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Assessment of listing and categorisation of animal diseases within the framework of the Animal Health Law (Regulation (EU) No 2016/429): *Salmonella* infection in poultry with serotypes of animal health relevance (*S*. Pullorum, *S*. Gallinarum and *S*. *arizonae*)

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Abstract

Salmonella infection in poultry (*Salmonella* Pullorum, *Salmonella* Gallinarum and *Salmonella arizonae*) has been assessed according to the criteria of the Animal Health Law (AHL), in particular criteria of Article 7 on disease profile and impacts, Article 5 on the eligibility of *Salmonella* to be listed, Article 9 for the categorisation of *Salmonella* according to disease prevention and control rules as in Annex IV and Article 8 on the list of animal species related to *Salmonella*. The assessment has been performed following a methodology composed of information collection and compilation, expert judgement on each criterion at individual and, if no consensus was reached before, also at collective level. The output is composed of the categorical answer, and for the questions where no consensus was reached, the different supporting views are reported. Details on the methodology used for this assessment are explained in a separate opinion. According to the assessment performed, *Salmonella* can be considered eligible to be listed for Union intervention as laid down in Article 5(3) of the AHL. The disease would comply with the criteria as in Sections 4 and 5 of Annex IV of the AHL, for the application of the disease prevention and control rules referred to in points (d) and (e) of Article 9(1). The assessment here performed on compliance with the criteria as in Section 1 of Annex IV referred to in point (a) of Article 9(1) is inconclusive. The main animal species to be listed for *Salmonella* according to Article 8(3) criteria are all species of domestic poultry and wild species of mainly Anseriformes and Galliformes, as indicated in the present opinion.

Keywords: *Salmonella*, *S*. Pullorum, Pullorum disease, *S*. Gallinarum, fowl typhoid, *S*. *arizonae*, salmonellosis, Animal Health Law, listing, categorisation, impact

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1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

The background and Terms of Reference (ToR) as provided by the European Commission for the present document are reported in Section 1.2 of the scientific opinion on the ad hoc methodology followed for the assessment of the disease to be listed and categorised according to the criteria of Article 5, Annex IV according to Article 9, and 8 within the Animal Health Law (AHL) framework (EFSA AHAW Panel, 2017).

1.2. Interpretation of the Terms of Reference

The interpretation of the ToR is as in Section 1.2 of the scientific opinion on the ad hoc methodology followed for the assessment of the disease to be listed and categorised according to the criteria of Article 5, Annex IV according to Article 9, and 8 within the AHL framework (EFSA AHAW Panel, 2017).

The present document reports the results of assessment on *Salmonella* infection in poultry with serotypes of animal health relevance (*Salmonella* Pullorum, *Salmonella* Gallinarum and *Salmonella arizonae*) according to the criteria of the AHL articles as follows:

- Article 7: *Salmonella* profile and impacts
- Article 5: eligibility of *Salmonella* to be listed
- Article 9: categorisation of *Salmonella* according to disease prevention and control rules as in Annex IV
- Article 8: list of animal species related to *Salmonella*.

2. Data and methodologies

The methodology applied in this opinion is described in detail in a dedicated document about the *ad hoc* method developed for assessing any animal disease for the listing and categorisation of diseases within the AHL framework (EFSA AHAW Panel, 2017).

3. Assessment

3.1. Assessment according to Article 7 criteria

This section presents the assessment of *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) according to the Article 7 criteria of the AHL and related parameters (see table 2 of the opinion on methodology (EFSA AHAW Panel, 2017)), based on the information contained in the factsheet as drafted by the selected disease scientist (see Section 2.1 of the scientific opinion on the ad hoc methodology) and amended by the AHAW Panel.

3.1.1. Article 7(a) Disease Profile

It is important to note that only two serovars of *Salmonella enterica* subspecies *arizonae* are considered to be of commercial significance, and only in turkeys because of their ability to be transmitted vertically from infected breeding flocks. These closely related serovars are thought to have been eradicated from all major turkey breeding nations, but their occurrence in low income countries or wild turkey populations is uncertain.

3.1.1.1. Article 7(a)(i) Animal species concerned by the disease

Susceptible animal species

Parameter 1 – Naturally susceptible wildlife species (or family/orders)

S. arizonae

Salmonella enterica subsp. *arizonae* includes around 100 serovars (Grimont and Weill, 2007) and has a broad host range. It can potentially cause infection, which is usually subclinical, in many species of birds, such as domestic fowl (*Gallus gallus*), ducks (*Anas platyrhynchos*), turkeys (*Meleagris gallapavo*), geese (*Anser anser*), quail (*Coturnix japonica*), guinea fowl (*Numida meleagris*) and pheasants (*Phasianus colchicus*) (Oros et al., 1998; Shivaprasad, 2008), and reptiles (Köbölkuti et al., 2008; Clancy et al., 2016). It should be noted that many 'Arizona' group isolates from reptiles and birds may be

of the biphasic *diarizonae* subspecies of *Salmonella enterica* (Hall and Rowe, 1992; Köbölkuti et al., 2008; Yong et al., 2008; Lukac et al., 2015; Clancy et al., 2016).

_S._ Gallinarum

Order Galliformes (Chappell et al., 2009); natural outbreaks of fowl typhoid (FT; *S.* Gallinarum) have been reported in sparrows, parrots, ring-necked doves, ostriches and peafowl (Harbourne, 1955). Clinical outbreaks among species other than chickens and turkeys are uncommon (Shivaprasad, 2000). Individual cases of disease have occasionally been reported in free-ranging game birds, such as partridges (Shivaprasad and Barrow, 2008).

_S._ Pullorum

Order Galliformes (Chappell et al., 2009); there are reports of naturally occurring infection in many bird species, although most cases are traced to some contact with chickens (Bullis, 1977). Natural outbreaks of Pullorum disease have been reported in quail, sparrows, parrots, canaries and bullfinch (Shivaprasad and Barrow, 2008), although clinical disease is unusual among species other than chickens, turkey and pheasants (Spickler, 2009).

Parameter 2 – Naturally susceptible domestic species (or family/orders)

S. arizonae

Turkey (*Meleagridis gallopavo*) is the principal species for infection with serovars O18:Z4,Z23 and O18:Z4,Z32 (Weiss et al., 1986; Hall and Rowe, 1992; Hafez, 2013). Other domestic poultry, including chickens (*Gallus gallus*) and ducks may occasionally show disease (Bigland and Quon, 1958; Silva et al., 1980), but economic effects are minor other than in turkey production. *Arizonae* serovars may be found in animal feed that has been contaminated by reptile faeces and may thereby be occasionally transmitted to domestic animals, especially laying hens that are fed on non-heat-treated feed, usually causing a transient subclinical infection.

_S._ Gallinarum

Order Galliformes; principal clinically affected species are chickens (*Gallus gallus*) (Bullis, 1977; Shivaprasad et al., 2013) and turkeys (*Meleagris gallopavo*) (Hafez, 2013), also pheasants, quail, guinea fowl, peafowl (Moore, 1946; AHVLA, 2008; Ravishankar et al., 2008; Macovei et al., 2010; Casagrande et al., 2014). Significant clinical outbreaks are uncommon apart from among chickens, turkeys and pheasants (Shivaprasad, 2000).

_S._ Pullorum

Order Galliformes; the principal host species is domestic chickens (*Gallus gallus*). Infection of turkeys (*Meleagris gallopavo*) is reported to follow contact with chickens in many cases (Shivaprasad and Barrow, 2008). Outbreaks in pheasants and guinea fowl are also reported (Hafez, 2013).

Parameter 3 – Experimentally susceptible wildlife species (or family/orders)

S. arizonae

Experimental infection of wildlife species with the turkey-associated O18 serovars is not reported.

_S._ Gallinarum

Corvids (rooks and jackdaws) manifested clinical disease with mortality following exposure by various routes (Harbourne, 1955). Pigeons appeared resistant to clinical disease following oral or parenteral exposure (Aydin et al., 1978).

_S._ Pullorum

S. Pullorum shows low virulence via the oral route in mice, and is cleared rapidly from systemic tissues after parenteral inoculation (Barrow, 1994).

Parameter 4 – Experimentally susceptible domestic species (or family/orders)

S. arizonae

Experimental infection of chicks with the turkey-associated O18 serovars has been reported (Youssef and Geissler, 1979; Silva et al., 1980), demonstrating clinical signs similar to neonatally

infected turkey poults in a proportion of individuals. Crop inoculation of turkey poults and chicks with similar doses of turkey Arizona group isolates resulted in more severe disease and mortality in the turkeys than in the chicks (Hinshaw and McNeil, 1946).

S. Gallinarum

Rabbits showed minor intestinal pathology following oral inoculation, whilst there was systemic persistence in mice of the same *S.* Gallinarum strain for over 2 weeks following intravenous inoculation (Barrow, 1994). However, clinical signs were not seen. Rats orally infected with a high dose (10^9 colony forming units (CFU)) of *S.* Gallinarum shed the organism in faeces for up to 121 days (Badi et al., 1992a). Experimental inoculation of chickens produces outcomes consistent with natural disease (Barrow, 1994; Berchieri et al., 2001).

S. pullorum

Natural or experimental disease has been reported in various mammalian species: chimpanzee, rabbit, guinea pig, chinchilla, pig, kitten, fox, dog, pig, mink, cow, rat (Bullis, 1977; Shivaprasad and Barrow, 2008), although details are sparse. Oral inoculation studies (Barrow et al., 1994) in rabbits, rats, guinea pigs and mice did not show clinical effects with doses (in the range 10^7 to 10^9 cfu) that caused clinical disease in chicks.

Reservoir animal species

Parameter 5 – Wild reservoir species (or family/orders)

S. arizonae

The relevant serovars are closely associated with turkeys. Wild turkeys are the likely principal wild reservoir species for turkey-specific serovars. *S. arizonae* is primarily carried by reptiles in warm countries, and these free-living animals can be considered reservoir hosts. Infection of poultry is often associated with contamination of feed or the production environment by reptile faeces (Köbölkuti et al., 2008; Clancy et al., 2016). Rodents may be an effective short-term reservoir or vector species on infected premises to facilitate persistence of infection between flocks (Goetz, 1962).

S. Gallinarum

The agent has been isolated from free-living corvids, pigeons, psittacine birds, ducks (Harbourne, 1955; Georgiades and Iordanidis, 2002; Spickler, 2009), chicken-house rats (Aydin et al., 1978; Badi et al., 1992b), and there is serological evidence of serovar Gallinarum in doves (Espinosa-Arguelles et al., 2010). Many avian species may be carriers (Barrow et al., 1994; Javed et al., 1994). Shedding by pigeons appeared to be transient following experimental oral exposure (Aydin et al., 1978). Rats from area of poultry houses harboured *S.* Gallinarum in intestines, while experimentally inoculated wild rats shed *S.* Gallinarum for 3 months following oral inoculation (Badi et al., 1992a). Red poultry mite (*Dermanyssus gallinae*) from infected poultry houses can harbour *S.* Gallinarum for months, and is the main route for carry-over between flocks (Zeman et al., 1982; Parmar and Davies, 2007; Ivanics et al., 2008). Infected red mites can be carried between farms on equipment or the clothing of workers or visitors, as well as being carried by wild birds moving between farms. Ticks (*Argas* spp.) also can harbour the agent but their role in epidemiology is uncertain (Stefanov et al., 1975).

S. Pullorum

The agent has been isolated from several free-living or semiwild avian species, including parrots, sparrows, quail, peacock, doves, pheasants and pigeons (Javed et al., 1994; Akhter et al., 2010; Hua et al., 2012), and has been isolated from the intestine of rats on affected fowl premises (Anderson et al., 2006). In many countries in which *S.* Pullorum has been eradicated from commercial scale poultry breeding and production, there remains a reservoir in wild and commercially bred game birds that are released into the wild for shooting. The regular, sporadic occurrence of Pullorum disease in hobbyist flocks in developed countries reflects the likely persistent presence of a wildlife reservoir (Shivaprasad and Barrow, 2008; Barrow and Freitas Neto, 2011; OIE, 2012).

Parameter 6 – Domestic reservoir species (or family/orders)

S. arizonae

Adult turkeys exhibit asymptomatic intestinal carriage and faecal shedding for extended periods (Shivaprasad, 2008). Historically, small numbers of isolates of the relevant serovars have been reported from other species, including dogs and sheep in the USA (Weiss et al., 1986), although the significance of this in respect of reservoir status is unknown and there are no recent supporting reports.

***S.* Gallinarum**

Domestic waterfowl (ducks, geese) appear to be largely resistant to clinical disease (Moore, 1946; Barrow et al., 1999; Shivaprasad, 2000), but can harbour the agent (Adzitey et al., 2012). It is thought that small backyard flocks of domestic fowl, which may never be subject to diagnostic investigations, represent an important reservoir of infection. Isolation of the agent has been reported from apparently asymptomatic commercially farmed chickens (4% of cloacal swab or faeces samples) in Bangladesh (Parvej et al., 2016).

***S.* Pullorum**

Domestic waterfowl (ducks, geese) appear to be largely resistant to clinical disease (Shivaprasad and Barrow, 2008), but can harbour the agent (Anderson et al., 2006; Hua et al., 2012). Isolation of the agent has been reported from apparently asymptomatic commercially farmed chickens (3.3% of cloacal swab or faeces samples) in Bangladesh (Parvej et al., 2016).

3.1.1.2. Article 7(a)(ii) The morbidity and mortality rates of the disease in animal populations

Morbidity

Parameter 1 – Prevalence/incidence

S. arizonae

Disease in turkeys is confined to the first few weeks of life and morbidity is highly variable, reflected in quoted mortality figures of 3.5–90% (Hafez, 2013).

Nineteen serotypes of *S. arizonae* were isolated from 6,577 samples collected from 371 different poultry houses of broilers in north-western Spain between 2011 and 2015 and prevalence in the sample was 0.29% (Lamas et al., 2016).

***S.* Gallinarum**

Morbidity and mortality are highly variable owing to effects of age, flock management, nutrition, stressors such as travel, other diseases, and variation between breeds of the primary (chicken) host (Shivaprasad, 2000; Freitas Neto et al., 2007; Chappell et al., 2009; Barrow and Freitas Neto, 2011). In respect of the last point, median parenteral lethal dose varies over a 10^7-fold range between inbred resistant and susceptible chicken breeds, likely mediated by features of the host's reticuloendothelial system (Barrow et al., 1994; Barrow and Freitas Neto, 2011). Brown egg-layers are known to be more susceptible than white egg-layers (Barrow and Freitas Neto, 2011). Experimentally, 60% morbidity was reported in outbred chickens (Chappell et al., 2009). Among Indian broiler flocks, there was a morbidity of approximately 10–15% in recent reports (Arora et al., 2015).

***S.* Pullorum**

Morbidity (and mortality) are highly variable owing to effects of age (younger birds are more susceptible, unlike fowl typhoid), flock management, nutrition, stressors such as travel, other diseases, and variation between breeds of the primary (chicken) host (Freitas Neto et al., 2007; Shivaprasad and Barrow, 2008; Chappell et al., 2009; Barrow and Freitas Neto, 2011). Brown egg-layers are known to be more susceptible than white egg-layers (Barrow and Freitas Neto, 2011). There is a clear age effect, with older growing and mature fowl often not exhibiting clinical signs, although (depending on other factors including breed susceptibility) acute disease may be seen in older fowl on some occasions and egg production and hatchability of eggs is usually affected (Shivaprasad and Barrow, 2008; OIE, 2012). Infected adult turkeys usually show no clinical signs (Hafez, 2013).

Parameter 2 – Case-morbidity rate (% clinically diseased animals out of infected ones)

S. arizonae

Accurate figures are not available for this.

S. Gallinarum

Accurate figures are not available for this. Given the breed-associated variation in susceptibility, the case-morbidity rate is likely to vary substantially.

S. Pullorum

Accurate figures are not available for this. Given the breed- and age-associated variation in susceptibility, the case-morbidity rate is likely to vary substantially (OIE, 2012).

Mortality

Parameter 3 – Case-fatality rate

S. arizonae

Mortality among poultry is variable. Although mortality may reach 90%, more commonly mortality is up to 15%, being highest in the first three weeks and continuing up to five weeks of age (Shivaprasad, 2008; Hafez, 2013).

S. Gallinarum

Classically, a high mortality is described for fowl typhoid (Shivaprasad et al., 2013), with a reported range of 10–93% of chicks infected at or around hatching (Shivaprasad and Barrow, 2008), although most outbreaks of severe clinical disease occur in adult laying or breeding birds, during the laying period. The case-fatality rate was consistently around 70% in recent outbreaks (2005–2013) among broiler chicks in India (Arora et al., 2015). However, again management, age, etc., affect outcomes and the morbidity rate is often much higher than mortality (Shivaprasad and Barrow, 2008). In a typical outbreak in a large cage laying flock, mortality can eventually reach 90%, with only isolated birds that carry genetic resistance remaining alive (Davies, 2016). In naturally infected birds, the outcome of the infection is marked by high morbidity and up to 80% mortality (Shivaprasad, 2000).

In affected turkey flocks, initial mortality is usually substantial, up to about 25%, and there is a tendency for intermittent recurrence of clinical disease over 2–3 weeks, with lower mortality during this phase (Hafez, 2013). Losses typically are lower on premises after the first outbreak of disease (Shivaprasad and Barrow, 2008).

Experimentally, the speed and degree of mortality was highly dose-dependent among 4-day-old chicks, ranging from 4% to 84% over 28 days post-inoculation (Berchieri et al., 2001). Oral median lethal doses for chickens of 10^4 and $10^{5.2}$ CFU have been claimed (Berchieri et al., 2001; Barrow and Freitas Neto, 2011).

S. Pullorum

Classically, a high mortality is described for Pullorum disease in young chickens and turkeys (Hafez, 2013; Shivaprasad et al., 2013), with up to 100% of chicks, and poults dying when infected at or around hatching (Shivaprasad and Barrow, 2008). Highest losses usually occur during the second week after hatching, with a rapid decline in case mortality between the third and fourth weeks of age. However, again management, age, etc., affect outcomes and the morbidity rate under commercial conditions is often much higher than mortality, which can be as low as 0% (Shivaprasad and Barrow, 2008).

Experimentally, oral inoculation of 1-day-old chicks and turkey poults with a virulent turkey-associated *S.* Pullorum strain resulted in mortality among turkey groups of 42–78%, peaking at 6–11 days post-inoculation; among chicken groups mortality was 66–75%, peaking at 13–22 days post-inoculation (Gwatkin, 1948). By contrast, oral inoculation of slightly older (4-day-old) layer chicks with 109 cfu of an unrelated *S.* Pullorum strain resulted in no acute disease or mortality (Berchieri et al., 2001).

AHVLA received intestinal swabs were from 10-day-old pheasant poults of which 100 had died out of 1,000 birds placed. (http://www.thepoultrysite.com/search/?cat=0&q=Salmonella+pullorum&x=9&y=8 Accessed 15/06/2017, AHVLA: *Salmonella* Pullorum in Gamebirds 29 July 2011).

3.1.1.3. Article 7(a)(iii) The zoonotic character of the disease

Presence

Parameter 1 – Report of zoonotic human cases (anywhere)

S. arizonae

Human disease associated with turkey serovars (O18:Z4,Z23 and O18:Z4,Z32) does not appear to have been reported in any detail (Shivaprasad, 2008). Isolates of these serovars have been reported from humans in the USA (Weiss et al., 1986), including 222 between 2003 and 2013 (CDC, 2016); these are unexpectedly high numbers and it is not clear whether these were associated with disease. It seems likely, given the data source, that at least some of these isolates were from individuals showing symptoms of illness warranting sampling and culture. Human infections with O18:Z4,Z23 and O18:Z4,Z32 were described among Latin Americans in California in the 1980s, and in the same report a link was identified between human arizonosis associated with other serovars and the consumption of reptile-associated folk medicines (Waterman et al., 1990). It is possible the O18 serovars are acquired in many cases by a similar route. There are numerous reports of human arizonosis, caused by other serovars, typically in association with reptiles or travel (Hall and Rowe, 1992; Shivaprasad, 2008; Di Bella et al., 2011; Gunal and Erdem, 2014). Gastroenteritis and systemic infections have been reported.

***S.* Gallinarum**

Being avian host-adapted, *S.* Gallinarum poses minimal zoonotic risk (Eswarappa et al., 2009; OIE, 2012). Just 13 of around 391,000 human *Salmonella* isolations from the US Centers for Disease Control and Prevention between 1996 and 2006 were reported as *S.* Gallinarum/Pullorum (CDC, 2008); in the period 2003–2013 the equivalent proportion was zero, from 462,000.

***S.* Pullorum**

Being avian host-adapted, *S.* Pullorum poses a very low zoonotic risk (Shivaprasad, 2000; OIE, 2012). Historical case reports in the literature indicate *S.* Pullorum can induce an acute, self-limiting enteritis after consuming highly contaminated food, typically infected eggs (Mitchell et al., 1946; Shivaprasad, 2000). More prolonged gastroenteritis was attributed to *S.* Pullorum in one case, but the immune status of the patient is unclear (Judefind, 1947).

3.1.1.4. Article 7(a)(iv) The resistance to treatments, including antimicrobial resistance

Parameter 1 – Resistant strain to any treatment even at laboratory level

S. arizonae

The agent is not known to be resistant to antibiotics, but data on incidence and trends in resistance is scarce as the organism has not been reported in recent years.

***S.* Gallinarum/*S.* Pullorum**

Clinical disease and losses can be suppressed by antibiotic treatment (Ravishankar et al., 2008; Barrow and Freitas Neto, 2011). Infection cannot be eliminated from flocks by use of antimicrobials (Georgiades and Iordanidis, 2002; Ravishankar et al., 2008; Barrow and Freitas Neto, 2011). Antibiotic resistances appear to reflect prevailing regional patterns of antibiotic usage and clonal dissemination of strains and reflects trends amongst *Salmonella enterica* isolates from poultry more generally (Javed et al., 1994; Georgiades and Iordanidis, 2002; Kumar et al., 2012; Agada et al., 2014). There is evidence, from survey and surveillance data, of increasing antimicrobial resistance over time (Zeman et al., 1982; Lee et al., 2003; Ivanics et al., 2008; Ravishankar et al., 2008; Barrow and Freitas Neto, 2011; Filho et al., 2016).

3.1.1.5. Article 7(a)(v) The persistence of the disease in an animal population or the environment

Animal population

Parameter 1 – Duration of infectious period in animals

S. arizonae

Acute disease with mortality in young turkeys has a duration typically of 3–5 weeks, but older animals may carry the agent in the intestinal tract and shed it chronically (Shivaprasad, 2008).

S. Gallinarum

Shedding in the faeces was reported during clinical disease 'and into the stage of convalescence' (Gauger, 1937). A more recent oral inoculation study, using relatively susceptible 18-week brown laying hens, showed a minority of hens to have positive caecal contents at each of 3, 7, 14 and 21 days post-inoculation (Oliveira et al., 2005). In the same report, other studies showed shedding usually occurred in the days shortly before death, from 7 to 28 days post-inoculation, or for one or more days from 11 to 27 days post-inoculation among those birds that survived.

S. Pullorum

There are no reliable data on the acute infectious period of chickens and turkeys. *S.* Pullorum colonises the gut poorly in the absence of clinical disease (Barrow and Freitas Neto, 2011), although experimentally, *S.* Pullorum-positive cloacal swabs were obtained from a minority of young and old hens at five weeks post-inoculation (Berchieri et al., 2001).

Parameter 2 – Presence and duration of latent infection period

S. arizonae

Since most infection in clinical cases is believed to be present at hatching, either through transovarian infection or pseudovertical transmission via shell penetration from faecal contamination, there may effectively be no latent period for newly hatched poultry. The agent readily colonises the intestinal tract of older birds, therefore faecal shedding is likely to start within a few hours of exposure (Shivaprasad, 2008). Experimentally in chicks, shedding of the agent was observed 24 h after oral or subcutaneous inoculation (Youssef and Geissler, 1979).

S. Gallinarum

Latency for shedding in droppings appeared to be around 7 days in a susceptible breed of laying hens, although transmission by contact with dead birds, also from around 7 days post-inoculation, appeared to be the more significant route as prompt removal of dead hens greatly reduced spread (Oliveira et al., 2005). Similarly, commercial layer hens inoculated orally yielded *S.* Gallinarum from cloacal swabs taken 1 week later (Berchieri et al., 2001). Latency before tissue or cloacal isolation following oral inoculation of mature laying hens of a relatively resistant phenotype was 3 days; *S.* Gallinarum was isolated from tissue but not cloaca/caecum after this, up to 4 weeks (Berchieri Júnior et al., 2000).

S. Pullorum

No published data was found regarding latency of shedding. As the agent is shed during the acute phase of disease (Barrow and Freitas Neto, 2011; OIE, 2012), it is reasonable to postulate that shedding starts before or at the onset of clinical signs, which may be as early as 3 days post-exposure in birds that are not infected *in ovo* (Hafez, 2013).

Parameter 3 – Presence and duration of the pathogen in healthy carriers

S. arizonae

Asymptomatic colonisation and shedding is the normal mode of intestinal carriage in adult turkeys, which may be long-lived. Systemic infection also occurs, leading to colonisation of reproductive tissues ovaries, oviducts, and stag testes and semen (Shivaprasad, 2008). Chicks (*Gallus gallus*) infected orally with a turkey serovar shed the agent for up to 49 days, after showing transient depression and inappetence (Youssef and Geissler, 1979).

S. Gallinarum

Intestinal carriage in chickens without overt disease appears to be common in areas where the disease is endemic: 23% of droppings cultured from Nigerian commercial poultry premises and 19% of cloacal swabs from Bangladeshi laying farms yielded the organism (Rahman et al., 2011; Agada et al., 2014). A lower frequency of detection (4% of samples) was reported in another Bangladeshi study of commercial flocks (Parvej et al., 2016). *S.* Gallinarum was isolated from the pharynx of seven fatal and eight carrier field cases for a few days to several months after the onset of clinical disease (Gauger, 1937). Birds surviving an outbreak may be asymptomatic carriers of the agent in reproductive tissues, but the incidence is uncertain.

S. Pullorum

Intestinal carriage may occur in chickens without overt disease: 3.3% of droppings cultured from Nigerian commercial poultry premises and 27% of cloacal swabs from Bangladeshi laying farms yielded the organism (Rahman et al., 2011; Agada et al., 2014). Isolation from 3.3% of cloacal or droppings samples was reported in another Bangladeshi study of commercial flocks (Parvej et al., 2016).

Systemic carriage of the agent by asymptomatic and recovered birds is a major issue. Following infection, in a proportion of birds *S.* Pullorum will persist in liver and spleen for 50 weeks or more, multiplying and spreading to the reproductive tract tissues in female birds at the time of sexual maturity (Gwatkin, 1948; Wigley et al., 2005; Chappell et al., 2009).

Environment

Parameter 4 – Length of survival (dpi) of the agent and/or detection of DNA in selected matrices (soil, water, air) from the environment (scenarios: high and low T)

S. arizonae

Survival is reported for up to 5 months in contaminated water, up to 17 months in feed, and 6–7 months in soil on turkey units (Shivaprasad, 2008). Survival characteristics appear similar to other Salmonellae, and Table 1 provides details of some of the documented survival times for *Salmonella* in various environments.

Table 1: Survival of *Salmonella* spp. in various environments (adapted from Mitscherlich and Marth, 1984)

Matrix	Serovar	Conditions	Initial count	Survival	Comments
Egg, fresh whole	Enteritidis	4°C and 25°C	Approx. 10^7 CFU	4°C: > 270, < 365 days 25°C: > 365 days	
	Typhimurium	4°C and 25°C	Approx. 10^7 CFU	4°C: > 180, < 270 days 25°C: > 365 days	
Egg, whole†	(Pullorum)	25°C		9 months	
Egg surface‡	(Pullorum)	Room temperature, ambient humidity	6×10^7 cfu.mL^{-1} contaminating suspension	Clean shell: 21 days Dirty shell (10% sterile hen faeces in *S.* Pullorum suspension): > 21 days	No change in recovery rate from dirty shell eggs over 21 days
Faeces, poultry	Typhimurium	Fresh, 19°C (pH 8.9) and 5–8.9°C (pH 8.1–8.9)	10^8 CFU/mL	19°C: < 6 days. 5°C–8.9°C: > 12, < 25 days	*Salmonella*-impregnated silk immersed in faeces
Faeces, rodent*				148 days	
Hatchery chick fluff	Senftenberg	Room temperature	Natural contamination	≥ 1484 days	Stored in polythene bags
Pasture	Typhimurium	Summer, New Zealand	2×10^7 CFU 25/cm^2	> 70, < 84 days	Applied in faecal suspension
Sweeper dust*				300 days	

a_w: water activity; CFU: colony forming units.
Data abstracted from Mitscherlich and Marth (1984), except *Jones (2011), †Stafseth et al. (1952) and ‡Lancaster and Crabb (1953).

S. Gallinarum

Survival for several years in favourable environments is claimed (Shivaprasad and Barrow, 2008). However, in poultry faeces inside and outdoors, survival times of up to 37 and 31 days, respectively, were noted experimentally for *S.* Gallinarum (Smith, 1955). Table 1 provides details of some of the documented survival times for *Salmonella* in various environments. These are likely to be the upper limit of values for *S.* Gallinarum, as it appears to be less hardy than many other serovars (Shivaprasad, 2000). Survival of *S.* Gallinarum in dormant red mites can be prolonged (at least 7 months) and can result in infection of birds placed in houses containing dormant mites (Zeman et al., 1982; Parmar and Davies, 2007; Ivanics et al., 2008).

S. Pullorum

Survival for several years in favourable environments is claimed (Shivaprasad and Barrow, 2008). However, in poultry faeces inside and outdoors, survival times of up to 37 and 31 days, respectively, were noted experimentally for *S.* Gallinarum biovar Gallinarum (Smith, 1955). Extended survival of *S.* Pullorum (no reduction in frequency of recovery over 3 weeks) was noted experimentally on the surface of eggs when sterilised chicken faeces were also present (Lancaster and Crabb, 1953). Table 1 provides details of some of the documented survival times for *Salmonella* in various environments, but *S.* Pullorum is considered to survive poorly outside the host, compared to most other serovars that are adapted to the intestine rather than systemic carriage (Shivaprasad, 2000).

3.1.1.6. Article 7(a)(vi) The routes and speed of transmission of the disease between animals, and, when relevant, between animals and humans

Routes of transmission

Parameter 1 – Types of routes of transmission from animal to animal (horizontal, vertical)

S. arizonae

Infection of hatching turkey poults is considered to be a consequence of vertical infection resulting from chronic infection of the reproductive tract tissues of parent birds and horizontal spread between newly hatched poults while still in the hatcher cabinets or during subsequent processing and transportation (Hinshaw and McNeil, 1946; Goetz, 1962; Crespo et al., 2004). There may also be trans-shell infection as a consequence of faeces contamination from shedding adult turkeys (Shivaprasad, 2008), but this is likely to be limited under field conditions unless faecally soiled eggs are hatched and no egg sanitisation is carried out prior to hatching. Horizontal transmission is likely between older birds, given the propensity of the agent for enteric colonisation and shedding.

S. Gallinarum

Horizontal transmission is considered to be the more common route in fowl typhoid (FT) (Barrow and Freitas Neto, 2011). Transmission within a flock was strongly enhanced when dead birds were left in situ for 48 h, indicating that horizontal transmission from carcases may be substantial (Oliveira et al., 2005). This may involve movement of red mites from dead to live birds. Quoted routes include cannibalism, wounds, eating eggs, faeces, feed, water, litter, human and wildlife vectors (Shivaprasad and Barrow, 2008). Recent experiments have failed to document egg contamination in chickens, or of survival of *S.* Gallinarum in artificially inoculated eggs (Berchieri et al., 2001; Oliveira et al., 2005). Nonetheless, some older studies did show egg contamination (Barrow and Freitas Neto, 2011), reproductive tract tissues are commonly culture-positive in carrier birds and vertical transmission is still considered to be a potentially important route of transmission (Barrow and Freitas Neto, 2011; OIE, 2012), particularly in turkeys where there is reportedly a predilection for infection of reproductive organs in adult carriers (Hafez, 2013). Field sampling has also indicated roles for rodent and invertebrate vectors, especially for blood-sucking arthropod parasites such as red poultry mite (Aydin et al., 1978; Badi et al., 1992b; Parmar and Davies, 2007; Ivanics et al., 2008; Spickler, 2009).

S. Pullorum

Vertical transmission is considered to be a crucial route for propagation and persistence of *S.* Pullorum in chickens and turkeys although horizontal transmission, particularly in incubators around the time of hatching, is significant for the extent and severity of disease (Mallmann and Moore, 1936; Gwatkin, 1945; Bullis, 1977; Barrow and Freitas Neto, 2011; Hafez, 2013). Transmission through shell penetration may have a minor role. On farms, quoted routes for horizontal transmission include introduction of infected birds into a holding, cannibalism, wounds, eating eggs, poultry faeces, feed, water, litter, human and wildlife mechanical vectors (Shivaprasad and Barrow, 2008).

Parameter 2 – Types of routes of transmission between animals and humans (direct, indirect, including food-borne)

S. arizonae

The relevant serovars (O18:Z4,Z23 and O18:Z4,Z32) have historically been isolated from various human foodstuffs (Weiss et al., 1986; Hall and Rowe, 1992), although evidence is lacking on the matter of transmission between poultry and humans of *S. enterica arizonae* (Shivaprasad, 2008).

S. Gallinarum

There are no firm data on routes of transmission between affected birds and humans. As egg infection does not appear to be common in FT, any food-borne transmission may be via carcasses of infected birds, although there are very few reports of any human disease. In respect of possible direct transmission, none of 90 faeces samples from poultry farm workers in an endemically affected area (Nigeria) yielded *S*. Gallinarum (Agada et al., 2014).

S. Pullorum

The historical case reports indicate food sources, particularly eggs (Mitchell et al., 1946; Judefind, 1947). In respect of possible direct transmission, none of 90 faeces samples from poultry farm workers in an endemically affected area (Nigeria) yielded *S*. Pullorum (Agada et al., 2014).

Speed of transmission

Parameter 3 – Incidence between animals and, when relevant, between animals and humans

S. arizonae

It is not established if there is any significant transmission between young turkey poults during the clinical disease phase. It is possible that all clinical disease results from infection *in ovo*.

S. Gallinarum

The classical pattern of clinical disease is of outbreaks, with rapid spread and high morbidity and mortality. This may, however, be slowed down by the use of *S*. *enteritidis* vaccine in laying and breeding flocks, leading to a gradual increase in mortality followed by an explosive outbreak as infection pressure exceeds vaccine protection. Incubation of the disease is typically 4–6 days, and death usually occurs 5–10 days after exposure (Shivaprasad, 2000; Spickler, 2009). Among turkeys, initial losses may extend over 2–3 weeks and there may be intermittent recurrence (Hafez, 2013). Disease may occur at and shortly after hatching, or acute and subacute disease can be seen among older animals, with carryover between flocks after repopulation (Cobb et al., 2005; Ivanics et al., 2008). Thus, transmission between animals occurs, by direct and indirect routes. It can be rapid enough to generate and sustain an outbreak with morbidity and mortality up to 61% via close contact, such as in hatchers (Shivaprasad and Barrow, 2008), and it can also occur over a longer timescale, causing recurrent or chronic disease patterns.

S. Pullorum

The classical pattern of clinical disease is of outbreaks in young birds, with a proportion of diseased and moribund chicks or turkey poults at hatching, rapid horizontal spread and high morbidity and mortality peaking during the second or third weeks of life, although in some cases disease may not be evident in the batch or flock until five to ten days after hatching (Shivaprasad and Barrow, 2008; Hafez, 2013).

The extent to which infection in newly hatched chicks results from vertical versus horizontal transmission is uncertain, although experimentally only a minority of eggs or chicks from infected hens have proved to harbour the agent (Mallmann and Moore, 1936; Berchieri et al., 2001). Therefore, it appears likely that transmission between newly hatched chicks can be rapid enough to generate and sustain an outbreak with high morbidity and mortality, peaking at two to three weeks of age. Vertical transmission, by its nature, occurs over a longer timescale.

Parameter 4 – Transmission rate (beta) (from R_0 and infectious period) between animals and, when relevant, between animals and humans

S. arizonae

There are no data published on transmission rate between birds during clinical or asymptomatic infection.

S. Gallinarum

There are no firm data published on transmission rate, and the known variations in species, age and breed susceptibilities, plus dose effects, suggest that the transmission rate is likely to be highly variable according to circumstances. In a typical outbreak in a large cage laying flock, mortality increases gradually within specific cages that are close to the point of introduction of infection into the

house. After a few days, there is a dramatic extension of mortality to other cages within the same stack and then, within 2–3 days, to other stacks (OIE, 2012).

***S.* Pullorum**

There are no firm data published on transmission rate, and the known variations in species, age and breed susceptibilities, plus dose effects, suggest that the transmission rate is likely to be highly variable according to circumstances.

3.1.1.7. Article 7(a)(vii) The absence or presence and distribution of the disease in the Union, where the disease is not present in the Union, the risk of its introduction into the Union

Presence and distribution

Parameter 2 – Type of epidemiological occurrence (sporadic, epidemic, endemic) at MS level

S. arizonae

The serovars of significance appear to have been largely or completely eradicated from European turkey production (EFSA, 2008; EFSA BIOHAZ Panel, 2012).

***S.* Gallinarum**

Sporadic; since 2005, there have been outbreaks reported in single years, or up to four-year periods, in domestic flocks in Belgium, Bulgaria, France, Germany, Hungary, Italy, the Netherlands and the UK. In Romania, the disease has been reported in all years to 2012, and the presence of the agent was reported in 2014–2016 (OIE, 2016c). The UK reports from 2005 have detailed up to three incidents a year in pheasants, and zero to six incidents a year in backyard poultry and large commercial laying flocks between 2002 and 2012 (AHVLA, 2008; Northern Ireland disease surveillance report, 2012; AHVLA, 2015).

***S.* Pullorum**

Sporadic; since 2005, the disease has been reported in single- or up to six-year periods in domestic flocks in the Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Romania and the UK (APHA, 2016). The UK reports from 2011 have detailed up to two incidents a year in pheasants and zero to three isolations a year from backyard poultry (OIE, 2016c).

Risk of introduction

Parameter 3 – Routes of possible introduction

S. arizonae

Potential routes include international trade in hatching eggs, chicks or breeding poultry, spread within territories from asymptomatic non-commercial poultry or wild and semiwild birds (pheasants, waterfowl, etc.) import of contaminated poultry meat, import of other animals carrying the agent.

***S.* Gallinarum**

Potential routes include international trade in hatching eggs, chicks or breeding poultry, spread within territories from asymptomatic non-commercial poultry or wild and semiwild birds (pheasants, waterfowl, etc.).

***S.* Pullorum**

Potential routes include international trade in hatching eggs, chicks or breeding poultry, spread within territories from asymptomatic non-commercial poultry, including fancy fowl (via trade and showing), or wild and semiwild birds (pheasants).

Parameter 4 – Number of animal moving and/or shipment size

S. arizonae

Aggregate of reported live imports of turkeys for all Member States (MS) in 2013: 43,793,000 birds (FAOstat).

Reported total turkey egg incubations in the European Union (EU) in 2014: 274 million (European Commission).

S. Gallinarum/*S.* Pullorum

Recent aggregated trade figures are given in Table 2. Some MS's report zero (or confidential) figures for some or all years, and such data is reported by the different MS's at their discretion. Thus, under-reporting may be quite common (EFSA, 2009).

Estimates of total hen's egg incubations (broilers and layer) in EU, using figures for 2015 (or latest reported year if not reported in 2015): 9.3 billion.

Reported total turkey egg incubations in EU in 2014: 274 million.

Table 2: Recent reported intra-EU trade and exports of chicks of *Gallus gallus*

Class of chick*	Intra-EU trades		Exports	
	2014	2015	2014	2015
Layer producer	60,132,000	45,162,000	16,896,000	18,011,000
Layer breeder	14,354,000	11,219,000	9,720,000	10,146,000
Broiler fattening	535,726,000	493,891,000	106,775,000	109,125,000
Broiler breeder	53,506,000	56,244,000	36,164,000	40,558,000

*: 'chicks' means live farmyard poultry the weight of which does not exceed 185 g. Values given are number of individual chicks. Source of data on trade and egg incubations: EUROSTAT (European Commission).

Parameter 5 – Duration of infectious period in animal and/or commodity

S. arizonae

The infectious period in surviving symptomatic birds is not clearly established; prolonged carriage and shedding is common (Shivaprasad, 2008).

S. Gallinarum

The infectious period in surviving symptomatic birds is not clearly established. Experimentally, faecal shedding of the agent was inconsistent (Berchieri Júnior et al., 2000) and occurred only occasionally, up to about one month after inoculation of laying hens (Oliveira et al., 2005).

S. Pullorum

The infectious period in surviving symptomatic birds is not clearly established.

Parameter 6 – List of control measures at border (testing, quarantine, etc.)

S. arizonae

Council Directive 2009/158/EC,[1] as updated by Commission Implementing Decisions 2011/214/EU and 2011/879/EU, specifies that, for approval for intra-community trade, turkey establishments participate in a surveillance programme for relevant *Salmonella arizonae* serovars. The ISO 6579 (Annex D) method that is used for monitoring zoonotic *Salmonella* serovars in the EU is also suitable for detection of the O18 turkey arizonae strains in turkeys that are subject to international trade. There are no stipulations on imports from third countries.

S. Gallinarum

Council Directive 2009/158/EC as updated by Commission Implementing Decisions 2011/214/EU and 2011/879/EU, specifies management and risk-based monitoring conditions for breeding flocks and hatcheries involved in international trade. In addition, for small consignments of imported birds (< 20) traded internationally within the EU and received from third countries, all birds are to have tested serologically negative for *S.* Gallinarum in the preceding month. The flock of origin of hatching eggs or day-old chicks is to have tested serologically negative for *S.* Gallinarum in the preceding 3 months, at a level which gives 95% confidence of detecting infection at 5% prevalence.

The OIE Terrestrial Code (OIE, 2017) recommends that Veterinary Authorities require an international veterinary certificate attesting that imported domestic birds showed no clinical sign of FT on the day of shipment; come from establishments which are recognised as being free from FT; and/or have been subjected to a diagnostic test for FT and Pullorum disease with negative results;

[1] Council Directive 2009/158/EC of 30 November 2009 on animal health conditions governing intra-Community trade in, and imports from third countries of, poultry and hatching eggs. OJ L 343, 22.12.2009, p. 74–113.

and/or were kept in a quarantine station for not less than 21 days prior to shipment. Certificates for hatching eggs or day-old birds should attest that the sources are recognised as being free from FT and comply with OIE-defined standards; that eggs and chicks were shipped in clean and unused packages, and that eggs have been disinfected in accordance with OIE-defined standards.

***S.* Pullorum**

Council Directive 2009/158/EC as updated by Commission Implementing Decisions 2011/214/EU and 2011/879/EU, specifies management and risk-based monitoring conditions for breeding flocks and hatcheries involved in international trade. In addition, for small consignments of imported birds (< 20) traded internationally within the EU and received from third countries, all birds are to have tested serologically negative for *S.* Gallinarum in the preceding month. The flock of origin of hatching eggs or day-old chicks is to have tested serologically negative for *S.* Gallinarum in the preceding 3 months, at a level which gives 95% confidence of detecting infection at 5% prevalence (Racicot et al., 2011).

The OIE Terrestrial Code (OIE, 2017) recommends that Veterinary Authorities require an international veterinary certificate attesting that imported domestic birds showed no clinical sign of Pullorum disease on the day of shipment; come from establishments which are recognised as being free from Pullorum disease; and/or have been subjected to a diagnostic test for Pullorum disease with negative results; and/or were kept in a quarantine station for not less than 21 days prior to shipment. Certificates for hatching eggs or day-old birds should attest that the sources are recognised as being free from Pullorum disease and comply with OIE-defined standards; that eggs and chicks were shipped in clean and unused packages, and that eggs have been disinfected in accordance with OIE-defined standards.

Parameter 7 – Presence and duration of latent infection and/or carrier status

S. arizonae

Asymptomatic colonisation and shedding is the normal mode of intestinal carriage in adult turkeys; this may be long-lived. Systemic infection also occurs, leading to colonisation of reproductive tissues ovaries, oviducts, stag testes and semen (Shivaprasad, 2008). Infected eggs may be produced over an extended period; in excess of 20 weeks in one study (Goetz, 1962; Kumar et al., 1974).

***S.* Gallinarum**

Among recovered or asymptomatic mature stock, it is thought that there may be a number of birds exhibiting long-term carriage of the agent, with potential to lay infected eggs, although this is a more obvious feature of biovar Pullorum (Shivaprasad, 2000; Shivaprasad and Barrow, 2008). The proportion of carriers, and duration of carriage, are not known and may depend on strain of bacterium and genotype of host. Experimentally, infections of young or in-lay hens were noted either to result in death or clearance of the agent from the host (Berchieri et al., 2001). However, in an historical study, *S.* Gallinarum was isolated from the pharynx of carrier field cases for up to several months after the onset of clinical disease (Gauger, 1937).

***S.* Pullorum**

Among recovered or asymptomatic mature stock there will be a number of birds exhibiting long-term carriage of the agent, with potential to lay infected eggs (Wigley et al., 2005; Shivaprasad and Barrow, 2008; Barrow and Freitas Neto, 2011). Systemic carriage has been observed for at least 50 weeks (Gwatkin, 1948; Chappell et al., 2009). In terms of commercial flock infection, this appears to be the most significant mode of latent carriage. However, carriage with shedding in faeces may also occur in mature stock (Rahman et al., 2011; Agada et al., 2014).

3.1.1.8. Article 7(a)(viii) The existence of diagnostic and disease control tools

Diagnostic tools

Parameter 1 – Existence of diagnostic tools

S. arizonae

Serological monitoring. Rapid serum plate, tube agglutination and microagglutination tests have been used, with a whole blood antigen test having proven useful in the field (Shivaprasad, 2008; Hafez, 2013). Bacteriological tests of faecal and environmental samples are relatively sensitive, unlike testing for *S.* Gallinarum or *S.* Pullorum and while an enzyme-linked immunosorbent assay (ELISA) was

developed by Nagaraja (1986) using outer membrane protein as a capture antigen, serological monitoring is rarely used and no commercial ELISA kits are currently available.

Isolation and identification of the agent. Culture techniques for isolation of non-typhoidal *Salmonella* from poultry samples and premises are also used to isolate *S. enterica arizonae*. Bismuth sulfite agar has proved to be a good medium for plating enrichment broths for *arizonae* in general (Hafez, 2013), some of which may be lactose fermenters or non-producers of hydrogen sulfide on standard media, but this discrimination is not needed for the O18 turkey *arizonae* strains. Monitoring of turkey flocks in the EU should use the Annex D of ISO 6579 method (CEN, 2007).

***S.* Gallinarum/*S.* Pullorum**

Serological monitoring. Originally developed and refined in the early 20th Century for *S.* Pullorum (Bullis, 1977; Hafez, 2013), tests include stained-antigen whole blood and rapid serum agglutination plate tests, the former being especially suitable for field use. Macroscopic tube agglutination and microagglutination tests are also commonly used (Shivaprasad and Barrow, 2008; OIE, 2012). Other serological tests have been developed as research and diagnostic tools, with the most commonly employed approach being ELISA-). No commercial ELISA kits are available.

Isolation and identification of the agent. Culture techniques and sampling strategies to optimise recovery of *S.* Gallinarum and *S.* Pullorum are well-established (OIE, 2012), although it is not easy to isolate the agent from faeces or environmental samples. Aseptically collected 'dead in shell' embryos or tissues from mortalities or serologically positive birds are recommended. There are established serological and biochemical tests to identify to serovar and biovar level. Additionally, molecular genetic approaches to identification using polymerase chain reaction (PCR) have been developed, although they are not yet internationally validated (Kang et al., 2011; Zhu et al., 2015).

Control tools

Parameter 2 – Existence of control tools

S. arizonae

The principal control tool for turkey production is the establishment of O18 *arizonae*-free breeding flocks. Some inactivated vaccines have been shown to prevent or reduce vertical transmission (Shivaprasad, 2008; Hafez, 2013), but none are commercially available.

S. Gallinarum/S. Pullorum

Established and validated methods to exclude infection include sourcing eggs/chicks from certified FT-clean/Pullorum disease-free flocks; segregating FT-clean/Pullorum disease-free stock from other poultry and birds; suitable cleaning and disinfection of accommodation; hygienic feed processing, sound biosecurity (Shivaprasad, 2000). Where infection is present, depopulation or test and remove policies based on serology are employed.

3.1.2. Article 7(b) The impact of diseases

3.1.2.1. Article 7(b)(i) The impact of the disease on agricultural and aquaculture production and other parts of the economy

The level of presence of the disease in the Union

Parameter 1 – Number of MSs where the disease is present

S. arizonae

S. enterica arizonae was not detected in a community-wide baseline *Salmonella* survey of turkey production conducted in 2006–2007. There is no recent evidence of isolations in EU Trends and Sources reports, nor in Great Britain Salmonella in Livestock reports.

***S.* Gallinarum**

Nine MS have reported disease in the last 10 years: Belgium, Bulgaria, France, Germany, Hungary, Italy, the Netherlands, Romania and the UK. In the last complete year (2015), one MS (Italy) reported disease, one (Romania) reported infection (OIE, 2016c).

***S.* Pullorum**

Eleven MS reported disease in the last 10 years, but in the last complete year (2015), no MS reported Pullorum disease (OIE, 2016c).

The loss of production due to the disease

Parameter 2 – Proportion of production losses (%) by epidemic/endemic situation

S. arizonae

In the event of disease outbreak, losses will be substantial as it is likely to involve one or more breeding flocks, given the nature of transmission. Culling, disinfection and replacement of the affected flock from clean stock would likely be required.

***S.* Gallinarum**

Losses depend on the level of production in which the infection is present. In non-endemic areas (e.g. EU), eradication of disease following sporadic outbreaks necessitates testing, culling (100% loss) and replacement of any affected breeding flock. Test and remove strategies are generally not viable for production flocks, owing to the high mortality experienced in a FT outbreak.

***S.* Pullorum**

Losses depend on the level of production in which the infection is present. In non-endemic areas (e.g. EU), eradication of disease following sporadic outbreaks necessitates testing, culling (100% loss) and replacement of any affected breeding flock. Grower/laying flocks require testing and culling with replacement where positive, or repeat testing with removal of reactors. Percent losses in the latter case will be variable, but labour and technical costs of serological testing will be substantial.

3.1.2.2. Article 7(b)(ii) The impact of the disease on human health

Transmissibility between animals and humans

Parameter 1 – Types of routes of transmission between animals and humans

S. arizonae

Transmission of turkey O18 *arizonae* strains to humans is not an established phenomenon, although isolation of the relevant serovars from human sources is regularly (but not commonly) reported in the USA (CDC, 2016).

S. Gallinarum

In the absence of evidence relating to the very small reported number of possible cases of human disease, any routes of transmission between animals and humans are speculative. *S*. Gallinarum was isolated from table eggs in Germany and Italy in 2004 (EFSA, 2005).

***S.* Pullorum**

Only food-borne routes of transmission have been reported.

Parameter 2 – Incidence of zoonotic cases

S. arizonae

Reports of human cases of arizonosis have not been associated with the serotypes that cause disease in the turkey industry.

***S.* Gallinarum**

There are two cases of human septicaemia and one of human empyema attributed to *S*. Gallinarum in the literature, all in individuals in the Middle East, and without evidence of immunodeficiency (Yousuf et al., 2001; Sharifi-Mood et al., 2006). The septicaemic cases had recent histories of vaccination with killed Typhoid vaccine, whilst the empyema case had a history of treatment for tuberculosis. Clinical *S*. Gallinarum infection in humans is extremely rare, and it is possible that in the existing case reports one or more isolates (for example non-motile *S*. *Enteritidis*) were misidentified, having been isolated in non-veterinary laboratories.

_S._ Pullorum

The reported cases and outbreaks are historical; many are attributed to eggs and occurred in the time before *S.* Pullorum was eradicated from commercial laying flocks in developed nations (Mitchell et al., 1946; Judefind, 1947; Tanev et al., 1964).

Transmissibility between humans

Parameter 3 – Human to human transmission is sufficient to sustain sporadic cases or community-level outbreak

S. arizonae

There is no published, or otherwise available, data that indicates human to human transmission of turkey serovars.

_S._ Gallinarum

There is no evidence of human to human transmission.

_S._ Pullorum

There is no evidence of human to human transmission. An historical experimental study reported that oral doses around 10^9–10^{10} cfu were required to elicit clinical symptoms in volunteers, and that with lower doses there was no evidence of faecal shedding (McCullough and Eisele, 1951).

Parameter 4 – Sporadic, endemic or pandemic potential

S. arizonae

Very low potential for disease with turkey serovars.

_S._ Gallinarum

Human disease, if it exists, is sporadic and rare.

S. Pullorum

Human disease is sporadic and rare.

The severity of human forms of the disease

Parameter 5 – Disability-adjusted life year (DALY)

S. arizonae

The principal source of data on human isolates of turkey-associated serovars are the US Centers for Disease Control and Prevention (CDC, 2008, 2016). Clinical details are not collected or reported. One summary, using US data to 1976, reported that O18:Z4,Z23 human infections were associated primarily with extraintestinal sources, whereas serovar O18:Z4,Z32 showed an extraintestinal to intestinal source ratio (0.44) that was similar to *arizonae* isolates generally (Weiss et al., 1986). Both serovars were reported as blood isolates in some cases, suggesting the potential for systemic infection in certain individuals.

_S._ Gallinarum

The very few reported human cases had severe illness, but this may be subject to reporting bias.

_S._ Pullorum

The reported human cases typically had fever, with variable other symptoms such as diarrhoea and headache. Where described, clinical effects were typically of short (2–3 days) duration. Long-term sequelae were not reported.

The availability of effective prevention or medical treatment in humans

Parameter 6 – Availability of medical treatment and their effectiveness (therapeutic effect and any resistance)

S. arizonae

Published descriptions of the treatment of human arizonosis do not include turkey-associated serovars. Patients with systemic arizonosis of other (or undetermined) serovars have been reported to

recover following therapy with suitable antibiotics (Di Bella et al., 2011; Gunal and Erdem, 2014). Commonly, human cases of arizonosis have co-morbidities or risk factors that may predispose to infection and, in some cases, may complicate treatment (Waterman et al., 1990; Hall and Rowe, 1992; Di Bella et al., 2011).

***S.* Gallinarum**

Treatment of the three reported human cases with antibiotic combinations guided by culture and sensitivity results, plus other appropriate interventional and supportive treatments, led to resolution of the clinical condition in all cases.

***S.* Pullorum**

Treatment of clinical cases would likely involve supportive care for enteritis, plus antibiotic treatment if systemic involvement was evident or suspected, for example in an immunocompromised patient. Treatment would not be expected to depart substantially from contemporary treatments for salmonellosis caused by other serovars.

Parameter 7 – Availability of vaccines and their effectiveness (reduced morbidity)

S. arizonae

There are no human vaccines specifically for arizonosis.

***S.* Gallinarum/*S.* Pullorum**

There are no human vaccines.

3.1.2.3. Article 7(b)(iii) The impact of the disease on animal welfare

Parameter 1 – Severity of clinical signs at case level and related level and duration of impairment

S. arizonae

Clinically affected poults may show some or all signs like depression, weakness, anorexia and diarrhoea. Nervous signs including paralysis, twisted necks and convulsions may occur, and some individuals develop eye infection resulting in blindness (Shivaprasad et al., 2006; Shivaprasad, 2008; Hafez, 2013). Poor and uneven growth of survivors may be seen.

***S.* Gallinarum**

Clinical signs of FT are typical of a septicaemic condition in poultry and include increased mortality and poor quality in chicks hatched from infected eggs. Weakness, decreased appetite, poor growth, diarrhoea or adherence of faeces to the vent and respiratory signs (gasping) are also seen in those birds that do not succumb to rapid death (Shivaprasad and Barrow, 2008; Shivaprasad et al., 2013). Older birds may show signs of anaemia, depression, laboured breathing and diarrhoea causing adherence of faeces to the vent (OIE, 2017). Survivors may show reduced egg production, egg hatchability and fertility (Shivaprasad and Barrow, 2008).

In turkeys, internal egg infection leads to death in shell or a moribund state in chicks with rapid death. Poults showing signs from around day five may show laboured breathing, greenish diarrhoea, increased thirst, anorexia, somnolence and retarded growth (Hafez, 2013). In older birds, disease severity will vary but may include decreased feed consumption, ruffled feathers, diarrhoea and decreases in egg production, fertility and hatchability (Cobb et al., 2005; Shivaprasad and Barrow, 2008). Mortality may occur without other obvious signs, and over short (days) or long (months) timescales (Cobb et al., 2005; Parmar and Davies, 2007; Ivanics et al., 2008).

***S.* Pullorum**

Clinical signs of Pullorum disease are typical of a septicaemic condition in poultry and include increased mortality and poor quality in chicks and poults hatched from infected eggs. Weakness, decreased appetite, poor growth, diarrhoea or adherence of faeces to the vent and respiratory signs (gasping) are also seen in those birds that do not succumb to rapid death. White diarrhoea may be seen in turkey poults. Some chicks and poults may become blind and/or show swelling of major limb joints (Hafez, 2013). Older birds typically are asymptomatic, but may show anorexia, depression, diarrhoea and dehydration. Survivors and asymptomatic birds may show reduced egg production, egg hatchability and fertility (Shivaprasad and Barrow, 2008; Hafez, 2013).

3.1.2.4. Article 7(b)(iv) The impact of the disease on biodiversity and the environment

Biodiversity

Parameter 1 – Endangered wild species affected: listed species as in CITES and/or IUCN list

S. arizonae

The relevant serovars are not considered to pose a significant disease threat other than among domestic turkeys.

***S.* Gallinarum/*S.* Pullorum**

The pathogen is not considered to pose a significant disease threat outside domestic poultry.

Parameter 2 – Mortality in wild species

S. arizonae

Mortality for the relevant serovars other than among domestic turkeys appears to be low.

***S.* Gallinarum/*S.* Pullorum**

Mortality outside domestic poultry (including pheasants) appears to be low.

Environment

Parameter 3 – Capacity of the pathogen to persist in the environment and cause mortality in wildlife

S. arizonae

Whilst avian wildlife may potentially carry the pathogen, and could theoretically acquire it from farmed flocks and their environs, there is no evidence of a capacity to cause substantial mortality in wildlife.

***S.* Gallinarum**

While avian wildlife may carry the pathogen, and potentially acquire it from farmed flocks and their environs, there is no evidence of a capacity to cause anything other than occasional, sporadic disease in individuals or groups of free-ranging birds. Predisposing causes for disease in wildlife are not understood.

***S.* Pullorum**

While avian wildlife may carry the pathogen, and potentially acquire it from farmed flocks and their environs, there is no evidence of a capacity to cause anything other than occasional, sporadic disease in individuals or groups of free-ranging birds. Predisposing causes for disease in wildlife are not understood, but close confinement of commercially reared game birds destined for release into the wild appears to be contributory in some cases.

3.1.3. Article 7(c) Its potential to generate a crisis situation and its potential use in bioterrorism

Parameter 1 – Listed in OIE/CFSPH classification of pathogens

S. arizonae

CFSPH: *S. arizonae* is listed among reptile-associated and non-typhoidal Salmonellae, but no reference to (non-zoonotic) turkey-associated serovars.

OIE: Arizonosis is not listed as a notifiable disease.

***S.* Gallinarum**

CFSPH: FT is listed as a disease of poultry/non-poultry birds. It is not on the zoonosis list.

OIE: FT is OIE-listed as a notifiable disease. Previously on List B (transmissible diseases considered to be of socioeconomic and/or public health importance within countries and are significant in the international trade of animals and animal products).

***S.* Pullorum**

CFSPH: Pullorum disease is listed as a disease of poultry/non-poultry birds. Not on the zoonosis list.

OIE: Pullorum disease is OIE-listed as a notifiable disease. Previously on List B (transmissible diseases considered to be of socioeconomic, and/or public health importance within countries and are significant in the international trade of animals and animal products).

Parameter 2 – Listed in the Encyclopaedia of Bioterrorism Defence of Australia Group

***S. arizonae*/*S.* Gallinarum/*S.* Pullorum**

Not listed.

Parameter 3 – Included in any other list of potential bio- agro-terrorism agents

***S. arizonae*/*S.* Gallinarum/*S.* Pullorum**

None found.

3.1.4. Article 7(d) The feasibility, availability and effectiveness of the following disease prevention and control measures

3.1.4.1. Article 7(d)(i) Diagnostic tools and capacities

Availability

Parameter 1 – Officially/internationally recognised diagnostic tool, OIE certified

S. arizonae

Sensitive isolation is possible from environmental material and tissues using OIE-approved culture methods for motile *Salmonella*, such as ISO 6579:2002/Amd 1:2007 (Annex D) (OIE, 2016b). In view of the utility of culture detection of this faecally shed agent, serological monitoring and detection techniques, although described (Jordan et al., 1976; Shivaprasad, 2008), are currently little used.

***S.* Gallinarum/*S.* Pullorum**

The stained antigen (whole blood, rapid serum) and tube- or microagglutination serological tests are internationally recognised and OIE certified (OIE, 2012).

Certain sampling and culture methods are recommended and detailed in the relevant OIE manual (OIE, 2012).

Effectiveness

Parameter 2 – Se and Sp of diagnostic test

S. arizonae

AS O18 *arizonae* are shed consistently in colonised adult birds, environmental sampling should allow sensitive detection, provided sensitive samples (e.g. boot swabs, dust) and a sensitive culture technique suited for coping with contaminant organisms is used (Carrique-Mas and Davies, 2008). Dead in shell embryos, hatch debris and dead poults have also been found to be sensitive indicators of breeding flock infection (Goetz, 1962; Kumar et al., 1974). Specificity depends on accurate identification of isolates using appropriate colonial, serological and biochemical discriminators (Carrique-Mas and Davies, 2008). Provided that isolates are carefully identified, the positive predictive value (PPV) of flock screening by culture is high, regardless of underlying risk, although the potential exists for certain *diarizonae* or other *S. enterica* subspecies bearing the O18 antigen to be wrongly identified as turkey-specific isolates. The negative predictive value (NPV) of screening breeding flocks should be very high if sensitive sampling and culture techniques are used, given the occurrence of obvious clinical disease and/or egg hatchability problems and low underlying risk of flock infection.

The strength of serological responses appear to vary according to stage of life and the age at which the bird becomes infected, with peaks described at around 1 month of age and, for later-infected birds, at point of lay (Kumar et al., 1974).

***S.* Gallinarum/*S.* Pullorum**

There is limited objective data on test performance, but the evidence indicates that serological results with existing tests should be interpreted at flock (rather than individual) level, and be complemented with bacteriological sampling of reacting birds. If the test is to be used for detecting

individual infected birds for culling, it should be repeated at least twice and preferably until the whole flock has given at least two negative tests (OIE, 2012).

Specificity. Serological tests should detect reactors to both Gallinarum and Pullorum biovars, owing to a shared antigenic structure. A lack of specificity can be attributed to infections with a variety of bacteria (coliforms, micrococci, streptococci and others), and non-Pullorum/Gallinarum reactors may range from few birds in a flock to as high as 30–40% (Shivaprasad and Barrow, 2008). Post-mortem examination of reacting birds, with bacteriological sampling, is necessary to complement and confirm a serological diagnosis of flock infection. The whole-blood antigen test is not suitable for use in turkeys or ducks, owing to a lack of specificity (OIE, 2012). Tube agglutination tests may be used with these species, but still produce a low proportion of false positives. Tube agglutination tests can also be used to confirm rapid slide agglutination test results.

The standard rapid serum agglutination (RSA) test, produced with *S*. Pullorum antigens by a French national monitoring laboratory, showed a specificity of 90%, with undiluted serum in ten 10-week-old specific-pathogen-free hens (Proux et al., 2002).

Using 10-week-old specific pathogen-free hens, Proux et al. (2002) demonstrated 99% (107/108 birds) specificity of the RSA Gallinarum/Pullorum test using neat serum, and 100% specificity using serum diluted 1:4. Specificity of 100% was also seen in another experimental study (Gast, 1997).

S. Gallinarum

Sensitivity. In one study (Proux et al., 2002), a single (atypical) strain of *S*. Gallinarum was administered intramuscularly to ten 10-week-old hens, and sera were examined 2 weeks post-inoculation using a *S*. Gallinarum-specific ELISA as a reference test. Sensitivity was 0%. The authors cautioned that this represents results from just a single strain of *S*. Gallinarum, but advised that antigen from both Gallinarum and Pullorum biovars be included in the RSA, before further evaluation. Based on this study the sensitivity for FT of a standard stained-antigen Pullorum test is in some doubt, but the study was small and did not show *S*. Gallinarum colonisation of the hens at one week after serological sampling. A recent field study in an endemically affected country (Bangladesh) showed birds that were seronegative with a whole blood stained-antigen to commonly be shedding *S*. Gallinarum (Rahman et al., 2011), thus emphasising the importance of selecting appropriate antigens and ensuring the quality of production and testing, including use of suitable control samples.

S. Pullorum

Sensitivity. With *S*. Pullorum, there is a variation in the ratio of 121, 122 and 123 subtypes of O antigen; the standard strain contains more 123 than 122, while the reverse is true of the variant form. Intermediate forms also exist. Therefore, it is necessary to use a polyvalent antigen in immunodiagnostic tests. In the study by Proux et al. (2002), birds were inoculated intramuscularly with one of 11 *S*. Pullorum strains, and a polyvalent rapid serum agglutination test demonstrated a sensitivity of 100% (108/108) at 2 weeks post-inoculation.

Another experimental trial, using mature hens inoculated orally with one of six field strains, yielded a sensitivity for detection, depending on inoculated strain, of 40–75% (whole blood antigen test) or 62–94% (tube agglutination test) at six weeks post-inoculation (Gast, 1997). Birds that were culture-positive at post mortem examination were most often seropositive (92–98% of samples).

Feasibility

Parameter 3 – Type of sample matrix to be tested (blood, tissue, etc.)

S. arizonae

Surveillance sampling is readily performed using culture of environmental (boot or drag) swabs, dust and hatchery waste.

S. Gallinarum/*S.* Pullorum

The rapid whole blood plate agglutination test is suitable for use in the field. Other validated serological tests are readily performed in the laboratory. For bacteriological culture, tissue samples are more rewarding than environmental or faeces samples, owing to low or intermittent shedding and competing organisms and inhibitory substances (OIE, 2012).

Direct enrichment of the sample in selenite broth, rather than the non-selective pre-enrichment that is used for non-host-adapted serovars is recommended for both SP and SG biovars of SG.

3.1.4.2. Article 7(d)(ii) Vaccination

Availability

Parameter 1 – Types of vaccines available on the market (live, inactivated, DIVA, etc.)

S. arizonae

Inactivated autogenous vaccines may be prepared using strains from infected flocks. Aluminium salt or oil adjuvants have proved effective. There is no commercial vaccine available.

***S.* Gallinarum**

The long-established rough mutant of *S.* Gallinarum (SG9R) (Harbourne, 1955) is the only licensed live vaccine strain available. It has been used by various companies, but SG9R vaccines are being superseded by rationally attenuated strains for non-typhoidal *Salmonella* infections. Furthermore, recent concerns over reversion to virulence have led to the vaccine being voluntarily withdrawn in some countries where FT is not endemic. Molecular genetic evidence of virulent SG9R-related strains in vaccinated flocks in Europe and Korea have been presented (Kwon and Cho, 2011; Van Immerseel et al., 2013). Inactivated autogenous vaccines may be prepared using strains from infected flocks.

***S.* Pullorum**

Owing to the successful eradication of *S.* Pullorum from commercial flocks and the lack of a clinical problem with outbreaks in mature flocks (by contrast with *S.* Gallinarum/fowl typhoid), there is little need or incentive for a licensed vaccine for Pullorum disease. The long-established rough mutant of *S.* Gallinarum (SG9R) (Harbourne et al., 1963) is the only licensed live vaccine strain likely to be efficacious against *S.* Pullorum, although *S.* Enteritidis vaccines are also likely to provide some cross-protection. Where SG9R is marketed it is licensed for fowl typhoid, not Pullorum disease. Recent concerns over reversion to virulence (Kwon and Cho, 2011; Van Immerseel et al., 2013) has led to the vaccine being voluntarily withdrawn in some countries where *S.* Gallinarum is not endemic. Inactivated autogenous vaccines may be prepared using strains from infected flocks, but again there are few circumstances where their use would be advocated compared with an eradication strategy.

Parameter 2 – Availability / production capacity (per year)

S. arizonae

There is no commercial vaccine available.

***S.* Gallinarum/*S.* Pullorum**

Vaccines using SG9R have been widely produced by various companies globally for many years, for control of typhoidal and non-typhoidal *Salmonella* (serovar Enteritidis) in *Gallus gallus*. The availability of such vaccines in Europe is variable, according to national regulatory policies.

Effectiveness

Parameter 3 – Field protection as reduced morbidity (as reduced susceptibility to infection and/or to disease)

S. arizonae

Reported effects include, variously, reduced shedding and prevention of systemic infection in breeders, reduction in the proportion of infected eggs laid, and prevention of infection in progeny from breeders held in a contaminated environment (Shivaprasad, 2008).

***S.* Gallinarum**

Vaccines for *Salmonella* are not capable of eradicating infection from flocks but can increase the threshold for infection, reduce the level of shedding of the organism and reduce vertical transmission in poultry (OIE, 2012). Vaccination with strain SG9R may sometimes precipitate high mortality in infected birds (Silva et al., 1981). SG9R vaccine was associated with protection against mortality up to 61 weeks of age in the face of repeated experimental challenge in a farm-scale trial with laying hens (Lee et al., 2007), but has not always been successful in the face of field outbreaks of FT. It is likely to be used preventatively, in regions where the disease is endemic or considered to be a high risk. There have been concerns about the potential for reversion of some live vaccines to virulence, resulting in

outbreaks of FT in vaccinated flocks or on holdings where a proportion of birds have been vaccinated (Kwon and Cho, 2011; Van Immerseel et al., 2013).

***S.* Pullorum**

Vaccines for *Salmonella* are not capable of eradicating infection from flocks but can increase the threshold for infection, reduce the level of shedding of the organism and reduce vertical transmission in poultry (OIE, 2012). There are few studies on vaccine protection of mature birds or of chicks hatched from *S.* Pullorum-infected flocks, as vaccination has not been regarded as a useful control strategy. Recent studies (Akter et al., 2012; Yin et al., 2015) showed that *S.* Pullorum, given as a formalin-killed alum-precipitated vaccine or a rationally attenuated live oral vaccine, provided protection against clinical effects of intramuscular challenge in 14-week-old (inactivated vaccine) or 12-day-old (live vaccine) chickens, but effects on vertical transmission or viability of derived chicks were not examined.

Parameter 4 – Duration of protection

S. arizonae

Duration of effects has not been documented.

***S.* Gallinarum**

Reduction of mortality was shown for the duration of a 61-week large-scale trial following administration of a SG9R vaccine to pullets at 6 and/or 18 weeks of age (Lee et al., 2007). In the field, duration of protection is likely to be variable and it is usual to repeat vaccination at least twice yearly.

***S.* Pullorum**

Reduction of mortality from fowl typhoid was shown for the duration of a 61-week large-scale trial following administration of a SG9R vaccine to pullets at 6 and/or 18 weeks of age (Lee et al., 2007). In the field, duration of protection is likely to be variable and it is recommended to repeat vaccination at least twice yearly.

Feasibility

Parameter 5 – Way of administration

S. arizonae

Generally, the inactivated vaccines are given by two or more intramuscular injections.

***S.* Gallinarum/*S.* Pullorum**

Where it is currently marketed, the SG9R vaccine is administered by subcutaneous injection. Intramuscular and oral administration has also been used (Shivaprasad and Barrow, 2008), although the latter routes appear to generate less effective protection (Silva et al., 1981).

3.1.4.3. Article 7(d)(iii) Medical treatments

Availability

Parameter 1 – Types of drugs available on the market

S. arizonae

Antibiotics and chemotherapeutic antimicrobial drugs are the only drugs used to treat avian arizonosis. Those listed for other systemic avian salmonellosis are likely to be at least partially effective (Shivaprasad and Barrow, 2008). These include sulfonamides, nitrofurans, aminoglycosides, tetracyclines and chloramphenicol.

***S.* Gallinarum**

Antibiotics and chemotherapeutic antimicrobial drugs are the only drugs used to treat clinical FT. Drugs and classes of drugs found to be at least partially effective include sulfonamides, nitrofurans, aminoglycosides, tetracyclines and chloramphenicol (Shivaprasad and Barrow, 2008). However, in most cases medication fails to contain infection in large flocks.

***S.* Pullorum**

Antibiotics and chemotherapeutic antimicrobial drugs are the only drugs used to treat clinical Pullorum disease. Drugs and classes of drugs found to be at least partially effective include sulfonamides, nitrofurans, aminoglycosides, tetracyclines and chloramphenicol (Shivaprasad and Barrow, 2008).

Parameter 2 – Availability / production capacity (per year)

***S. arizonae*/*S.* Gallinarum/*S.* Pullorum**

All of the licensed drugs/classes are produced in volume. The availability of some (e.g. chloramphenicol, furazolidone) for veterinary use is restricted by law in some territories, and their use is not permitted in the EU.

Effectiveness

Parameter 3 – Therapeutic effects on the field (effectiveness)

S. arizonae

Antibiotic/antimicrobial chemotherapeutic treatment of carrier adults does not prevent infection of eggs (Goetz, 1962). No drug or combination has been found capable of eliminating infection from a treated flock, but antibacterial drugs may reduce morbidity and losses if given to young poults (Hinshaw and McNeil, 1946; Kumar et al., 1974), dramatically so if given at the hatchery (Shivaprasad, 2008).

***S.* Gallinarum/*S.* Pullorum**

No drug or combination has been found capable of eliminating infection from a treated flock, although the listed drugs have sometimes been found to reduce mortality (Shivaprasad and Barrow, 2008). Only colistin and tetracyclines are permitted to be used for FT/Pullorum disease in laying hens without the need for withholding eggs from sale, and their effectiveness is limited.

Feasibility

Parameter 4 – Way of administration

S. arizonae

Reportedly effective treatments have been given by injection at the hatchery, and in feed on rearing premises (Hinshaw and McNeil, 1946; Kumar et al., 1974; Pomeroy et al., 1989; Shivaprasad, 2008).

***S.* Gallinarum/*S.* Pullorum**

Depending on the class of antimicrobial, effective systemic concentrations, as required for a septicaemic condition, can be achieved by administration in drinking water (e.g. chlortetracycline) or by injection (e.g. aminoglycosides). For medication of commercial flocks, daily injection is usually not feasible.

3.1.4.4. Article 7(d)(iv) Biosecurity measures

Availability

Parameter 1 – Available biosecurity measures

S. arizonae

Biosecurity as recommended and often implemented for *Salmonella* spp. generally include clean and secure feed transport and storage, exclusion and control of bird, rodent and other wildlife plus arthropods, water hygiene, visitor and fomite restrictions, perimeter security and proper disposal of dead birds.

***S.* Gallinarum/*S.* Pullorum**

Biosecurity as recommended and often implemented for *Salmonella* spp. and *Campylobacter* spp. generally include clean and secure feed transport and storage, exclusion and control of bird, rodent and other wildlife plus arthropods, water hygiene, visitor and fomite restrictions, perimeter security and proper disposal of dead birds (Shivaprasad, 2000).

Effectiveness

Parameter 2 – Effectiveness of biosecurity measures in preventing the pathogen introduction

S. arizonae

Implementation of total confinement, bird- and rodent-proof buildings and feed hygiene, alongside thorough cleaning and disinfection, was highly successful at preventing infection of primary breeder flocks (Shivaprasad, 2008). Segregation of birds of uncertain infection status into small groups in widely separated pens on disinfected and/or previously unused premises allowed elimination of O18 *arizonae* following intensive monitoring and culling of all birds in affected pens (Jordan et al., 1976).

***S.* Gallinarum/*S.* Pullorum**

The effectiveness of biosecurity measures is suggested by the sustained absence of FT/Pullorum disease in commercial flocks despite intermittent identification of the agent in small extensively farmed flocks in the same countries (Shivaprasad and Barrow, 2008; EFSA, 2009). There is little or no quantitative data on the effectiveness of specific measures in respect of FT/Pullorum disease prevention.

Feasibility

Parameter 3 – Feasibility of biosecurity measures

S. arizonae

Implementation of total confinement, bird- and rodent-proof buildings and feed hygiene, alongside thorough cleaning and disinfection, was highly successful at preventing infection of primary breeder flocks (Shivaprasad, 2008). Segregation of birds of uncertain infection status into small groups in widely separated pens on disinfected and/or previously unused premises allowed elimination of O18 *arizonae* following intensive monitoring and culling of all birds in affected pens (Jordan et al., 1976).

***S.* Gallinarum/*S.* Pullorum**

The effectiveness of biosecurity measures is suggested by the sustained absence of FT/Pullorum disease in commercial flocks despite intermittent identification of the agent in small extensively farmed flocks in the same countries (Anderson et al., 2006; AHVLA, 2008; Shivaprasad and Barrow, 2008). There is little or no quantitative data on the effectiveness of specific measures in respect of FT/Pullorum disease prevention.

3.1.4.5. Article 7(d)(v) Restrictions on the movement of animals and products

Availability

Parameter 1 – Available movement restriction measures

***S. arizonae*/*S.* Gallinarum/*S.* Pullorum**

National health and monitoring schemes exist within EU MSs, implementing requirements of Council Directive 2009/158/EC, as updated by Commission Decision 2011/214/EU[2] and Commission Implementing Decision 2011/879/EU[3] for, amongst other things, licensing of intra-community trade, trade between MS's and certain third countries, and trade between health scheme members. Council Directive 2009/158/EC, as updated by Commission Decision 2011/214/EU and Commission Implementing Decision 2011/879/EU requires removal of approval of the establishment and for trading movement restrictions to be placed on premises where infection with these organisms is identified or suspected. If approval has been withdrawn because of an outbreak caused by *S.* Pullorum, *S.* Gallinarum or *S. arizonae*, this may be restored after negative results have been recorded in two tests performed with an interval of at least 21 days on the establishment following sanitary slaughter of the infected flock and after disinfection for which the effectiveness has been verified by suitable tests on dried surfaces. An example of a scheme which is operated by the poultry industry in

[2] 2011/214/EU: Commission Decision of 1 April 2011 amending Annexes II to IV to Council Directive 2009/158/EC on animal health conditions governing intra-Community trade in, and imports from third countries of, poultry and hatching eggs. OJ L 90, 6.4.2011, p. 27–49.

[3] 2011/879/EU: Commission Implementing Decision of 21 December 2011 amending Annexes II and IV to Council Directive 2009/158/EC on animal health conditions governing intra-Community trade in, and imports from third countries of, poultry and hatching eggs. OJ L 343, 23.12.2011, p. 105–116.

collaboration with the competent authority is the UK has a Poultry Health Scheme (Defra, 2013), membership of which is suspended in the event of suspected or diagnosed flock infection with relevant serovars of *S*. *enterica arizonae*/*S*. Gallinarum/*S*. Pullorum.

Effectiveness

Parameter 2 – Effectiveness of restriction of animal movement in preventing the between farm spread

***S. arizonae*/*S*. Gallinarum/*S*. Pullorum**

The agent has the potential for extended carriage by some birds, can survive on fomites and in faeces for some time, but is not known to be capable of airborne travel between premises except perhaps via avian intermediaries. Therefore, restricting the movement of birds from affected flocks will effectively restrict spread of the agent between premises. However, the agent may additionally be transferred between premises via eggs, humans (catching crews, shared workers, etc.), vehicles and other mobile equipment.

***S*. Gallinarum**

Use of second-hand cages and non-national maintenance engineers is thought to have been responsible for some infections in large laying hen flocks.

Feasibility

Parameter 3 – Feasibility of restriction of animal movement

***S. arizonae*/*S*. Gallinarum/*S*. Pullorum**

The principal affected species are usually moved, as whole flocks or substantial proportions thereof, two or three times in their lives from hatchery to rearing/fattening accommodation, from rearing to laying or fattening accommodation, and from fattening or laying accommodation to slaughter. Movement of individual birds or small groups is generally not undertaken in commercial poultry production. Given the organised, large-scale and relatively infrequent movement of individual commercial flocks, movement restriction may readily be applied at a flock or premises level if disease is diagnosed in the flock. Tracing and destruction of eggs from affected breeding flocks should not pose a major challenge provided batches are routinely tracked appropriately.

***S*. Gallinarum/*S*. Pullorum**

Restricting the movement of fancy fowl for shows, etc., is potentially more difficult, given the frequency with which they may be moved, and the comparative lack of statutory regulation on trade and movement of small numbers of birds within the EU, compared with commercial birds.

3.1.4.6. Article 7(d)(vi) Killing of animals

Availability

Parameter 1 – Available methods for killing animal

***S. arizonae*/*S*. Gallinarum/*S*. Pullorum**

Recognised methods of mass killing on-farm include hypercapnia (carbon dioxide exposure), anoxia (nitrogen or argon in foam, water foam) and ventilation shutdown. Methods used for smaller numbers of birds include CO_2 or gaseous anoxia in containers or confined airtight spaces, injection of chemical agents (e.g. pentobarbitone), cervical dislocation, percussive stunning, decapitation and electrocution using appropriately designed equipment (NAHEMS, 2015; OIE, 2016a). However, in the EU according to the Council Regulation (EC) No 1099/2009[4], there is a welfare requirement for stunning before (or as part of) the lethal technique and consequently certain techniques are not permitted. These include foam smothering without anoxic gas, ventilation shutdown and decapitation, plus electrocution without a prestun and cervical dislocation outside of limits on weight and number of birds per operator. In individual cases where, under exceptional circumstances, compliance with those rules may put human health at risk or may significantly slow down the process of eradication of a disease the MS Competent Authority may derogate from such provisions, but this is unlikely to be the case with

[4] Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. OJ L 303, 18.11.2009, p. 1–30.

S. arizonae/*S.* Gallinarum/*S.* Pullorum infections. Birds that are not showing symptoms may also be sent to slaughter plants, with carcasses being used for heat-treated food products or as animal by-products.

Parameter 2 – Effectiveness of killing animals (at farm level or within the farm) for reducing /stopping spread of the disease

S. arizonae

The greatest benefit of depopulation in respect of preventing spread of disease is likely to occur when the flock in question is a breeding flock. Methods that do not involve mass-handling of animals will minimise the risk of disease spread by operators. Given the mode of transmission, killing of a fattening flock that experienced disease among poults is unlikely to affect control of the disease more widely.

***S.* Gallinarum/*S.* Pullorum**

The greatest benefit of depopulation in respect of preventing spread of disease is likely to occur when the flock in question is a breeding flock. Methods that do not involve mass-handling of animals will minimise the risk of disease spread by operators. Killing of commercial production flocks will eliminate the risk of contamination of any equipment, vehicles and personnel that are shared between premises, provided suitable decontamination of people and equipment used in the depopulation is performed. Killing of flocks destined for other (laying or fattening) premises will prevent contamination of those premises. Killing and removal of an infected flock will not prevent carry-over to another flock on the same premises unless thorough decontamination, including acaricidal treatment if red mite is present (for *S.* Gallinarum), is performed between flocks (Parmar and Davies, 2007). Disruption caused by removing one flock on a multiflock site may lead to spread of disease within the holding.

***S.* Pullorum**

Historically, SP was eradicated from many commercial breeding poultry flocks by repeat serological testing and culling reactors. The limited environmental persistence and infectivity of the organism and minimal involvement of vectors made this possible, but it would not be economically feasible on modern large scale breeding enterprises, which are maintained free of infection in most high-income countries by a high level of biosecurity within the whole breeding pyramid.

Feasibility

Parameter 3 – Feasibility of killing animals

***S. arizonae*/*S.* Gallinarum/*S.* Pullorum**

The mass-killing methods detailed previously all have limitations, for example the need for birds to be at low level with house-wide CO_2 killing, the need for suitable foam generation supplies and equipment for large-scale nitrogen and argon use, and welfare and legal prohibitions on several techniques, discussed previously. However, many methods are used successfully when needed (and when selected appropriately) with other disease outbreaks, for example avian influenza.

3.1.4.7. Article 7(d)(vii) Disposal of carcasses and other relevant animal by-products

Availability

Parameter 1 – Available disposal option

***S. arizonae*/*S.* Gallinarum/*S.* Pullorum**

Incineration, slaughter for human consumption (for healthy birds in the flock) or rendering. Other methods (burial, composting) are not permitted in the EU.

Effectiveness

Parameter 2 – Effectiveness of disposal option

***S. arizonae*/*S.* Pullorum**

All methods are well-established and may be used successfully (CAST, 2008). Preventing spread of the infectious agent depends upon excluding access to carcasses by wildlife likely to carry and spread *S. enterica arizonae*/*S.* Pullorum especially wild birds and rodents.

_S._ Gallinarum

All methods are well-established and may be used successfully (CAST, 2008). Preventing spread of the infectious agent depends upon excluding access to carcasses by wildlife likely to carry and spread *S*. Gallinarum, i.e. wild birds and rodents. Elimination of red mites by prolonged heat treatment of poultry houses, as well as effective disinfection, is required to prevent carry-over of infection into replacement flocks.

Feasibility

Parameter 3 – Feasibility of disposal option

S. arizonae/_S._ Gallinarum/_S._ Pullorum

The use of incineration would depend on there being an accessible, suitably licensed incinerator of suitable capacity. This is unlikely to be universally available.

3.1.5. Article 7(e) The impact of disease prevention and control measures

3.1.5.1. Article 7(e)(i) The direct and indirect costs for the affected sectors and the economy as a whole

Parameter 1 – Cost of control (e.g. treatment/vaccine, biosecurity)

_S._ arizonae

In the EU, elimination and exclusion of the disease is the principal control strategy. Therefore costs of control are essentially those of eradication (as below). Maximal biosecurity is required for the breeding flocks, which is recommended in any event for disease (including *Salmonella*) prevention more generally. Therefore, it is difficult to assign a nominal cost of such measures specifically for the prevention and control of *S*. *enterica arizonae*.

_S._ Gallinarum/_S._ Pullorum

In the EU, elimination and exclusion of the disease is the principal control strategy. Therefore, costs of control are essentially those of eradication (as below). The same biosecurity and hygiene measures are used for the prevention and control of non-typhoidal *Salmonella*, *S*. Gallinarum/Pullorum and, where applicable, *Campylobacter* spp. Therefore, it is difficult to assign a nominal cost of such measures specifically for the prevention and control of FT/Pullorum disease.

_S._ Gallinarum

Current vaccination programmes are subject to the labour cost of injecting birds individually, with protocols recommending two doses, either of an SG9R live strain or a killed bacterin, or a sequential combination of both (Paiva et al., 2009).

Parameter 2 – Cost of eradication (culling, compensation)

S. arizonae

Costs depend on the level in the breeding pyramid in which the disease occurs. In the UK, costs of testing and culling are borne by the flock owner. Insurance policies may be available. Historically, control was achieved in the USA following first recognition of the disease (in the 1940s) by intensive monitoring of breeder flocks and candidate breeding birds, via serological testing and bacteriological sampling of poult mortalities, seropositive birds and dead-in-shell embryos (Goetz, 1962). An outbreak in the UK in 1968 arising from imported eggs was arrested without a complete cull of the affected flock by serological screening, segregation of birds into small groups on clean premises and further intensive serological and bacteriological monitoring, with culling of affected groups (Jordan et al., 1976). Such an approach is likely to be economically feasible only among birds with high genetic value.

_S._ Gallinarum

Costs depend on the level in the breeding pyramid in which the disease occurs. Test and remove strategies are not usually employed in the EU, given the high mortality with FT. For such an approach, the costs of repeated blood sampling and testing all birds (compared with surveillance sampling) may exceed the value of the flock. In the UK, costs of testing and culling for FT are borne by the flock owner. Insurance policies may be available, albeit at often prohibitive premium costs.

_S._ Pullorum

Costs depend on the level in the breeding pyramid in which the disease occurs. For a test-remove-retest approach, the costs of repeated blood sampling and testing all birds (compared with surveillance sampling) may exceed the value of the flock. In the UK, costs of testing and culling for Pullorum disease are borne by the flock owner. Insurance policies may be available, albeit at often prohibitive premium costs.

Parameter 3 – Cost of surveillance and monitoring

S. arizonae

This is the predominant cost of *S. enterica arizonae* in the EU, where the disease has been eliminated from commercial flocks. Under the UK National Control Programme for *Salmonella* in turkeys (Defra, 2008), bacteriological samples (boot swabs +/– dust samples) are to be taken from every fattening flock, and every three weeks from all breeding flocks, for submission to an approved testing laboratory. Three-weekly samples of hatchery waste are an alternative for breeding flocks in lay. As an example, current UK Animal and Plant Health Agency costs (excluding Value Added Tax) are £19.80 for combined culture of up to 10 swabs.

_S._ Gallinarum/_S._ Pullorum

This is the predominant cost of SG/SP in developed countries where the disease has been eliminated from commercial flocks (Shivaprasad, 2000). As an example, under the UK Poultry Health Scheme (Defra, 2013), all flocks (fowl, turkeys, ducks, guinea fowl, partridges, pheasant, quails) in lay (i.e. breeding and commercial egg production) are to be tested at least once a year, with the initial test at or near the point of lay. Samples either for serology (up to 60 samples, depending on flock size) or bacteriology (dead-in-shell and cull chicks, meconium or hatch tray liners) are submitted to an approved testing laboratory. Current UK Animal and Plant Health Agency costs (excluding Value Added Tax) are between £7.90 and £13.50 per sample for serology and £41.55 for combined culture of up to 60 chick carcasses.

Parameter 4 – Trade loss (bans, embargoes, sanctions) by animal product

S. arizonae

EU rules (Council Directive 2009/158/EC) state that source premises for international trade in hatching eggs and birds should be regularly monitored to demonstrate freedom from *S. enterica arizonae*. However, country-wide freedom from the disease is not required. Given the low zoonosis risk, trade in eggs and poultry for human consumption is not subject to controls relating to the presence or absence of *S. enterica arizonae* in source flocks.

_S._ Gallinarum

EU rules (Council Directive 2009/158/EC) and OIE recommendations (OIE, 2017) state that source flocks for international trade in hatching eggs and birds should be certified as free from FT. However, country-wide freedom from the disease is not required. Given the negligible zoonosis risk, trade in eggs and poultry for human consumption is not subject to controls relating to the presence or absence of FT in source flocks.

_S._ Pullorum

EU rules (Council Directive 2009/158/EC) and OIE recommendations (OIE, 2017) state that source flocks for international trade in hatching eggs and birds should be certified as free from Pullorum disease. However, country-wide freedom from the disease is not required. Given the low zoonosis risk, trade in eggs and poultry for human consumption is not subject to controls relating to the presence or absence of *S.* Pullorum in source flocks.

Parameter 5 – Importance of the disease for the affected sector (% loss or € lost compared to business amount of the sector)

_S._ arizonae

Currently, the costs of the disease within the EU are mostly those of surveillance. In the event of a substantial outbreak, for example occurring following undetected infection in a breeding flock, the short-term cost of detection, culling, decontamination and repopulation could be substantial.

***S.* Gallinarum/*S.* Pullorum**

Currently, the costs of the disease within the EU are mostly those of surveillance. In the event of a substantial outbreak, for example occurring following undetected infection in a breeding flock, the short-term cost of detection, culling, decontamination and repopulation could be substantial. Such a scenario unfolded in the USA in the early 1990s with the *S.* Pullorum biovar (Shivaprasad and Barrow, 2008), although a quantitative assessment of the costs was not reported. In 1939, before the biovars Gallinarum and Pullorum were eradicated from the poultry industry in the USA, an estimate was given that Pullorum disease cost that industry 'hundreds of thousands of dollars' per year (Bullis, 1977).

3.1.5.2. Article 7(e)(ii) The societal acceptance of disease prevention and control measures

***S. arizonae*/*S.* Gallinarum/*S.* Pullorum**

There is broad public acquiescence in the culling of poultry for disease control purposes. Concern has been expressed by campaigning groups about the necessity for culling (Laville and Harding, 2005) or methods used, particularly ventilation shutdown in recent avian influenza outbreaks (CWF, 2016), but objections outside of groups opposed to intensive farming appear to be minimal.

3.1.5.3. Article 7(e)(iii) The welfare of affected subpopulations of kept and wild animals

Parameter 1 – Welfare impact of control measures on domestic animals

S. arizonae

Culling interventions in breeding flocks are subject to welfare considerations around handling for blood sampling, transport and killing. These are not peculiar to *S. enterica arizonae* control.

***S.* Gallinarum/*S.* Pullorum**

Culling or test and remove interventions in commercial flocks are subject to welfare considerations around handling for blood sampling, transport and killing. These are not peculiar to *S.* Gallinarum/*S.* Pullorum control. Occasional disease in pet chickens, fancy fowl and small backyard flocks may be treated, if desired by the owner, with euthanasia of any moribund birds. However, culling of affected birds or the whole flock is likely to be recommended, using small-scale euthanasia methods such as lethal injection or cervical dislocation. Given the nature of the human–chicken relationship, many owners accept death and culling of clinical cases without veterinary involvement, although breeding and showing enthusiasts who own rare breeds may need more persuading, on welfare and disease control grounds, to euthanise birds.

Parameter 2 – Wildlife depopulation as control measure

S. arizonae

While close control of wildlife access to breeding flocks is highly important in the prevention of infection, depopulation of wild birds or other animals has not been used as a control measure. Pest control biosecurity measures around poultry establishments include exclusion (not usually killing) of wild birds, and rodent baiting, trapping and exclusion using conventionally accepted and licensed methods, albeit with some welfare compromises for the controlled species.

***S.* Gallinarum/*S.* Pullorum**

Depopulation of wild birds has not been used as a control measure, given the sporadic carriage and rare occurrence of disease associated with *S.* Gallinarum in wild species, and the well-established effectiveness of other controls on the transmission of *S.* Gallinarum within and between commercial flocks. Pest control biosecurity measures around poultry establishments include exclusion (not usually killing) of wild birds, and rodent baiting, trapping and exclusion using conventionally accepted and licensed methods, albeit with some welfare compromises for the controlled species.

3.1.5.4. Article 7(e)(iv) The environment and biodiversity

Environment

Parameter 1 – Use and potential residuals of biocides or medical drugs in environmental compartments (soil, water, feed, manure)

S. arizonae

In developed countries, antimicrobial drugs are rarely used in commercial-sized flocks affected by *S. enterica arizonae*. Biocides are used for routinely for cleaning and disinfection between flocks (McLaren et al., 2011), and not specifically for control and prevention of arizonosis. Therefore, the use and amount of such chemical agents cannot be ascribed specifically to *S. enterica arizonae* control. Agents used include environmentally short-lived biocides such as peroxygen compounds, halogens and aldehydes, or more persistent chemicals such as quaternary ammonium and phenolic compounds. Concerns regarding biocide and antimicrobial resistance as a consequence of the use of disinfectants on farms are not currently supported by available data (Wales and Davies, 2015).

S. Gallinarum

In developed countries, antimicrobial drugs are rarely used in commercial-sized flocks affected by FT. Biocides are used for routinely for cleaning and disinfection between flocks (McLaren et al., 2011), and not specifically for control and prevention of FT. Therefore, the use and amount of such chemical agents cannot be ascribed specifically to FT control, other than occasionally in response to an outbreak. Agents used include environmentally short-lived biocides such as peroxygen compounds, halogens and aldehydes, or more persistent chemicals such as quaternary ammonium and phenolic compounds. Concerns regarding biocide and antimicrobial resistance as a consequence of the use of disinfectants on farms are not currently supported by available data (Wales and Davies, 2015).

Large volumes of diesel oil are needed to heat poultry farms for a sufficient period to eliminate red mite carriers of *S.* Gallinarum. Persistent acaricides are also likely to be used.

S. pullorum

In developed countries, antimicrobial drugs are rarely used in commercial-sized flocks affected by Pullorum disease. Biocides are used for routinely for cleaning and disinfection between flocks (McLaren et al., 2011), and not specifically for control and prevention of Pullorum disease. Therefore, the use and amount of such chemical agents cannot be ascribed specifically to Pullorum disease control, other than occasionally in response to an outbreak. Agents used include environmentally short-lived biocides such as peroxygen compounds, halogens and aldehydes, or more persistent chemicals such as quaternary ammonium and phenolic compounds. Concerns regarding biocide and antimicrobial resistance as a consequence of the use of disinfectants on farms are not currently supported by available data (Wales and Davies, 2015).

Biodiversity

Parameter 2 – Mortality in wild species

S. arizonae

S. enterica arizonae of turkey-related serovars does not appear to be associated with substantial wild species mortality.

S. Gallinarum/S. Pullorum

Being highly host-adapted, *S.* Gallinarum/*S.* Pullorum appears to cause only sporadic disease or occasional outbreaks in wild birds, with a very restricted number of species within which this has been reported (Shivaprasad and Barrow, 2008). Therefore, wild species mortality appears to be very low.

3.2. Assessment according to Article 5 criteria

This section presents the results of the expert judgement on the criteria of Article 5 of the AHL about *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) (Table 3). The expert judgement was based on Individual and Collective Behavioural Aggregation (ICBA) approach described in detail in the opinion on the methodology (EFSA AHAW Panel, 2017). Experts have been provided with information of the disease

factsheet mapped into Article 5 criteria (see supporting information, Annex A), based on that the experts indicate their Y/N or 'na' judgement on each criterion of Article 5, and the reasoning supporting their judgement.

The minimum number of judges in the judgement was 11. The expert judgement was conducted as described in the methodological opinion (EFSA AHAW Panel, 2017). For details on the interpretation of the questions, see Appendix B of the methodological opinion (EFSA AHAW Panel, 2017).

Table 3: Outcome of the expert judgement on the Article 5 criteria for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*)

Criteria to be met by the disease: According to AHL, a disease shall be included in the list referred to in point (b) of paragraph 1 of Article 5 if it has been assessed in accordance with Article 7 and meets all of the following criteria		**Final outcome**
A(i)	The disease is transmissible	Y
A(ii)	Animal species are either susceptible to the disease or vectors and reservoirs thereof exist in the Union	Y
A(iii)	The disease causes negative effects on animal health or poses a risk to public health due to its zoonotic character	Y
A(iv)	Diagnostic tools are available for the disease	Y
A(v)	Risk-mitigating measures and, where relevant, surveillance of the disease are effective and proportionate to the risks posed by the disease in the Union	Y
At least one criterion to be met by the disease: In addition to the criteria set out above at points A(i)-A(v), the disease needs to fulfil at least one of the following criteria		
B(i)	The disease causes or could cause significant negative effects in the Union on animal health, or poses or could pose a significant risk to public health due to its zoonotic character	Y
B(ii)	The disease agent has developed resistance to treatments and poses a significant danger to public and/or animal health in the Union	N
B(iii)	The disease causes or could cause a significant negative economic impact affecting agriculture or aquaculture production in the Union	Y
B(iv)	The disease has the potential to generate a crisis or the disease agent could be used for the purpose of bioterrorism	N
B(v)	The disease has or could have a significant negative impact on the environment, including biodiversity, of the Union	N

Colour code: green = consensus (Yes/No).

3.2.1. Outcome of the assessment of *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) according to criteria of Article 5(3) of the AHL on its eligibility to be listed

As from the legal text of the AHL, a disease is considered eligible to be listed as laid down in Article 5 if it fulfils all criteria of the first set from A(i) to A(v) and at least one of the second set of criteria from B(i) to B(v). According to the assessment methodology (EFSA AHAW Panel, 2017), a criterion is considered fulfilled when the outcome is 'Yes'. According to the results shown in Table 3, *Salmonella* complies with all criteria of the first set and with two of the second set. Therefore, *Salmonella* can be considered eligible to be listed for Union intervention as laid down in Article 5(3) of the AHL.

3.3. Assessment according to Article 9 criteria

This section presents the results of the expert judgement on the criteria of Annex IV referring to categories as in Article 9 of the AHL about *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) (Tables 4–8). The expert judgement was based on ICBA approach described in detail in the opinion on the methodology. Experts have been provided with information of the disease factsheet mapped into Article 9 criteria (see supporting information, Annex A), based on that the experts indicate their Y/N or 'na' judgement on each criterion of Article 9, and the reasoning supporting their judgement. The experts decided to assess some Article 9 criteria separately for the *Salmonella* pathogens, on the basis of the evidence available. In this case

in Tables 4–6, the outcome of the assessment is reported by pathogen. The minimum number of judges in the judgement was 10. The expert judgement was conducted as described in the methodological opinion (EFSA AHAW Panel, 2017). For details on the interpretation of the questions, see Appendix B of the methodological opinion (EFSA AHAW Panel, 2017).

Table 4: Outcome of the expert judgement related to the criteria of Section 1 of Annex IV (category A of Article 9) for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) (CI = current impact; PI = potential impact)

Criteria to be met by the disease: The disease needs to fulfil all of the following criteria		**Final outcome**		
		***S.* Pullorum**	***S.* Gallinarum**	***S. arizonae***
1	The disease is not present in the territory of the Union OR present only in exceptional cases (irregular introductions) OR present in only in a very limited part of the territory of the Union	NC	NC	NC
2.1	The disease is highly transmissible	NC	NC	na
2.2	There be possibilities of airborne or waterborne or vector-borne spread	Y		na
2.3	The disease affects multiple species of kept and wild animals OR single species of kept animals of economic importance	Y		
2.4	The disease may result in high morbidity and significant mortality rates	Y		
At least one criterion to be met by the disease: In addition to the criteria set out above at points 1–2.4, the disease needs to fulfil at least one of the following criteria				
3	The disease has a zoonotic potential with significant consequences on public health, including epidemic or pandemic potential OR possible significant threats to food safety	N		
4 (CI)	The disease has a significant impact on the economy of the Union, causing substantial costs, mainly related to its direct impact on the health and productivity of animals	N		
4 (PI)	The disease has a significant impact on the economy of the Union, causing substantial costs, mainly related to its direct impact on the health and productivity of animals	Y		
5(a)(CI)	The disease has a significant impact on society, with in particular an impact on labour markets	N		
5(a)(PI)	The disease has a significant impact on society, with in particular an impact on labour markets	N		
5(b)(CI)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	N		
5(b)(PI)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	Y		
5(c)(CI)	The disease has a significant impact on the environment, due to the direct impact of the disease OR due to the measures taken to control it	N		
5(c)(PI)	The disease has a significant impact on the environment, due to the direct impact of the disease OR due to the measures taken to control it	N		
5(d)(CI)	The disease has a significant impact on a long-term effect on biodiversity or the protection of endangered species or breeds, including the possible disappearance or long-term damage to those species or breeds	N		
5(d)(PI)	The disease has a significant impact on a long-term effect on biodiversity or the protection of endangered species or breeds, including the possible disappearance or long-term damage to those species or breeds	N		

Colour code: green = consensus (Yes/No); yellow = no consensus (NC); red = not applicable (na), i.e. insufficient evidence or not relevant to judge.

Table 5: Outcome of the expert judgement related to the criteria of Section 2 of Annex IV (category B of Article 9) for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) (CI = current impact; PI = potential impact)

Criteria to be met by the disease: The disease needs to fulfil all of the following criteria		**Final outcome**		
		***S.* Pullorum**	***S.* Gallinarum**	***S. arizonae***
1	The disease is present in the whole OR part of the Union territory with an endemic character AND (at the same time) several Member States or zones of the Union are free of the disease	NC	NC	NC
2.1	The disease is moderately to highly transmissible	NC	NC	na
2.2	There be possibilities of airborne or waterborne or vector-borne spread	Y		na
2.3	The disease affects single or multiple species	Y		
2.4	The disease may result in high morbidity with in general low mortality	N		
At least one criterion to be met by the disease: In addition to the criteria set out above at points 1–2.4, the disease needs to fulfil at least one of the following criteria				
3	The disease has a zoonotic potential with significant consequences on public health, including epidemic potential OR possible significant threats to food safety	N		
4 (CI)	The disease has a significant impact on the economy of the Union, causing substantial costs, mainly related to its direct impact on the health and productivity of animals	N		
4 (PI)	The disease has a significant impact on the economy of the Union, causing substantial costs, mainly related to its direct impact on the health and productivity of animals	Y		
5(a)(CI)	The disease has a significant impact on society, with in particular an impact on labour markets	N		
5(a)(PI)	The disease has a significant impact on society, with in particular an impact on labour markets	N		
5(b)(CI)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	N		
5(b)(PI)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	Y		
5(c)(CI)	The disease has a significant impact on the environment, due to the direct impact of the disease OR due to the measures taken to control it	N		
5(c)(PI)	The disease has a significant impact on the environment, due to the direct impact of the disease OR due to the measures taken to control it	N		
5(d)(CI)	The disease has a significant impact on a long-term effect on biodiversity or the protection of endangered species or breeds, including the possible disappearance or long-term damage to those species or breeds	N		
5(d)(PI)	The disease has a significant impact on a long-term effect on biodiversity or the protection of endangered species or breeds, including the possible disappearance or long-term damage to those species or breeds	N		

Colour code: green = consensus (Yes/No); yellow = no consensus (NC); red = not applicable (na), i.e. insufficient evidence or not relevant to judge.

Table 6: Outcome of the expert judgement related to the criteria of Section 3 of Annex IV (category C of Article 9) for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) (CI = current impact; PI = potential impact)

Criteria to be met by the disease: The disease needs to fulfil all of the following criteria		**Final outcome**		
		***S.* Pullorum**	***S.* Gallinarum**	***S. arizonae***
1	The disease is present in the whole OR part of the Union territory with an endemic character	NC	NC	NC
2.1	The disease is moderately to highly transmissible	NC	NC	na
2.2	The disease is transmitted mainly by direct or indirect transmission	Y		
2.3	The disease affects single or multiple species	Y		
2.4	The disease usually does not result in high morbidity and has negligible or no mortality AND often the most observed effect of the disease is production loss	N		
At least one criterion to be met by the disease: In addition to the criteria set out above at points 1–2.4, the disease needs to fulfil at least one of the following criteria				
3	The disease has a zoonotic potential with significant consequences on public health, or possible significant threats to food safety	N		
4(CI)	The disease has a significant impact on the economy of parts of the Union, mainly related to its direct impact on certain types of animal production systems	N		
4(PI)	The disease has a significant impact on the economy of parts of the Union, mainly related to its direct impact on certain types of animal production systems	N		
5(a)(CI)	The disease has a significant impact on society, with in particular an impact on labour markets	N		
5(a)(PI)	The disease has a significant impact on society, with in particular an impact on labour markets	N		
5(b)(CI)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	N		
5(b)(PI)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	Y		
5(c)(CI)	The disease has a significant impact on the environment, due to the direct impact of the disease OR due to the measures taken to control it	N		
5(c)(PI)	The disease has a significant impact on the environment, due to the direct impact of the disease OR due to the measures taken to control it	N		
5(d)(CI)	The disease has a significant impact on a long-term effect on biodiversity or the protection of endangered species or breeds, including the possible disappearance or long-term damage to those species or breeds	N		
5(d)(PI)	The disease has a significant impact on a long-term effect on biodiversity or the protection of endangered species or breeds, including the possible disappearance or long-term damage to those species or breeds	N		

Colour code: green = consensus (Yes/No); yellow = no consensus (NC); red = not applicable (na), i.e. insufficient evidence or not relevant to judge.

Table 7: Outcome of the expert judgement related to the criteria of Section 4 of Annex IV (category D of Article 9) for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*)

Criteria to be met by the disease: The disease needs to fulfil all of the following criteria		**Final outcome**
D	The risk posed by the disease in question can be effectively and proportionately mitigated by measures concerning movements of animals and products in order to prevent or limit its occurrence and spread	Y
The disease fulfils criteria of Sections 1, 2, 3 or 5 of Annex IV of AHL		Y

Colour code: green = consensus (Yes/No)

Table 8: Outcome of the expert judgement related to the criteria of Section 5 of Annex IV (category E of Article 9) for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*)

Diseases in category E **need to fulfil criteria of Sections 1, 2 or 3 of Annex IV of AHL** and/or the following:		**Final outcome**
E	Surveillance of the disease is necessary for reasons relating to animal health, animal welfare, human health, the economy, society or the environment (If a disease fulfils the criteria as in Article 5, thus being eligible to be listed, consequently category E would apply.)	Y

Colour code: green = consensus (Yes/No).

3.3.1. Non-consensus questions

This section displays the assessment related to each criterion of Annex IV referring to the categories of Article 9 of the AHL where no consensus was achieved in form of tables (Tables 9–13). The proportion of Y, N or 'na' answers are reported, followed by the list of different supporting views for each answer.

Table 9: Outcome of the expert judgement related to criterion 1 of Article 9 for *S.* Pullorum

Question		**Final outcome**	**Response**		
			Y (%)	**N (%)**	**na (%)**
1(cat.A)	The disease is not present in the territory of the Union OR present only in exceptional cases (irregular introductions) OR present in only in a very limited part of the territory of the Union	NC	64	36	0
1(cat.B)	The disease is present in the whole OR part of the Union territory with an endemic character AND (at the same time) several Member States or zones of the Union are free of the disease	NC	18	82	0
1(cat.C)	The disease is present in the whole OR part of the Union territory with an endemic character	NC	18	82	0

NC: non-consensus; number of judges: 11.

Reasoning supporting the judgement

Supporting Yes for 1 (cat.A):

- Disease due to *S.* Pullorum infection is reported sporadically in the EU.
- Eleven MS's reported *S.* Pullorum infection in the last 10 years, but in the last complete year for which data are available (2015), there have been no reports of Pullorum disease.

Supporting Yes for 1 (cat.B):

- Disease due to *S.* Pullorum infection has been reported sporadically in the EU from 12 member states since 2005.

Supporting Yes for 1 (cat.C):

- *S.* Pullorum infection can be widespread and possibly under-reported, e.g. in exotic animals and wildlife, with an endemic character.

Table 10: Outcome of the expert judgement related to criterion 1 of Article 9 for *S.* Gallinarum

Question		Final outcome	Response		
			Y (%)	N (%)	na (%)
1(cat.A)	The disease is not present in the territory of the Union OR present only in exceptional cases (irregular introductions) OR present in only in a very limited part of the territory of the Union	NC	55	45	0
1(cat.B)	The disease is present in the whole OR part of the Union territory with an endemic character AND (at the same time) several Member States or zones of the Union are free of the disease	NC	27	73	0
1(cat.C)	The disease is present in the whole OR part of the Union territory with an endemic character	NC	18	82	0

NC: non-consensus; number of judges: 11.

Reasoning supporting the judgement

Supporting Yes for 1 (cat.A):

- Disease due to *S.* Gallinarum infection is reported sporadically in the EU.

Supporting Yes for 1 (cat.B):

- Nine MS's have reported *S.* Gallinarum in the last 10 years: Belgium, Bulgaria, France, Germany, Hungary, Italy, the Netherlands, Romania and the UK. In the last complete year (2015), one MS (Italy) reported disease and another one (Romania) reported infection.

Supporting Yes for 1 (cat.C):

- *S.* Gallinarum infections can be widespread and possibly under-reported, e.g. in exotic animals and wildlife, with an endemic character.

Table 11: Outcome of the expert judgement related to criterion 1 of Article 9 for *S. arizonae*

Question		Final outcome	Response		
			Y (%)	N (%)	na (%)
1(cat.A)	The disease is not present in the territory of the Union OR present only in exceptional cases (irregular introductions) OR present in only in a very limited part of the territory of the Union	NC	63	37	0
1(cat.B)	The disease is present in the whole OR part of the Union territory with an endemic character AND (at the same time) several Member States or zones of the Union are free of the disease	NC	27	73	0
1(cat.C)	The disease is present in the whole OR part of the Union territory with an endemic character	NC	9	91	0

NC: non-consensus; number of judges: 11.

Reasoning supporting the judgement

Supporting Yes for 1 (cat.A):

- Disease due to *S. arizonae* infection is not reported in the EU.

Supporting Yes for 1 (cat.B):

- *S. arizonae* has not been detected during last years in turkeys however it could be under-reported and could be detected in wildlife.

Supporting Yes for 1 (cat.C):

- *S. arizonae* infections can be widespread and possibly under-reported, e.g. in exotic animals and wildlife, with an endemic character.

Table 12: Outcome of the expert judgement related to criterion 2.1 of Article 9 for *S.* Pullorum

Question		Final outcome	Response		
			Y (%)	N (%)	na (%)
2.1(cat.A)	The disease is highly transmissible	NC	27	73	0
2.1(cat.B,C)	The disease is moderately to highly transmissible	NC	73	27	0

NC: non-consensus; number of judges: 11.

Reasoning supporting the judgement

Supporting Yes for 2.1 (cat.A):

- According to the factsheet, transmission between newly hatched chicks can be rapid enough to generate and sustain an outbreak with high morbidity and mortality. In general, *Salmonella* species are rapidly transmitted, and most individuals become infected within a few days of being introduced into a naïve flock.

Supporting Yes for 2.1 (cat.B,C):

- The transmission rate is highly variable.

Table 13: Outcome of the expert judgement related to criterion 2.1 of Article 9 for *S.* Gallinarum

Question		Final outcome	Response		
			Y (%)	N (%)	na (%)
2.1(cat.A)	The disease is highly transmissible	NC	27	73	0
2.1(cat.B,C)	The disease is moderately to highly transmissible	NC	73	27	0

NC: non-consensus; number of judges: 11.

Reasoning supporting the judgement

Supporting Yes for 2.1 (cat.A):

- According to the factsheet, transmission between newly hatched chicks can be rapid enough to generate and sustain an outbreak with high morbidity and mortality.

Supporting Yes for 2.1 (cat.B,C):

- The transmission rate is highly variable.

3.3.2. Outcome of the assessment of criteria in Annex IV for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) for the purpose of categorisation as in Article 9 of the AHL

As from the legal text of the AHL, a disease is considered fitting in a certain category (A, B, C, D or E corresponding to point (a) to point (e) of Article 9(1) of the AHL) if it is eligible to be listed for Union intervention as laid down in Article 5(3) and fulfils all criteria of the first set from 1 to 2.4 and at least one of the second set of criteria from 3 to 5(d) as shown in Tables 4–8. According to the assessment methodology (EFSA AHAW Panel, 2017), a criterion is considered fulfilled when the outcome is 'Yes'. With respect to different type of impact where the assessment is divided into current and potential impact, a criterion will be considered fulfilled if at least one of the two outcomes is 'Y' and, in case of no 'Y', the assessment is inconclusive if at least one outcome is 'NC'.

A description of the outcome of the assessment of criteria in Annex IV for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) for the purpose of categorisation as in Article 9 of the AHL is presented in Tables 14–16.

Table 14: Outcome of the assessment of criteria in Annex IV for *S.* Pullorum for the purpose of categorisation as in Article 9 of the AHL (CI = current impact; PI = potential impact)

Category	Article 9 criteria										
	1° set of criteria					2° set of criteria					
	1	2.1	2.2	2.3	2.4	3	4	5a	5b	5c	5d
	Geographical distribution	Transmissibility	Routes of transmission	Multiple species	Morbidity and mortality	Zoonotic potential	Impact on economy	Impact on society	Impact on animal welfare	Impact on environment	Impact on biodiversity
A	NC	NC	Y	Y	Y	N	CI: N PI: Y	N	CI: N PI: Y	N	N
B	NC	NC	Y	Y	N	N	CI: N PI: Y	N	CI: N PI: Y	N	N
C	NC	NC	Y	Y	N	N	N	N	CI: N PI: Y	N	N
D	Y										
E	Y										

Table 15: Outcome of the assessment of criteria in Annex IV for *S.* Gallinarum for the purpose of categorisation as in Article 9 of the AHL (CI = current impact; PI = potential impact)

Category	Article 9 criteria										
	1° set of criteria					2° set of criteria					
	1	2.1	2.2	2.3	2.4	3	4	5a	5b	5c	5d
	Geographical distribution	Transmissibility	Routes of transmission	Multiple species	Morbidity and mortality	Zoonotic potential	Impact on economy	Impact on society	Impact on animal welfare	Impact on environment	Impact on biodiversity
A	NC	NC	Y	Y	Y	N	CI: N PI: Y	N	CI: N PI: Y	N	N
B	NC	NC	Y	Y	N	N	CI: N PI: Y	N	CI: N PI: Y	N	N
C	NC	NC	Y	Y	N	N	N	N	CI: N PI: Y	N	N
D	Y										
E	Y										

Table 16: Outcome of the assessment of criteria in Annex IV for *S. arizonae* for the purpose of categorisation as in Article 9 of the AHL (CI = current impact; PI = potential impact)

Category	Article 9 criteria										
	1° set of criteria					2° set of criteria					
	1	2.1	2.2	2.3	2.4	3	4	5a	5b	5c	5d
	Geographical distribution	Transmissibility	Routes of transmission	Multiple species	Morbidity and mortality	Zoonotic potential	Impact on economy	Impact on society	Impact on animal welfare	Impact on environment	Impact on biodiversity
A	NC	na	na	Y	Y	N	CI: N PI: Y	N	CI: N PI: Y	N	N
B	NC	na	na	Y	N	N	CI: N PI: Y	N	CI: N PI: Y	N	N
C	NC	na	Y	Y	N	N	N	N	CI: N PI: Y	N	N
D	Y										
E	Y										

According to the assessment here performed, *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) complies with the following criteria of the Sections 1–5 of Annex IV of the AHL for the application of the disease prevention and control rules referred to in points (a) to (e) of Article 9(1):

1) To be assigned to category A, a disease needs to comply with all criteria of the first set (1, 2.1–2.4) and according to the assessment *S.* Pullorum and *S.* Gallinarum comply with criteria 2.2, 2.3 and 2.4 and the assessment is inconclusive on compliance with criteria 1 and 2.1, whereas *S. arizonae* complies with criterion 2.3 and 2.4, the assessment is not applicable on criteria 2.1 and 2.2 and inconclusive on compliance with criterion 1. To be eligible for category A, a disease needs to comply additionally with one of the criteria of the second set (3, 4, 5a–d) and *S.* Pullorum, *S.* Gallinarum and *S. arizonae* comply with criteria 4 and 5b, but not with 3, 5a, 5c and 5d.
2) To be assigned to category B, a disease needs to comply with all criteria of the first set (1, 2.1–2.4) and according to the assessment *S.* Pullorum and *S.* Gallinarum comply with criteria 2.2 and 2.3, but not with criterion 2.4 and the assessment is inconclusive on compliance with criteria 1 and 2.1. *S. arizonae* complies with criterion 2.3, but not with criterion 2.4, the assessment is not applicable on criteria 2.1 and 2.2 and inconclusive on compliance with criterion 1. To be eligible for category B, a disease needs to comply additionally with one of the criteria of the second set (3, 4, 5a–d) and *S.* Pullorum, *S.* Gallinarum and *S. arizonae* comply with criteria 4 and 5b, but not with 3, 5a, 5c and 5d.
3) To be assigned to category C, a disease needs to comply with all criteria of the first set (1, 2.1–2.4) and according to the assessment *S.* Pullorum and *S.* Gallinarum comply with criteria 2.2 and 2.3, but not with criterion 2.4 and the assessment is inconclusive on compliance with criteria 1 and 2.1. *S. arizonae* complies with criteria 2.2 and 2.3, but not with criterion 2.4, the assessment is not applicable on criterion 2.2 and inconclusive on compliance with criterion 1. To be eligible for category C, a disease needs to comply additionally with one of the criteria of the second set (3, 4, 5a–d) and *S.* Pullorum, *S.* Gallinarum and *S. arizonae* comply with criterion 5b, but not with 3, 4, 5a, 5c and 5d.
4) To be assigned to category D, a disease needs to comply with criteria of Section 1, 2, 3 or 5 of Annex IV of the AHL and with the specific criterion D of Section 4, with which *Salmonella* complies.

5) To be assigned to category E, a disease needs to comply with criteria of Section 1, 2 or 3 of Annex IV of the AHL and/or the surveillance of the disease is necessary for reasons relating to animal health, animal welfare, human health, the economy, society or the environment. The latter is applicable if a disease fulfils the criteria as in Article 5, with which *Salmonella* complies.

3.4. Assessment of Article 8

This section presents the results of the assessment on the criteria of Article 8(3) of the AHL about *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*). The Article 8(3) criteria are about animal species to be listed, as it reads below:

'3. Animal species or groups of animal species shall be added to this list if they are affected or if they pose a risk for the spread of a specific listed disease because:

a) they are susceptible for a specific listed disease or scientific evidence indicates that such susceptibility is likely; or
b) they are vector species or reservoirs for that disease, or scientific evidence indicates that such role is likely'.

For this reason, the assessment on Article 8 criteria is based on the evidence as extrapolated from the relevant criteria of Article 7, i.e. the ones related to susceptible and reservoir species or routes of transmission, which cover also possible role of biological or mechanical vectors.[5] According to the mapping, as presented in Table 5, Section 3.2 of the scientific opinion on the ad hoc methodology (EFSA AHAW Panel, 2017), the main animal species to be listed for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) according to the criteria of Article 8(3) of the AHL are as displayed in Tables 17–19.

Table 17: Main animal species to be listed for *Salmonella* Pullorum infection in poultry according to criteria of Article 8 (source: data reported in Section 3.1.1.1)

	Class	Order	Family	Genus/Species
Susceptible	Aves	Galliformes	Phasianidae	*Gallus gallus* *Meleagris gallopavo* pheasants (not specified) quails (not specified)
			Odontophoridae	Not specified
			Numididae	Not specified
		Passeriformes	Passeridae	Not specified
			Fringillidae	*Serinus* spp. *Pyrrhula* spp.
		Psittaciformes	Not specified	
	Mammalia	Rodentia	Muridae	*Mus* spp. *Rattus* spp.
			Caviidae	*Cavia porcellus*
			Chinchillidae	*Chinchilla* spp.
		Primates	Hominidae	*Pan* spp.
		Lagomorpha	Leporidae	Not specified
		Artiodactyla	Suidae	*Sus* spp.
			Bovidae	*Bos* spp.
		Carnivora	Felidae	*Felis catus*
			Canidae	*Vulpes vulpes* *Canis lupus*
			Mustelidae	*Neovison* spp. *Mustela* spp.

[5] A vector is a living organism that transmits an infectious agent from an infected animal to a human or another animal. Vectors are frequently arthropods. Biological vectors may carry pathogens that can multiply within their bodies and be delivered to new hosts, usually by biting. In mechanical vectors, the pathogens do not multiply within the vector, which usually remains infected for shorter time than in biological vectors.

	Class	Order	Family	Genus/Species
Reservoir	Aves	Galliformes	Phasianidae	Quails (not specified) Pheasants (not specified) *Gallus gallus* Peafowl (not specified)
			Odontophoridae	not specified
		Anseriformes	Anatidae	*Anas platyrhynchos* *Anser anser*
		Passeriformes	Passeridae	Not specified
		Columbiformes	Columbidae	Not specified
		Psittaciformes	Not specified	
	Mammalia	Rodentia	Muridae	*Rattus* spp.
Vectors	None			

Table 18: Main animal species to be listed for *Salmonella* Gallinarum infection in poultry according to criteria of Article 8 (source: data reported in Section 3.1.1.1)

	Class	Order	Family	Genus/Species
Susceptible	Aves	Galliformes	Phasianidae	*Gallus gallus* *Meleagris gallopavo* Partridges (not specified) Pheasants (not specified) Quails (not specified) Peafowl (not specified)
			Odontophoridae	Not specified
		Passeriformes	Passeridae	Not specified
			Corvidae	*Corvus frugilegus* *Coloeus monedula*
		Psittaciformes	Not specified	
		Columbiformes	Columbidae	*Streptopelia capicola*
		Struthioniformes	Struthionidae	*Struthio camelus*
	Mammalia	Lagomorpha	Leporidae	Not specified
		Rodentia	Muridae	*Rattus* spp.
Reservoir	Aves	Galliformes	Phasianidae	*Gallus gallus*
		Passeriformes	Corvidae	Not specified
		Columbiformes	Columbidae	Not specified
		Psittaciformes	Not specified	
		Anseriformes	Anatidae	*Anas platyrhynchos* *Anser anser*
	Mammalia	Rodentia	Muridae	*Rattus* spp.
	Arachnida	Mesostigmata	Dermanyssidae	*Dermanyssus gallinae*
		Ixodida	Argasidae	*Argas* spp.
Vectors	Mammalia	Rodentia	Not specified	
	Arachnida	Mesostigmata	Dermanyssidae	*Dermanyssus gallinae*

Table 19: Main animal species to be listed for *Salmonella arizonae* infection in poultry according to criteria of Article 8 (source: data reported in Section 3.1.1.1)

	Class	Order	Family	Genus/Species
Susceptible	Aves	Galliformes	Phasianidae	*Meleagris gallopavo* *Gallus gallus* *Coturnix japonica* *Phasianus colchicus*
			Numididae	*Numida meleagris*
		Anseriformes	Anatidae	*Anas platyrhynchos* *Anser anser*
	Reptilia	Not specified		
Reservoir	Aves	Galliformes	Phasianidae	*Meleagris* spp.
	Reptilia	not specified		
	Mammalia	Rodentia	Not specified	
Vectors	Mammalia	Rodentia	Not specified	

4. Conclusions

TOR 1: *for each of those diseases an assessment, following the criteria laid down in Article 7 of the AHL, on its eligibility of being listed for Union intervention as laid down in Article 5(3) of the AHL;*

- According to the assessment here performed, *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) complies with all criteria of the first set and with two criteria of the second set and therefore can be considered eligible to be listed for Union intervention as laid down in Article 5(3) of the AHL.

TOR 2a: *for each of the diseases which was found eligible to be listed for Union intervention, an assessment of its compliance with each of the criteria in Annex IV to the AHL for the purpose of categorisation of diseases in accordance with Article 9 of the AHL;*

- According to the assessment here performed, *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) meets the criteria as in Sections 4 and 5 of Annex IV of the AHL, for the application of the disease prevention and control rules referred to in points (d) and (e) of Article 9(1) of the AHL. According to the assessment here performed, it is inconclusive whether *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) complies with the criteria as in Section 1 of Annex IV of the AHL, for the application of the disease prevention and control rules referred to in point (a) of Article 9(1) of the AHL. Compliance of *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) with the criteria as in Section 1 is dependent on a decision on criteria 1 and 2.1.

TOR 2b: *for each of the diseases which was found eligible to be listed for Union intervention, a list of animal species that should be considered candidates for listing in accordance with Article 8 of the AHL.*

- According to the assessment here performed, the main animal species that can be considered to be listed for *Salmonella* infection in poultry with serotypes of animal health relevance (*S.* Pullorum, *S.* Gallinarum and *S. arizonae*) according to Article 8(3) of the AHL are all species of domestic poultry and wild species of mainly Anseriformes and Galliformes, as reported in Tables 17–19 in Section 3.4 of the present document.

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Abbreviations

AHAW	EFSA Panel on Animal Health and Welfare
AHL	Animal Health Law
CDC	Centers for Disease Control and Prevention
CFU	colony forming units
CFSPH	Center for Food Security and Public Health
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DALY	Disability-adjusted life year
ELISA	enzyme-linked immunosorbent assay
FT	fowl typhoid
ICBA	Individual and Collective Behavioural Aggregation
IUCN	International Union for Conservation of Nature
MS	Member States
NPV	negative predictive value
OIE	World Organisation for Animal Health
PCR	polymerase chain reaction
PPV	positive predictive value
RSA	rapid serum agglutination
ToR	Terms of Reference