pass through PMMI undetected. Therefore, of the 1,038 positive *M. bovis* samples taken at the abattoir in 2010 (AHVLA 2011), we can
estimate that somewhere between 1,000 (if sensitivity is 50%) and 20,000 (5% sensitivity) infected cattle went undetected into the food chain in 2010.

Of interest is the difference in the tissue type where TB lesions were found in slaughterhouse versus positive tuberculin reactors, which was analysed in an unpublished study by AHVLA (Richard Clifton-Hadley, AHVLA, personal communication). TB-associated lesions were significantly more likely to be found in the lungs, pleura, liver, and “other” organs (including kidney/spleen) in slaughterhouse cases compared to reactors, and significantly less likely to be identified in the trachea-bronchial and mediastinal lymph nodes of slaughterhouse cases. This unpublished study indicates that there are differences in carcase pathology of slaughterhouse TB cases, which may or may not modify the sensitivity of current and/or visual-only PMMI. Further research would seem to be warranted.

The sensitivity of PMMI-detection of TB-associated lesions for younger animals is presumed to be much lower than for adult cattle. Animals that have just been exposed to TB will probably have a lower chance of developing PMMI-detectable lesions, because of a short time period to slaughter. However, no direct evidence to support this assumption was found in the literature.

Impact on public health

Human infection with *M. bovis* is clinically indistinguishable from *M. tuberculosis*, and hence only culture of the organism confirms *M. bovis* infection. People may be exposed to *M. bovis* via occupational exposure on the farm or in the abattoir, or through foodborne exposure.

Meat-borne transmission of *M. bovis* is theoretically possible, but it has not been documented in the UK or EU to date. In any case, in accordance with the legislation, beef carcases from cattle with localised TB infection are passed fit for human consumption after the relevant TB-affected material has been condemned (i.e. removed from the meat chain (Grange and Yates 1994; Ashford, Whitney et al. 2001; de la Rua-Domenech 2006)). The authors of a quantitative risk assessment for human *M. bovis* infection via meat consumption in the UK estimated that a maximum of 24
new cases per year could be attributed to beef consumption (ACMSF 2010; ACMSF 2011). This estimate of 24 cases is likely to be a large over-estimate, because it was assumed that all cases in under-35 year olds can be attributed to meat consumption. Given that most cases of *M. bovis* are far more likely to be attributed to raw milk consumption (the sale of raw milk is still legal in England and Wales), then this figure is likely to be much lower in reality. Hence, even a potential rate of 20,000 undetected carcases entering the food chain results in what is highly likely to be a negligible meat-borne risk.

The omission of the incision of lymph nodes from meat inspection procedures is assumed to reduce the likelihood of occupational exposure, hence occupational exposure in the abattoir is considered no further in this risk assessment. Occupational exposure of farmers, vets, abattoir workers etc… has been recorded as causing bovine TB infection, but it is very rarely seen in the UK (de la Rua-Domenech 2006).

*Impact on animal health/welfare*

In 2010, 22.2% of all new confirmed (OTF status withdrawn) herd breakdowns\(^5\) were identified during PMMI (AHVLA 2011). Where TB is identified by meat inspection in a previously Officially-Tuberculosis Free (OTF) herd, typically a sole animal is identified (Olea-Popelka, Costello et al. 2008). Therefore, omitting incision of lymph nodes and palpation is likely to reduce sensitivity of detection of TB-associated lesions at PMMI to near zero. Consequently we can expect a reduction in the number of herds identified as TB-positive through PMMI if non-conforming systems are included in visual-only PMMI (although it is unknown how many positive herds remain unidentified through current PMMI).

While a significant percentage of breakdown herds are identified during PMMI in the UK, it can be presumed that most of these herds would *eventually* be detected by the mandatory tuberculin test programme. The importance of PMMI as an indicator of TB infection is higher in four-yearly testing areas (such as Scotland and the far North

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\(^5\) A herd breakdown is defined as a herd that has had one or more suspect TB reactors identified at either tuberculin test or meat inspection. If TB is confirmed, then the herd is classified as a confirmed herd breakdown.
and East of England) than for yearly-testing areas - 45.4% and 21.3% of Officially Tuberculosis Free Withdrawn (OTF-W) herds are identified through PMMI, respectively. The additional contribution of PMMI to TB-detection on top of the tuberculin test programme depends on the rate of spread of TB in the affected herd, the frequency of testing, the type and size of the herd and other factors (Broughan et al. 2011). If lymph node incision was omitted from PMMI there may be a delay in detecting new breakdown herds resulting in additional animals/herds becoming infected.

The OTF status of cattle herds with suspect cases of TB detected by PMMI is initially suspended by AHVLA, pending laboratory culture results. Once a submission from PMMI has been confirmed by culture of M. bovis at AHVLA (approximately 75% of all submissions), a herd is assigned OTF-W status. The probability of confirmation of a breakdown/OTF-W status increases with the time since the last routine herd test. Around 30-50% of herds re-tested within a year of routine testing are confirmed, peaking at 66% for herds tested 3-4 years previously (AHVLA 2011). In 2010, 382 herds (41.6% of all OTF-W new incidents identified within the abattoir) had skin-test positive reactors, comprising a total of 2,694 cattle (an average of 7.8 reactors per reactor-positive herd). Hence we can reasonably assume that around 3,000 reactors are removed each year due to PMMI: this will not impact on public health where the risk is already negligible, but could be important in reducing the numbers of days-at-risk in which TB-infected cattle remain able to pose a transmission risk to other cattle or wildlife.

The implications of the proposed changes in PMMI for TB control programmes in the UK are hard to ascertain. In high-risk areas, cattle herds will be tested on farm every year anyway, and so the impact of the removal of PMMI as an effective animal health surveillance tool in preventing the transmission of infection within-herd and/or between herds is probably limited. While within-herd (cattle-to-cattle) transmission rates are hard to determine, modelling and observational data suggest that spread of infection between cattle on the same herd would be in the region of single figures over the course of 1-4 years (Barlow, Kean et al. 1997; Phillips, Foster et al. 2003; Fischer, van Roermund et al. 2005; Conlan, McKinley et al. 2012). We assume any infected herds in these areas would be detected relatively quickly through mandatory
tuberculin skin testing, relative to the rate of TB spread through the herd. However, Officially-Tuberculosis Free (OTF) herds in low-risk areas will only be tested once every four years, with the implication that infection could become relatively widespread in that timeframe, and potentially pose a risk to other herds if animals are moved. While the proportion changes yearly, around 40-50% of herds currently fall within the yearly-interval testing parish; roughly the same percentage falls within the four-yearly interval testing parish.

Risk estimation

Of the estimated 100 or so new confirmed human cases of \textit{M. bovis} per year in the UK, there is no substantial evidence that any could be attributed to meat consumption. It is possible that meat from infected cattle is contaminated with \textit{M. bovis}. In one study 5\% of reactors or dangerous contacts with No Visible Lesions (NVLs) yielded viable \textit{M. bovis} from edible carcase tissue or offal (ACMSF 2003). Nevertheless, human meat-borne infection is extremely unlikely given the level of contamination is probably very low due to the typical localised type of infection found in most UK cattle (Liebana, Johnson et al. 2008). Cooking and drying are also effective in reducing the amount of \textit{M. bovis} in muscle tissue (Merkal and Whipple 1980; van der Merwe, Bekker et al. 2009); in addition, the dose required for human infection via the gastrointestinal route is likely to be several orders of magnitude higher than that for aerosol transfer (ACMSF 2011). As stated previously, meat from undetected infected cattle (and from detected cattle with affected areas being removed) has been entering the food chain for decades with no evidence of meat-borne transmission. Hence, while it is possible that there would be an increase in the proportion of TB-infected cattle remaining undetected during PMMI if visual-only inspection was extended to non-conforming systems, the relative increase in risk to public health from \textit{M. bovis} is negligible, as is the overall risk to public health from consumption of beef.

Despite an increase in bovine TB incidence in cattle and increases in the UK population over the last two decades, the number of \textit{M. bovis} cases reported annually has decreased, or at the very least remained constant, over the same time period (HPA 2010). The rate of occupational exposure is clearly linked to the number of infected cattle in the UK, but there has been little evidence for a corresponding increase in the
number of *M. bovis* infections in humans due to contact with TB-infected cattle. Bovine TB infection via occupational exposure remains very rare. It is estimated above that around 3,000 reactors are removed each year due to PMMI; hence if these are not removed there is, at most, 3,000 extra cattle for humans to be exposed to via occupational activities. It is extremely unlikely this number of infected cattle would result in measurably more occupational exposure cases. The overall increased risk to public health would be **negligible**.

Given that the within-herd spread of TB is probably slow and results in sporadic cases only, the rationale for maintaining incision of the lymph nodes is more compelling for low-risk herds/areas than it is for high-risk herds/areas. Given the current importance of PMMI in detecting a significant proportion of breakdown herds, it is impossible to assess the relative increase in risk to animal health as negligible. However, given the epidemiology of TB in cattle, then the relative increase in risk to animal health is probably very low - low, although this cannot be stated with great confidence as there are significant uncertainties present in this assessment. Further research is required to make a more certain assessment and rule out a higher relative risk.

2.4.3 *Fasciola hepatica* in all species

*Overview*

*F. hepatica*, commonly known as liver fluke, is a common trematode parasite of ruminants which has a major impact on livestock in terms of morbidity and mortality (Salimi-Bejestani, McGarry et al. 2005). Eggs from the adult worm inhabiting the host’s bile duct enter the duodenum with the bile and leave the host via the faeces. The snail *Lymnaea truncatula* forms the intermediate host ingesting the eggs and subsequently depositing cercariae on blades of grass where they can remain viable for 1 year. Sheep are more susceptible to infestation than cattle, goats and deer as they graze the grass more closely and the majority of the cercariae encyst low down (especially on marshy land). When the grass is eaten by grazing animals the cysts dissolve in the small intestines; the embryos then pass to the liver and develop into adult flukes where they can live for up to 10 years. Heavily infested hosts may die
and those with lighter infestations may suffer inhibited growth and reduced
production efficiency (Fox, White et al. 2011).

The disease is usually diagnosed in the live animal either on the basis of microscopic
observation of eggs in faeces (Boray 1985), serological tests for parasitic antigens or
specific antibodies in serum. Few of these tests have been validated for large-scale
diagnostic purposes. Over the past 40 years fascioliasis in cattle has increased in
significance with the number of cases being diagnosed increasing and the infestation
being detected in areas where it was previously considered unlikely. Fascioliasis is
treated and controlled through the strategic use of flukicidal drugs. Control is aided
by preventing cattle grazing snail-infested habitats and by the use of molluscicides to
reduce snail numbers.

Fascioliasis in ruminants can occur as either acute or chronic forms. Chronic
fascioliasis is the most common clinical syndrome associated with liver fluke
infection in sheep and cattle. It occurs when the parasites reach the hepatic bile ducts
causing bile duct obstruction, destruction of liver tissue, hepatic fibrosis (scarring) and
anaemia. Cattle typically present with signs of weight loss, anaemia and chronic
diarrhoea. Acute fascioliasis results from swelling and congestion of the liver due to
invasion by large numbers of young flukes. In deer, infection is most common in roe
deer in which it may be fatal. Other deer species have more resistance (Parr and Gray
2000).

Enhanced surveillance for human fascioliasis was carried out after a reported increase
in livestock Fasciola cases in the UK. For the year 2008-2009, 11 human cases were
confirmed by reference laboratories in England and Wales. Clinical features of both
acute and chronic infection in man include fever, upper abdominal pain, malaise,
eosinophilia, and impaired liver function. All cases were either in people who had
recently travelled to fascioliasis-endemic areas of the globe or had consumed Fasciola
infested vegetation from abroad (Chand, Herman et al. 2009). Fascioliasis is
sometimes included in zoonotic diseases in the literature since the infestation occurs
both in animals and humans, but in this case there was no evidence of direct zoonotic
(animal-to-human) transmission of Fasciola cases in the UK.
Difference in prevalence between conforming and non-conforming animals

FSA PMMI data shows a marked increase in prevalence of detected fascioliasis in older cattle with an annual average of 20,838 cases per 100,000 cattle over the past 4 years compared to 142 cases per 100,000 calves. Animals with access to pasture would be more at risk of encountering cercariae than calves kept indoors. Although data suggest that the risk from ovine fluke infection is increasing in the UK as a result of changing climatic conditions (Fox, White et al. 2011), there have been no nationwide surveys to estimate the prevalence of *F. hepatica* in sheep. In a New Zealand study (Charleston, Kissling et al. 1990) the national prevalence of *Fasciola* infestation in lambs was 0.05% compared with 4.41% for older sheep. However, no information was given for age of sheep at slaughter or husbandry type. FSA meat inspection data suggest an average prevalence of 6746/100,000 cases of *Fasciola* in sheep and 2019/100,000 in goats for GB. Commercial dairy goats sent to slaughter are not likely to be affected by fascioliasis because they are housed indoors (Nick Clayton, British Goat Society – personal communication). Veterinary investigation surveillance data collected by AHVLA (from the VIDA - Veterinary Investigation Diagnosis Analysis - database) shows a majority of VIDA submissions for goats diagnosed with acute/chronic fascioliosis from older goats. The rate of submission for sheep older than 12 months is twice as high as for sheep less than 12 months of age.

From FSA meat inspection records, the rate of detection of *Fasciola* in deer was 30 per 100,000 wild deer and 6,233 recordings per 100,000 farmed deer. The prevalence of *Fasciola* detection at PMMI for wild deer is probably greatly under-estimated due to the practice of presenting the carcase only (i.e. minus pluck-heart, liver and lungs) for inspection at the slaughterhouse unless the hunter suspects any abnormality.

*Sensitivity of detection*

Current mandatory meat inspection procedures for liver in bovines are as follows. Bovines under 6 weeks of age require visual inspection of the liver and the hepatic and pancreatic lymph nodes, palpation and, if necessary, incision of the liver and its lymph nodes. Bovines over 6 weeks of age require visual inspection and palpation of
the liver, hepatic and pancreatic lymph nodes, and the incision of the gastric surface
of the liver (and at the base of the caudate lobe for bovines) to examine the bile ducts.
For sheep and goats the mandatory meat inspection requirements are visual inspection
and palpation of the liver and hepatic and pancreatic lymph nodes and incision of the
gastric surface of the liver to examine the bile ducts. The EFSA opinion on meat
inspection procedures for lambs and goats (EFSA 2004) defines Fasciola as being
detectable by observation or incision at slaughter. The more serious cases of
fascioliasis may be accompanied by cholangitis which is detectable by visual
inspection. In other cases incision of bile ducts is necessary for detection. For deer
mandatory meat inspection requires visual inspection only with incision where
deemed necessary if abnormalities are detected. This procedure would not change
under visual-only meat inspection so the sensitivity of detection of Fasciola for deer
would remain the same.

Rapsch et al. (2006) estimated the true prevalence of clinical and sub-clinical Fasciola
hepatica in slaughtered Swiss cattle, and determined that the sensitivity of meat
inspection (visual liver inspection only) was around 55-70%.

In New Zealand routine liver inspection procedure of sheep at slaughter involves
visual inspection and palpation only. In a New Zealand study (Kissling 1989)
researchers compared Fasciola detection between visual/palpation and gastric liver
surface incision method at slaughter. They calculated that of all liver fluke affected
lamb livers 6.65% would be missed by palpation but detected by single gastric
incision whilst for sheep livers the figure would be 4.94%.

Assuming that the sensitivities of meat inspection procedures in cattle and sheep/goats
are roughly similar then we can conclude that some livers contaminated with fluke do
pass through current meat inspection, and that more would remain undetected if
regular incision of the liver was omitted from older cattle and sheep/goats. However,
from current meat inspection data, herd-level sensitivity for cattle would probably
remain broadly constant (as within-herd prevalence is relatively high), but would
potentially drop slightly for older sheep/goats (less so for lambs) as within-herd
detection prevalence is already relatively low.
**Impact on public health**

Incisions of the liver are aimed specifically at the detection of liver fluke. As human liver fluke infections do not occur from ingestion of infested bovine/ovine liver there is no increased public health risk from omission of these incisions. Despite the described parallel rise in human and veterinary fascioliasis, there is no evidence that recent human cases resulted from zoonotic transmission within the UK (Chand, Herman et al. 2009).

Although the association of fascioliasis with other microbial infections has been documented these have only been demonstrated either experimentally or fortuitously (Ogunrinade and Adegoke 1982). It is therefore not possible to categorise the risk to public health of secondary bacterial infection.

**Impact on animal health**

Although clinical signs in the animal at farm level allow the farmer to instigate a fluke management programme, many cases of *F. hepatica* are subclinical and are only detected by the presence of lesions during PMMI. Approximately 20% of slaughterhouse throughput of cattle over the age of 8 months is found to have *Fasciola* infested livers. Using coproscopy as the gold standard, liver inspection was estimated to have an average sensitivity of 63.2% (55.6-70.6%; 95% credible interval) (Rapsch, Schweizer et al. 2006). We can therefore make a broad statement that up to 30-40% of liver fluke would be missed under visual-only PMMI (although of course some of this 30-40% would be missed under other combinations of visual/palpation/incision procedures). This under-detection could be detrimental to animal health and welfare if the lack of feedback to the farmer prevents instigation of a fluke management programme. However, given the current prevalence of *Fasciola* in cattle, it is unlikely that the drop in animal-level sensitivity would significantly impact herd-level sensitivity (as it is unlikely that all infected cattle within a herd would be missed).
In a comparison of New Zealand and European community ovine liver inspection procedures (Kissling 1989) incision at PMI detected an additional three Fasciola-affected livers per 10,000 lambs (in addition to 45 that would be detected by visual/palpation only) and 22 livers/10,000 adult sheep. Although this was compared to a visual and palpation PMMI technique it is still considered that a visual only procedure should be sufficient to detect enough liver fluke to identify most if not all affected herds.

Of concern are recent findings that cattle infected with F. hepatica can have altered responsiveness (delayed type hypersensitivity reaction and cytokine response) to M. bovis BCG infection with reduced interferon – gamma responsiveness in co-infected animals (Flynn, Mulcahy et al. 2009). A significant negative association between exposure to F. hepatica and diagnosis of M. bovis using the single intradermal comparative cervical tuberculin test has also been established (Claridge, Diggle et al. 2012). Such interactions could have implications for M. bovis disease diagnosis and progression.

Similarly damaged liver tissue resulting from fluke infestation can become infected with clostridium bacteria in particular C. novyi which causes “Black disease”, an acute and fatal disease in both sheep and cattle. However, this condition can be detected visually so the detection rate between traditional and visual only PMMI will remain the same with no consequential impact on animal health.

**Risk estimation**

F. hepatica is not a meatborne hazard, and hence the risk to public health is negligible in both current and visual-only PMMI of both conforming and non-conforming systems.

Despite detection of clinical signs at the farm level the frequency of detection of F. hepatica at PMMI is still high for cattle over 8 months of age (~20%), sheep (7%) and farmed deer (6.5%), indicating many cases are subclinical. Visual-only PMMI would likely reduce sensitivity of detection in all species, but probably not enough to significantly reduce herd-level sensitivity. The increased risk to animal health
through omission of liver incisions and palpation would probably be negligible for all species, but given the lack of information regarding the reduction of sensitivity for cattle and farmed deer the increased risk might be very low rather than negligible. It is not possible to judge how a very low decrease in the rate of PMMI detection of *F. hepatica* positive herds would impact on surveillance for bovine TB, but again any impact is likely to be small given that herd-level sensitivity would probably be maintained given a change to visual-only PMMI.

### 2.4.4 *Cysticercus bovis* in cattle

**Overview**

Bovine cysticercosis is a zoonotic disease for which cattle are the intermediate hosts of the human tapeworm *Taenia saginata*. Humans acquire infection by ingesting raw or undercooked infected beef and the cycle is completed by the ingestion by cattle of faecally disseminated eggs in the environment. Taeniasis in people causes abdominal discomfort, mild diarrhoea, weight loss and emotional distress. It is easily treated by the use of antihelmintics.

Viable cysticerci in muscles can be easily missed at PMMI since the translucent cysts blend with the surrounding host tissue. Only upon death and degeneration of the parasite is there a sufficient host inflammatory response to create a more detectable lesion. Cysticercosis infections can consist of both viable and degenerate cysticerci so the detection of only degenerate cysts does not imply the absence of infective cysts elsewhere in the carcase. *T. saginata* is less of a public health concern than *T. solium* (the helminth cycling between humans and pigs) but has proved more difficult to eradicate due to: a greater difficulty in detecting animals that are lightly infected; and a global propensity to consume raw or semi-cooked beef (Pawlowski and Murrel 2001). In spite of its low sensitivity, regulated PMMI of cattle at slaughter for cysticercosis helps to reduce transmission of these parasites.

*Difference in prevalence between conforming and non-conforming animals*
C. bovis still persists in Europe today with prevalence of bovine cysticercosis varying between 0.007% and 6.8% based on meat inspection reporting (Dorny, Vallée et al. 2000). The rates of detection from UK meat inspection data from 2008-2011 are 0.008% (15/190,493) and 0.032 (2674/8,484,371) for slaughtered calves and adult cattle respectively.

The sensitivity of meat inspection of carcases with light infestations (1-10 cysts) of C. bovis is believed to be low (27%), rising to 43% for animals with 11-20 cysts and 78% when 20 or more cysts are present (EFSA 2005). The available research thus suggests that the prevalence of bovine cysticercosis in the EU as determined through meat inspection is greatly underestimated (Dorny and Praet 2007); the actual prevalence could be 3 – 10 times higher. Heavy infestations in cattle are uncommon, with light infections being most common as a result of accidental ingestion of eggs that have been disseminated in the environment. Hence, if similar sensitivities are applied to current UK meat inspection procedures, then the prevalence of C. bovis infection could be anywhere between 24 and 80 per 100,000 calves slaughtered (0.008%*3*100,000 – 0.008%*10*100,000), and 100 – 300 per 100,000 adult cattle slaughtered.

While detection of cysts is more difficult in calves than in adult cattle, the seroprevalence of bovine cysticercosis does appear to be positively correlated with increasing age (Dorny, Vercammen et al. 2000). This is explained by the fact that infection is accidental and that the risk of historical exposure increases with the age of the animal. Hence, we can reasonably ascertain that the difference in incidence rates between calves and adult cattle is real (although maybe not as great as indicated by meat inspection data).

Sensitivity of detection

Mandatory meat inspection includes incisions into the internal (pterygoideus) and external (masseter) mastication muscles (not applicable to animals under six weeks of age), a lengthwise incision of the heart in cattle of all ages and visual examination of the cut surfaces. However, only a proportion of the cysts are located in these so-
called predilection sites, i.e. the heart (15.7%) and masseter muscles (6.5%) (Dorny and Praet 2007). In addition, the success of the method is highly dependent on the skills of the meat inspector and stage of degeneration of the cysticerci. If an animal has generalised infection the carcase and offal are declared unfit for human consumption. If the infection is localised, detected cysts are removed and the carcase has to be stored at a temperature not exceeding –10°C for > 14 days or -7°C for > 3 weeks before release for human consumption. This cold treatment kills any viable cysticerci.

Since the early 1990s EU regulated modifications were introduced in meat inspection methods in order to reduce costs and time of veterinary control (EFSA 2000). These included a reduction in the number of incisions of the organs, including the heart, at PMMI. There is some evidence that the reduction in the number of cuts in the heart has led to a reduction in sensitivity of meat inspection for cysticercus detection (Dorny, Vallée et al. 2000). Decreased cases reported in an industrial abattoir in Northern Italy in 1992-1993 were attributed not to a real decrease in cysticercosis but to a reduction in the number of cuts in some organs according to the new EU regulations and hence to a reduction in sensitivity of inspection (EFSA 2000). An abattoir trial aiming to increase the detection level of C. bovis at meat inspection performed several additional heart incisions in a total of 1,088 slaughtered cattle in Switzerland. With the EU-approved routine meat inspection, bovine cysticercosis was diagnosed in 1.8% (20/1088) of the slaughtered animals. Additional incisions into the heart muscle revealed a further 29 cases, indicating that the prevalence was at least 4.5% (Eichenberger, Stephan et al. 2011). Another study in Canada found similar results: after experimental infection of calves with C. bovis, a more thorough examination of the heart during the inspection procedure was the most practical method for optimising the PMMI detection of infected animals. The results of this study have been incorporated into the Canadian Food Inspection Agency’s (CFIA) procedures for the PMMI of veal calves for cysticercosis.

The heart is widely regarded to be a predilection site for cysticerci. Cysts in cardiac muscle degenerate earlier; the resulting lesions persist longer than in skeletal muscle so are more likely to be detected at PMMI at an earlier stage of infection. In 2004
EFSA was asked to assess the risks of a simplified meat inspection of the presence of Cysticercus cysts in calves kept under specific management conditions (EFSA 2005). Their review identified poor sensitivity, especially for lightly infected animals. Their opinion suggested that in the region of 40% of cysts would be identified through the surface area of heart exposed by the current mandated incisions. They recommended a semi-quantitative risk profiling of veal calf herds based on the system used to produce the animals and history/epidemiology of infection on the farm. Low-risk herds may be inspected without the need to incise the heart or other organs. They cited as support for this recommendation various published findings, where current meat inspection procedures have a negligible impact on reducing the level of public health risk in a country where C. bovis infection of cattle is low.

Impact on public health

In a risk assessment model for human infection with T. saginata in New Zealand under current PMMI conditions the mean number of human infections per year as a result of consumption of C. bovis infected beef in the export and domestic market was estimated at 0.5 and 1.1 respectively (vanderLogt, Hathaway et al. 1997). Using a 1997 population estimate for New Zealand of 3,781,270 individuals (using NZ government webtool - http://www.stats.govt.nz/tools_and_services/tools/interactive-pop-pyramid.aspx), then this translates to an infection rate of roughly 18.9 and 41.6 per 100,000 population for export and domestic markets respectively. If PMMI procedures were not carried out for the detection of C. bovis the mean numbers of human infections was estimated to increase to 0.61 and 1.3 respectively, roughly a 20% increase.

Ninety-eight human cases of T. saginata were reported in the UK in 2011. During the same year, 975 cases of bovine cysticercus were recorded at PMMI but a possible 2,925 – 9,750 cases were undetected (assuming an under detection rate of 3 to 10-fold). Assuming the 98 cases arose as a consequence of these undetected cases this equates to 1 case of human infection from every 30 – 100 undetected cases, which is a relatively high rate of infection. Over the last 12 years 1,207 Taenia cases were recorded by the HPA (unpublished data, HPA), of which roughly 98% were T.
saginata. However, no other information on these cases as regards source of infection was available as these data are not routinely collected at the HPA.

Impact on animal health/welfare

Naturally occurring C. bovis infections in cattle are unlikely to produce any clinical signs. Heavy infestations will occasionally show muscle stiffness and fever though such infestations are rare in GB. The main reasons for the persistence of T. saginata in Europe include the low sensitivity of current meat inspection protocols and cattle husbandry systems which allow grazing on pastures and drinking from water streams (assuming water streams and surface water are contaminated with T. saginata eggs) (Dorny and Praet 2007). Most types of sewage treatment plant cannot eliminate T. saginata eggs from purified water (Rickard, Arundel et al. 1981). Two of the biggest risk factors for cattle infection are application of slurry from sewage plants on pastures and Taenia eggs in effluent from sewage treatment plants. Bovine cysticercosis is not transmitted directly from cattle-to-cattle. The Canadian Food Inspection Authority (CFIA) has a National Cysticercosis Programme aimed at detecting and eradicating infected cattle. All abattoirs must report suspicion of C. bovis to the CFIA which then places infected farms of origin under government control and carries out eradication of infection where the source is known. The CFIA retains control of the premises until there is slaughter evidence that the herd is C. bovis free. Cattle from infected farms are moved under licence to slaughter. If C. bovis is detected at PMMI in GB the feedback from the meat inspectors to producers is via a rejected meat receipt or via email if the producer is set up on the FSA’s IT system. This information is considered by the FSA to be for the producer to act upon. The FSA does not check or follow up if any action was taken by the producer (Howard Betts FSA-personal communication).

It is unsure how effective feedback, concerning C. bovis detection, from the FBO to the farmer is. As the biggest risk factors for cattle infection are slurry and leakages from sewage plants, the dissemination of T. saginata eggs in the environment can make it difficult to ascertain the source of infection if cattle are diagnosed with C. bovis. This along with the lack of any regulated treatment for the disease in the live animal makes it difficult for the farmer to compile an eradication programme.
However, as Cysticercosis is usually subclinical and current PMMI remains the only form of general surveillance for *C. bovis* any reduction in detection by employing a visual-only PMMI could be considered a potential risk.

**Risk Estimation**

Bovine cysticercosis is of great public health interest, as shown by the number of EFSA opinions concerning cysticercus over the past 12 years (Dorny, Vallée et al. 2000; EFSA 2004; EFSA 2005; EFSA 2010). However, the severity of human *T. saginata* infestation is usually low because symptoms are, in most cases, mild and infection is easily treated. In terms of the number of cases, if the New Zealand risk assessment is broadly applicable to the UK situation, we can expect an increase in the number of human cases per year of around 20% (from approximately 100 cases per year to around 120) if a move from traditional to visual-only meat inspection is allowed for all cattle. Therefore, the increase in risk from allowing non-conforming systems to undergo visual-only PMMI is considered low-medium, but the overall absolute risk to public health is very low – low, because of the small number of extra cases involved.

The risk to animal health/welfare incurred by changing to a visual-only PMMI method for calves under the age of 8 months is very low determined by the low prevalence of the disease and the difficulty in visualising cysts in this animal group at PMMI (meaning the relative change in sensitivity will be minimal). The increased risk to animal health/welfare incurred by changing to a visual-only PMMI method for animals over the age of 8 months is considered to be very low-low. Although the frequency of detection at PMMI is low, removing the heart incisions is likely to reduce sensitivity of meat inspection even further.

### 2.4.5 Brief discussion of negligible risk hazard/species pairings

An important reason for the assessment of many of the other hazard/species pairings as ‘negligible’ is that visual-only PMMI would not see a large change in procedures
from current PMMI. For example, the incision of lymph nodes is not required in sheep or goats, and hence the primary method for identifying *M. bovis* is already non-mandatory for these species. It is therefore unsurprising that *M. bovis* in sheep/goats and deer is rarely detected at the slaughterhouse; there were no positive submissions from sheep/goats and 14/15 positive submissions from farmed and wild deer over a four year period (2008-2011) respectively. A drop in the rate of detection due to visual-only PMMI of deer would be a negligible risk to public or animal health/welfare.

PMMI detection of Johne’s disease in GB has very little impact on either public or animal health, due to its low diagnostic sensitivity. Meat inspection currently detects very low numbers of suspect Johne’s disease cases in cattle (around 100 per year) and wild deer (0.5 per year) and has not identified a single case in sheep, goats, or farmed deer between 2008 and 2011. The proposed change in meat inspection procedures to a visual-only technique could only affect detection of Johne’s disease in cattle as this is the only animal group currently subject to mandatory palpation of the mesenteric lymph nodes. The others already undergo visual-only appraisal of the relevant tissues. The links between *Mycobacterium Avium Paratuberculosis* (MAP) and public health are still debatable (see Appendix II), but it would appear that the meat-borne risk is negligible. With regard to animal health, even in a worst-case scenario, where all the recently identified cases would be missed by the change in inspection procedure, the numbers remain very low. Thus, a change to visual-only meat inspection is very likely to be of negligible risk to animal health. As PMMI is the only detection method for MAP, it may be necessary to conduct other surveillance activities if visual-only PMMI was introduced, or at least retain traditional PMMI procedures in areas of high MAP risk.

*Dictyocaulus spp.* and Jaagsiekte are not zoonotic. *E. rhusiopathiae* and CLA are considered to be occupational human hazards; the omission of incisions and palpation of lymph nodes/organs presumably only lower the already extremely small risk to meat inspectors.

Diagnosis of joint ill (causative agent *E. rhusiopathiae*), Jaagsiekte, *Dictyocaulus spp.* and CLA is most likely in the live animal at the farm, and so there is a limited value
of feedback to farmers. Only CLA is explicitly recorded as a condition at meat inspection, the others would be recorded as more general conditions (joint ill, lung lesions). Hence there is a further limit to the usefulness of any feedback to the farmer. It was assessed that the sensitivity of visual-only PMMI for each of these four animal diseases would be slightly less than for traditional PMMI, but that these drops in sensitivity should not significantly affect herd-level sensitivity, as these diseases are quite common within an infected herd/flock (it is herd-level sensitivity which is important for feedback to farmers).
Benefit assessment

2.4.6 Overview

The aim of PMMI is to protect public health (meat safety, occupational health); animal health (notifiable (exotic) disease, endemic (production) diseases); and animal welfare. In addition, it contributes to food quality. There is potential to achieve benefits from a move from current, traditional PMMI procedures to a visual-only system in all these distinct areas. The potential for benefits was recognised in the EU revision of meat inspection for beef paper (EFSA 2004). The main public health benefits arising from omitting or reducing manual (palpation and/or incision) PMMI techniques include likely reductions in cross-contamination of meat with pathogenic microorganisms. This could be either between different sites of the same carcase and/or between different carcasses and/or between organs and carcases (depending on the number of inspectors involved and the distribution of tasks between them). Visual only inspection would also reduce the exposure of inspectors to occupational hazards, as well as exposure of the meat to microbial hazards originating from the inspectors.

In addition, omitting or reducing manual examinations would enable more rational and effective direction of some of the resources (both manpower and financial) towards other public health-relevant activities - particularly better exploitation of the food chain information and a greater focus on abattoir process hygiene controls (EFSA 2004). Furthermore, moving from laborious and monotonous manual tasks (related to a single animal that is most often abnormality-free) towards a wider range of more intellectually stimulating tasks (related to varied animal populations and FCI) might be expected to increase both the motivation and the satisfaction of inspectors.

Benefits may arise either as a direct consequence of the changes examined in the context of this research, or indirectly.
2.4.7 Direct benefits of revised inspection protocol

Public health - food safety

It has been postulated that omitting palpation and incision procedures at PMMI will result in reduced microbiological contamination of carcases and offal. Incision of lymph nodes may transfer organisms to the surface of meat and offals. Incising muscles (masseters) increases the surface area for contamination (deep muscle tissues are generally regarded as sterile). Palpating carcases and offals may distribute any organisms present more widely on the surface of individual carcases/offals, and transmit organisms between carcases/offals.

Assuming that the hands of inspectors and their knives are microbiologically ‘clean’ at the start of a period of inspection, palpation and incision should not add to the overall burden of microbiological contamination of carcases/offals. The impact of the inspection activities, however, will be the redistribution of organisms present on carcases/offals on and between individual carcases/offals when they arrive at the inspection station. In the case of inspectors being undetected symptomless carriers/shedders of pathogens (e.g. *Salmonella*), their handling of meat can mediate additional contamination.

The most relevant foodborne (meat-borne) zoonoses infections include *Salmonella* spp., *Campylobacter* spp., *E. coli* O157:H7 and other Shiga-toxin-producing *E. coli*. These organisms do not cause any lesions that are detectable under current PMMI procedures. Possible contamination of carcases can occur at many points in the slaughtering process from the initial slaughter through to PMMI and on to trimming and boning. Legislation requires abattoir operators to minimise contamination through implementing HACCP-based procedures. PMMI is a standardised and regulated procedure for all abattoirs, carried out by official inspectors, and outside the operator’s HACCP-based system.

Contamination of carcases with faeces and subsequent cross contamination of further carcases can occur at any point in the slaughter process. Between-abattoir differences...
in process hygiene performance can result in differences in the hygienic status of the final carcases presented for PMMI. However, PMMI involving routine handling is another stage where additional bacterial cross contamination can occur, including with enteric pathogens. The surface of the carcase can be contaminated by palpation and with bacteria residing in the lymph nodes and/or organs via incision.

Benefit assessment related to microbial status of the final carcases

The majority of discussions on the benefits of reducing cross contamination as a result of omitting incision/palpation from PMMI have centred on the pig industry. In a recent scientific opinion on meat inspection of pigs (EFSA 2011) it is stated that the food safety risks of Salmonella and Yersinia enterocolitica cross-contamination of pig carcases exceeds the risks posed by hazards associated with conditions targeted by palpation/incision. For example, it was considered that incising lymph nodes to detect tuberculosis-like lesions can have a detrimental effect on the overall microbial safety of meat, which may exceed the public health benefits of detecting abscesses caused by Mycobacterium. Studies on the release, and subsequent cross-contamination, of enteric pathogens from lymph nodes as a result of PMMI incision concluded that mandatory incision represents a cross-contamination risk (Pointon, Hamilton et al. 2000), Nesbakken 2003). The contents of the intestines also represent contamination risks for Y. enterocolitica if the slaughterhouse personnel accidentally cut into the viscera. Other mandatory procedures, for example, incision of the heart, were shown to cause cross-contamination, as did the examination of other body sites after inspection of the head by the same inspector (P. Willeberg, personal communication quoted in Pointon, 2000). Similarly, the presence of Salmonella spp. in cattle livers has been shown to rise from 32% at evisceration to 82% after PMMI (Samuel, O’Boyle et al. 1980) demonstrating a rise in cross contamination as a result of mandatory inspection procedures. However, a study of pigs in Australia found a 2.5-fold reduction in combined Salmonella and Y. enterocolitica contamination prevalence on 800 visually-only inspected finished carcases (0.250%) compared with 800 traditionally inspected carcases (0.625%), but the difference was not statistically significant (Hamilton, Gallas et al. 2002). However, it is unknown whether the 2.5-fold reduction found in that particular low pathogen-occurrence situation would have been more significant in a higher pathogen-occurrence situation, as the occurrence of
these pathogens on pig carcases can be as high as > 40% for *Y. enterocolitica* (Van Damme, Habib et al. 2010) or *Salmonella* spp. (Small, James et al. 2006; Blagojevic, Antic et al. 2011). Further evidence (for pigs) will be generated in a current FSA trial of visual-only versus current PMMI, where contamination level of carcases will be compared under the two systems. Initial results from this study indicate that there was no difference found in the isolation of *Yersinia* spp. or *Salmonella* spp., total aerobic plate count or the presence/absence of *Enterobacteriaceae* from traditional and visual-only PMMI inspected carcases. However, when present the *Enterobacteriaceae* count was lower on carcases that had been visually inspected than traditionally inspected, implying less contamination. Nevertheless, it should be noted that PMMI procedures differ between animal species in terms of both the total amount of manual handling and the carcase sites/organs handled. Consequently, expected PMMI-mediated cross contamination can differ between animal species in both the contamination location/distribution and its levels. Therefore, the PMMI-mediated cross-contamination effects determined in one species (e.g. pigs) cannot be directly extrapolated to another (e.g. cattle).

In summary, while data is sparse, manual meat handling used in PMMI procedures (incision into potentially contaminated lymph nodes, palpation) probably increases the likelihood of cross-contamination (numbers and/or prevalence of pathogens) of the final carcase and organs, and a number of EFSA opinions have come to the same conclusion (EFSA 2004; EFSA 2011). Therefore, we may conclude that eliminating incisions into, and reducing palpation of, organs and lymph nodes will reduce the total number of pathogenic organisms on an individual carcase and/or the total number of carcases contaminated.

The current EFSA opinions on meat inspection have used final carcase contamination levels (numbers and/or prevalence of pathogens) as the endpoint by which to judge potential benefits to omitting mandatory palpation/incision procedures. On balance, based on prevailing information and views in published literature, we would assess that there are reductions in the microbiological contamination of the final carcase by using visual-only PMMI, but with a high level of uncertainty as this conclusion is based more on expert opinion than data. It is not known how significant this
reduction in microbiological contamination would be in terms of protecting public health.

Benefit assessment related to public health risk at the time of food consumption

The risk that PMMI-mediated cross-contamination poses to public health at the time of food consumption is unknown. We do not know how many human infections (of several relevant hazards), acquired via consumption of each of several meat species and of each of a large number of other foods possibly cross-contaminated from meat/meats along the food chain, would be prevented by omitting incision/palpation of lymph nodes/organs.

In the only study we could find that has attempted to indicate the food safety impact of visual-only PMMI, Hamilton et al. (2002) concluded that levels of protection for food safety were the same for traditional and visual-only PMMI of pigs. This was on the basis that there was no significant difference in the Salmonella and Y. enterocolitica contamination prevalence of 150 retail samples of pork that had been produced from carcases of visual-only PMMI pigs and 150 retails samples of pork from carcases of traditional PMMI pigs. Nevertheless, it should be noted that the total number of tested retail samples was small considering the situation of a low pathogens’ prevalence (0.250-0.625%) on carcases in the study. How relevant the study by Hamilton et al. (2002) is to the red meat industry overall and to industries for each animal species within it, or to meat inspection in general and to inspection of each animal species within it, is unknown.

There are many complicated routes involving the eventual transfer of foodborne hazards from the carcase of a recently slaughtered animal to humans, via meat consumption and/or via consumption of other foods possibly cross-contaminated from meat along the food chain. Hence, any contamination of the edible carcase that occurs because of PMMI-mediated contamination is just one element of the eventual number of organisms a person will consume in an exposure event. Any contamination caused by PMMI (i.e. redistribution of organisms from lymph nodes and/or organs to edible parts of the carcase) must be considered in this light.
However, what we are not able to conclude, because the required studies have yet to be done, is whether this reduction in organisms is a significant benefit to public health. That is, is there a measurable reduction in the number of Salmonella, E. coli O157:H7 etc... infections due to beef, lamb and venison consumption (and/or consumption of other foods possibly cross-contaminated from meats)?

Much more research is required to establish with any confidence what the quantifiable benefits to public health might be from a move to visual-only PMMI. There are no studies quantitatively comparing foodborne hazards such as Salmonella spp. on carcases that have undergone traditional or visual-only PMMI for red meat species. These studies would be required before further assessment of public health benefits can be made. The results for contamination levels of carcases from both systems could, for example, be used in quantitative risk assessment models in order to assess the relative burden of disease from carcases inspected in either way.

The extent of any microbiological benefits from omitting palpation and incisions will be dependent on whether, and to what extent, handling of carcasses is required to position the carcass to enable its proper visual inspection. This can be affected by the design of the slaughterline, and how much carcase handling is involved in visual inspection (which can vary between abattoirs). Some changes to the physical layout of inspection stations, carcase dressing procedures, and the way in which carcases and offals are presented for inspection may be required (depending on the species) so to avoid carcase handling before its visual inspection.

Public health - occupational hazards

The use of sharp knives to make incisions in organs by official inspectors, working in the hazardous conditions of slaughterhouses carries clear risks of injury. Repetitive strain injury is a potential hazard for official inspectors carrying out identical incisions on organs at high line speeds. Less incision and handling of carcases and organs will reduce exposure of inspectors to certain zoonotic hazards such as Erysipelothrix.
Animal health and welfare

No direct benefits to animal health or welfare.

2.4.8 Indirect benefits of changed inspection protocol

In order to establish any relevant indirect benefits through the saving of official inspectors’ time, one of the project’s experts visited several cattle and sheep slaughterhouses to observe current PMMI practices and assess deployment of resources. Each procedure that would be omitted by visual-only PMMI is listed for cattle and sheep/goats, along with an estimation of i) the amount of handling that would be omitted and ii) the time saved in the overall meat inspection process of each carcase (see Tables 2a and 2b).

Table 2a: Estimated change in handling and time saved for mandatory procedures for visual-only PMMI of cattle.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Calves &lt; 6w</th>
<th>Cattle &gt; 6w</th>
<th>Change in handling if omitted</th>
<th>Time saved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Palpate</td>
<td>Incise</td>
<td>Palpate</td>
<td>Incise</td>
</tr>
<tr>
<td>Retropharyngeal LNs</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tongue</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masseters</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Lungs</td>
<td>✓</td>
<td>(✓)</td>
<td>✓</td>
<td>(✓)</td>
</tr>
<tr>
<td>Bronchial/mediastinal LNs</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trachea/bronchi</td>
<td>(✓)</td>
<td>(✓)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hepatic/pancreatic LNs</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastric/mesenteric LNs</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Umbilical region</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joints</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(✓) Incision if lungs intended for human consumption
b. Minus sign indicates if there is a reduction in the amount of handling of the carcase required. Two or more indicates greater reductions in handling.

c. Addition sign indicates if there is a reduction in the amount of time in meat inspection of animal if procedure removed. Two or more indicates greater reductions in time.

Table 2b: Change in handling and time saved for mandatory procedures for visual-only PMMI of sheep/goats.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Sheep</th>
<th>Young sheep</th>
<th>Change in handling if omitted</th>
<th>Time saved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Palpate</td>
<td>Incise</td>
<td>Palpate</td>
<td>Incise</td>
</tr>
<tr>
<td>Lungs</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bronchial/mediastinal LN</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Umbilical region</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joints</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Omitting palpation and incision procedures will save some official inspector time, but the proportion of time spent on these activities relative to the total time spent on inspection is highly dependent on a number of operational factors, including:

- The proportion of “suspect” animals requiring more detailed PMMI (including use of palpation and/or incision, in addition to visual inspection). This is the ratio between those animals and “non-suspect” animals requiring visual-only PMMI, within the population presented for slaughter. Namely, visual-only PMMI is meant to be applied in a routine/normal slaughter situation only (presumably, a large majority of animals), and in any other situation visual examination would be followed by palpation/incision too. Only non-suspect animals would be eligible for routine/normal slaughter and visual-only PMMI, and those animals are: a) NOT considered as posing higher risk according to FCI, b) NOT showing relevant abnormalities at ante-mortem inspection and c) NOT showing relevant abnormalities at visual PMMI. However, any relevant issues noticed in respect to a) and/or b) and/or c) would result in re-
categorisation of those animals into “suspect” category with use of palpation/incision in addition to visual examination.

- Slaughter line speed
- Abattoir layout and equipment
  - all cattle offals presented to the official inspector at one inspection point c.f. inspector down time through constant movement between inspection points;
  - rise and fall platform to inspect entire cattle carcases c.f. fixed inspection platforms;
  - mechanised c.f. manual lines;
  - presentation of sheep carcases to inspectors;
  - capacity and operation of rectification rails and detained rooms.

- Class of animals
  - Young, prime c.f. adult, cull
  - More pathology in older animals

**Cattle**

For most cattle (except calves < 6 weeks) the benefits of visual inspection apply only to offals and heads since no palpation or incision of the carcase is currently required. There will be time savings from visual-only inspection, but these will be dependent on the size/throughput of the abattoir and the ratio of suspect/non-suspect animals.

It was noted that compliance with the requirements for inspection of the green offal may have been influenced by a combination of (1) the location of green offal inspection points (usually on the opposite side of the line to all other inspection activities) and (2) the general belief of inspection staff, supported by the outcome of other FSA research, that green offal inspection adds very little to the detection of pathology (Alonso, Dadios et al. 2011).

**Sheep/goats**
Visual only inspection has potential resource benefits for both carcase and offal inspection.

Inspection of lamb carcases requires palpation of the umbilical region and joints. There is an opportunity to save some official inspector resource by moving to visual inspection at carcase inspection, but it is beyond the scope of this work to quantify it.

Total resource saving at each abattoir will be a multifactorial function including aspects such as the speed of the line, throughput and the proportion of suspect cases requiring more detailed examination.

In most abattoirs, official inspectors must lift sheep carcases to carry out visual inspection of the neck and forequarters, which are sites where contamination may be commonly found. To obtain real benefits, from efficiency and contamination aspects, physical modifications at the inspection point would be required to enable inspection to be done without manipulation of carcases. Changes in carcase dressing and presentation, as have been implemented in Australia and New Zealand (Jackman and Hathaway 2006), would be necessary to permit fully ‘hands off’ inspection.

A further option is one introduced in New Zealand (Jackman and Hathaway 2006), where the slaughterhouse operator is required to identify, detect and remove any contamination at the point on the line where the forequarters are still on the spreaders and can be easily inspected. This may require a change of policy by FSA about the division of responsibility for inspection and audit between food business operators and the competent authority.

**Options for re-directed resources**

- Capture and recording of PMMI findings

PMMI findings are a valuable source of information for: livestock producers and their veterinarians (to provide feedback about animal health status and the effectiveness of on-farm control measures); national animal disease surveillance (for the detection of exotic diseases, monitoring of endemic diseases and identification of emerging
diseases); and animal welfare monitoring (pathological findings may be indicators of welfare issues on farm, during transport, at the abattoir lairage or during stunning).

A reliable and practical system for the capture and recording of PMMI findings – both pathology and contamination incidents – and the correlation of pathology with individual animals or batches of animals was observed in only one of the four abattoirs visited. Capture of PMMI findings generally relied on mechanical counters or inspector memory, with no correlation of inspection findings with individual animals or batches of animals. The one exception was an abattoir where a terminal of the operator’s plant computer system had been installed adjacent to the head and offal inspection point to capture accurate information for individual cattle.

The current method in use for cattle and sheep records PMMI findings under pathology category headings as number of occurrences for each category per day for the abattoir. At present there is no formalised system for routinely recording findings against animals/batches of animals and their producers. We understand that FSA is in the process of implementing an IT system\(^6\) to enable inspection results to be recorded in a more accurate and useful form and to be correlated with the animals concerned. This will be essential for the implementation of a risk-based inspection system.

Routine capture of data by official inspectors about contamination findings was not carried out at some of the abattoirs visited, particularly for sheep where high line speeds and lack of practical recording systems were considered to afford limited time for data recording by inspectors. The detection and accurate recording of contamination incidents is an important component of PMMI to enable FSA to monitor operators’ compliance with their HACCP-based food safety plans.

Accurate and reliable data capture at the inspection point requires time. Better capture and recording of PMMI for cattle and sheep would be a significant and practical use of MHI resources saved by a move to visual inspection.

\(^6\) at the time of publication of the report, the IT system mentioned was up and running for poultry and pigs, and in the process of roll out for cattle.
All Official Veterinarians (OVs) at the abattoirs visited reported deficiencies in the FCI system. It was stated that it is very rare for FCI to record any deviations from perfect health – even when abnormalities in animals submitted to the abattoir are clearly present.

Visual-only inspection may be applied on the basis of an analysis of the risks presented by animals submitted for slaughter. Risk assessment relies on a functional system of FCI, part of which is the receipt by producers of information about previously slaughtered animals from the same source.

Although the FCI framework is in place, it is apparent that FCI does not currently fulfil its intended purpose - to inform risk-based decisions by the OV and abattoir operator. Resources saved by visual-only PMMI may afford an opportunity for FSA staff to take steps to secure compliance with FCI requirements and ensure that FCI delivers its desired aims at the production/slaughter interface of the food chain. In addition, the savings may enable applying an improved and expanded FCI system, that would include consideration of a range of additional on-farm and at-abattoir generated information leading to risk categorisation of farms, risk categorisation of abattoirs, etc…

2.4.9 Observations out of the scope of the project

The scope of this project is PMMI and does not include operator activities. However, it is important to acknowledge that PMMI is only one factor that affects the microbiological quality of meat and offals leaving the slaughterhall. At some abattoirs visited for the project it was observed that there was a considerable amount of handling of carcases by plant staff around the carcase inspection point, particularly by operatives placed immediately before the inspection point to remove surface contamination. The benefits of visual-only PMMI on the microbiological quality of carcases and offal may be relatively insignificant if dressing is not performed to high standard and carcase handling by plant staff is not kept to a minimum.
Visual inspection may have negative practical impact on official inspector performance. The action of making the current mandatory incisions concentrates the inspector’s attention on the organ and demonstrates that each carcase/offals has/have been inspected. Official inspectors expressed the view that visual-only PMMI may reduce their concentration and could result in visible lesions not being detected.

3 Discussion

The modernisation of meat inspection in Europe is continuing with several EFSA Scientific Opinions either underway (red meat species) or published (swine, poultry) to propose changes to PMMI (EFSA 2011; EFSA 2012). This risk assessment fits into the context of this modernisation by focusing on the aspect of visual-only PMMI. While visual-only PMMI is already allowed under certain conditions for pigs and red meat species, it has not been implemented in the UK.

The results of this risk assessment for cattle, sheep/goats and wild/farmed deer suggest that the only increased risk for public health through meat is from *C. bovis* in cattle. The increase in meat-borne risk of *C. bovis* if all cattle were allowed to undergo visual-only PMMI was considered to be low-medium, up from a very low human burden under the current rules of traditional PMMI (100 cases per year, but most of these are likely to be caused by consuming beef abroad).

The most recent EFSA report on cysticercus (EFSA 2010) concluded that monitoring should continue to be based on traditional meat inspection according to current European legislation, because more sensitive methods are not yet commercially available or fully validated for a routine diagnosis. Regulation (EC) No 854/2004 currently allows the use of serological tests on cattle, and it was recommended within the EFSA opinion that such tests be further developed for use as a routine surveillance tool as soon as possible. In preliminary studies, the Ag-ELISA method indicated 3.09% of cattle were Cysticercus-positive whilst only 0.26% positives were detected...
by conventional meat inspection (Dorny, Vallée et al. 2000). However, this was 12 years ago and as yet there is still no validated test for the detection of *C. bovis* suitable as a replacement for meat inspection.

Another EFSA opinion also expressed concern over TB in cattle should visual-only meat inspection be allowed for all cattle (EFSA 2004). However, the results of a recent UK risk assessment suggest that TB cannot be classed as anything but a negligible meat-borne risk (ACMSF 2010). Meat inspection may indirectly contribute to protecting consumers from TB if they drink raw milk by identifying positive-yet-OTF herds supplying raw milk in between tuberculin tests, but the likelihood of such an occurrence is small given the small number of raw milk suppliers currently trading.

With regards to animal health/welfare, we concluded that there would be an increase in risk for TB in cattle (very low - low increase, but with wide uncertainty), *F. hepatica* in cattle and deer and *C. bovis* in cattle (both very low – low increase). These conclusions were made as the removal of the relevant mandatory incisions would mean that the *relative* sensitivity of detection of these hazards would be reduced, potentially sufficiently so to reduce herd-level sensitivity. Herd-level sensitivity is an important aspect of meat inspection, as the real value of meat inspection for animal health (surveillance) is feedback to farmers.

In order to conduct the risk assessment we assumed that there would be 100% feedback of conditions to farmers, and 100% positive action from farmers given feedback on any of these conditions. The judgements made about the increases in relative risk to animal health are borderline with the assumptions of 100% feedback and compliance, but probably verge on negligible given realistic assumptions about the level of feedback to farmers that currently occurs for *F. hepatica* and *C. bovis*. In addition, surveillance of *C. bovis* and *F. hepatica* is preferred by serology at the herd level. Only for TB in cattle, where there is a control programme in force, and it is known that 10-20% of breakdown herds within the UK are identified during meat inspection, does removing the mandatory incisions of the head and neck lymph nodes pose a realistic threat to animal health/welfare because of the detriment to the overall sensitivity of animal surveillance.
A review of bovine TB incidents detected in the slaughterhouse was undertaken by the AHVLA in 2010 (AHVLA 2010). As expected, submissions of suspect TB lesions were higher in abattoirs located in high-risk areas (South-west England and Wales), but significantly lower in 4 yearly testing parishes. The confirmation rate of *M. bovis* by culture/histology was also higher in high-risk areas. However, there was a marked increase in the percentage of breakdown herds identified by PMMI within 4 yearly testing parishes - 45% - versus 16-21% in yearly tested parishes. These results confirm the assumption that slaughterhouse PMMI is more valuable for low-risk areas where herds are routinely tested at less regular intervals, although there may well be a decreased sensitivity and specificity of slaughterhouse detection in these areas.

The main result for PMMI animal health surveillance of TB in cattle is that around 3,000 reactor cattle are slaughtered per year as a result of OTF-status being withdrawn through TB detection at the abattoir, which will have some value in preventing the transmission of disease. However, while on average more reactors are detected the longer the time since the last routine herd test, the majority of new OFT-W incidents identified in the slaughterhouse come from yearly-tested herds (593/654 - 90.6%) (AHVLA 2011). Given the relatively slow spread of TB it could be argued that yearly-tested herds are tested regularly enough to minimise any potential risk of TB spread through non-detection of slaughterhouse cases given visual-only PMMI; pre-movement testing would reduce this risk still further. That would then leave in the region of 60-70 herds (at current rates of infection) that would not be identified under visual-only PMMI in higher test interval parishes. It is not possible to confirm without further research whether the removal of up to 700 reactors per year in these low-risk areas (70 herds * 10, a worst-case estimate of the average number of reactors per herd), and subsequent movement restrictions on the affected herds, is crucial in preventing the further spread of TB into low-risk areas.

While outside the scope of this qualitative assessment, further quantitative analysis of new OTF-W incidents detected at the slaughterhouse could more accurately describe the increase in the number of days-at-risk as a result of visual-only PMMI (i.e. the total time in which cattle remain undetected in their herds before the next tuberculin test), which could give an indication of how important surveillance of cattle at slaughter is to the efforts in controlling/preventing the spread of TB in cattle.
There are many factors that need to be considered when developing any bovine TB policy, including the economics of the farm and the political considerations involved.

No factors apart from public health and animal health/welfare are considered in this assessment, and explicitly so. As with current parish testing intervals, a reasonable approach to visual-only PMMI may be to consider the risk on a regional rather than national basis, and/or on the basis of certain conforming and non-conforming systems.

In summary, if clear benefits to public health and/or animal health/welfare can be achieved by moving to a visual-only PMMI inspection method for all systems of production (or at least relaxing the definition of a conforming system, for example by allowing outside production) then there may well be a strong case for a change to the current EC regulation. The only potentially compelling reason is to maintain the maximum possible sensitivity of bovine TB surveillance in order to achieve eradication of the disease (where of course doing anything to reduce the status quo could be argued as potentially dangerous, especially in light of the increased incidence in cattle TB over the previous decade). It is outside the scope of this project to determine the cost-benefit of such a policy.

With regards to the benefit assessment, it is not possible to state the relative benefit to public health due to the reduction in cross-contamination that may occur during visual-only PMMI compared to traditional PMMI. For this, further research would be required. An indirect benefit to public and/or animal health/welfare may be the diversion of the official inspector’s time away from mandatory incisions to potentially more productive matters, such as ensuring accurate reproduction of condition statistics. Such accuracy is required in order to ensure the value of Food Chain Information, and to maximise the potential to analyse meat inspection data in an epidemiologically rigorous way. A distinct improvement has been made to data collection by the rolling out of electronic databases for meat inspection of cattle and sheep/goats, which should include production system information. However, even these data are suspect if meat inspectors are too busy performing their mandatory tasks to make accurate recordings.
The results of the risk and benefit assessments are intended to provide further evidence for the on-going discussions at EU level over the modernisation of meat inspection. In summary, there appears to be a genuine rationale for considering visual-only PMMI of all cattle, sheep/goats and farmed/wild deer, which should be discussed further by risk managers and policy makers at both a UK and EU level.

4 Acknowledgements

The authors would like to thank the following persons for their assistance in obtaining data and providing expert opinion for the risk and benefit assessments: from AHVLA Jenifer Broughan, Elizabeth Ely, Jon Weston, Helen Gartner and Adam Brouwer; and from the UK FSA, Javier Dominguez, Carles Orri (the project officer), Howard Betts, Andrew Bullock and Andrea Cranfield. The project was funded by the UK Food Standards Agency.
5 References

ACMSF (2003). Possible health risks to consumers of meat from cattle with evidence of *Mycobacterium bovis* infection (ACM/652).


AHVLA (2010). Analysis of bovine tuberculosis incidents detected in the slaughterhouse.


Alban, L., B. Steenberg, et al. (2011). Overview on current practices of meat inspection in the EU. A report produced by the Danish Agriculture and Food Council for EFSA.


Brady, C., D. O'Grady, et al. (2008). "Relationships between clinical signs, pathological changes and tissue distribution of Mycobacterium avium..."
subspecies paratuberculosis in 21 cows from herds affected by Johne's disease. "Veterinary Record 162(5): 147-152.


EFSA (2010). Development of harmonised schemes for the monitoring and reporting of Cysticercus in animals and foodstuffs in the European Union.


Eichenberger, R. M., R. Stephan, et al. (2011). "Increased sensitivity for the diagnosis of Taenia saginata cysticercosis infection by additional heart examination
compared to the EU-approved routine meat inspection." Food control 22(6): 989-992.


## Appendix I Hazard Identification

### Table A1: Hazard Identification for cattle

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Decision criteria</th>
<th>Detect via incision/palpation only</th>
<th>Potential public health risk</th>
<th>Potential animal health risk</th>
<th>Carried forward</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Johne’s disease (<em>Mycobacterium avium</em> subsp paratuberculosis)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td><em>Mycobacterium avium</em></td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td><em>Mycobacterium bovis</em></td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Erysipelothrix rhusiopathiae (joint ill)</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Actinobacillus lignieresii (wooden tongue)</td>
<td></td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Aeromonas hydrophila</td>
<td></td>
<td>×</td>
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<td>×</td>
<td>x</td>
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<tr>
<td>Anthrax (<em>Bacillus anthracis</em>)</td>
<td></td>
<td>×</td>
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<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Arcanobacterium pyogenes</td>
<td></td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
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<tr>
<td>Arcobacter spp (formerly <em>Campylobacter</em> spp.)</td>
<td></td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td><em>Bacillus</em> cereus</td>
<td></td>
<td>×</td>
<td>✓**</td>
<td>×</td>
<td>x</td>
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<tr>
<td>Bartonella spp.</td>
<td></td>
<td>×</td>
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<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Bibersteinia trehalosi septicaemia (formerly <em>pasteurella</em>)</td>
<td></td>
<td>×</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Botulism (<em>Clostridium botulinum</em> toxin type C&amp;D)</td>
<td></td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Brucella abortus</td>
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<td>×</td>
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<tr>
<td><em>Campylobacter</em> spp.</td>
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<td>✓</td>
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<tr>
<td><em>Clostridium</em> chauvoei disease (Black leg)</td>
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<tr>
<td><em>Clostridium</em> difficile</td>
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<tr>
<td><em>Clostridial novyi</em> disease (Black disease)</td>
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<tr>
<td><em>Clostridium perfringens</em> type A</td>
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<td>×</td>
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<td>x</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em> type D</td>
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<td>✓</td>
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<tr>
<td><em>Clostridial</em> septicum diseases</td>
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<tr>
<td><em>Clostridium</em> sordellii</td>
<td></td>
<td>×</td>
<td>✓</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Calf diptheria (<em>Fusobacterium necrophorum</em>)</td>
<td></td>
<td>×</td>
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<td>x</td>
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<td>Dermatophilus congoensis</td>
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<td>Human Pathogenic <em>E.coli</em> (STEC/VTEC)</td>
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<td><em>Histophilus somni</em></td>
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<tr>
<td>Infectious bovine keratoconjunctivitis (<em>Moraxella bovis</em>)</td>
<td></td>
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<td>x</td>
<td>x</td>
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<tr>
<td>Leptospira hardjo</td>
<td></td>
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<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Leptospirosis (milk drop)</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Listeria monocytogenes</td>
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<td>Hazard (cont’d)</td>
<td>Decision criteria</td>
<td>Detect via incision/palpation only</td>
<td>Potential public health risk</td>
<td>Potential animal health risk</td>
<td>Carried forward →</td>
</tr>
<tr>
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<td>-------------------</td>
<td>------------------------------------</td>
<td>------------------------------</td>
<td>-----------------------------</td>
<td>-------------------</td>
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<tr>
<td>Lyme disease (Borrelia burgdorferi)</td>
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<td>Mannheima (Pasteurella haemolytica)</td>
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<td>Mycoplasma bovis</td>
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<td>Pasteurella multocida</td>
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<tr>
<td>Q fever (Coxiella burnetti)</td>
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<td>Salmonella spp.</td>
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<td>Staphylococcus aureus</td>
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<td>Streptococcus spp.</td>
<td></td>
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<td>✗</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td>Tetanus (Clostridium tetani)</td>
<td></td>
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<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Yersinia enterocolitica/pseudotuberculosis</td>
<td></td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>

**Viruses**

| Bovine Leukosis Virus                              | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Bluetongue (Reoviridae)                            | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Bovine papular stomatitis virus                    | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Bovine viral diarrhoea virus (BVDV)                | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Coronavirus                                        | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Foot and mouth disease (Picornaviridae)            | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Infectious Bovine Rhinotracheitis (IBR) (Bovine herpesvirus 1) | ✗ | ✗ | ✗ | ✗ | ✗ |
| Louping ill (Flaviviridae)                         | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Malignant catarrhal fever (gammaherpesvirus)       | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Mucosal disease (Flaviviridae)                     | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Papillomatosis (bovine papilloma virus)            | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Parainfluenza 3 virus                              | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Pseudocowpox (Parapox virus)                       | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Rabies (Lyssavirus)                                | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Respiratory syncytial virus (bovine)               | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Rotavirus                                          | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
| Winter dysentry (bovine coronavirus)               | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |

**Parasites**

| Hydatidosis (Echinococcus granulosus)              | ✗                 | ✗                                  | ✗                           | ✗                          | ✗                 |
### Decision criteria

<table>
<thead>
<tr>
<th>Hazard (cont’d)</th>
<th>Detect via incision/palpation only</th>
<th>Potential public health risk</th>
<th>Potential animal health risk</th>
<th>Carried forward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung worm (parasitic pneumonia ‘husk’)<em>Dictyocaulus viviparus</em></td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Anaplasma phagocytophilum</em> (Tick borne fever)</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><em>Babesia microti</em> (red water fever)</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><em>Taenia saginata cysticercus</em> (cysticercus bovis)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Fasciola hepatica</em></td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><em>Chorioptes</em> spp (surface mite)</td>
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<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><em>Coccidiosis (Eimeria</em> spp.)*</td>
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<td>✗</td>
<td>✓</td>
<td>✗</td>
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<tr>
<td><em>Cooperia</em> spp.</td>
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<tr>
<td><em>Cryptosporidiosis</em> spp.</td>
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<td>✓</td>
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</tr>
<tr>
<td><em>Giardia</em> spp.</td>
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<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><em>lice</em></td>
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<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><em>Paramphistomum</em> spp. (stomach fluke)</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><em>Parasitic gastroenteritis (Ostertagia ostertagi)</em></td>
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<td>✗</td>
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<td>✗</td>
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<tr>
<td><em>Ringworm (Trichophyrum verrucosum)</em></td>
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<tr>
<td><em>Sarcocystis hominis</em></td>
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<td><em>Sarcopotes</em> spp (burrowing mite)</td>
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<tr>
<td><em>Scab (psoroptic mange)</em></td>
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<tr>
<td><em>Toxoplasma gondii</em></td>
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<tr>
<td><em>Trichostrongylus</em> spp</td>
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<td>✗</td>
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<tr>
<td><em>Warble fly</em></td>
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<tr>
<td><strong>Prions</strong></td>
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<tr>
<td><em>Bovine spongiform encephalopathy</em></td>
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<td>✓</td>
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1894
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1907
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<td>Detect via incision/palpation only</td>
</tr>
<tr>
<td><strong>Bacteria</strong></td>
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<tr>
<td>Caseous lymphadenitis (Corynebacterium pseudotuberculosis)</td>
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<tr>
<td>Erysipelothrix rhusiopathiae (joint ill)</td>
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<tr>
<td>Johne's disease (Mycobacterium avium subsp. paratuberculosis)</td>
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</tr>
<tr>
<td>Mycobacterium bovis</td>
<td>✓</td>
</tr>
<tr>
<td>Aeromonas hydrophila</td>
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</tr>
<tr>
<td>Anthrax (Bacillus anthracis)</td>
<td>x</td>
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<td>Arcanobacterium pyogenes</td>
<td>x</td>
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<tr>
<td>Bacillus cereus</td>
<td>x</td>
</tr>
<tr>
<td>Bibersteinia trehalosi septicaemia (formerly pasteurella)</td>
<td>x</td>
</tr>
<tr>
<td>Botulism (Clostridium botulinum toxin) type C&amp;D</td>
<td>x</td>
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<tr>
<td>Brucella melitensis</td>
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<td>Campylobacter spp.</td>
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</tr>
<tr>
<td>Chlamydophila abortus</td>
<td>x</td>
</tr>
<tr>
<td>Clostridial novyi disease (Black disease)</td>
<td>x</td>
</tr>
<tr>
<td>Clostridial diseases NOS</td>
<td>x</td>
</tr>
<tr>
<td>Clostridium perfringens type A</td>
<td>x</td>
</tr>
<tr>
<td>Clostridium perfringens type B (lamb dysentery)</td>
<td>x</td>
</tr>
<tr>
<td>Clostridium perfringens type C</td>
<td>x</td>
</tr>
<tr>
<td>Clostridium perfringens type D (pulpy kidney disease)</td>
<td>x</td>
</tr>
<tr>
<td>Clostridium septicum (malignant edema)</td>
<td>x</td>
</tr>
<tr>
<td>Dermatophilus congolensis</td>
<td>x</td>
</tr>
<tr>
<td>Human pathogenic E.coli (STEC/VTEC)</td>
<td>x</td>
</tr>
<tr>
<td>Footrot (Dichelobacter nodosus)</td>
<td>x</td>
</tr>
</tbody>
</table>
and *Fusobacterium necrophorum*.

<table>
<thead>
<tr>
<th>Hazard (cont’d)</th>
<th>Decision criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Detect via incision/palpation only</td>
</tr>
<tr>
<td>Keratoconjunctivitis</td>
<td>x</td>
</tr>
<tr>
<td>Leptospirosis (<em>Leptospira hardjo</em>)</td>
<td>x</td>
</tr>
<tr>
<td><em>Listeria</em> spp.</td>
<td>x</td>
</tr>
<tr>
<td>Mannheimiosis (<em>Mannheimia haemolytica</em>)</td>
<td>x</td>
</tr>
<tr>
<td><em>Mycoplasma ovipneumoniae</em></td>
<td>x</td>
</tr>
<tr>
<td>Q fever (<em>Coxiella burnetti</em>)</td>
<td>x</td>
</tr>
<tr>
<td><em>Salmonella</em> spp.</td>
<td>x</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>x</td>
</tr>
<tr>
<td>Staphylococcal dermatitis</td>
<td>x</td>
</tr>
<tr>
<td><em>Streptococcus</em> spp.</td>
<td>x</td>
</tr>
<tr>
<td>Tetanus (<em>Clostridium tetani</em>)</td>
<td>x</td>
</tr>
<tr>
<td><em>Yersinia enterocolitica</em></td>
<td>x</td>
</tr>
</tbody>
</table>

### Viruses

<table>
<thead>
<tr>
<th>Virus</th>
<th>Decision criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPA (Jaagsiekte sheep retrovirus)</td>
<td>✓</td>
</tr>
<tr>
<td>Bluetongue (<em>reoviridae</em>)</td>
<td>x</td>
</tr>
<tr>
<td>Border disease (<em>Flaviridae</em>)</td>
<td>x</td>
</tr>
<tr>
<td>CAE or MV (Lentivirus)</td>
<td>x</td>
</tr>
<tr>
<td>Contagious Echthyma (Orf) parapoxvirus</td>
<td>x</td>
</tr>
<tr>
<td>Foot and mouth disease (<em>Picornaviridae</em>)</td>
<td>x</td>
</tr>
<tr>
<td>Louping ill (<em>Flaviridae</em>)</td>
<td>x</td>
</tr>
<tr>
<td>Malignant catarrhal fever (<em>gammaherpesvirus</em>)</td>
<td>x</td>
</tr>
<tr>
<td>Rabies (lyssavirus)</td>
<td>x</td>
</tr>
<tr>
<td>Respiratory syncytial virus (ovine)</td>
<td>x</td>
</tr>
<tr>
<td>Rotavirus (group B)</td>
<td>x</td>
</tr>
</tbody>
</table>

### Parasites

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Decision criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Dicrocoelium dendriticum</em> (liver fluke)</td>
<td>✓</td>
</tr>
<tr>
<td><em>Dictyocaulus filaria</em> (lungworm)</td>
<td>✓</td>
</tr>
<tr>
<td><em>Fasciola hepatica</em></td>
<td>✓</td>
</tr>
<tr>
<td><em>Anaplasma phagocytophilum</em> (Tick borne fever)</td>
<td>x</td>
</tr>
<tr>
<td>Blowfly (Myiasis)</td>
<td>x</td>
</tr>
<tr>
<td>Coccidiosis (<em>Eimeria</em> spp.)</td>
<td>x</td>
</tr>
<tr>
<td>Cryptosporidiosis spp.</td>
<td>⨗</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Hazard (cont’d)</strong></td>
<td>Detect via incision/palpation only</td>
</tr>
<tr>
<td>Cysticercus tenuicollis (tape worm)</td>
<td>⨗</td>
</tr>
<tr>
<td>Cystericus ovis (sheep measles)</td>
<td>⨗</td>
</tr>
<tr>
<td>Giardia spp.</td>
<td>⨗</td>
</tr>
<tr>
<td>Haemonchosis (haemonchus contortus)</td>
<td>⨗</td>
</tr>
<tr>
<td>Headfly</td>
<td>⨗</td>
</tr>
<tr>
<td>Hydatidosis (Echinococcus granulosus)</td>
<td>✓</td>
</tr>
<tr>
<td>Mange/lice</td>
<td>⨗</td>
</tr>
<tr>
<td>Nematodiosis (Nematodirus battus)</td>
<td>⨗</td>
</tr>
<tr>
<td>Paramphistomum spp. (stomach fluke)</td>
<td>⨗</td>
</tr>
<tr>
<td>Parasitic gastroenteritis (Ostertagia ostertagi)</td>
<td>⨗</td>
</tr>
<tr>
<td>Ringworm (Trichophytum verrucosum)</td>
<td>⨗</td>
</tr>
<tr>
<td>Scab (psoroptes spp.)</td>
<td>⨗</td>
</tr>
<tr>
<td>Taenia multiceps (Coenurosis or Gid)</td>
<td>⨗</td>
</tr>
<tr>
<td>Toxoplasma gondii</td>
<td>⨗</td>
</tr>
<tr>
<td>Trichostrongylus spp</td>
<td>⨗</td>
</tr>
<tr>
<td><strong>Prion</strong></td>
<td></td>
</tr>
<tr>
<td>Scrapie</td>
<td>⨗</td>
</tr>
</tbody>
</table>

1911
1912
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1914
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1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
Table A2: Hazard Identification for farmed/wild deer

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Detect via incision/palpation only</th>
<th>Potential public health risk</th>
<th>Potential animal health risk</th>
<th>Carried forward →</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacteria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Erysipelothrix rhusiopathiae</em> (Erysipelas)</td>
<td>✓</td>
<td>✓*</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Johne’s disease (<em>Mycobacterium avium</em> subsp. paratuberculosis)</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mycobacterium avium</td>
<td>✓</td>
<td>✓*</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mycobacterium bovis</td>
<td>✓</td>
<td>✓*</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Aeromonas hydrophila</td>
<td>×</td>
<td></td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Arcanobacterium pyogenes</td>
<td>×</td>
<td>✓*</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><em>Arcobacter</em> spp. (formerly <em>Campylobacter</em> spp.)</td>
<td>×</td>
<td>✓**</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Bartonella spp.</td>
<td>×</td>
<td>✓*</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Brucella abortus</td>
<td>×</td>
<td></td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td><em>Campylobacter</em> spp.</td>
<td>×</td>
<td>✓**</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><em>Clostridium chauvoei</em> disease (Black leg)</td>
<td>×</td>
<td></td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Clostridial novyi disease (Black disease)</td>
<td>×</td>
<td></td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em> type A</td>
<td>×</td>
<td>✓✓**</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Clostridial diseases NOS</td>
<td>×</td>
<td></td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><em>Dermatophilus congolensis</em></td>
<td>×</td>
<td></td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Human pathogenic <em>E.coli</em> (STEC/VTEC)</td>
<td>×</td>
<td>✓✓✓**</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Leptospira hardjo (Leptospirosis)</td>
<td>×</td>
<td>✓*</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Listeria monocytogenes</td>
<td>×</td>
<td>✓✓✓*</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Lyme disease ( <em>Borreliaburgdorferi</em>)</td>
<td>×</td>
<td>✓*</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Pasteurella multocida</td>
<td>×</td>
<td>✓*</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><em>Salmonella</em> spp.</td>
<td>×</td>
<td>✓✓✓**</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><em>Staphylococcus</em> spp.</td>
<td>×</td>
<td>✓**</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Streptococcus spp.</td>
<td>×</td>
<td>✓**</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><em>Yersinia enterocolitica/pseudotuberculosis</em></td>
<td>×</td>
<td>✓**</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td><strong>Viruses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adenovirus Hemorrhagic Disease</td>
<td>×</td>
<td></td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Bluetongue (<em>Reoviridae</em>)</td>
<td>×</td>
<td></td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>Bovine viral diarrhoea virus (BVDV)</td>
<td>×</td>
<td></td>
<td>✓</td>
<td>×</td>
</tr>
</tbody>
</table>

66
<table>
<thead>
<tr>
<th>Contagious Ecthyma (Orf)</th>
<th>✓</th>
<th>✓*</th>
<th>✓</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazard (cont’d)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detect via incision/palpation only</td>
<td>Potential public health risk</td>
<td>Potential animal health risk</td>
<td>Carried forward</td>
</tr>
<tr>
<td>Foot and mouth disease (Picornaviridae)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Herpesvirus (see malignant catarrhal fever)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Louping ill (Flaviridae)</td>
<td>x</td>
<td>✓*</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Malignant catarrhal fever (gammaherpesvirus)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Papilloma virus (Fibromas)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Rabies (lyssavirus)</td>
<td>x</td>
<td>✓*</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td><strong>Parasites</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasciola hepatica</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hydatidosis (Echinococcus granulosus)</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lung worm (parasitic pneumonia 'husk')Dictyocaulus viviparus</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Anaplasma phagocytophilum (Tick borne fever)</td>
<td>x</td>
<td>✓*</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Babesia microti (red water fever)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Cooperia spp.</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Cryptosporidiosis spp.</td>
<td>x</td>
<td>✓**</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Elaphostrongyulus cervi (tissue worms)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Giardia spp.</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Haemonchosis (haemonchus contortus)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Lice</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Nasal bot flies (cephenemia)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Parasitic gastroenteritis (Ostertagia ostertagi)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Taenia tenuicollis (Cysticercus bovis)</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Toxoplasma gondii</td>
<td>x</td>
<td>✓✓**</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Trichostrongylus spp</td>
<td>x</td>
<td>✓*</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Warble fly</td>
<td>x</td>
<td>x</td>
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<tr>
<td><strong>Prions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic Wasting Disease</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>1931</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1932</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1933</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1934
1935
1936 ✓ = transmission from meat to humans via foodborne route and via handling of meat - number of ticks signifies scale
1937 ✓* = transmission from meat to humans via handling of meat only - number of ticks signifies scale
1938 ✓** = transmission from meat to humans via foodborne route only - number of ticks signifies scale
1940
1941
1942
1943
1944
Appendix II  Exposure and consequence assessments for hazard/species pairings with negligible increases in risk

Mycobacterium bovis in other species

M. bovis in sheep and goats

Overview

Reported incidents of *M. bovis* in sheep and goats in the UK are very low. These animal populations are regarded as being ‘spillover’ hosts for *M. bovis* infection where infection occurs only as long as there is input from an external source. Sheep should be considered as ‘dead end’ hosts in that they play no significant role in the onward transmission of *M. bovis*, whilst goats can be ‘amplifier’ hosts which appear capable of transmitting *M. bovis* to other species (AHVLA website). There are no mandatory TB testing requirements for non-bovine species so disease surveillance mostly relies on post mortem detection at either PMMI or by private veterinarians. Evidence of TB infection for both sheep and goats is notifiable.

Currently, TB testing for sheep and goats is only carried out when TB is suspected in the herd or flock following *post-mortem* examination or when flocks/herds are linked epidemiologically to a breakdown in cattle. Movement restrictions are also imposed to contain any further disease spread. These restrictions last until the herd or flock tests negative using the tuberculin skin test (following the voluntary slaughter of any test positive animals) or until the cohort of exposed and potentially infected animals has been removed.

Spoligotyping and variable number tandem repeat typing of isolates of *M. bovis* from sheep and goats can be carried out to assist in determining the source of TB breakdowns retrospectively. Possible sources for *M. bovis* infection of sheep and goats include: environmental contamination of animal housing, co-grazing with infected cattle or grazing of infected pasture, infection by a common wildlife source (Houlihan 2008)
Difference in prevalence between conforming and non-conforming animals

EC regulation 1244/2007 defines sheep and goats suitable for visual only meat inspection as being less than 12 months old and 6 months old respectively. According to the AHVLA TB culture database there have been no M. bovis positive submissions from sheep < 12 months of age over the last 6 years and positive submissions from goats < 6 months of age could be linked to a single outbreak of M. bovis on one holding in 2008. For sheep > 12 months of age, prevalence is low (24 positive submissions in 2011) but has been increasing over the last 2 years possibly as a consequence of increased awareness of the infection in sheep. Since the reported outbreak of M. bovis in Golden Guernsey goats in 2008, submissions for culture have been declining for goats with only one submission (cultured negative) in 2011.

Sensitivity of detection

TB is not a specifically recorded condition on FSA PMMI forms for sheep and goats despite meat inspection being the only form of surveillance for this condition. Suspect TB associated lesions detected at PMMI are submitted to AHVLA for culture but are not noted on the PMMI form. The FSA throughput numbers at slaughter in 2011 were 11 million and 12,500 animals for sheep and goats respectively. Corresponding numbers of TB culture positive cases were 30 (0.00027%) and 6 (0.048%)(TBTB). EC regulations state that no incision of lymph nodes or lungs is required at PMMI of sheep and goats. The AHVLA TB database indicates that most positive submissions from sheep are associated with lesions in the bronchial and mediastinal lymph nodes, so most TB lesions are not detected under current traditional PMMI regulations nor would be by visual-only PMMI.

Impact on public health

The potential public health impact via consumption of lamb, mutton and goat meat can be assumed to be less than that from beef (See bovine M. bovis section for discussion above). Unpasteurised milk or dairy products made with unpasteurised milk from M. bovis infected sheep and goats can constitute a risk to consumers. In
England and Wales there are no restrictions on sales of unpasteurised sheep or goats milk although only 27 producers are registered with AHVLA to sell raw goat’s milk and 3 to sell raw sheep’s milk. Sales of raw drinking milk and cream from any species are banned in Scotland. The ACMSF concluded that the risk to human health from \textit{M. bovis} in unpasteurised sheep and goat milk and milk products is likely to be very low but with uncertainties due to lack of data.

Furthermore, as lungs and associated lymph nodes are not incised at current PMMI a change to visual-only examination would not have a significant public health impact compared with the present situation.

\textit{Impact on animal health}

\textit{M. bovis} in non-bovine farmed animals is rare and this population of livestock is not considered to represent a significant reservoir of disease for other animals or be of any significance in the persistence of TB in cattle (DEFRA 2011). However, it is still possible that severely infected sheep and goats could act as vectors of infection for other animals.

\textit{Risk estimation}

The incidence of \textit{M. bovis} in sheep and goats in GB is considered to be rare. Mandatory incision of lymph nodes or lungs for the detection of TB associated lesions is not carried out at PMMI for these animals.

TB Very few TB culture positive cases in sheep and goats were detected by PMMI for the period 2008-2011 inclusive and TB is not a specifically recorded condition as documented by the FSA. It is therefore considered that the relative (and absolute) risk to public and animal health is \textbf{negligible} if a visual only PMMI procedure was employed for sheep and goats.

\textit{TBB}
M. bovis was first recorded in UK farmed deer in 1985 in red deer that had been imported from Hungary (Bode 1995) but might have been present in wild deer populations prior to this. Deer may be infected with both bovine and avian TB via both the respiratory and alimentary routes. In an infected population many animals only show signs of subtly swollen lymph nodes and many are asymptomatic carriers. Hotspot areas, where significant levels of TB are found in wild deer, are usually associated with high TB infection rates in cattle and with high deer densities. In the UK, herds of wild red, fallow and sika deer are frequently closely associated with farmed livestock, grazing the same pasture and consuming the same crop fadders. Most reports of M. bovis infection have occurred in these species. Deer-to-deer transmission occurs by both respiratory and alimentary routes via faecal contamination of pasture and sharing of feedstuffs (Böhm 2007).

Farmed deer are subject to the same considerations as regards TB as mentioned above for sheep and goats. Government tuberculosis deer orders provide for control of TB in farmed deer herds only, not in wild populations. At present it is mandatory for suspected TB in any deer to be reported to Defra but the powers of control (movement restriction orders) apply only to deer from enclosed premises. Detection of M. bovis in a wild deer population can only be recorded as an incident with no follow up regulatory controls and would, therefore, have little consequence on the subsequent disease status of the group.

M. bovis infection in deer is usually subclinical whilst in advanced disease, emaciation is the most typical sign. Detection of TB in non-bovine species occurs either in abattoirs, as part of routine meat inspection or during post mortem examinations carried out by private veterinarians, or at gralloching for deer by the stalkers. For farmed deer PMMI-based surveillance is the primary detection method of M. bovis and is largely concentrated in a small number of specialist abattoirs – there is no surveillance skin testing. Detection of M. bovis in wild deer relies upon the experience of the hunter in the field and his knowledge of tuberculosis-associated abnormalities in the viscera. A trained hunter (with knowledge of requirements of Regulation 853/2004) must attach a numbered declaration stating that the animal was found to be free of any abnormal characteristics. If the carcase is accompanied by a
declaration the head and viscera do not need to be taken along with the body to the
game handling establishment. If, however, a trained person is not present the head,
heart, lungs and liver must be delivered with the deer carcase. The lymph nodes of the
head region are the most common sites of lesions caused by *M. bovis* in farmed and
wild deer (de Lisle 2001).

*Difference in prevalence between conforming and non-conforming animals*

EC regulation 1244/2007 does not define any specifications for deer populations
suitable for visual-only PMMI, although two distinct production systems exist. Wild
deer production is generally unregulated with no FCI or prior knowledge of animal
history. Farmed deer, on the other hand, are more likely to be part of an integrated
production system. FSA meat inspection data records *Mycobacterium* spp. occurring
on average in 40/100,000 farmed deer and 3/100,000 wild deer over the past 4 years.
It should be acknowledged, however, that TB suspect submissions to the AHVLA TB
database confirmed as *M. avium* are far more prevalent than *M. bovis* so it can be
assumed that a high percentage of PMMI-detected *Mycobacterium* spp are likely to be
*M. avium*. This is confounded by the fact that gross lesions caused by
*paratuberculosis* and *M. avium* in deer are indistinguishable from lesions caused by
*M. bovis*. PMMI data could also be subject to bias as the viscera of wild deer, where
TB-associated abnormalities could reside, are often left in the field and so are not
subject to full meat inspection. The British Deer Society states that in some localised
areas of Exmoor the levels of TB infection in wild deer may be as high as 50% but
with no active surveillance of *M. bovis* in either farmed or wild deer it is impossible to
determine a definitive prevalence of the disease in either of these populations.
Outbreaks of TB infection are often seen in deer younger than 2 years whilst older
carrier animals may have few or no obvious lesions. The total number of deer
submissions to the AHVLA TB database is low (average of 55 annually over the past
6 years) with the incidence of *M. bovis* averaging 23 annual confirmed submissions in
wild deer and ~ 2 confirmed cases in farmed deer. We would expect higher numbers
of wild deer submissions given that wild deer samples include survey samples from
known high-risk areas.

*Sensitivity of detection*
EC regulations covering meat inspection at PMMI of farmed game are vague stating that ‘the inspection is to include palpation and, where judged necessary, incision of those parts of the animal which have undergone any change or are suspect for any other reason.’ For inspection of wild game the official veterinarian is instructed to carry out a visual examination of the carcase and cavities and to observe/palpate the organs, where appropriate, to examine for characteristics indicating that the meat presents a health risk. Data on the specificity and sensitivity of PMMI in deer is scarce. Based on experience of TB in cattle, sensitivity is estimated to be between 10-87% whilst expert opinion on specificity varies from 15-98% (EFSA 2008). The wide range in estimates may be due to differences in stage of infection and in the inspection routine. If PMMI is to be effective inspectors must be well trained, examine the correct tissues and increase submissions of identified suspect lesions for laboratory examination (EFSA 2008). There is a high proportion of TB infected deer with no visible lesions with PMMI reportedly identifying TB associated lesions in less than 50% of culture positive deer (Whiting et al., 1994). Furthermore, the number of TB cases in farmed and wild deer detected at PMMI by observation, palpation or incision is unknown. Abattoir meat inspection remains the only form of surveillance for *M. bovis* in both farmed and wild deer. However, as there is no mandatory incision at current PMMI of deer there would not be a significant reduction of TB detected cases with a move to a visual-only PMMI.

**Impact on public health**

There is no peer-reviewed literature showing conclusive evidence of meat-borne *M. bovis* infection in humans from consuming venison. Although PMMI is the only form of surveillance for *M. bovis* in deer the impact on public health from moving to a visual only PMMI is considered negligible given the very rare incidence of *M. bovis* in both farmed and wild deer, and considering that incision at current PMMI is not mandatory.

**Impact on animal health**
Deer are not currently considered significant in the epidemiology of TB in cattle or badgers in England (Delahay, Smith et al. 2007). It is not known whether infection can persist in wild deer in the absence of any other source of infection. The same range and geographic distribution of DNA isolates from M. bovis from cattle, deer and badger have been found indicating transmission between these hosts, but not showing the direction of spread of infection (Duarte, Domingos et al. 2008). In GB wild deer have increased in density and expanded their geographical range over recent years. Further increases in deer abundance may exacerbate the potential for disease persistence and spread in livestock-deer communities (Bohm, Hutchings et al. 2009). A quantitative risk model looking at the M. bovis exposure risk posed to cattle by wild deer relative to badgers in England and Wales (Ward, Smith et al. 2009) concluded that there would be localised areas where the relative risks posed by deer may be considerable. In addition, where there are infected wild deer populations the risks to cattle may be additive to those posed by badgers.

Risk estimation

The incidence of M. bovis in farmed and wild deer in the UK is considered to be very low. Mandatory incision of lymph nodes or lungs for the detection of TB associated lesions is not carried out currently at PMMI for these animals, and so detection rates are correspondingly low. It is therefore considered that the risk to public and animal health would be negligible if a visual-only meat inspection procedure was employed.

Erysipelothrix rhusiopathiae in all species

Overview

E. rhusiopathiae is a ubiquitous environmental bacterium found as a pathogen in a wide variety of animals. Infection can occur via the mucous membranes, abrasions or skin lesions (Smith 1998). Although domestic pigs are believed to be the major reservoir (Reboli 1989) E. rhusiopathiae can cause joint and navel infections in cattle and sheep. Infection is characterised by non-suppurative polyarthritis and laminitis; systemic infection is rare (Cross 1977).
*E. rhusiopathiae* infection commonly occurs via the umbilical cord wound, abrasions caused by docking and castration or small skin abrasions from the dipping vat. Infection may cause a local reaction at the point of entry (navel ill) or pass in the bloodstream around the body localizing in the joints, leading to joint ill. On-farm diagnosis in the live animal is common as *E. rhusiopathiae* infection very often has a constant incubation period allowing diagnosis to be made from procedural history and clinical signs.

*E. rhusiopathiae* is a zoonotic agent transmitted to people via occupational exposure. The majority of animal to human transmissions cause localised skin infections known as Erysipeloid, an occupational hazard mostly affecting individuals working with raw meat and fish including abattoir workers, fishermen and butchers (Conklin and Steele 1979).

**Difference in prevalence between conforming and non-conforming animals**

There has been an annual average of 328 recordings of joint/navel ill per 100,000 calves over the past four years (FSA meat inspection data). Joint/navel ill is not recorded for adult cattle. However, if the recording categories of joint/navel ill and joint lesions are combined for calves, then there is certainly a higher detection rate for calves versus adult cattle joint lesions (389.5 per 100,000 calves versus 226.1 per 100,000 adult cattle). There are no figures, however, indicating what proportion of diagnoses is made from observation, palpation or incision at PMMI, or what bacterium was the causative agent in the condition/s. Because navel infections in calves usually arise as a result of infection with *E. coli* or *Arcanobacter pyogenes*, and *E. rhusiopathiae* occurs rarely in calves (EFSA 2003), we assume that the majority of joint ill cases recorded by meat inspectors are not caused by *E. rhusiopathiae*.

Submissions to the AHVLA Veterinary Investigation Diagnostic Analysis (VIDA) database diagnosed as ‘joint ill’ were all from animals less than 3 months of age (unpublished data, AHVLA VIDA). Conversely, *E. rhusiopathiae* is rarely associated
with disease, such as bacterial endocarditis, in adult cattle (Edwards, Schock et al. 2009).

Joint ill is relatively rare in goats compared with sheep. The relative resistance of goats to the bacterial infection was demonstrated by challenging with disproportionately large number of Erysipelothrix organisms without the animals succumbing to disease (Yeh, Chen et al. 1990). Post mortem detection of joint ill is not a recorded condition in sheep or goats but VIDA recordings of the pathogen are categorised as ‘navel ill/joint ill’ ‘erysipelas’ and ‘arthritis due to E. rhusiopathiae’.

Submissions diagnosed as joint ill were all from animals less than 3 months of age whereas ‘erysipelas’ and ‘arthritis due to E. rhusiopathiae’ submissions were diagnosed in occasional submissions from adult animals indicating that disease is infrequently present in the older animal (unpublished data, AHVLA VIDA).

Post mortem detection of joint ill is not a recorded condition in deer. There have been no reports of E. rhusiopathiae in deer in Britain (Dr. John Fletcher, Veterinary Deer Society, personal communication) and the incidence in the rest of the world is rare (Bohm, Bollwahn et al. 1980). In summary, E. rhusiopathiae appears to be more common in younger bovine/ovines, and rare in deer.

Sensitivity of detection

Currently mandatory meat inspection procedures in bovines less than 6 weeks of age, sheep and goats include visual inspection and palpation of the umbilical region and joints. Incision can be undertaken if deemed necessary. EFSA considers arthritis and joint ill in sheep and goats to be detectable by observation and palpation (EFSA 2004).

There is no mandatory inspection of joints in bovines over 6 weeks of age. However, EFSA (2004) states that pathology of the joints are relatively frequent in cattle and require a routine visual inspection followed by incision, if necessary, to ascertain possible septic conditions leading to involvement of the carcase as a whole. The exclusion of such animals from normal slaughter based upon careful ante-mortem
examination is preferable. Arthritic carcases are partially or totally condemned at the
abattoir depending on whether infection is localised or systemic.

There is no directly comparable data to assess the change in sensitivity of detection of
*E. rhusiopathiae* by British meat inspectors if they switched to visual only
examination. Affected live animals will usually be lame and have swollen joints but a
better view of the damage to the joints will be gained after the carcase has been
skinned. There is no published information indicating the percentage of joint lesions
are caused by *E. rhusiopathiae* or the percentage of joint lesions identified by
observation, palpation or incision at post mortem. Detection can vary according to
hind joint lesions or fore joint lesions. In relation to hind joint lesions (even if there is
no apparent swelling) visual inspection of the iliac lymph nodes usually provides an
indication of abnormalities present, and therefore incision of the joint may be required
as a further investigative measure if no apparent pathology is present. Due to the
presentation of the carcase, joint lesions in the fore quarter are picked up by visual
inspection. An incision is often required to ascertain whether the swelling is just a
buildup of fluid or another pathology (Andrea Cranfield, Senior meat inspector –
personal communication).

It is unlikely that there would be a significant decrease in detection of *E.
rhusiopathiae* if a visual only PMMI technique were to be adopted in either
conforming or non-conforming animals, as visual inspection (followed by limited
palpation in suspect cases) would be likely to identify most cases of joint ill.

**Impact on public health**

**Meat-borne transmission:**

There are no reports of *E. rhusiopathiae* entering the food chain and affecting public
health via consumption of beef/lamb/goat/venison meat. Man is infected through
wounds and skin abrasions, but is very resistant to other entry routes (PAHO 2001).

More than forty years ago, two cases of bacteremia (one with endocarditis) reportedly
occurred after ingestion of undercooked pork (Grieco and Sheldon 1970) but the exact
scenario/point of the pathogen’s entry is poorly documented.

**Occupational transmission:**

Reliable figures on Erysipeloid in humans are difficult to find. Systemic infection in
humans is uncommon but has been found to cause endocarditis in rare cases (less than
1% of infections), usually after occupational exposure to animals, most commonly
domestic swine (Gorby and Peacock 1988). Animal to human transmission is
typically by direct cutaneous contact and so reducing the amount of contact with *E.
rhusiopathiae* during visual-only meat inspection probably decreases slightly the risk
to public (occupational) health.

**Impact on animal health**

Joint ill is a major welfare problem in lambs and is most often caused by poor
hygienic practices. However, most sheep farmers follow a flock health plan drawn up
in association with their vet so may have a suitable disease treatment plan for their
flock.

**Risk Estimation**

*E. rhusiopathiae* is a zoonotic organism, but affects people rarely and mainly via
occupational exposure. Hence, the risk of animal-to-human transmission would
probably be reduced if palpation/incision were omitted in PMMI as there would be
reduced exposure between the infected animal and operator. It is also unlikely that
any decrease in detection would lead to an increase of infection in the live animals on
the farm, as most farmers would probably be aware of the infection due to lame
animals on the farm before meat inspectors identified the condition. Reports of *E.
rhusiopathiae* in deer and goats are rare. The overall risk to public health, as well as
to animal health, from changing from current to a visual-only PMMI procedure for
animals from conforming and non-conforming systems is therefore considered
negligible for all species.
Caseous lymphadenitis in sheep and goats

Overview

Caseous lymphadenitis (CLA) is a condition caused by the bacterium *Corynebacterium pseudotuberculosis*. It is a chronic, often subclinical, disease characterised by abscess formation in the lymph nodes and viscera, particularly in the lungs (Dorella, Fachin et al. 2006). In the UK, the most common sites of abscesses are the superficial lymph nodes of the head and neck. The lymph nodes of the limbs and torso are affected less commonly. These lesions are generally detectable as firm, discrete swellings beneath the skin. The visceral form of the disease is also commonly found in the UK.

*C. pseudotuberculosis* can survive for up to 5 months in soil and is also viable in faeces and faecally-contaminated sheep dips. Transmission occurs when superficial wounds are contaminated with material from external abscesses, e.g. at shearing, tagging, castration and by aerosol transmission from lung forms of CLA. Infected animals can also shed the organism in faeces and milk. Housing, close confinement for prolonged periods in a contaminated environment and trough feeding are likely to be important risk factors (Baird and Malone 2010).

CLA has been in the UK for approximately 20 years at relatively low levels but a recent geographical spread in incidental reporting suggests that CLA is an emerging and a potentially important problem in British sheep flocks. Antibiotic treatment is fairly ineffective against CLA and no vaccine is currently licensed for use in the UK. Controlling the disease can be successful via identification and removal of infected carrier sheep using serological tests to detect antibodies to Phospholipase D (PLD). The PLD ELISA has been used in an established disease eradication and control scheme in the Dutch dairy goat industry (Baird and Malone 2010).

CLA occasionally causes infection after occupational exposure, leading to potentially serious swelling of the axillary lymph nodes in man. However, the disease risk is low.
when sensible hygienic precautions are taken by farmers and vets when dealing with infected animals.

Difference in prevalence between conforming and non-conforming animals

Prevalence of detection at abattoirs in the UK is relatively low with an average of 6.08 recordings per 100,000 animals for sheep over the past 4 years and 9.32 recordings for goats. Evidence suggests that the relative prevalence of CLA is higher in adult sheep than in lambs. VIDA submissions positively confirmed as CLA also suggest a distinction between age groups for sheep over 12 months of age versus animals less than 12 months of age (unpublished data, AHVLA VIDA).

Sensitivity of detection

In a survey of Australian feral goats head, body and visceral lesions were present in 49.3%, 46.7% and 12.3% of affected goats respectively. Lung lesions were relatively uncommon (Batey, Speed et al. 1986). Clinical presentation in goats is commonly on the superficial lymph nodes mainly on the head and neck whilst visceral lesions are more common in sheep (Malone, Fee et al. 2006). It has been estimated that in the UK between 25% and 50% of animals with CLA have only internal lesions (Malone, Fee et al. 2006), Baird et al 2010).

Impact on public health

Although very rare, human occupational infections with the sheep/goat strain have been recorded amongst farm and abattoir workers. In people, infections are associated with flu-like symptoms, fluctuating fever and chronic lymph gland enlargement.

Impact on animal health

Clinical inspection of sheep detects many cases of CLA. However, some visceral lesions in the lung parenchyma would remain undetected at meat inspection if the lungs were not incised. As part of the sheep and goat health scheme the Scottish Agricultural College (SAC) promoted a CLA monitoring scheme using a serological
However, uptake was poor with less than 10 flocks tested under the scheme (Brian Hosie, SAC, personal communication).

In summary, it is likely that whilst most infected goats would be detected ante-mortem, there may be a number of infected sheep that are only identified at PMMI. Some of these sheep may have lesions that are only detectable by palpation/incision, hence the sensitivity of meat inspection may decrease by a small margin for CLA. However, CLA is a common infection, infecting between 16% and 36% of a herd in one study (Malone, Fee et al. 2006), so it is very unlikely that a herd would remain completely undetected during visual-only PMMI. Therefore the value of PMMI as an animal surveillance tool for CLA infection would be likely to remain even if incision/palpation is omitted.

**Risk estimation**

Zoonotic transmission of CLA is occupational, so moving to visual-only PMMI of small ruminants would reduce the public health risk. Zoonotic transmission is rare so that the risk to public health given either current or visual-only PMMI of conforming or non-conforming sheep populations can be classed as negligible.

A potential risk to small ruminant health exists because of the role PMMI may play in surveillance for the disease. However this risk is likely to be negligible given that while individual animal sensitivity may decrease, herd-level sensitivity of meat inspection would probably remain unaffected. Regular use of an ELISA to test and remove positive sheep, in association with clinical inspections and changes in farm management, can greatly reduce the incidence of CLA in affected flocks (Malone, Fee et al. 2006; Baird and Malone 2010).

**Dictyocaulus spp. in all species**

**Overview**
Different species of the *Dictyocaulus* lungworms are found in cattle and deer (*D. viviparus*), and sheep and goats (*D. filaria*). Adult worms in the lung produce eggs that hatch almost immediately. The larvae from these eggs migrate up the trachea of the host where they are swallowed and consequently passed out in faeces contaminating pasture. The cycle is completed by subsequent animals ingesting the larvae which migrate to the lungs until they reach the airways where they mature into adults. The passage of larvae through the lungs and the presence of adults in the airway causes the clinical signs of lungworm-associated respiratory disease.

The clinical signs of lungworm infestation range from moderate coughing, with slightly increased respiratory rates, to severe persistent coughing and respiratory distress. Reduced milk yields and weight loss accompany many infections in cattle, sheep, and goats. Diagnosis is based on clinical signs, epidemiology and presence of larvae in faeces, as subclinical infections can occur in all species. ELISA tests are available in some laboratories, but because the antigens used are derived from adult worms, the test is not suitable for detecting all stages of infection.

There is an effective vaccine against lungworm currently given to susceptible stock prior to turnout. However, this practice relies on the animals subsequently being exposed to natural lungworm infection to allow them to develop full immunity. Failure to expose animals in this way will result in a risk of lungworm in subsequent years. Lungworm has been traditionally managed by both vaccination and the use of anthelmintics. A reduction in use of the vaccine in recent years and an increasing reliance on the use of anthelmintics has resulted in a steep rise in the number of lungworm cases in older cattle (van Dijk 2004).

Severe clinical signs and lesions are only seen with heavy lungworm infestation. Clinical disease has an incubation period of around three weeks from ingestion and can, therefore, occur a few days before larvae appear in the faeces. By the time clinical disease is present, the health of the cow or calf is already severely compromised by the extensive damage that can be caused by worms in the lung tissues.
The role of deer in the transmission of lungworm is not yet totally clear. Infective *D. viviparus* larvae isolated from Roe deer can produce infections in cattle. There are, however, indications that these isolates are less pathogenic for cattle and that no outbreaks of lungworm disease result from infections (Jorgensen and Vigh-Larsen 1986). There is also molecular evidence that the *Dictyocaulus* species found in wild cervids are different from those isolated from bovines (Divina, Wilhelmsson et al. 2000). *Dictyocaulus* spp. are probably the commonest helminth parasites in deer, causing pathological changes in bronchi and larger bronchioles. *Dictyocaulus* spp. were present in 15% of both wild red and sika deer. The level of infection was higher in males than females. Infection with *Dictyocaulus* spp. showed no significant differences in relation to age or region.

*Dictyocaulus* spp. are not zoonotic.

**Difference in prevalence between conforming and non-conforming animals**

Estimating the prevalence of lungworm disease in any species based on current available data is difficult as little high quality surveillance is being carried out. In cattle it was traditionally known as a disease of calves but since 1993 it has also been recognized as a disease of adult cattle. From 1993-2003 76% of the total cases of lungworm in cattle involved cattle older than one year. VIDA data from the last 9 years show a similar trend with rates of lungworm detection in cattle older than 8 months just higher than that from calves (unpublished data, AHVLA VIDA). It is still one of the most commonly diagnosed respiratory diseases in cattle.

In a review on the control of pneumonia in housed calves (Shoo, Wiseman et al. 1990), *D. viviparus* is described as being a likely pathogen only in adult cows (classed as over 1 year of age) and dairy calves housed after a season at grass.

Prevalence of lungworm in sheep relative to age is not clear-cut. The overall trend since 2003 appears to be for more confirmed cases in sheep < 12 months although this situation has been revered in some years (unpublished data AHVLA VIDA). Submissions are low for both age sets of animals, an annual average of 0.1 submissions per 100,000 animals for all ages.
Sensitivity of detection

Despite lungworm being an increasingly diagnosed respiratory disease *Dictyocaulus viviparus* in cattle and deer, and *Dictyocaulus filaria* in sheep and goats, are not recorded conditions at PMMI. Lung conditions detected *post-mortem* are categorised as either lung lesions or pneumonia/pleurisy. *Post mortem* requirements for cattle are observation, palpation and incision of lungs in the posterior third, perpendicular to their main axes. Mandatory PMMI requirements for deer are observation only whilst observation and palpation is required for sheep and goats. The trachea and main branches of the bronchi are incised lengthways and bronchial and medistinal lymph nodes are incised. Expert opinion is that lungworm would be detectable by palpation of the lungs at PM in cattle, sheep/goats and deer (Andrea Cranfield, Senior Meat Inspector, FSA). If palpation of lungs were to be removed from PMMI there may be a reduction in sensitivity of detection of low level lungworm infections.

Impact on animal health

Surveillance for lungworm appears to focus on the live animal. There is no specific recording of lungworm as the causative agent for lung lesions or pleurisy/pneumonia, at PMMI so it is difficult for the FBO to provide accurate feedback to the farmer. Detection of lungworm in the live animal allows the farmer to implement a vaccination/anthelmintics programme. The lack of feedback from the FBO to the farmer due to the absence of lungworm recording at PMMI will mean that there is no impact on animal health if a visual-only PMMI is employed.

Risk estimation

Lungworm is not a recorded condition for rejection at PM though expert opinion states that lung lesions detected are primarily due to pneumonia or lungworm. In the literature it is stated that the incidence of lungworm is similar in both calves under 8 months of age and older cattle. Surveillance of lungworm is largely based on clinical investigations rather than post mortem findings (van Dijk 2004). Although expert
opinion states that lungworm in cattle, sheep/goats and deer requires palpation for
detection, the risk to animal health incurred by changing to a visual only PM method
is considered to be **negligible**. This is due to the lack of recording of the condition at
PM and the extensive surveillance in the live animal.

**Jaagsiekte in sheep/goats**

*Overview*

Ovine pulmonary adenocarcinoma (OPA, or Jaagsiekte) is a chronic pulmonary
disease of small ruminants, caused by Jaagsiekte Sheep Retrovirus (JSRV).
Horizontal transmission occurs between adults and young animals, and lambs have
been shown to be infected perinatally (Salvatori, de las Heras et al. 2004; Caporale,
Centorame et al. 2005). There is some evidence that infection at a young age results in
an increased severity of clinical signs and macroscopic lesions (Salvatori, de las Heras
et al. 2004). Close contact with infected animals is the major risk factor for
transmission of JSRV (Griffiths, Martineau et al. 2010), and only a proportion of
infected animals go on to develop OPA pathology or clinical signs (Sharp and
DeMartini 2003; Caporale, Centorame et al. 2005).
The disease has a long incubation period (Caporale, Centorame et al. 2005) and
usually presents in older animals as non-specific clinical signs such as loss of
condition, followed by the development of respiratory difficulty, particularly when
herded (Stevenson, Finley et al. 1982; Hunter and Munro 1983). Terminal cases are
identified by respiratory distress and the production of pulmonary fluid, which is
visualised by elevating the hind legs of the animal (“wheelbarrow test”) (Voigt,
Kraemer et al. 2007; Cousens, Graham et al. 2008).

Post mortem evidence includes enlarged lungs with lesions present in both lungs and
the appearance of firm tumours of varying size often separated from the adjacent
normal lung tissue. Pleurisy may be evident over the surface of the tumour and
abscesses are often present in the adenomatous tissue (OIE 2008). Pathological
findings can be complicated by secondary bacterial infection (Stevenson, Finley et al.
1982), and histopathology is required for a definitive diagnosis.
Difference in prevalence between conforming and non-conforming animals

Relative prevalence of OPA in the UK is higher in adult sheep than in lambs, according to AHVLA VIDA submission data (AHVLA VIDA, unpublished data). Animals kept indoors are at greater risk of JSRV infection (Griffiths, Martineau et al. 2010).

Sensitivity of detection

Meat inspection data from 2008-2011 show that approximately 5% of all animals have ‘lung lesions’. However, this is non-specific for OPA, as it includes multiple pathologies and aetiologies. Expert opinion suggests that the majority of lung lesions are either due to lungworm or pneumonia (Andrea Cranfield, FSA Operations Group, personal communication). ‘Tumours’ are detected in approximately 2 animals per 100,000 slaughtered, which could reflect OPA in the majority of cases (Salvatori, de las Heras et al. 2004).

Expert opinion indicates that a visual-only inspection of the lungs is likely to miss more cases of OPA than traditional inspection (Chris Cousens pers. Comm.). Necropsy data show gross post mortem inspection of clinically healthy ewes from known OPA-positive herds has a sensitivity of detection ranging between 0 and 75% (Voigt, Kraemer et al. 2007; Cousens, Graham et al. 2008). Sensitivity of detection of OPA by gross pathology in adult animals with mild or suspicious (but not severe) clinical signs (i.e. those that might not be detected at ante mortem inspection) was 71% in one study (Voigt, Kraemer et al. 2007). It is important to note that these data refer to necropsy procedures, which are more thorough than meat inspection, and thus 75% sensitivity could be considered the ‘best-case’ scenario for the latter. By contrast, in a large-scale New Zealand study, visual meat inspection of lamb lungs was shown to have a sensitivity of detection of pneumonic lesions (a classification that includes OPA) of only 17% (Goodwin-Ray, Stevenson et al. 2008).

Impact on public health
Ovine pulmonary adenocarcinoma is not zoonotic.

**Impact on animal health**

JSRV spreads horizontally within a herd and has been shown to infect lambs from a young age. Within-herd prevalence in infected flocks can be high (Garcia-Goti, Gonzalez et al. 2000; Cousens, Graham et al. 2008) the incubation period is usually long (months-years); and infection is often clinically and/or macroscopically silent within the individual. Meat inspection (either traditional or visual-only) is therefore unlikely to be an effective tool for diagnosis of OPA in a herd. However, visual-only PMMI will be likely to reduce the sensitivity of detection of PM meat inspection, although it should be noted that OPA is not currently recorded at meat inspection as a condition in its own right.

**Risk estimation**

While non-conforming, adult animals are at greater risk of OPA and the sensitivity of detection of visual-only meat inspection would be less than for traditional meat inspection, OPA is not currently recorded at meat inspection. Therefore, accurate information is unable to be passed back to the farmer. In the absence of meaningful feedback, visual-only PMMI is unlikely to result in any change in risk to animal health, i.e. the consequences of change are negligible.

**Mycobacterium avium subspecies paratuberculosis in all species**

**Overview**

Johne’s disease is caused by infection with *Mycobacterium avium* subspecies *paratuberculosis* (MAP), usually at a young age. In cattle, sheep and goats Johne’s disease presents as a clinical syndrome of weight loss and/or diarrhoea several months or years later (Davis and Madsen-Bouterse 2012). Johne’s disease in deer can present similarly, or as an acute or subacute debilitation and collapse in young animals.
Various studies have shown that susceptibility to Johne’s disease, either in terms of infection, or extent of clinical progression and/or faecal shedding of MAP, decreases with age (Dore, Pare et al. 2010; Mackintosh, Clark et al. 2010). In cattle, limiting exposure of calves to adult faeces is the most important element of Johne’s disease control (Dore, Pare et al. 2010; Marce, Ezanno et al. 2011).

The main pathological findings in cattle, sheep and goats are thickening of the distal small intestine, distension of the draining lymphatics, and enlargement of the associated lymph nodes (Buergelt, Hall et al. 1978; Corpa, Garrido et al. 2000; Greig 2000). In deer, thickening of the small intestinal wall is less frequent, and enlargement and oedema of the mesenteric and ileocaecal lymph nodes is commonly seen (Marco, Ruiz et al. 2002; de Lisle, Yates et al. 2003).

There has long been conjecture regarding the link between Johne’s disease and Crohn’s disease in man (Uzoigwe, Khaisa et al. 2007). MAP has been isolated from patients with Crohn’s disease, but also from patients with other diseases, and healthy people (Davis and Madsen-Bouterse 2012). Studies of high-risk groups that have been exposed to clinical Johne’s in animals have failed to show an association between the two diseases (SCAHW 2000).

**Difference in prevalence between conforming and non-conforming animals**

Meat inspection recorded a prevalence rate of 4.7 cases per 100,000 adult cattle slaughtered in the period 2008-2011. No calves were identified with the condition. Herd prevalence of bovine Johne’s disease in Great Britain has previously been shown to be between 3.5% and 4.9% (Cetinkaya, Egan et al. 1996), although a much higher regional prevalence (75-78% of dairy herds, and 44-46% beef suckler herds) has recently been estimated in South-West England (Woodbine, Schukken et al. 2009). Herd-level prevalence is thought to be over 50% in several European countries (Nielsen and Toft 2009). A mean of 3,381 cases per year has been diagnosed by AHVLA laboratories over the period 2008-2011 (AHVLA, 2012).

An increased prevalence in older cattle has been shown (Gasteiner, Awad-Masalmeh et al. 2000), and in the UK, Johne’s disease has not been detected at slaughter in
calves younger than 8 months (FSA, 2012). Animals reared in contact with adult faeces (e.g. those with access to pasture, or contact with their dam) are also at higher risk (Dore, Pare et al. 2010). Thus, adult cattle, and those reared in extensive systems, are at higher risk of developing Johne’s disease than animals from conforming systems.

Johne’s is not a recorded condition at meat inspection for sheep or goats. The prevalence of Johne’s disease in British sheep is thought to be between 1% and 5% of individual animals (Greig 2000; Scott 2012). Flock-level prevalence in Europe is considered to be above 20% (Nielsen and Toft 2009). Like Johne’s disease in cattle, the disease occurs in older animals that have usually been infected with MAP at a young age.

Two wild deer were recorded with Johne’s Disease during meat inspection over the period 2008-2011, giving a prevalence rate of 0.47/100,000 wild deer shot and inspected. No farmed deer were recorded with the disease. The presence of farmed deer has been associated with an increased risk of bovine Johne’s disease in England (Cetinkaya, Erdogan et al. 1997).

Sensitivity of detection

Two studies on Johne’s disease-affected cattle herds show that between 24% and 53% of MAP-positive cattle did not have visually-identifiable lesions on post mortem (Buergelt, Hall et al. 1978; Brady, O’Grady et al. 2008). Meat inspection procedures for adult cattle currently include palpation and, where considered necessary, incision of the gastric and mesenteric lymph nodes (EC 854/2004). Omitting palpation of the lymph nodes during meat inspection is likely to result in some, but not all, of these cases being missed (Dominguez, Watson, personal communication, FSA). Due to the low numbers of presumptive Johne’s cases detected by the existing method, the absolute difference in the sensitivity of detection between traditional and visual-only meat inspection is likely to be very low.

Pathological changes in MAP-positive sheep/goats, particularly goats, are not always evident grossly (Corpa, Garrido et al. 2000; Greig 2000; Tafti and Rashidi 2000).
Some studies show between 36% and 67% of MAP-positive animals from clinically affected flocks have either no gross lesions, or very mild ones that are easily missed at necropsy which is a more thorough, and therefore sensitive, examination than meat inspection (Carrigan and Seaman 1990; Perez, Marin et al. 1996). Studies from Australia show that flock-level sensitivity of detecting ovine Johne’s disease by manual and visual meat inspection is between 30-36% in low-prevalence areas (Sergeant 2003), although this is likely to be an over-estimate.

Palpation and incision of the gastrointestinal tract, mesentery and associated lymph nodes of sheep and goats are not currently performed at PMMI. There is therefore no change in sensitivity of detecting this disease in small ruminants. No cases of Johne’s in either sheep or goats have been detected in the abattoir by this visual appraisal between 2008-2011.

The prominent pathological change in Johne’s-affected deer is enlarged or abnormal mesenteric lymph nodes. Abattoir detection of this pathology by visual inspection has been shown to be highly specific (at least 94.6%) for MAP-positivity but sensitivity is low (12-13.3%) (Hunnam 2011). There is some evidence to suggest that this method is more reliable in young animals (Stringer, Wilson et al. 2011). Similarly to sheep and goats palpation and incision of the gastrointestinal tract, mesentery and associated lymph nodes of farmed deer are not currently performed at PMMI. There is therefore no change in sensitivity of detecting this disease in these animals.

In GB, only two suspect cases of Johne’s disease (in wild deer) have been detected at meat inspection in the last four years (FSA, 2012). The pluck of wild deer is usually left in the field unless abnormalities are detected visually by the hunter. This practice is already a visual-only inspection so there will be no change in sensitivity of detection of Johne’s disease in wild deer.

Impact on public health

Meat from clinical and subclinically affected cattle can contain disseminated MAP (Alonso-Hearn, Molina et al. 2009; Eltholth, Marsh et al. 2009) and go on to enter the food chain. However, very little data exist on the persistence of MAP in processed or
cooked meat. The sole study investigating the presence of MAP in retail beef found no evidence of the bacteria in 200 samples of ground beef (Jaravata, Smith et al. 2007). Heating of MAP-contaminated lymph node/meat composites, where the bacteria were present in greater amounts than in muscle alone, showed that cooking to medium rare “greatly reduced” the amount of viable MAP present, and cooking to well-done eliminated viable MAP (Mutharia, Klassen et al. 2010).

A New Zealand study has shown that MAP was isolated from skeletal muscle or blood in 71% and 62%, respectively, of sheep with confirmed clinical Johne’s disease; it was also detected in 13% and 3% of muscle or blood from sheep with no gross or histopathological evidence of Johne’s disease (Smith, West et al. 2011).

Zoonotic transmission potential of MAP is still debated. Presently, there is no evidence of meat-borne transmission of MAP to humans, but there is a view from the National Advisory Committee on Microbiological Criteria for Food (NACMCF) that the possibility should be further investigated (NACMCF 2010).

Impact on animal health

Johne’s disease may not present with clinical signs for several months or even years after infection. Despite serological tests indicating a high herd prevalence of infection for cattle with approximately 7% cattle testing positive PMMI data for detection of Johne’s disease are considerably less indicating a low sensitivity of detection for traditional PMMI techniques (Woodbine 2009). As the difference in the sensitivity of detection between current and visual-only meat inspection is likely to be very low and current detection rates are already very low there is likely to be negligible impact on animal health for cattle.

There would be no impact on animal health for sheep, goats and deer as palpation and incision of the gastrointestinal tract, mesentery and associated lymph nodes is not currently performed so a visual only PMMI is already in place for these species.

Risk estimation
PMMI detection of Johne’s disease in GB has very little impact on either public or animal health, due to its low diagnostic sensitivity. Meat inspection currently detects very low numbers of suspect Johne’s disease cases in cattle and wild deer and has not identified a single case in sheep, goats, or farmed deer between 2008 and 2011. The proposed change in meat inspection procedures to a visual-only technique could only affect detection of Johne’s disease in cattle or farmed deer, as these are the animal groups currently subject to mandatory palpation of the mesenteric lymph nodes. The others already undergo visual-only appraisal of the relevant tissues. Wild deer form a unique population in that PMMI is currently the only point of surveillance for MAP detection. However, as stated above the current visual-only PMMI will not be changed under the new proposals.

The links between MAP and public health are still debatable, but it would appear that the meat-borne risk is negligible so the impact of a change to visual-only PMMI would also be negligible.

With regard to animal health, even in a worst-case scenario, where all the recently identified cases would be missed by the change in inspection procedure, the numbers remain very low. Thus, a change to visual-only meat inspection is very likely to be of negligible risk to animal health.

Appendix III Flow diagram of TB testing in GB – taken from de la Rua-Domenech, 2006
Figure 5 Bovine TB in Great Britain: schematic representation of the protocols for tuberculin testing of cattle, TB meat inspection and notification of positive results to the local food and public health authorities (Adapted from: Advisory Committee on the Microbiological Safety of Foods. Report on Mycobacterium bovis: A review of the possible health risks to consumers of meat from cattle with evidence of Mycobacterium bovis infection. Hayes: Food Standards Agency Publications; 2002).