A qualitative risk assessment of the microbiological risks to consumers from the production and consumption of uneviscerated and eviscerated small game birds in the UK

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1 Introduction

The production and consumption of wild game birds has become a major industry in the UK. Since the beginning of the 21st century, the wild game sector has evolved from what has been viewed, historically, as a minority sport to a food production industry in its own right (ADAS, 2005). Promotion by celebrity chefs, better marketing and increasing use of farmers' markets, independent butchers and mail order supplies have meant that more people can now access, and are buying and eating, wild game than ever before. Concurrently, the low-fat, healthy-eating properties of game-bird meat and its free-range, 'natural' reputation have made it popular with today's consumers both at home and when eating out.

Wild game birds, like other livestock species, are known to carry pathogens that can adversely affect the health of humans. Unlike farmed animals, the habitat and dietary and migration habits of game birds can influence their role in the international spread of zoonotic infection (Abulreesh, 2007; Hubalek, 2004; Kobayashi, et al., 2007). Although their relatively low population density and more mature age at slaughter mitigate against high-level carriage of foodborne bacterial pathogens, birds carrying pathogenic bacteria in their intestines can pose a direct risk of human infection via consumption of undercooked meat and can also disseminate pathogens into the food processing environment (EFSA, 2012a).

The slaughter process for game meat is less controlled than for farmed livestock species, such as pigs, poultry and cattle, where commercial production is governed by stringent food hygiene regulations. The microbiological condition of shot game birds can be compromised by the conditions of primary production. Location of shot within the carcass, evisceration, handling hygiene and maintenance of the

cold chain can all affect the spread and proliferation of contaminating organisms within game meat (Mead & Scott, 1997). Removal of the viscera is normal practice in the processing of game birds and current EC regulations (853/2004 Annex 111) state that evisceration must be carried out, or completed, without undue delay upon arrival of the birds at the game-handling establishment, unless the competent authority permits otherwise. Exemptions following specific requests from Approved Game Handling Establishments (AGHE) can, and do, occur at the discretion of the Food Standards Agency (FSA). Private and domestic consumption are also exempt from this regulatory stipulation.

Traditionally, small game birds, such as woodcock and snipe, have been cooked with the intestines intact and the viscera are often ingested as part of the final dish. The viscera of birds infected with a pathogen may contain numbers capable of causing human illness. Consumption of the uneviscerated bird could, therefore, expose the consumer to a higher risk of infection than that posed by an eviscerated bird. This risk depends primarily on the cooking step and whether it is sufficient to reduce pathogen numbers to below the level required for an infectious dose for the consumer. With farmed livestock, the process of commercial evisceration is known to be a risk for cross-contamination of carcasses with pathogens and to individuals carrying out the evisceration (EFSA, 2010). It is not uncommon, however, for consumers to eviscerate wild game birds themselves, presenting a significant risk of intestinal rupture and consequent spillage of contents onto the carcass and the operator's hands during this process (Mead & Scott, 1997). Consequently, other food products within the game handling environment may become contaminated with any pathogens present.

EC regulations exist for all game supplied for human consumption, e.g. Regulation (EC) No 172/2004, for general food law requirements, Regulation (EC) No 852/2004 for general hygiene requirements for food businesses and Regulation (EC) No 853/2004 for additional hygiene rules regarding businesses producing food of animal origin. Hygiene guidelines are also provided by the FSA (FSA, 2008) but there has been no formal assessment of the potential risks to UK consumers from production and consumption of uneviscerated small game birds compared to eviscerated birds. Hence, there has been no formal consideration of what, if any, modifications to hygiene regulations might be required to control the risks to public health from the production and consumption of uneviscerated birds.

In this paper we discuss a qualitative risk assessment for the microbiological risks to the consumer from the production and consumption of a number of species of small game birds, both 'in the home' and 'outside the home'. The scope of this risk assessment was to consider only the risk to the consumer and not to other people involved in the production/processing of the birds. However, if the consumer is directly involved in production/processing, then this is also considered; for home consumption, the consumer can have a more active role in preparation of the bird, possibly even shooting it themselves, and being involved in dressing and cooking the bird. A simple risk ranking exercise is then carried out to compare the relative risks between the outputs of the risk assessment.

2 Materials and Methods

2.1 Risk assessment scope and approach

The assessment considered zoonotic microbiological hazards present in 9 different species of small wild game birds (snipe, woodpigeon, woodcock, mallard, teal, widgeon, grey partridge, red-legged partridge and quail). The term 'wild birds' included birds that have been hatched/reared under controlled conditions before being released into the wild, in accordance with the definition in Regulation (EC) No 853/2004. 'Farmed birds' refer to those that remain on a commercial poultry farm until slaughter which, in this instance, includes only quail. Whilst quail are regarded as farmed birds, and not game, from the point of view of production, it is possible that they could be regarded as game by the consumer and therefore treated as such when it comes to preparation and cooking, including preparing the bird effilé (partial evisceration where the heart, liver, lungs, gizzard, crop and kidneys are not removed from the carcass) and cooking only until the flesh is 'pink'. To be considered 'wild', game birds must have been killed by hunting if they are to be supplied for human consumption.

The main outputs of the risk assessment were an overall evaluation of the consumer risk from handling and consumption of the wild game species. These outputs were then used to compare the qualitative levels of risk to public health between consumption of eviscerated and uneviscerated small game birds for all the hazards/game bird combinations. Absolute risk estimates are generally subject to large uncertainty in qualitative risk assessments such as this one, due to large data gaps; the strength is in the subsequent comparison between the different factors, such as hazards, bird species and the eviscerated vs. uneviscerated state.

The risk assessment followed the Codex framework of hazard identification, hazard characterisation, exposure assessment and risk characterisation (CAC, 1999). For

each potential hazard/bird combination, the four steps were assessed qualitatively using the definitions (EFSA, 2006) in Table 1. These were then combined to give overall estimates of risk.

TABLE 1 HERE

At an early stage in the risk assessment it was acknowledged that the lack of published literature concerning the wild game sector would require information to be sourced from elsewhere. Therefore, throughout the assessment, expert opinion was sought as a substitute where published data were lacking. Experts were selected from a list of industry bodies, and individual experts involved in the wild game sector drawn up in collaboration with the Scottish FSA. Full references to personal communications with acknowledged experts can be found in the final report (Horigan, et al., 2013)

2.2 Hazard Identification

A comprehensive list of the major microbiological hazards potentially present in game birds was developed according to literature evidence and expert opinion. The full list of the 87 hazards considered is given in the final report to the Scottish FSA (Horigan, et al., 2013). Using a combination of literature review and expert opinion, hazards were shortlisted by considering those that current knowledge suggests could be of public health concern due to the production and/or consumption of wild game birds (not including occupational hazards) in the UK. The hazards shortlisted were: *Salmonella* spp., *Escherichia coli* (verotoxigenic), *E. coli* (antimicrobial resistant), *Campylobacter* spp., *Toxoplasma gondii* and *Listeria*

142 *monocytogenes*. *Chlamydophila psittaci* was also included as an example of a
143 contact/inhalation pathogen which may have different associated risks.

144 2.3 Hazard profiles

145 The remaining elements of the Codex framework (hazard characterisation,
146 exposure assessment and risk characterisation) were applied in 'Hazard Profiles'
147 (Bassett & McClure, 2008).These profiles considered an assessment of the
148 prevalence and microbiological load of the identified hazards in both eviscerated
149 and uneviscerated wild game birds throughout the processing chain, taking into
150 account the relative consumption of individual species of bird, evaluation of the
151 dose response and severity of any adverse effects associated with infection for
152 each specific pathogen. This process is outlined in Fig. 1.

153 FIGURE 1 HERE

154 Fig. 2 shows the detailed framework outlining the different potential pathways
155 from the shot game bird to the consumer along the processing chain.

156 FIGURE 2 HERE

157 Within each stage, the figure shows the risk factors to be considered and those
158 elements that can affect the pathogen prevalence/concentration; for example,
159 maintenance of the cold chain, process hygiene, skill of processor and duration of
160 each stage. These factors are subdivided according to their effect on the exposure
161 of consumers of game birds, either by increasing pathogen load or their potential
162 for cross-contamination. Data were collected for each pathogen/bird species
163 combination, for each stage of the risk assessment. These data include information
164 on the survival, growth and cross-contamination capability of the pathogen at each

stage and were used to assess the likelihood and degree of any change in prevalence and concentration of the pathogen during each stage of the pathway in the medium in question (i.e. live bird, carcass or meat product). Whilst an extensive literature review was carried out, a shortage of published data on the processing of wild game birds meant that, for many stages, it was necessary to supplement the data with expert opinion. At the end of each stage we estimate two qualitative scores: for the *prevalence* and *concentration* of the pathogen. For the prevalence score we combined the prevalence score at the end of the previous stage with the information on the risk of a change in prevalence during the current stage. A similar method is followed for the concentration score. There are many different methods in the literature for combining qualitative scores in a risk assessment, such as the methods used in a previous risk assessment on wild game (Coburn, Snary, Kelly, & Wooldridge, 2005), and the 'risk matrix' approach (Gale, et al., 2010). The latter approach relies on the scores being treated like probabilities so they can be 'multiplied' together with the resulting probability being equal to or lower than the lowest probability. For this risk assessment we predominantly follow the methodology employed by Coburn (Coburn, et al., 2005), but adapt as necessary when our framework differs.

The number of birds consumed was based upon the number of birds shot or slaughtered (Table 2). The number of birds consumed uneviscerated was difficult to quantify, but expert opinion considered that the only species consumed in this manner were woodcock and snipe; estimates suggest that approximately 10% are eaten uneviscerated (BASC, 2013).

TABLE 2 HERE

189 The consequence of exposure of consumers of game birds to the relevant
190 pathogens was calculated in terms of both severity and duration of effects. Whilst
191 infectious-dose (dose-response) data are useful for characterising foodborne
192 hazards, data for *C. psittaci, T. gondii* and *E. coli* (antimicrobial resistant) were
193 non-existent. Conversely, although data were available for *Salmonella* spp.,
194 *Campylobacter* spp. and verotoxigenic *E. coli,* the unknown pathogenicity of
195 strains found in game birds with regard to human infection should be noted. Not all
196 strains found in wild game birds have been identified in humans and not all are
197 likely to cause serious clinical symptoms in people, e.g. pigeon-adapted strains of
198 *S.* Typhimurium DT2 and DT99 (Rabsch, et al., 2002).

199 It is also possible that people regularly involved in game bird production or
200 consumption may acquire some immunity to pathogens for which regular exposure
201 occurs (Havelaar, et al., 2009).
202 The wild game bird industry has a complex structure involving a variety of
203 distribution pathways under different regulatory controls and inspection remits. In
204 addition, the regulations themselves are complex and allow for exemptions and
205 variable interpretation affecting both the holding times and the temperature
206 control within the risk framework (Fig. 2). Compounding this complexity is a lack
207 of knowledge on the actual numbers of birds entering the pathway and the
208 subsequent numbers that go down individual pathway routes. Furthermore, the
209 pathogens considered in this risk assessment are generally asymptomatic in the live
210 bird, and do not cause visible pathology, making them impossible to detect
211 visually. They are also not usually subject to routine surveillance activities, where
212 tests are performed on a batch of birds or carcasses to determine if a particular
213 pathogen is present.

Whilst some data are available on the prevalence of pathogens in game birds (Table 3), no reliable data on pathogenic load was available. Thus, estimates of initial pathogen concentrations are based on the qualitative data for prevalence and given the same qualitative score. This is based on the assumption that within-group prevalence and mean numbers of organisms carried are normally related.

TABLE 3 HERE

3 Results

3.1 Hazard profiles

The scores for prevalence and concentration of each individual pathogen throughout the framework were evaluated as illustrated in Figures 3 & 4 using *Campylobacter* as an example. The remaining pathogen scores, along with more detailed evidence and references can be found in the full report to the Scottish FSA (Horigan, et al., 2013).

FIGURE 3 HERE

FIGURE 4 HERE

Qualitative values for each stage were assessed as described in Materials & Methods. The individual risk to a consumer of game birds, *if* a contaminated product was encountered, could often be quite high, as the evidence suggested that for most pathogen/species combinations, there was occasionally a risk of the pathogen concentration, immediately prior to cooking, being high enough in some

products to cause human infection. A factor that has influenced the risks presented here is the assumption that there is a greater tendency to serve game undercooked or 'pink' outside the home than when cooked by the consumer in the home environment. This assumption is based on a combination of expert opinion which considered that restaurants and catering establishments were more likely to serve game birds undercooked. Consumers cooking game birds within the home, however, were thought to mainly use methods, such as roasting and casserole cooking, which would be more likely to ensure a thoroughly heated product.

Taking into account the different levels of consumption of individual species of bird, and the dose response and severity of infection for each specific pathogen, the overall risks for each pathogen/species combination suggest that there is an increased risk to the consumer of some eviscerated wild bird species from *Campylobacter* spp. and *T. gondii* compared to the other pathogens considered (Figs 5 & 6). The risk to the consumer of uneviscerated wild game bird species was very low/ very low-low for all pathogen/species combinations.

FIGURE 5 HERE

FIGURE 6 HERE

An increased risk of infection from these pathogens was observed for mallard, red-legged partridge, quail, widgeon and woodpigeon. It is interesting to note that the first three species include a high proportion of farm-reared birds, whilst woodpigeon may have a close association with human activities in rural and suburban areas. The higher risk scores are likely to be skewed towards these species because of the high number of birds consumed in these categories and the higher prevalence of pathogens associated with them (see Table 3), although it is difficult to determine whether this is due to an increased number of studies on

farmed birds, because of their economic importance, or whether it reflects a true difference in prevalence.

3.2 *Campylobacter*

A *Low-Medium* risk is associated with *Campylobacter* spp. in eviscerated woodpigeon and mallard consumed outside the home. These birds have a medium initial prevalence of *Campylobacter* spp., are eaten in large numbers and are more likely to be served undercooked outside the home, thereby not ensuring complete thermal inactivation of the bacteria at the time of consumption. The issue of undercooking is important when considering the fact that shot perforation of the gut can lead to microbial contamination of muscle tissue that would otherwise remain sterile (El-Ghareeb, Smulders, Morshdy, Winkelmayer, & Paulsen, 2009). Campylobacter has a low infectious dose in humans (Teunis, et al., 2005) and it is possible that the combination of muscle contamination and undercooking could result in a level of *Campylobacter* contamination high enough to cause infection in the game bird consumer.

For woodcock and snipe, the risk associated with *Campylobacter* spp. in eviscerated birds consumed both in and outside the home was considered to be *Very Low-Low*. Woodcock and snipe are wild, solitary birds and numbers consumed are small compared to those of woodpigeon, mallard and red-legged partridge. It is likely that these two species would have less exposure to pathogens than farm-reared birds as they are considered to have little, if any, contact with humans or their environment (GWCT, 2013).

Outside the home, the overall risk of human infection with *Campylobacter* spp. from uneviscerated snipe and woodcock was considered to be *Very Low-Low*. The predilection for undercooking outside the home, combined with the low infectious dose of *Campylobacter* spp. and the known tendency of snipe and woodcock to be consumed uneviscerated increase the risk to the individual from *Very Low* to *Very Low-Low*.

3.3 *T. gondii*

The risk of human infection with *T. gondii* from eviscerated mallard and red-legged partridge was assessed as *Low*. This was a considered risk because of the high number of potentially infected birds consumed and the tendency to cook the meat until it is only 'pink', which could result in tissue cysts retaining their viability after cooking. Although the dose response characteristics of *T. gondii* are unknown, the severity of infection in humans and longevity of symptoms is such that the risk to game bird consumers is considered to be *Low* in these two avian species.

3.4 Eviscerated vs. Uneviscerated birds

Generally it was considered that, for all pathogens except *T. gondii,* removal of the viscera provided the greatest reduction in pathogen numbers. However, cross-contamination during plucking and evisceration, and the ability of many bacterial organisms to multiply in a time and temperature dependant manner could increase the prevalence of pathogenic bacteria at these processing stages (Chiarini, Tyler, Farber, Pagotto, & Destro, 2009; Christensen, 2001). The extent of cross-

contamination and, therefore, the increase in pathogen prevalence from this cause will depend on the efficiency of the evisceration technique. Conditions under which carcasses are eviscerated in the processing plant and the home have different implications for the risk of cross-contamination. Commercially, game birds are eviscerated manually and operatives will normally be trained to minimise gut rupture and spillage of contents by removing the viscera with care. However, the equipment and procedures used are not designed to prevent all microbial cross-contamination and are unlikely to do so. The high throughput of birds in a commercial operation will increase the risk of cross contamination despite the skill of the workforce employed. Thus, any hazardous organisms present, even at a relatively low prevalence, may spread among the batch of carcasses being processed, but the expectation is that they would be largely destroyed during subsequent cooking (Geoff Mead personal communication). It has been asserted that uneviscerated poultry could have better microbial characteristics and extended shelf life than eviscerated poultry (Mulder, 2004) and the muscle tissue of uneviscerated game birds and poultry stored at refrigerated temperatures has been shown to remain sterile for several days (Mead, Chamberalin, & Borland, 1973). Thus, levels of cross-contamination resulting from the processing of an uneviscerated game bird are likely to be lower than those from birds undergoing the evisceration process.

Domestic evisceration usually involves only one or two carcasses at a time so the chance of one of the birds being positive for a foodborne zoonosis is low compared to commercial scale processing. The risk of gut rupture and spread of microorganisms depends upon the prevalence of pathogens, the skill of the

individual concerned and the care taken. In a small-scale study (Mead & Scott, 1997), home evisceration led invariably to rupture of the gut and, again, food safety depends mainly on the adequacy of the cooking process. In the domestic situation, the principal hazard is in spreading microbes to other foods, during and after the evisceration process.

Since cooking of game is the main control factor, any differences in handling procedures during carcass preparation should be less important, provided that the meat is cooked adequately

Overall it was considered that for uneviscerated birds, other than snipe and woodcock, the risk of human infection for all pathogens is *Very Low*, including the risk from *Listeria monocytogenes,* the only bacterial pathogen considered that is capable of multiplying at refrigeration temperatures.

4 Discussion

The overall risks to consumers of game birds in the UK for the majority of the pathogens/avian species considered in this assessment were *Very Low*. This was primarily due to a low frequency of consumption of certain game bird species in the UK population, low prevalence of pathogens in the species studied and effective cooking to reduce the pathogen load before consumption. The assessment considers that a product could reach the cooking stage with a relatively high pathogen load, due to a series of unfortunate 'rare events'. For example, a bird with a high initial concentration of a pathogen has its gut

perforated by shot and muscle tissue becomes contaminated; it is then hung for long enough to allow growth of the pathogen within the muscle, or human error leads to inadequate implementation of control measures, such as storing the bird at room temperature. In these cases, there is a risk of human infection due to inadequate cooking or cross-contamination of the kitchen environment and other cooked or ready-to-eat foods.

The evidence suggested that there was, overall, no greater risk associated with the consumption of uneviscerated game birds than with eviscerated birds. In some pathogen/species combinations, the assessment even suggested that the risk from eviscerated game birds may be slightly higher. This was due to the risk of cross-contamination during the evisceration process outweighing the reduction in pathogenic organisms due to removal of the viscera. Additionally, there was evidence that the cooking of uneviscerated birds was more likely to remove microbiological hazards due to the method of cooking (uneviscerated birds tend to be thoroughly roasted). By contrast, eviscerated birds are often served ‘rare’, a practice thought to be less common for uneviscerated birds.

We were unable to find evidence for human consumption of uneviscerated birds other than woodcock and snipe in the UK. Nevertheless, it could not be stated with certainty that other species of wild game bird were never consumed uneviscerated. There is anecdotal evidence of consuming squab (baby pigeon) and quail, either uneviscerated or effilé. If the viscera are not completely removed until after/during cooking, then there is still the possibility of cross-contamination up to this point, even if the viscera themselves are not actually consumed. We

estimated the frequency of uneviscerated preparation/consumption of these birds to be *Negligible-Very Low*. If there is now, or in the future, an increased frequency of consumption of these birds, then the overall risk should be re-examined.

The assessed risks from the game handling routes that are covered here can only be as accurate as the data used to inform them. The wild game industry is not as regulated as other farmed livestock industries and suitable data are deficient in some areas. In general, a satisfactory level of expert knowledge was available to assess the risks. We have highlighted the following areas in which data were deficient and have therefore introduced uncertainty into the risk estimate:

- Limited studies on prevalence of pathogens in game birds in the UK, in particular woodcock and snipe.
- Concentrations of pathogens in live game birds
- Numbers of birds following each distribution pathway
- Frequency of consumption of wild game in and outside the home
- Frequency of consumption of uneviscerated bird species
- Probability/magnitude of cross-contamination during processing
- Survival/growth behaviour of pathogens during the framework pathway stages, taking temperature and duration into consideration.
- Data on pathogenicity of *Salmonella* and *Campylobacter* strains found in wild birds, especially with regard to species-specific serotypes.

The results of this risk assessment suggest that, while large outbreaks of zoonotic infection among consumers due to wild game consumption are unlikely, sporadic, infectious events may occur due to combinations of 'rare-event, hygiene-related errors' in the field-to-fork chain and/or inadequate cooking of the game bird in or

outside the home. However, the data gaps identified increase the level of uncertainty surrounding the results. It is widely acknowledged that the game bird sector is a growing industry and it is possible that production of farm-reared birds may become further intensified to cope with the increased demand for those birds that will be released for shooting and human consumption. The intensification of game bird production could lead to changes in the levels of risk presented by zoonotic pathogens to human health. It is therefore recommended that the conclusions of this assessment are periodically revisited to assess whether improved data are available to update the assessment or significant changes have occurred that would affect the findings.

5 Acknowledgements

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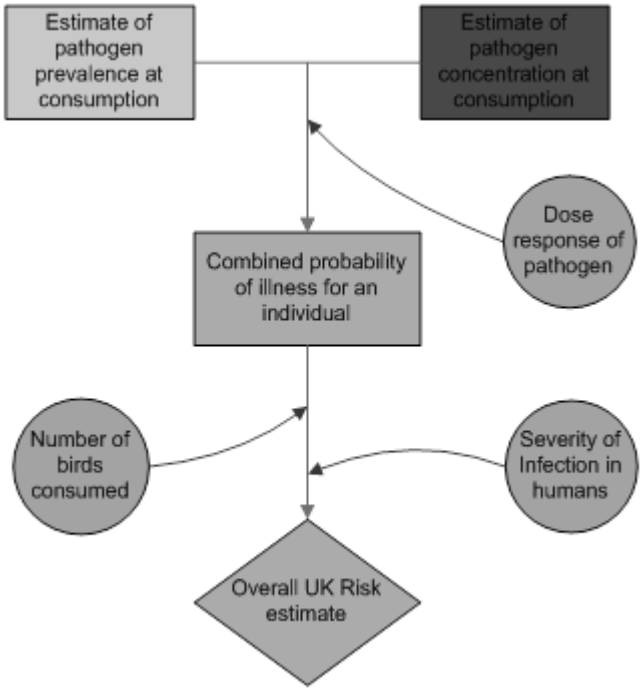
Figures

Figure 1:



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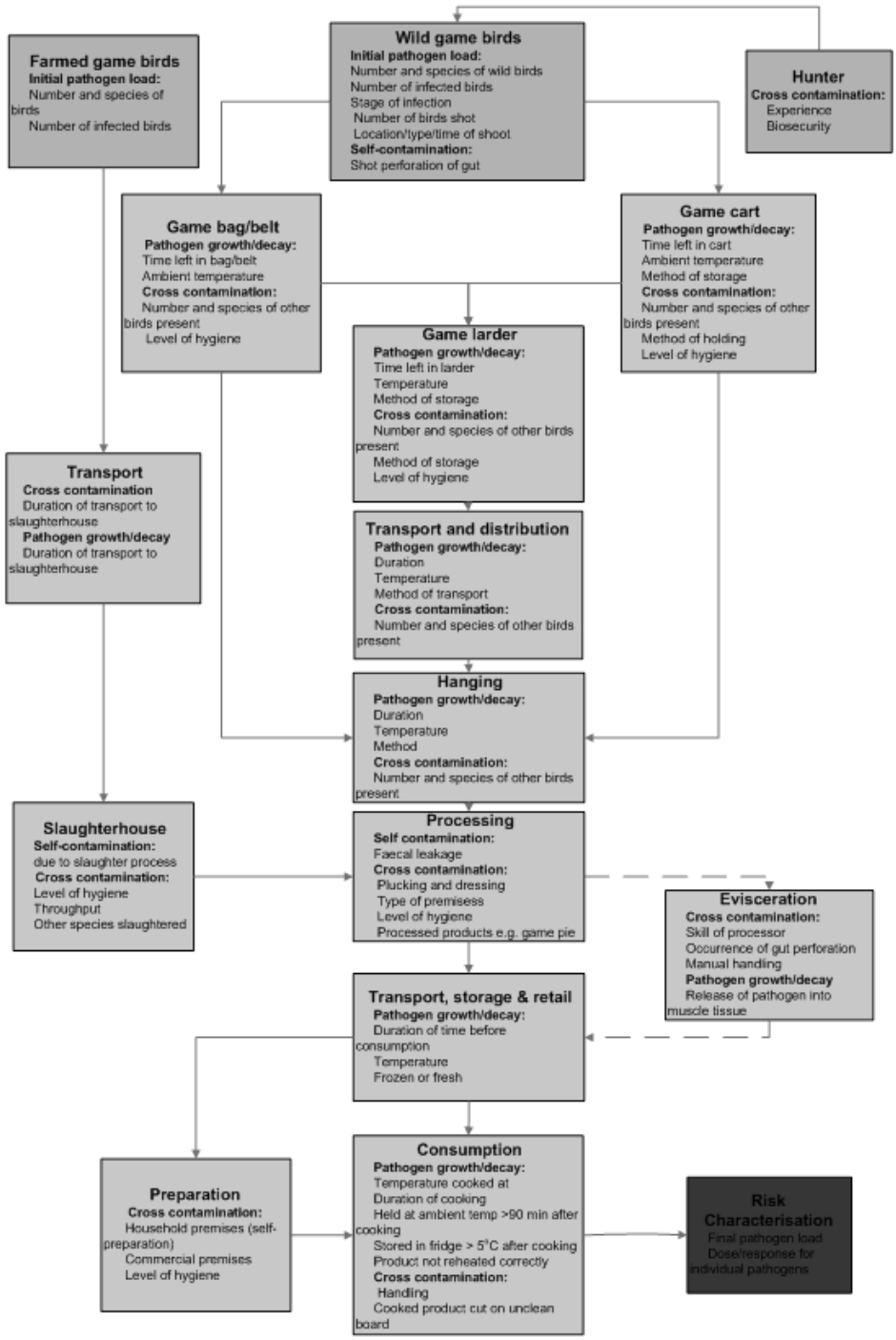

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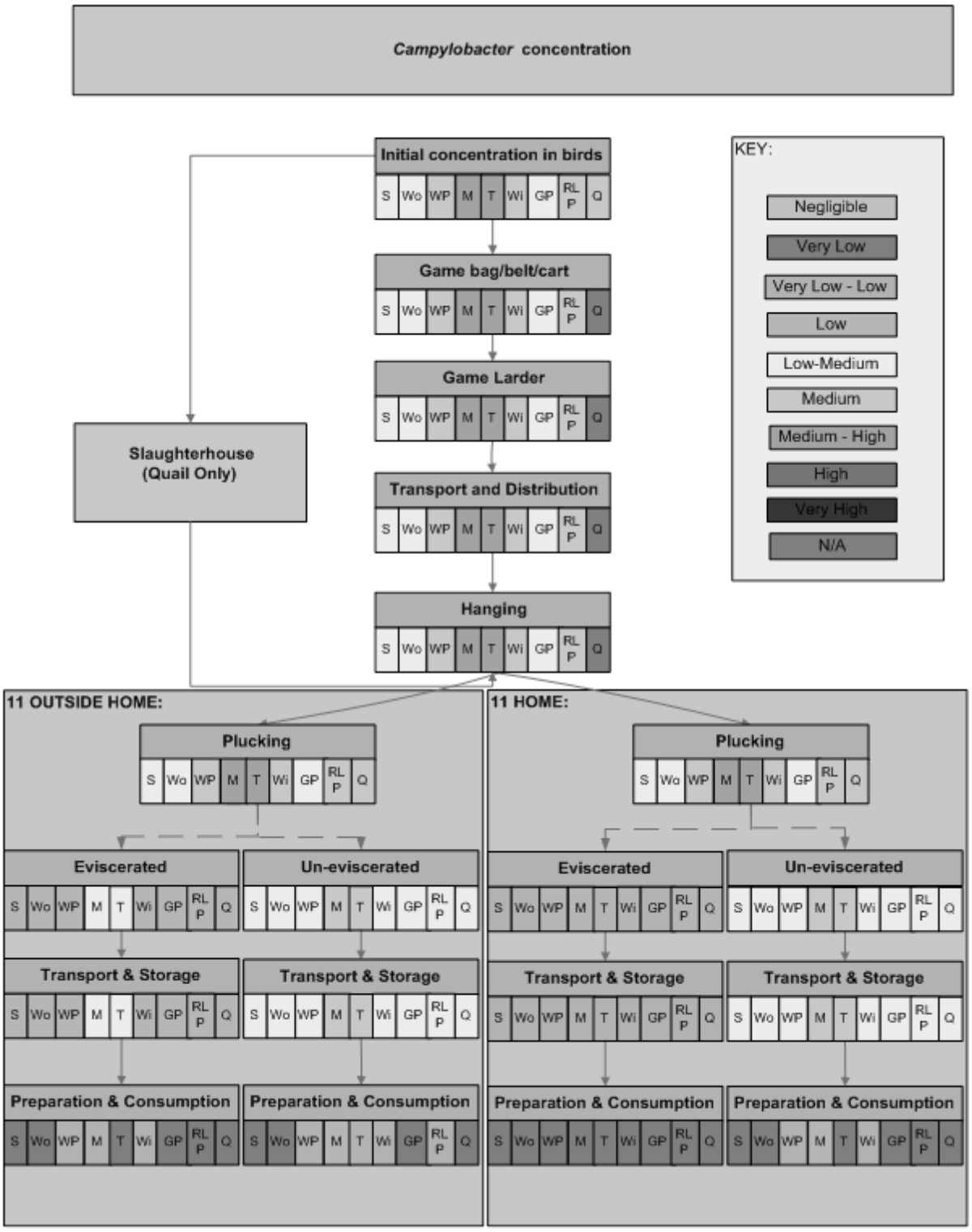

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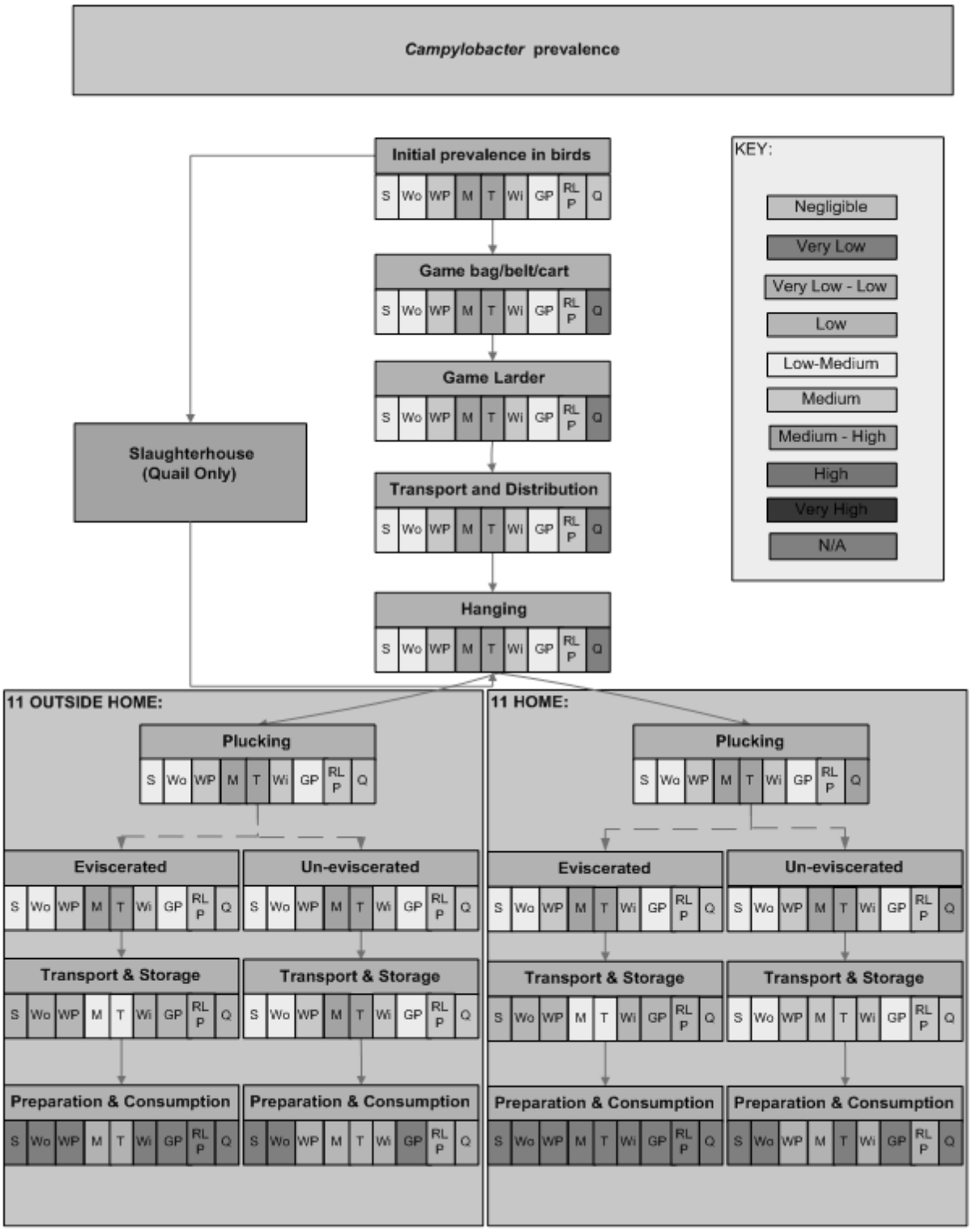

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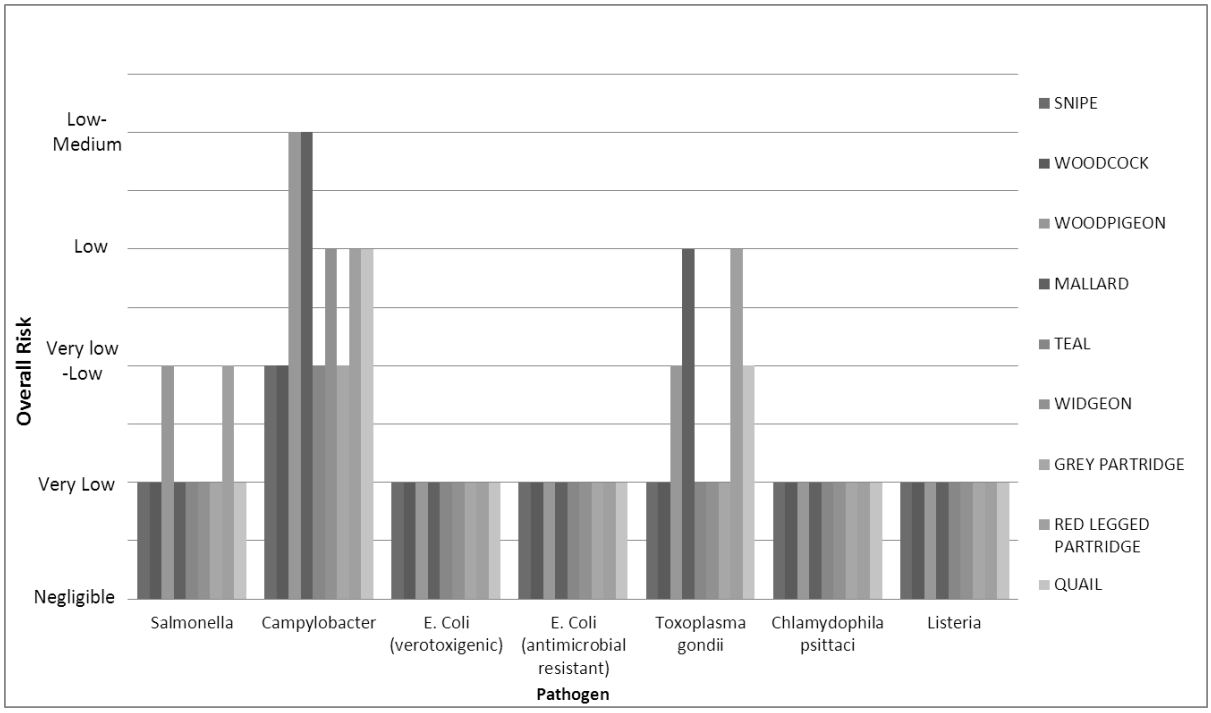

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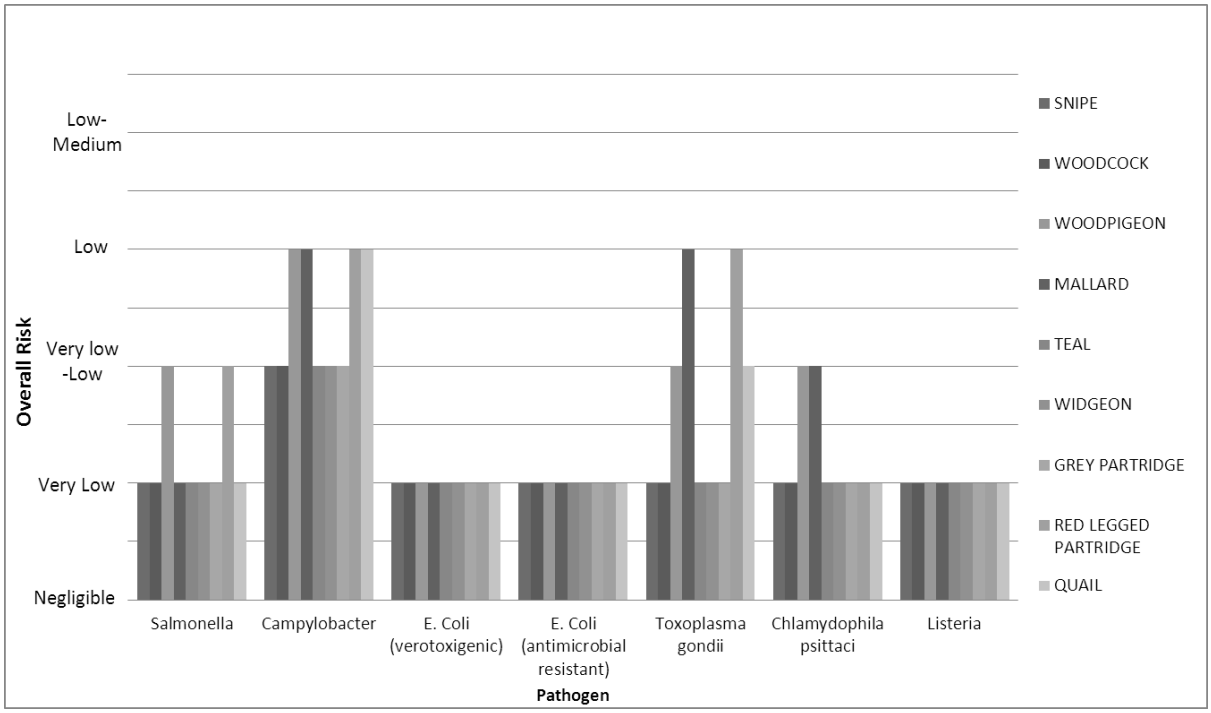

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Tables

Table 1: Definitions of qualitative scores (EFSA, 2006)

Term	Definition
Negligible	So rare that it does not merit to be considered
Very Low	Unlikely to occur
Low	Rare, but may occur occasionally
Medium	Occurs regularly
High	Occurs very regularly
Very High	Is almost certain to occur

Table 2: Numbers of individual bird species shot/slaughtered

Number of birds shot/slaughtered	Snipe	Woodcock	Woodpigeon	Mallard	Teal	Widgeon	Grey Partridge	Red legged Partridge	Quail
Estimated range	25,000 - 30,000[1]	100,000 - 225,000[2]	3,600,000 - 7,000,000[3]	873,000 - 1,350,000[4]	48500 - 75000[5]	48500 - 75000[5]	200,000 - 300,000[6]	2,400,000[7]	864,237[8]
Qualitative estimate	Low	Medium	Very High	High	Low	Low	Medium	Very High	High

1 Andrew Hoodless pers. comm. quoted in (Consultants, 1997; Henderson, 1993)

2 (Consultants, 1997; International, 2013; PACEC, 2006)

3 (Consultants, 1997; PACEC, 2006)

4 (Consultants, 1997; PACEC, 2006)

5 Expert opinions suggests that Teal and Widgeon each make up a maximum of 5% of total ducks shot

6&7 (PACEC, 2006)

8 AHVLA Poultry Register 2011 data

Table 3: Prevalence of pathogens in individual bird species

Pathogen	Snipe	Woodcock	Woodpigeon	Mallard	Teal	Widgeon	Grey Partridge	Red legged Partridge	Quail

Salmonella	Low prevalence based on expert opinion	0% (n=1) (Kobayashi, et al., 2007); 3.5% (n=28) (SAGIR, 2012)	0.6% - 4.5% (Kinjo, Morishige, Minamoto, & Fukushi, 1983a); (Pennycott, 1994) 20 reports (AHVLA, 2011)	0.2% - 4% (Mitchell & Ridgwell, 1971); (Fallacara, Monahan, Morishita, & Wack, 2001)	0.2% - 3.4% (Mitchell & Ridgwell, 1971); (Fallacara, et al., 2001)	0% (Mitchell & Ridgwell, 1971); (Kobayashi, et al., 2007)	0%-0.5% (Beer & Durrling, 1989)	0.5%-1% (Beer & Durrling, 1989) 1 incident 2010 (AHVLA, 2011)	No incidents 2008/9 (AHVLA, 2011)
Campylobacter	Present (Workman, Mathison, & Lavoie, 2005)	present (Waldenstrom, et al., 2002)	12.5% - 86.4% (Kinjo, Morishige, Minamoto, & Fukushi, 1983b); (Itoh, Saito, Yanagawa, Sakai, & Ohashi, 1982); (Vazquez, et al., 2010)	21.6% - 73% (Hartog, Wilde, & Boer, 1983); (Colles, Ali, Sheppard, McCarthy, & Maiden, 2011)	60% (Gargiulo, et al., 2011)	21.6% - 73% (Hughes, et al., 2009)	49% (Dipineto, et al., 2009)	23% ((Diaz-Sanchez, Mateo Moriones, Casas, & Hoefle, 2012)	commercial quails are not tested;20% cloacal swab (McCrea, et al., 2006)
E. coli (verotoxigenic)	Low prevalence based on expert opinion	Low prevalence based on expert opinion	12.5% (VTEC) 0.34% O157 (Dell'Omo, et al., 1998)	Low prevalence based on expert opinion	Low prevalence based on expert opinion	Low prevalence based on expert opinion	Low prevalence based on expert opinion	Low prevalence based on expert opinion	Low prevalence based on expert opinion
E. coli (antimicrobial resistant)	Low prevalence based on expert opinion	Low prevalence based on expert opinion	1.5%-3% (Radimersky, et al., 2010); (Duan, et al., 2006)	Presence of ESBL (Ivan Literak, et al., 2010) 6% (Tausova, et al., 2012)	Low prevalence based on expert opinion	Low prevalence based on expert opinion	~6% based on data for wild red-legged partridges	6%wild, 45%farmed (Diaz-Sanchez, et al., 2012)	Isolated from Japanese quail with colibacillosis (Roy, Purushothaman, Koteeswaran, & Dhillon, 2006); 8.9% (da Costa Abreu, et al., 2010)
Chlamydophila psittaci	Present in other members of the Scolopacidae family (Kaleta & Taday, 2003)	Present in other members of the Scolopacidae family (Kaleta & Taday, 2003)	47% (Bracewell & Bevan, 1986) 59.7% (Vazquez, et al., 2010)	23% (Bracewell & Bevan, 1986) 75% (Evans, Chalmers, Woolcock, Farmer, & Taylor-Robinson, 1983)	23% (Bracewell & Bevan, 1986)	23% (Bracewell & Bevan, 1986)	Antibodies present by ELISA (Ziedler, Hlinak, Raetz, Werner, & Ebner, 1995)	100% morbidity in farmed Chukar partridge (Erbeck & Nunn, 1999)	100% morbidity in farmed quail (Erbeck & Nunn, 1999) Experimental infection (Batta, Asrani, Katoch, Sharma, & Joshi, 1999)
Toxoplasma gondii	Possibility of infection from earthworms (Ruiz & Frenkel,	Possibility of infection from earthworms (Ruiz & Frenkel, 1980);	9% - 12% (Cong, et al., 2012) ; (I. Literak, Hejlicek, Nezval, & Folk, 1992)	11.5% - 14% (Cong, et al., 2012); (I. Literak, et al.,	11.5% - 14% (Cong, et al., 2012);0 % (I. Literak, et al.,	11.5% - 14% (Cong, et al., 2012) Antibodies present	18.7% (I. Literak, et al., 1992)	Experimental infection (Sedlak, Literak, Vitula, & Benaak, 2000);	25% (Shaapan, Khalil, & Nadia, 2011)

	1980); (Bettiol, Obendorf, Nowarkowski, & Goldsmid, 2000)	(Bettiol, et al., 2000)		1992)	1992)	(Murao, et al., 2008)		(Martinez-Carrasco, et al., 2004)	
Listeria monocytogenes	Common in healthy wild birds (Hellstrom, Kiviniemi, Autio, & Korkeala, 2008)	Common in healthy wild birds (Hellstrom, et al., 2008)	0.9% - 3.4% faecal presence (Weber, Potel, & Schafersch midt, 1995) 25% (Hellstrom, et al., 2008)	Common in healthy wild birds (Hellstrom, et al., 2008)	Common in healthy wild birds (Hellstrom, et al., 2008)	Common in healthy wild birds (Hellstrom, et al., 2008)	Present (Weis & Seeliger, 1975)	Evidence of outbreak of clinical listeriosis (AHVLA, 2011a)	Susceptible to experimental infection (Nikuradze, 1970)

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