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

4
5 Horigan, V.^{1*}, Davies, R.H.¹, Kelly, L.A.^{1, 2}, Mead, G.C.³, Irvine, R.M.¹, Simons,
6 R.R.L.¹

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9
10 1. Animal health and Veterinary Laboratory Agency, New Haw, Addlestone,
11 Surrey, KT15 3NB, UK

12 2. University of Strathclyde, Department of Mathematics and Statistics,
13 Richmond Street, Glasgow, G1 1XH, UK

14 3. Independent consultant

15
16
17 *Author for correspondence. Tel: +44 01932 357150 E-mail:
18 Verity.Horigan@ahvla.gsi.gov.uk

25 **1 Introduction**

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

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

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

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

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

73 EC regulations exist for all game supplied for human consumption, e.g. Regulation
74 (EC) No 172/2004, for general food law requirements, Regulation (EC) No 852/2004
75 for general hygiene requirements for food businesses and Regulation (EC) No
76 853/2004 for additional hygiene rules regarding businesses producing food of
77 animal origin. Hygiene guidelines are also provided by the FSA (FSA, 2008) but
78 there has been no formal assessment of the potential risks to UK consumers from
79 production and consumption of uneviscerated small game birds compared to
80 eviscerated birds. Hence, there has been no formal consideration of what, if any,
81 modifications to hygiene regulations might be required to control the risks to
82 public health from the production and consumption of uneviscerated birds.

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

93 **2 Materials and Methods**

94

95 **2.1 Risk assessment scope and approach**

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

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

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

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

123 TABLE 1 HERE

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

132 **2.2 Hazard Identification**

133 A comprehensive list of the major microbiological hazards potentially present in
134 game birds was developed according to literature evidence and expert opinion.
135 The full list of the 87 hazards considered is given in the final report to the Scottish
136 FSA (Horigan, et al., 2013). Using a combination of literature review and expert
137 opinion, hazards were shortlisted by considering those that current knowledge
138 suggests could be of public health concern due to the production and/or
139 consumption of wild game birds (not including occupational hazards) in the UK.
140 The hazards shortlisted were: *Salmonella* spp., *Escherichia coli* (verotoxigenic), *E.*
141 *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

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

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

188 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.

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

219 TABLE 3 HERE

220 **3 Results**

221

222 **3.1 Hazard profiles**

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

228 FIGURE 3 HERE

229 FIGURE 4 HERE

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

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

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

250 FIGURE 5 HERE

251 FIGURE 6 HERE

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

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

262

263 **3.2 *Campylobacter***

264

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

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

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

290

291 **3.3 *T. gondii***

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

300

301 **3.4 Eviscerated vs. Uneviscerated birds**

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

308 contamination and, therefore, the increase in pathogen prevalence from this cause
309 will depend on the efficiency of the evisceration technique. Conditions under
310 which carcasses are eviscerated in the processing plant and the home have
311 different implications for the risk of cross-contamination. Commercially, game
312 birds are eviscerated manually and operatives will normally be trained to minimise
313 gut rupture and spillage of contents by removing the viscera with care. However,
314 the equipment and procedures used are not designed to prevent all microbial
315 cross-contamination and are unlikely to do so. The high throughput of birds in a
316 commercial operation will increase the risk of cross contamination despite the skill
317 of the workforce employed. Thus, any hazardous organisms present, even at a
318 relatively low prevalence, may spread among the batch of carcasses being
319 processed, but the expectation is that they would be largely destroyed during
320 subsequent cooking (Geoff Mead personal communication). It has been asserted
321 that uneviscerated poultry could have better microbial characteristics and
322 extended shelf life than eviscerated poultry (Mulder, 2004) and the muscle tissue
323 of uneviscerated game birds and poultry stored at refrigerated temperatures has
324 been shown to remain sterile for several days (Mead, Chamberlain, & Borland,
325 1973). Thus, levels of cross-contamination resulting from the processing of an
326 uneviscerated game bird are likely to be lower than those from birds undergoing
327 the evisceration process.

328

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

333 individual concerned and the care taken. In a small-scale study (Mead & Scott,
334 1997), home evisceration led invariably to rupture of the gut and, again, food
335 safety depends mainly on the adequacy of the cooking process. In the domestic
336 situation, the principal hazard is in spreading microbes to other foods, during and
337 after the evisceration process.

338

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

342

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

347

348 **4 Discussion**

349

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

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

364

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

375

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

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

386

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

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

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

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

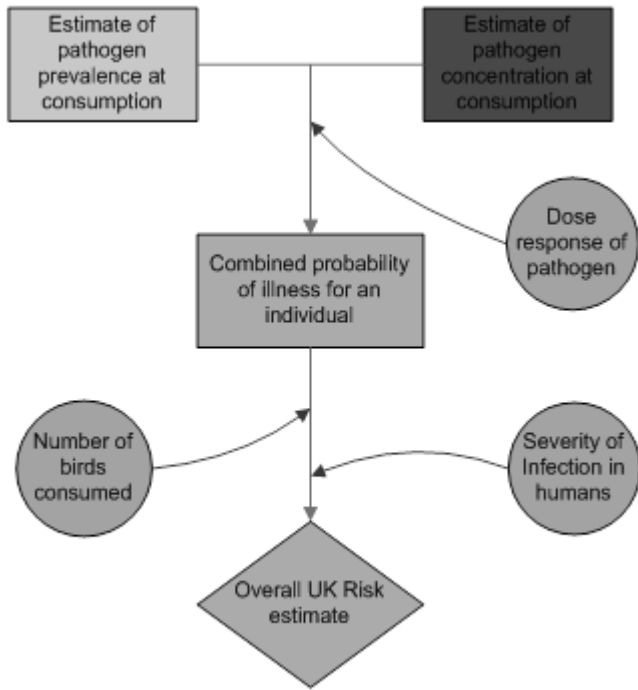
418 **5 Acknowledgements**

419

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423 game sector and AGHEs whose cooperation made this study possible.

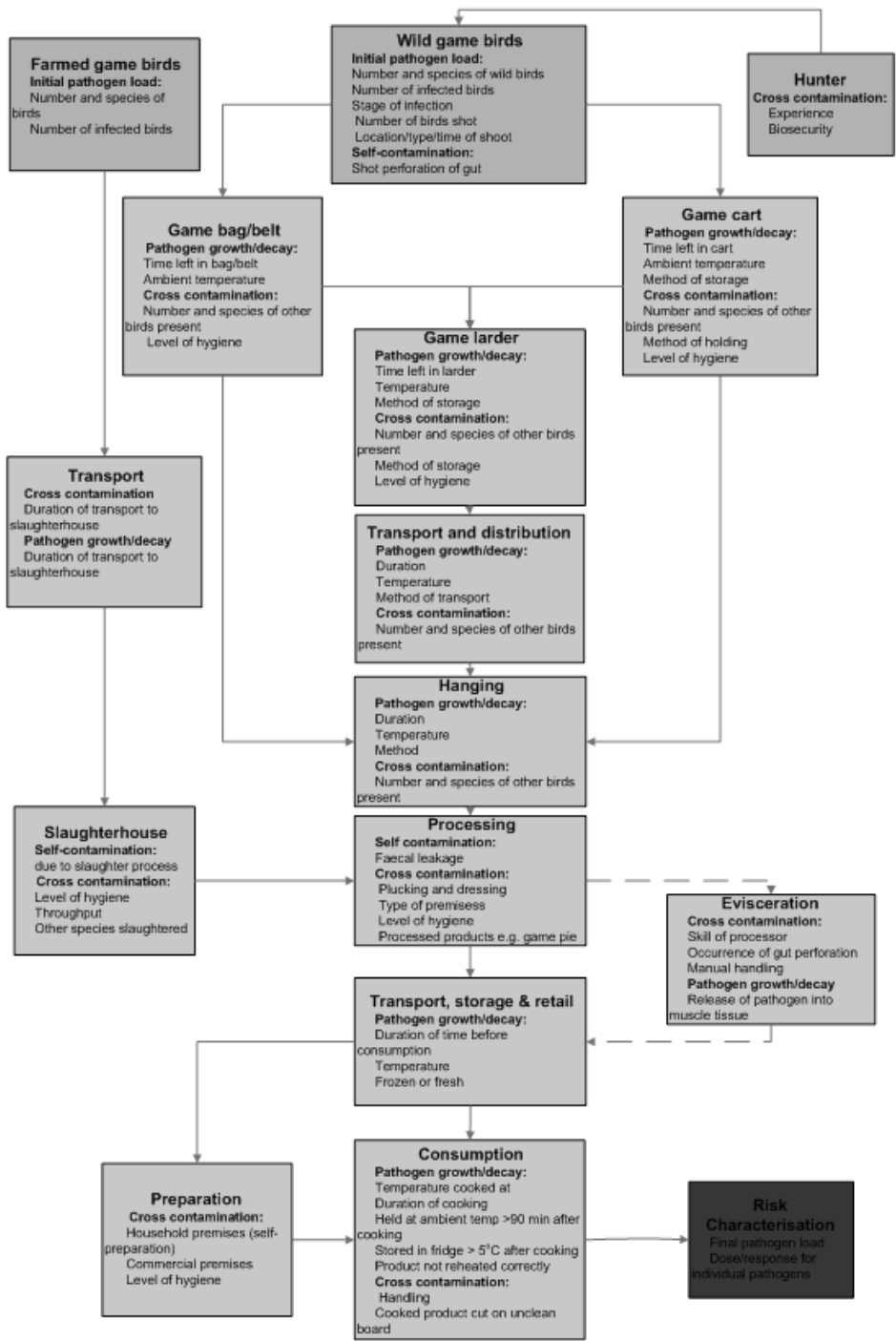
424 **Figures**

425 Figure 1:



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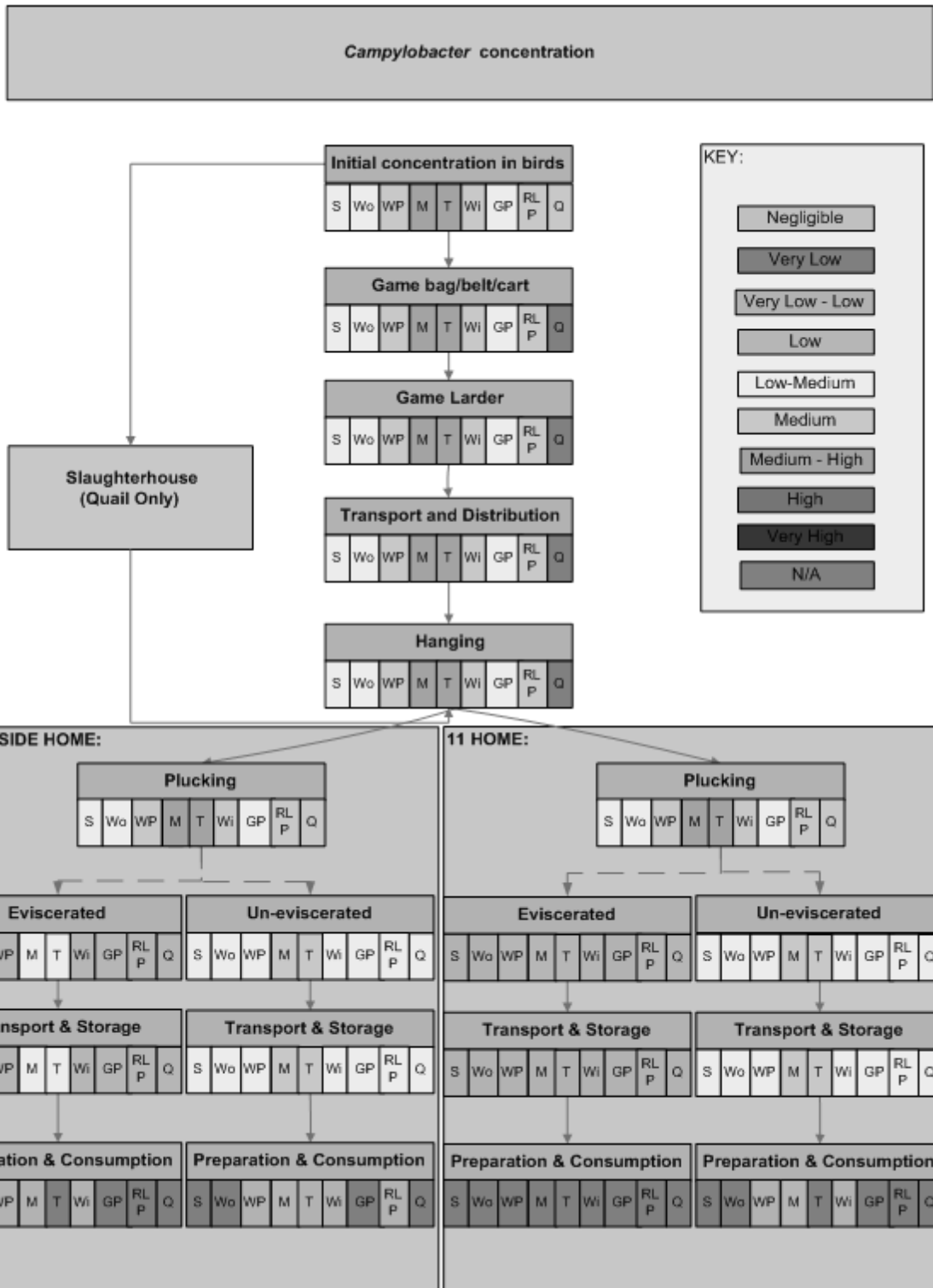
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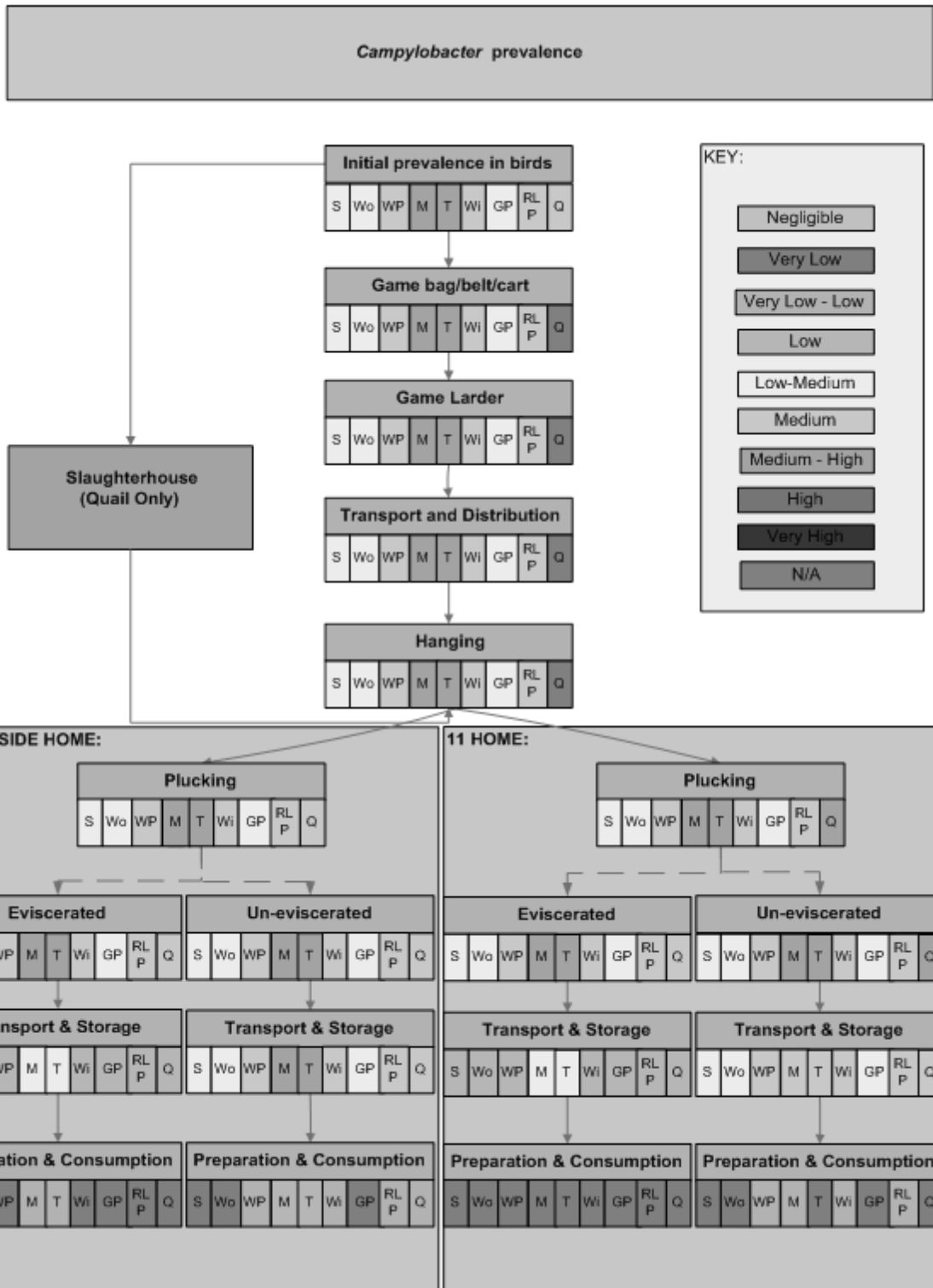
430 Figure 3:



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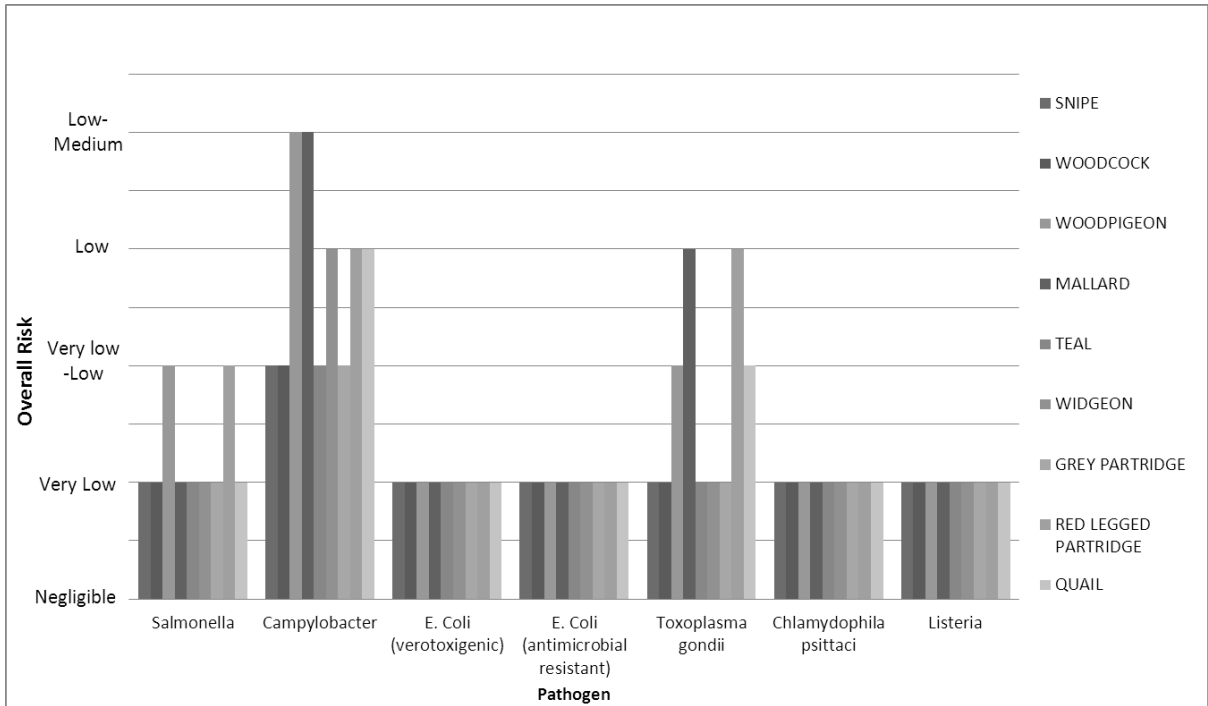
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433 Figure 4:



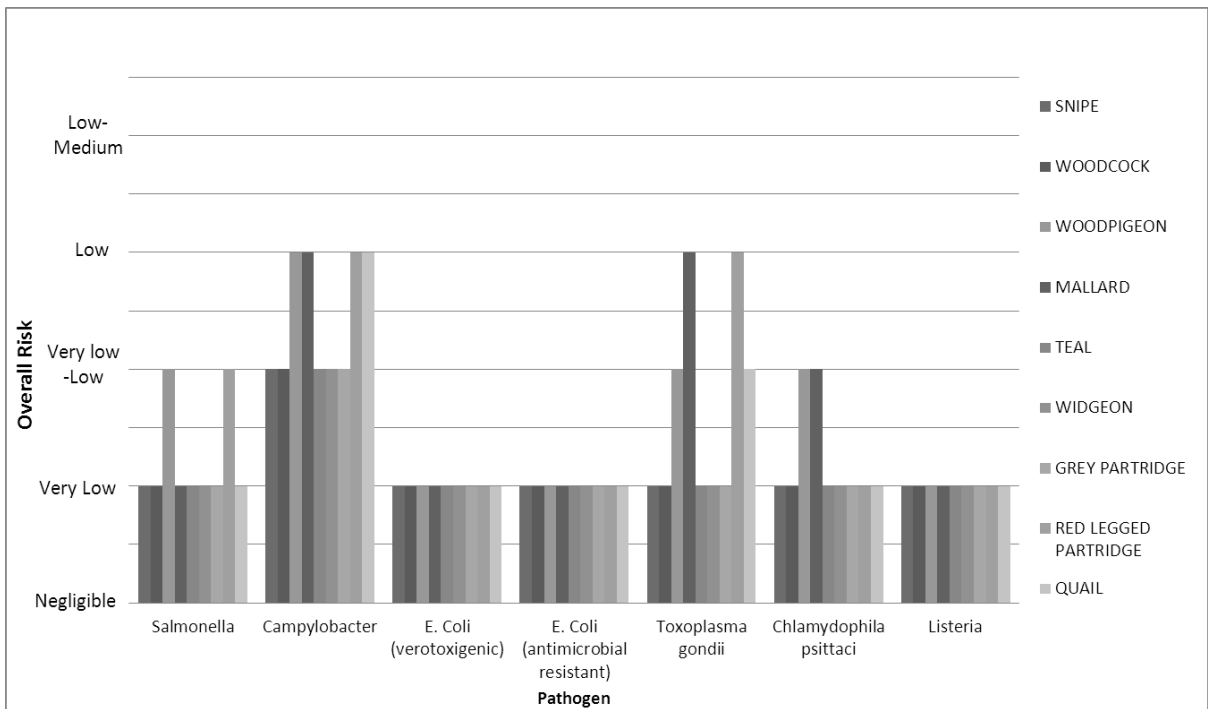
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435 Figure 5



436

437 Figure 6



438

439

440

441 **Tables**

442 **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

443

444

445

446 **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

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

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

449 ³ (Consultants, 1997; PACEC, 2006)

450 ⁴ (Consultants, 1997; PACEC, 2006)

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

452 ^{6&7} (PACEC, 2006)

453 ⁸ AHVLA Poultry Register 2011 data

454 **Table 3: Prevalence of pathogens in individual bird species**

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Pathogen	Snipe	Woodcock	Woodpigeon	Mallard	Teal	Widgeon	Grey Partridge	Red legged Partridge	Quail
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<i>Salmonella</i>	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, & Fukushima, 1983a); (Pennycott, 1994) 20 reports (AHVLA, 2011)	0.2% - 4% (Mitchell & Ridgwell, 1971); (Fallacara, et al., 2001)	0.2% - 3.4% (Mitchell & Ridgwell, 1971); (Fallacara, et al., 2001)	0% (Mitchell & Ridgwell, 1971); (Kobayashi, et al., 2007)	0%-0.5% (Beer & Durrilling, 1989)	0.5%-1% (Beer & Durrilling, 1989) 1 incident 2010 (AHVLA, 2011)	No incidents 2008/9 (AHVLA, 2011)
<i>Campylobacter</i>	Present (Workman, Mathison, & Lavoie, 2005)	present (Waldenstrom, et al., 2002)	12.5% - 86.4% (Kinjo, Morishige, Minamoto, & Fukushima, 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% (Dipinetto, et al., 2009)	23% ((Diaz-Sanchez, Mateo Moriones, Casas, & Hoefle, 2012)	commercial quails are not tested; 20% cloacal swab (McCrea, et al., 2006)
<i>E. coli</i> (verotoxigenic)	Low prevalence based on expert opinion	Low prevalence based on expert opinion	12.5% (VTEC) 0.34% O157 (Dell'Ormo, 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
<i>E. coli</i> (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) 100% morbidity in farmed quail (Erbeck & Nunn, 1999) Experimental infection (Batta, Asrani, Katoch, Sharma, & Joshi, 1999)
<i>Chlamydia psittaci</i>	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, Chalmer, 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)
<i>Toxoplasma gondii</i>	Possibility of infection from earthworms (Ruiz & Frenkel,	Possibility of infection from earthworms (Ruiz & Frenkel,	9% - 12% (Cong, et al., 2012) ; (I. Literak, Hejlíček, 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)	
<i>Listeria monocytogenes</i>	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 (Hellstr om, et al., 2008)	Common in healthy wild birds (Hellstr om, et al., 2008)	Common in healthy wild birds (Hellstro m, 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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