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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): infection with Equine Herpesvirus-1

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Abstract

Equine Herpesvirus-1 infection 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 the disease to be listed, Article 9 for the categorisation of the disease according to disease prevention and control measures as in Annex IV and Article 8 on the list of animal species related to Equine Herpesvirus-1 infection. The assessment has been performed following a methodology composed of information collection and compilation, and expert judgement on each criterion at individual and collective level. The outcome is the median of the probability ranges provided by the experts, which indicates whether the criterion is fulfilled (66–100%) or not (0–33%), or whether there is uncertainty about fulfilment (33–66%). For the questions where no consensus was reached, the different supporting views are reported. According to the assessment performed, Equine Herpesvirus-1 infection can be considered eligible to be listed for Union intervention according to Article 5 of the Animal Health Law with 33–90% certainty. According to the criteria as in Annex IV of the AHL related to Article 9 of the AHL for the categorisation of diseases according to the level of prevention and control, it was assessed with less than 1% certainty that EHV-1 fulfils the criteria as in Section 1 (category A), 1–5% for the criteria as in Section 2 (category B), 10–66% for the criteria as in Section 3 (category C), 66–90% for the criteria as in Section 4 (category D) and 33–90% for the criteria as in Section 5 (category E). The animal species to be listed for EHV-1 infection according to Article 8(3) criteria are the species belonging to the families of Equidae, Bovidae, Camelidae, Caviidae, Cervidae, Cricetidae, Felidae, Giraffidae, Leporidae, Muridae, Rhinocerontidae, Tapiridae and Ursidae.

Keywords: Equine herpesvirus-1 infection, horse, Equidae, Animal Health Law, listing, categorisation, impact

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Waiver: In accordance with Article 21 of the Decision of the Executive Director on Competing Interest Management a waiver was granted to an expert of the Working Group. Pursuant to Article 21(6) of the aforementioned Decision, the concerned expert was allowed to take part in Section 3.1 of the scientific output but was not allowed to take up the role of WG member until 18 June 2021.

Declarations of interest: The declarations of interest of all scientific experts active in EFSA's work are available at https://ess.efsa.europa.eu/doi/doiweb/doisearch.

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1. Introduction

1.1. Background as provided by the European Commission

Chapter 2 of Part 1 of Regulation (EU) 2016/429 ('Animal Health Law' (AHL)) provides for the criteria for listing of diseases, listing of species and categorisation of listed diseases. Using those criteria, EFSA has provided valuable assistance to the Commission in preparation of tertiary legislation under Regulation (EU) 2016/429 on the list of diseases as well as the categorisation, that lead to the adoption of Commission Delegated Regulation (EU) 2018/1629 and Commission Implementing Regulation (EU) 2018/1882. The outbreak of equine herpesvirus-1 (EHV-1) in the context of a major equestrian competition in early 2021 has drawn the attention to this infection. As infection with EHV-1 is not included in the list of diseases in Annex II to the AHL, but affects high value breeding and sport horses and the equine sector as a whole, the Commission may be asked to place infection with EHV-1 onto that list. An assessment of EHV-1 with a view to its possible inclusion into the list of diseases would be necessary in accordance with a set of criteria provided for in the AHL.

Hence the Commission needs scientific advice for the assessment of the significance of infection with EHV-1 within the framework of this already known listing and categorisation according to the AHL (https://doi.org/10.2903/j.efsa.2017.4783), in the same manner it was carried out previously (https://doi.org/10.2903/j.efsa.2017.4946).

The criteria provided for in Article 7 and 8 and Annex IV of the AHL shall be used as a basis for this analytical assessment. The risk manager needs a scientific advice in order to:

1) assess if EHV-1 infection causes disease for which control measures at the EU level are justified;
2) proceed with the profiling of the disease in view to its categorisation; and
3) assign listed species to EHV-1 infection identified as eligible for EU intervention.

The Commission has identified the following issues for which concrete elements of science may provide good basis for formulating policies and/or adapt current approach:

- provisions for safe trade (entry into the Union and trade within the Union) in equine animals and their germinal products from countries affected by EHV-1;
- identifying possible routes and risks of spreading EHV-1 between equine animals resident in the Union and those imported from third countries;
- effects of the respective infection of equine animals with EHV-1, including aspects stemming from different susceptibility of various species to EHV-1 and of different virulence of various EHV-1 viruses;
- measures to monitor occurrence of EHV-1 in equine animals and mitigate mortality due to EHV-1 infection, whether regulatory measures or non-regulatory ones.

1.2. Terms of Reference as provided by the European Commission

Scientific opinion in accordance with Article 29 of Regulation (EC) No 178/2002

In accordance with Article 29 of Regulation (EC) No 178/2002, the Commission asks EFSA to provide a scientific opinion as regards the listing and categorisation under the AHL of EHV-1, including the following:

1) assess, following the criteria laid down in Article 7 of the AHL, its eligibility of being listed for Union intervention as laid down in Article 5(3) of the AHL

if found eligible to be listed for Union intervention, provide:

2) 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;
3) a list of animal species that should be considered candidates for listing in accordance with Article 8 of the AHL.

This listing and categorisation should be executed according the method defined in Scientific Opinion 'Ad hoc method for the assessment on listing and categorisation of animal diseases within the framework of the Animal Health Law' (EFSA AHAW Panel, 2017).

Scientific and technical assistance in accordance with Article 31 of Regulation (EC) No 178/2002[1].

Where the outcome of the assessment in point I suggests listing of the disease in accordance with Article 5(3) of Regulation (EU) 2016/429, the Commission asks EFSA to provide, in accordance with Article 31 of Regulation (EC) No 178/2002, scientific and technical assistance concerning the following:

a) assess the potential of EHV-1, notably its neurotropic variant, to affect equine animals in the Union;
b) assess the performance of the available diagnostic methods for the detection of EHV-1, including its neurotropic single point mutations;
c) describe and assess possible methods and feasible risk mitigation measures to ensure safe international and EU trade in equine animals and their germinal products, including movement restrictions.

1.3. Interpretation of the Terms of Reference

The interpretation of the terms of reference (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 Articles 9 and 8 within the Animal Health Law (AHL) framework (EFSA AHAW Panel, 2017).

The present document reports the results of assessment on disease according to the criteria of the AHL articles as follows:

- Article 7: EHV-1 infection profile and impacts;
- Article 5: eligibility of EHV-1 infection to be listed;
- Article 9: categorisation of EHV-1 infection according to disease prevention and control rules as in Annex IV;
- Article 8: list of animal species related to EHV-1 infection.

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). In the present opinion, this methodology has been modified in order to better take into account the uncertainty, as follows.

The assessment methodology is based on expert judgement on the AHL criteria performed using the individual and collective behavioural aggregation.

To perform the judgement, the expert panel (the EFSA Panel on animal health and welfare) is provided individually with the disease fact sheet, a document containing all relevant information about the criteria according to the AHL, the so-called assessment parameters, together with interpretations and definitions of some wording used in Articles 5 and 9 of AHL (EFSA AHAW Panel, 2017).

For the judgement, the criteria of Articles 5 and 9 are compiled in a form and phrased in such a way that they could be translated into questions ('*How certain are you that the statement X is true?*') to which probability ranges could be given as answers based on Table 1 (EFSA Scientific Committee, 2018).

Table 1: Approximate probability scale recommended for harmonised use in EFSA

Probability term	Subjective probability range
Almost certain	99–100%
Extermely likely	95–99%
Very likely	90–95%
Likely	66–90%
About as likely as not	33–66%
Unlikely	10–33%
Very unlikely	5–10%
Extremely unlikely	1–5%
Almost impossible	0–1%

[1] These ToRs will be addressed in a separate scientific report by March 2022.

In situations where there is a total lack of evidence, the possible answer could be 0–100% (which is different from 33% to 66%, due to the amount of evidence available). The answer 'not applicable' (n.a.) is also an option and should be used when the question is irrelevant to be judged or not applicable or when it impossible to answer the question, e.g. antibiotic resistance for viral disease or public health impact for a non-zoonotic disease.

Using Table 1, the experts should indicate their answer for each of the criteria of Articles 5 and 9. Multiple ranges can be chosen to reflect a wider uncertainty (e.g. 90–95% and 95–99%, which would correspond to 90–99%).

The method to perform the expert judgement for each disease is implemented in two rounds:

Round 1: Individual judgement

First, each expert performs their individual judgement. On the basis of the evidence collected from Article 7 criteria, mapped into Article 5 and 9 criteria, the experts are asked to provide their answers individually, which are the probability ranges described in Table 1, as well as reasonings for each of the individual answers.

In order to provide advice about a certain disease to be listed and categorised according to the AHL, it should be assessed whether the criteria of Articles 5 and 9 are fulfilled or not. In order to define whether the criterion related to each question is fulfilled, two thresholds were set on the probability scale, i.e. at 33% and at 66%. Therefore, we have assigned three 'probability zones', 0–33%, 33–66% and 66–100%, which correspond to 'criterion not fulfilled', 'uncertainty about criterion fulfilment' and 'criterion fulfilled', respectively. The yellow zone (33–66%) is completed with all combinations of ranges for which neither the upper bound is below 33% nor the lower bound above 66%.

0–33%	**33–66%**	**66–100%**
Criterion not fulfilled	Uncertainty about criterion fulfilment	Criterion fulfilled

According to this definition, when all individual answers are within one probability zone, this would mean that the Panel has consensus on that criterion.

When the answers fall into more than one of these three 'probability zones' or the (upper and/or lower) bounds of at least one answer lay in more than one, no consensus about criterion fulfilment is reached, and the experts are requested to provide the reasoning/arguments leading to their answer. In this case, a collective discussion based on the provided reasonings is needed (see Round 2: Collective judgement). When the panel has consensus on a criterion, the question is not further discussed collectively.

The individual answers are summarised and displayed visually. Experts are informed about the collective outcome of their individual judgement.

Round 2: Collective judgement

The collective judgement consists of a 'behavioural aggregation' of the assessors (EFSA AHAW Panel, 2017), i.e. a discussion among all assessors to reach an agreement, where the individual judgements produced in Round 1 have not reached a consensus. These are discussed in a meeting, where additional material/information may be supplied by the assessors present and the collected reasonings from each assessor are discussed.

The aim of the collective discussion is to seek consensus, i.e. the panel of experts consensually moving towards one of the three probability zones and in each case, reasonings related to the change of probability zone are reported.

At the beginning of the discussion of each Article 5 and 9 criterion, all the experts' probability ranges were graphically shown. Based on the reasoning/arguments provided, the assessors discussed and may finally change their individual answers.

The outcome of the collective judgement, for each criterion, is the median of the probability ranges provided by the experts, which indicates whether the criterion is fulfilled or not, or uncertain.[2] Criterion fulfilment is therefore based on the probability zone where the overall probability range, i.e. median range, lays in. The median of the series of probability ranges has been computed as the midvalue of the series ordered in descending order (for details, see Annex 6.1.1). Only the responses from experts

[2] As in the opinion on methodology (EFSA AHAW Panel, 2017), the criteria about impact (criteria 4 and 5a-d) are assessed both for the current and potential impact (see e.g. Annex 8.1.15), then in the final results, these are combined by taking the largest range of probability of the two.

having taken part in both individual and collective judgement are counted per question in the final output.

For reasons of transparency and completeness of displaying the distribution of the individual answers provided by each expert, these are reported as graphs in Annex 6 in this opinion. For the criteria for which the median falls into more than one of the 'probability zones' and for which there is uncertainty about fulfilment of the criterion, or for which the bounds of at least one answer lay in more than one 'probability zone', the graphs are supplemented by the supporting reasoning/arguments on each individual answer (see Annex 6.2).

For the overall outcome on listing and categorisation of the disease according to Article 5 and 9 criteria, the median ranges for each set of questions were aggregated as described in Annex 6.1.2.

Following the individual judgement, and during the collective judgement until the final adoption, additional information or clarification of certain points can be added into the fact sheet for consideration. The fact sheet can also be revised and/or improved when necessary, until adoption.

Reassessment: In the case of substantial changes in the fact sheet that can impact the outcome of the assessment already done, the target question should be reassessed under collective judgement (not necessarily involving the same experts).

3. Assessment

3.1. Assessment according to Article 7 criteria

This section presents the assessment of EHV-1 infection according to the Article 7 criteria of the AHL and related parameters, as in Table 2 of the opinion on methodology (EFSA AHAW Panel, 2017), based on the information contained in the fact sheet as drafted by the selected disease scientist (see Section 2.1 of the scientific opinion on the ad hoc methodology) and amended by the expert panel.

3.1.1. Article 7(a) disease profile

Equine herpesvirus (EHV) 1 is a double-stranded DNA virus of the family Herpesviridae, subfamily *Aphaherpesvirinae*, genus *Varicellovirus*, affecting equids (ICTV, 2020). At least nine herpesviruses, also belonging to subfamily *Gammaherpesvirinae* infect equids, but EHV-1 and, to a lesser extent, EHV-3 and EHV-4 pose the most serious health risks leading to one of the most important and prevalent diseases of the horses worldwide (Oladunni et al., 2019). The disease caused by EHV-1 or the closely related EHV-4 in horses is usually called equine rhinopneumonitis (ER). EHV-1 and EHV-4 share genetic, antigenic and epidemiological characteristics, but they significantly differ in pathogenicity. While EHV-4 is responsible of a less severe disease, the clinical picture caused by EHV-1 infection varies from subclinical infection to a severe disease involving the respiratory system, and occasional but severe sequelae as abortion, neonatal and perinatal death and neurological disease, often called equine herpesvirus myeloencephalopathy (EHM), can occur, with a possible fatal outcome (OIE, 2019b).

The infection with EHV-1 is listed by the OIE, while it is not subject to compulsory notification in the European Union. In some MSs (i.e. Italy, Spain, Sweden), EHV-1 infection or ER (caused by EHV-1 and/or EHV-4) is notifiable, while in others, Codes of Practice or rules managing EHV-1 infection are adopted by Horse Associations, Boards or Equestrian Federations. For this reason, occurrence of EHV-1 is often under-reported despite the wide presence among horses in Europe. In 2021, Europe experienced the most severe EHV-1 epidemic outbreak in the last decades. An EHV-1 outbreak originating in an International Horse Jumping event hold in Valencia (Spain) rapidly spread to over 30 premises in different MSs, leading to the cancellation of sport horse events in 12 European countries. At least, 18 dead horses were reported (https://inside.fei.org/fei/ehv-1). The magnitude of this event caused an increasing awareness and concern about ER at European Union level.

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

Susceptible animal species

At least nine herpesviruses, belonging to subfamilies *Aphaherpesvirinae* and *Gammaherpesvirinae* are important pathogens for horses and donkeys (Table 1). EHV-1 and other herpesviruses with a close genetic and antigenic relatedness play a role in the infection of a broad spectrum of mammals. Interspecies transmission of EHV-1 occurs and can cause fatal outcome in non-natural hosts. Moreover,

EHV-1 produces variants and recombinant strains with other herpesviruses, representing a potential emerging hazard for interspecies infections (Wohlsein et al., 2011; Azab et al., 2018).

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

Despite that herpesviruses are usually considered species-specific, increasing evidence indicates that the host range of EHV-1 goes far beyond equine species. Unexpectedly, several equid herpesviruses, most with a strong antigenic relatedness with EHV-1, have been isolated in recent years from equid and non-equid species, either in wildlife or captive animals in zoos. Their clinical and epidemiological relevance in different mammal species is still under investigation (Azab et al., 2018).

Although no studies are available in literature, wild horses (e.g. Przewalski's horse, *Equus ferus* supsp. *przewalskii*) are presumed to be susceptible to EHV-1 infection (Borchers et al., 1999).

In zebra species and subspecies, EHV-1, EHV-9 and a subtype of EHV-1, sometimes named 'zebra-borne equine alphaherpesvirus 1', were frequently isolated from asymptomatic and diseased animals. A higher seroprevalence in free ranging zebras than in captive individuals has been described, with values up to 84% in a survey performed in Kenya (Wolff et al., 1986; Barnard and Paweska, 1993; Blunden et al., 1998; Guo et al., 2014; Abdelgawad et al., 2015, 2016; Lopez et al., 2016; Guevara et al., 2018). These findings could suggest the zebra as a natural and definitive host for the previous-mentioned herpesviruses.

Among other equids, onager (Hemione or Asiatic wild ass) (*Equus hemionus*), African wild ass (*Equus africanus asinus*) and Somali wild ass (*Equus africanus somalicus*) were found to be naturally infected with EHV-1 (Montali et al., 1985; Abdelgawad et al., 2015; Goodrich et al., 2020).

Infections of EHV-1 were also reported among non-equid perissodactyls, such as Indian tapir (*Tapirus indicus*) (clinical signs and death) and Indian white and black rhinoceros (*Rhinoceros unicornis*, *Diceros bicornis*) (seropositivity or severe disease), which are critically endangered species (Göltenboth et al., 1996; Fischer-Tenhagen et al., 2000; Abdelgawad et al., 2014, 2015).

Fatal disease with neurological disorder in polar bear (*Ursus maritimus*) and in black bear (*Ursus americanus*) have been associated with infection with EHV-9 and a recombinant EHV-9/EHV-1 virus and EHV-1, respectively (Schrenzel et al., 2008; Donovan et al., 2009; Wohlsein et al., 2011; Greenwood et al., 2012). In a zoo, EHV-1-positive guinea pigs (*Cavia porcellus*) died after ataxia and paralytic disorders, showing also abortions and stillbirths (Wohlsein et al., 2011). Apparently accidental hosts such as Thomson's gazelle (*Eudorcas thomson*) (Kennedy et al., 1996; Wohlsein et al., 2011; Guo et al., 2014; Sakaguchi et al., 2017), fallow deer (*Dama dama*) (Kinyili and Thorsen, 1979; Abdelgawad et al., 2016), blackbuck (*Antelopa cervicapra*) and giraffe (*Giraffa camelopardalis reticulate*) have been reported to be infected with EHV-1 or EHV-9 (Chowdhury et al., 1988; Borchers et al., 2006; Kasem et al., 2008). EHV-9 can be also named Gazelle herpesvirus (GHV) (Fukushi et al., 1997).

It is important to note that EHV-9 or other EHV-1-related viruses could have caused infections that were reported in the past as EHV-1, due to the low specificity of diagnostic tests (Kasem et al., 2008; Schrenzel et al., 2008).

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

The horse is the natural host of EHV-1 (and EHV-2, EHV-3, EHV-4, EHV-5) (Table 1). The virus is prevalent in all the equine populations worldwide (Slater, 2014; OIE, 2019b) and some authors estimated a prevalence higher than 60% (Allen, 2002a; Lunn et al., 2009). The prevalence of infection is related to the horse management in stabling and movements and seems not related to breed or horse category (e.g. sport, breeding, meat production, etc.). The breeding sector is probably the most affected by EHV-1, because of the late-term abortion of mares in stud farms, neonatal foal deaths and the resultant (usually voluntary movement restrictions). When EHV-1 causes the unexpected presentation of several abortions in apparently healthy mares in the same farm, this phenomenon is called 'abortion storm'. The sector of sport horses (equestrian sports) and race horses is heavily affected, as it implies frequent movement of animals for competition and thus higher chance of transmission; in case of EHV-1 neurological disease, animal movement restrictions need to be applied. In horses kept for meat production, EHV-1-induced abortion may be an important problem, although the slaughter sector is less involved because horse movements are not frequent, other than to the abattoir, thus with less epidemiological implications. Nevertheless, this lack of evidence may also be due to less investigation of EHV-1 in this horse category.

The donkey (and its hybrids with horse: mule and hinny) is susceptible to the infection, but the clinical consequences of EHV-1 infection are much less severe than those observed in the horse.

However, there were cases of abortions and neurological disorders reported in donkeys (van Maanen et al., 2017; Falcao Câmara et al., 2020). In the donkey, other herpesviruses were also detected (Table 2). EHV-6, EHV-7 and EHV-8 were renamed Asinine herpesvirus 1, 2 and 3 (AHV-1, AHV-2, AHV-3) (Ma et al., 2013). A high prevalence of EHV-1 was found in serological surveys performed in this species, suggesting that donkeys could represent an alternative host for EHV-1 (van Maanen et al., 2002; Ataseven et al., 2009; Yildirim et al., 2015). It is important to underline that serological assays in herpesviruses can lead to cross reactions between EHV-1 and AHV-3 or other equid herpesviruses and that Asinine and Equine herpesviruses present a high level of genetic and antigenic similarity. These aspects can bias the results of studies with positive cases.

Published studies reported the infection of domestic cattle (Chowdhury et al., 1988; Crandell et al., 1988; Pagamjav et al., 2007), lama (*Lama glama*), alpaca (*Vicugna pacos*) (Rebhun et al., 1988), captive camelids (*Camelus bactrianus*) and cervids (Bildfell et al., 1996; Slater, 2014).

Table 2: Equid herpesviruses (EHV) and Asinine (AHV) classification (ICTV[(a)]), susceptible wild and domestic species and clinical signs

Virus	Subfamily	Genus	Susceptible Species (natural host)	Clinical Signs
EHV-1	Alphaherpesvirinae	*Varicellovirus*	Horse (Slater, 2014)	Respiratory, neurological, abortion (Slater, 2014)
EHV-2	Gammaherpesvirinae	*Percavirus*	Horse (Slater, 2014)	Not well defined, respiratory and ocular pathogen (Blakeslee et al., 1975; Collinson et al., 1994; Kershaw et al., 2001; Williams et al., 2007)
EHV-3	Alphaherpesvirinae	*Varicellovirus*	Horse (Slater, 2014)	Venereal, coital exanthema (Slater, 2014)
EHV-4	Alphaherpesvirinae	*Varicellovirus*	(exclusively) Horse (Slater, 2014)	Respiratory, few reporting of neurological and abortion (Slater, 2014)
EHV-5	Gammaherpesvirinae	*Percavirus*	Horse (Slater, 2014)	Not well defined, respiratory and ocular pathogens (Hart et al., 2008; Slater, 2014) Equine multinodular pulmonary fibrosis (Niedermaier et al., 2010; Slater, 2014)
EHV-6 or AHV-1	Alphaherpesvirinae	*Varicellovirus*	Donkey (Falcao Câmara et al., 2020) Associated with infections in wild equids: asses and zebras (Slater, 2014)	Venereal, coital exanthema (Falcao Câmara et al., 2020)
EHV-7 or AHV-2	Gammaherpesvirinae	*Rhadinovirus*	Donkey (Bell et al., 2008; Falcao Câmara et al., 2020) Associated with infections in wild equids: asses and zebras (Slater, 2014)	Not well defined, abortion reported (LeCuyer et al., 2015)
EHV-8 or AHV-3	Alphaherpesvirinae	*Varicellovirus*	Horse (Liu et al., 2012), donkey (Falcao Câmara et al., 2020; van Maanen et al., 2017) Associated with infections in wild equids: asses and zebras (Slater, 2014)	Rhinitis, reporting of abortion and neurological signs (Garvey et al., 2018)

Virus	Subfamily	Genus	Susceptible Species (natural host)	Clinical Signs
EHV-9 or Gazelle Herpes Virus (GHV)	Alphaherpesvirinae	*Varicellovirus*	Donkey (Falcao Camara et al., 2020), wild equids: asses and zebras (Slater, 2014); Thomson's gazelle (Fukushi et al., 1997; Wolfe, 2015)	Reported to cause fatal encephalitis in a number of non-equid species, including Thomson's gazelles and blackbucks (Wolfe, 2015)
AHV-4	Gammaherpesvirinae	Unclassified	Donkey (Falcao Camara et al., 2020)	Pneumonia (Kleiboeker et al., 2002; Mendoza et al., 2018)
AHV-5	Gammaherpesvirinae	Unclassified	Donkey (Falcao Camara et al., 2020)	Pneumonia, multinodular pulmonary fibrosis, neurological disease (Kleiboeker et al., 2002; Vengust et al., 2008; Mendoza et al., 2018)
AHV-6	Gammaherpesvirinae	Unclassified	Donkey (Falcao Camara et al., 2020)	–

EHV: Equine herpesvirus; AHV: Asinine herpesvirus.
(a): International Committee on Taxonomy of Viruses.

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

No evidence is available on this issue.

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

Experimental infection of horses can be successfully performed in order to identify the mechanism of pathogenesis and the efficacy of pharmacological therapies (Goehring et al., 2010a,b; Perkins et al., 2010; Goehring et al., 2011a,b; Brosnahan et al., 2012; Hussey et al., 2013; Goehring et al., 2013; Holz et al., 2019).

In laboratory settings, EHV-1 resulted as a pathogen for golden or Syrian hamster (*Mesocricetus auratus*), newborn mouse (*Mus musculus)*, newborn cat (*Felis catus)* and young guinea pig (*Cavia porcellus)* treated with immunosuppressive therapy. The pathogenicity for rabbit is variable (Castrucci, 1979; Azab et al., 2018). The hamster and mice are the most commonly used animal models to investigate pathogenic aspects (Slater, 2014).

Studies indicate that cat, dog, cattle and goat are susceptible to EHV-9, showing clinical disease and virus isolation after experimental infection (Taniguchi et al., 2000; Yanai et al., 2003; El-Habashi et al., 2011).

Reservoir animal species

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

Zebra species and subspecies have been found infected on several occasions by EHV-1 and the closely related EHV-9 with a possible similar epidemiological pattern to that of horses, such as latency infectious status, widespread infection, role of reservoir, prevalent subclinical infection (Greenwood et al., 2012; Abdelgawad et al., 2015, 2016; Guevara et al., 2018). Reported infections and serological positivity in asymptomatic zebras and other animals housed nearby in zoos suggest the possibility that zebras likely carry the virus as the definitive host and could play a role as a reservoir (Kasem et al., 2008; Donovan et al., 2009; Greenwood et al., 2012). This role has been confirmed for both EHV-1 and EHV-9, and the co-infection by these two viruses in a zebra was demonstrated, suggesting the origin for recombinant strains (Abdelgawad et al., 2016).

The possible role of reservoir of species other than horses found infected or serological positive to EHV-1 and related herpesviruses is still under debate.

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

The principal reservoir of EHV-1 is the domestic horse population, and multiple factors are important for the establishment of EHV-1 in a population, as discussed below.

The equine herpesviruses establish lifelong latency in infected horses. The virus hides in the trigeminal ganglia, respiratory lymphoid tissues and circulating lymphocytes and viral reactivation and shedding can occur at any time after a stress factor exposure, such as overworking, transportation, pregnancy,

weaning, castration, etc. (Burrows and Goodridge, 1975; Edington et al., 1985; Slater et al., 1994; Laval et al., 2021).

Moreover, most of the global equine population is considered latently infected with EHV-1 (Allen, 2002a; Dunowska, 2014; Slater, 2014; Dunowska et al., 2015; OIE, 2019b). Studies based on the direct diagnosis of the virus in latency sites in post-mortem examinations, estimated infection prevalences in the range 15–88% (Edington et al., 1994; Carvalho et al., 2000; Taouji et al., 2002; Pusterla et al., 2010b; Pusterla et al., 2012).

When EHV-1 is present in a population, horses become infected in the early years of life. It has been proven that asymptomatic mares shed the virus and transmit (horizontal transmission) the infection to their foals before and after weaning (Gilkerson et al., 1999a,b). In addition, foals were hypothesised to act as a source of EHV-1 (shedding virus when stressed) because of their high EHV-1 prevalence in a cohort of animals born from EHV-1-vaccinated mares (Foote et al., 2004; Patel and Heldens, 2005).

The high prevalence (seroprevalence ranging from 20% to 75%), the possibility of silent latent infection and the phylogenetic analyses showing close relatedness among EHVs and AHVs raised the hypothesis that donkeys may also serve as reservoir for other equids (van Maanen et al., 2002; Falcao Camara et al., 2020; Goodrich et al., 2020).

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

Morbidity

Parameter 1 – Prevalence/Incidence

An EHV-1 infection can be the result of: (a) a new infection in a susceptible, naïve horse; (b) a reactivation of a latently infection; (c) a new infection in a previously infected horse that has become negative. The latter case is possible because the immunity post infection is solid but lasts up to about 6 months (Reed and Toribio, 2004; Slater, 2014; OIE, 2019b).

The latent EHV-1 infection has a high prevalence, higher than 60% (Allen, 2002a; Lunn et al., 2009), in equine populations worldwide (Allen, 2002b; Lunn et al., 2009; Dunowska, 2014; Slater, 2014; OIE, 2019b; Oladunni et al., 2019), although the proportion of infected horses showing clinical signs is much lower. The true prevalence is hard to estimate due to the complex relationship of EHV-1 and its equine host, especially due to the virus latency (Dunowska, 2016). As mentioned above, some authors estimated a prevalence higher than 60%, while the prevalence of infection ranging from 15% to 88% in equine populations in France, Brazil, New Zealand, UK and the USA was estimated based on direct detection of EHV-1 by real-time polymerase chain reaction (RT-PCR) post-mortem examination in latency target organs (Edington et al., 1994; Carvalho et al., 2000; Taouji et al., 2002; Pusterla et al., 2010b; Pusterla et al., 2012; Dunowska et al., 2015).

The prevalence estimated by both serological surveys and direct diagnosis on nasal or nasopharyngeal swabs underestimates the true prevalence of infected horses (OIE, 2019b). The latency hides the virus to the horse immune system, leading to a possible serological negative result in infected horses. The presence of the virus in the nasal epithelium and the related positive findings with direct diagnosis through nasal/nasopharyngeal swabs is intermittent and occurs only when stressors reactivate the virus from latency or in newly infected naive horses or in newly infected horses with a past exposure after the transient immunity (Slater, 2014; OIE, 2019b). Nevertheless, seroprevalence studies found variable results (e.g. 11%, 21%, 24%, 37%) in random sampling surveys carried out in Australia, New Zealand, Caribbean and Egypt, respectively (Gilkerson et al., 1999; Amer et al., 2011; Dunowska et al., 2015; Bolfa et al., 2017). In the European Union, studies reported a seroprevalence of 8%, 16%, 27%, 28% and 86% in Italy, Poland, Spain, the Netherlands and Lithuania, respectively (van Maanen et al., 2005; Liutkevičien et al., 2006; Grądzkli and Boguta, 2009; Zappulla et al., 2013; Cruz et al., 2016).

Studies investigating the detection of EHV-1 nucleic acid by RT-PCR in nasal/nasopharyngeal swabs from healthy horses or horses with respiratory disorders in Algeria, Ethiopia, Korea and the USA found positivity ranging between 2% and 12% (Pusterla et al., 2016; Laabassi et al., 2017; Negussie et al., 2017a; Seo et al., 2020), while Zappulla et al. (2013), Stasiak et al. (2020) found all results negative from healthy horses in Italy and Poland.

At herd level, infection is widespread, with herd prevalence estimated at 74% and 90% in Spain and Poland, respectively, by Cruz et al. (Cruz et al., 2016) and Grądzkli and Boguta (2009).

As the emergence of new cases is often the result of the reactivation of a past infection, the EHV-1 incidence is difficult to define and to calculate. Longitudinal cohort studies, investigating the status of EHV-1 in holdings in the USA where the infection was thought to be endemic, found 4% of RT-PCR-positive horses from nasal/nasopharyngeal swab samples and 11% of foals seroconverting at 1 month of age (Brown et al., 2007). The incidence of infection was found to be high (about 35%) in unweaned, unvaccinated foals born from vaccinated mares in the first 5 weeks of life (Foote et al., 2006).

Outbreaks can occur also in a closed population of horses (e.g. a farm without introduction of animals from outside), because of the reactivation of a latent infection.

Interestingly, the only known equine population free from EHV-1 is the one resident in Iceland, where EHV-1 has not been found to date. This population has lived isolated in the country for more than 1000 years. However, in recent studies, EHV-2, EHV-3 and EHV-5 were found in horses in Iceland (Torfason et al., 2008; Thorsteinsdottir et al., 2021).

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

The majority of the EHV-1-infected horses do not show any clinical signs, due to infection being latent. The severity of the clinical form of the disease depends on many factors such as age, immune and health status and virus strain involved (Nugent and Paillot, 2009; Kydd et al., 2012; Slater, 2014; Oladunni et al., 2019; Zarski et al., 2021). Factors having an effect on the pathogenicity and on the possible development of severe sequelae after the respiratory disease are still under debate.

There is lack of reliable data on morbidity or case morbidity rate in the literature. The only source of official data on EHV-1 occurrence rates is OIE WAHIS. However, in the WAHIS database, a case definition is missing and a 'case' could be attributable to a positive laboratory test with no clinical signs or to a clinical disease. Moreover, respiratory disease, abortion and EHM are not differentiated. According to the semester reporting data from worldwide notification of EHV-1 in OIE WAHIS during 2014–2019, the recorded median morbidity, defined as the number of cases/number of susceptible animals, was 10.6% (Q1: 2.0%; Q3: 31.3%) with a minimum value of 0.4% and a maximum value of 100%.

In the literature, the frequency of the presentation of clinical signs is reported as low at the population level. Respiratory disease is described as more common, while abortion and EHM are sporadic (Allen, 2002a; van Maanen et al., 2002; Slater, 2014; OIE, 2019b). When an EHV-1 outbreak occurs, the case morbidity is generally higher in the outbreak than at population level (Reed and Toribio, 2004; Dunowska, 2014; Oladunni et al., 2019).

A small percentage of the infected horses develop an upper respiratory disease with fever, depression, anorexia and nasal discharge. The occurrence of clinical respiratory form is considered uncommon, even if a morbidity up to 100% can be reached in outbreaks in densely populated clusters of susceptible horses (Allen, 2002a). In a large and comprehensive study performed in 652 3-year-old racetrack horses, subject to movement for competitions, training and auctions, 30% of the horses showed apparent upper respiratory signs and among them, 14% seroconverted for EHV-1 (Sherman et al., 1977). In observational studies on respiratory diseases, nasal discharge or other signs referable to the upper respiratory disease were reported in less than 4% of the studied horses (Burrell et al., 1996; Gross et al., 2000; Wood et al., 2005). Some authors failed to demonstrate an association between clinical respiratory signs and EHV-1 infection, suggesting that the EHV-1 infection is generally self-limited to the upper respiratory tract (Christley et al., 2001; Newton et al., 2003; Slater, 2014; Dunowska, 2016). The eventual severe rhinitis and bronchopneumonia is more likely ascribed to secondary bacterial infections in which EHV-1 acts as a predisposing factor (Dunowska, 2014). Interestingly, in an EHV-1 outbreak in a stud farm with 169 horses, 7% of adult horses developed respiratory signs, while the percentage was 43% in foals (Sutton et al., 2019).

EHV-1 is responsible for both sporadic and epidemic abortions trends (Gilkerson et al., 1999). EHV-1-induced abortions are reported as uncommon events, especially since a proper management and related biosecurity measures applied in breeding centres can reduce the natural rate of occurrence. Most abortion occurrences involve only one or two mares in a group (Allen, 2002a). However, in premises where an EHV-1 outbreak starts, an epidemic trend with a high percentage of abortion is often observed (Allen, 2002a). Consolidated data registered about 7–10% of pregnancy failing in equine bred populations (Allen et al., 2007; Cecere and Dascanio, 2014; Rose et al., 2018). Among the pregnancy failures, EHV-1 was considered responsible for 4–21% of the abortion cases in studies performed in France, Germany, Hungary, Italy and UK (Ricketts et al., 2001; Leon et al., 2008; Szeredi et al., 2008; Smith et al., 2010; Laugier et al., 2011; Marenzoni et al., 2013; Weber et al., 2018; Roach et al., 2021). After an EHV-1 abortion index case in a closed population in a holding or a farm, higher

percentages of abortions are usually reported. In outbreak investigation reports, prevalences of up to 67% were reached (van Maanen et al., 2000; Barbic et al., 2012) after the introduction of horses. Not surprisingly, in one case, the introduced horses were serologically tested and found EHV-1 negative (Barbic et al., 2012). Lower prevalence of abortion, below 30%, was found in vaccinated mares, but vaccination did not totally prevent abortion (Frymus et al., 1986; Barrandeguy et al., 2002; Sutton et al., 2019). It is important to note that a proportion of EHV-1-associated abortions can occur without infecting the fetus, leading to an underestimated prevalence of abortion caused by EHV-1, when the diagnosis is performed only on the aborted fetus and not on the mare (Smith et al., 1992; Paillot et al., 2008).

EHM is a rare event, sequelae of EHV-1 infection, that can occur also without premonitory respiratory signs (Slater, 2014). EHM is considered sporadic although the presentation and the severity of neurological signs are highly variable (Dunowska, 2014). EM can be observed in outbreaks of varying importance (Henninger et al., 2007; USDA, 2011; Barbić et al., 2012; Burgess et al., 2012; Vereecke et al., 2021). The extent of an outbreak depends on numerous factors, at virus level: involved virus strain; at animal level: age, sex, immune status, concurrent disease, stress level; at country/holding level; animal density, number and conditions of horse movement, biosecurity measures applied, control measures, official notification of EHV-1, EHV-1 case definition, horse industry management (Goehring et al., 2006; Allen, 2008; Perkins et al., 2009; Traub Dagartz et al., 2013; Pusterla et al., 2014, 2020; van Galen et al., 2015; Garvey et al., 2019; Dunuwille et al., 2020).

The proportion of horses showing neurological signs on premises where EHM outbreak events were reported has been observed to 1% and 15% in Croatia, France, Canada (Barbic et al., 2012; Weese, 2017; Sutton et al., 2019), 6% and 34% in the USA (Henninger et al., 2007; USDA et al., 2011) in longitudinal or retrospective studies carried out in EHV-1 outbreaks. In the Netherlands, six EHM outbreaks were investigated and the proportion of horse with neurologic dysfunction out of present horses in the premises ranged from 10% to 33% (Goehring et al., 2006).

The ability to cause EHM was associated in the past with specific EHV-1 strains (the so-called neuropathogenic strains) with a specific DNA polymerase gene mutation (gene open reading frame 30: N752), but virus strains without this mutation have been isolated in several outbreaks with horses suffering for neurological signs (Goehring et al., 2006; Nugent et al., 2009; van Galen et al., 2015; Garvey et al., 2019; Dunuwille et al., 2020; Sutton et al., 2020; Pusterla et al., 2020; Vereecke et al., 2021).

Recently, several papers and reports documented an increase in EHM occurrence (Oladunni et al., 2019), but recent increased awareness among stakeholders may have led to notification of cases that would otherwise not have been discovered. Still it is not sure whether it is a real increase of cases or an increased reporting. APHIS-USDA classified the EHM as a re-emerging disease (USDA, 2008) and high rates of morbidity were recorded subsequently in some outbreaks in Europe (Gryspeerdt et al., 2011; Pronost et al., 2012; Walter et al., 2013; van Galen et al., 2015) and worldwide (Henninger et al., 2007; Tsujimura et al., 2011; Burgess et al., 2012; McFadden et al., 2016; Negussie et al., 2017b).

Mortality

Parameter 3 – Case fatality rate

Although there is lack of reliable data on case fatality rate in the literature, death is considered a rare event in EHV-1-infected horses. A mortality (number of deaths/number of exposed susceptible animals) ranging from 0.5% to 10% was reported in published investigation studies of outbreaks (Henninger et al., 2007; USDA, 2011; Barbic et al., 2012; Pronost et al., 2012; Weese, 2017), although this does not consider the general assumption that most horses are infected, thus leading to a much larger denominator and even lower case fatality rate.

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

There is no evidence of human infection with EHV-1.

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

Resistance of EHV strains to treatments is not described nor reported (Gryspeerdt et al., 2011); however, there are reports of antiviral drugs (e.g. valacyclovir) use in the field outside marketing authorisation. Despite many efforts of researches in pharmaceutical treatments that can limit EHV-1 clinical signs, especially the neurological sequelae of EHV-1 infection, no antiviral drugs have been proven effective in the field up to date (Slater, 2014; Oladunni et al., 2019; Laval et al., 2021). The respiratory signs are often self-limiting and do not need specific treatment. Broad-spectrum antibiotics

are often administered to avoid secondary bacterial infections. Antimicrobial resistance of the possible bacterial infections should be taken into account.

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

The EHV-1 infection in horses is characterised by a lifelong duration and the establishment of latency in lymphatic or neuronal tissues, from where the virus can periodically reactivate and be excreted, to infect another susceptible host (Welch et al., 1992; Dunowska et al., 2014). The frequency of latency and reactivation is host dependent and many endogenous and exogenous factors are believed to have an effect on the virus life cycle. EHV-1 is a persistent virus and horses become infected in the first years of age (Gilkerson et al., 1999b). The duration of the infectious period with intermittent virus shedding is potentially the whole life of the infected horse.

From an infected horse, after reactivation and subsequent cell-associated viraemia, the virus can be excreted through respiratory aerosol, aborted placenta and fetus.

The shedding from nasal secretion from infected horses can last up to 3 weeks, depending on horse immune status and virus strain properties (Gibson et al., 1992; Slater et al., 1994; Allen, 2002b; Perkins et al., 2010; Pusterla et al., 2010a; 2010; Dunowska et al., 2014).

Parameter 2 – Presence and duration of latent infection period

Like other herpesviruses, EHV-1 establishes a latency, which provides a successful strategy to a lifelong persistent infection in the animal. After the primary replication in the epithelial cells of the upper respiratory tract, EHV-1 reaches draining lymph nodes, nerve endings of the peripheral nervous system and peripheral blood mononuclear cells. The long-term latency is established in trigeminal ganglia, respiratory lymphoid tissues and circulating lymphocytes (Slater, 2014; Laval et al., 2021). During latency, the entire viral genome is present in the infected cell, but only a limited part undergoes transcription.

Factors inducing the reactivation after latency have been widely studied. The importance of any stressors, such as weaning, foaling, castration, transport and rehousing, is extensively recognised as the trigger to induce, months or years after the primary infection, virus replication and dissemination to target organs. Reactivation can be silent, without clinical manifestation but virus shedding occurs (Edington et al., 1985; Gibson et al., 1992; Oladunni et al., 2019). Endothelial cell infection of target organs after viraemia can result to abortion or EHM (Burrows et al., 1975).

The latency period lasts the whole life in an infected horse, as demonstrated by the virus finding in post-mortem examinations in the literature (Edington et al., 1994; Carvalho et al., 2000; Taouji et al., 2002; Pusterla et al., 2010a, 2012; Dunowska et al., 2015).

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

The principal source of EHV-1 is represented by the reactivation of the infection in latently infected horses. Most of the infected horses carry the virus showing no clinical signs or light respiratory signs (e.g. nasal discharge) that can go unnoticed. The subclinical status of lifelong latently infected horses is prevalent in horses, which shed the virus through nasal shedding in particular situations and for a limited period, up to 14 days (Slater et al., 1994; Allen, 2002b; Oladunni et al., 2019; Laval et al., 2021).

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)

EHV-1, like other member of Herpesviridae family, is an enveloped virus. The envelope glycoproteins are crucial for survival, transmission and cell infection. Commonly used disinfectant and environmental conditions (temperature, desiccation, light ultraviolet exposure) can inactivate the virus. Despite indirect contact was found to play a role in virus transmission in EHV-1 outbreak investigations, very few studies have been performed on the virus persistence outside the equine hosts to date. Different materials and environmental conditions have been found to have an impact on EHV-1 viability outside the horse.

In case of EHV-1 abortion, placenta, uterine fluids and fetal tissue containing a high quantity of virus (Allen, 2002a) may contaminate the environment, representing a significant source of the virus (Patel et al., 2005).

In 1959, Doll demonstrated that EHV-1 can survive and remain infectious for hamster for up to 7 days in straw, on glass and iron, up to 14 days on wood, paper and rope, and up to 42 days on horsehair and burlap (Doll et al., 1959). Saklou et al. demonstrated that EHV-1 viability could be maintained for up to 48 h in all the tested materials such as plastic, polyester-cotton tissue, straw, wood shavings and leather in three different environment settings and temperatures. Their findings indicate that the type of material has a stronger impact in comparison with temperature on EHV-1 persistence (Saklou et al., 2020).

EHV-1 transmission through faeces has been speculated by Dayaram et al. (2021), after the direct finding of various species of Equine Herpesviruses (PCR-positive tests) in faeces of zebras (Seeber et al., 2019).

It is also possible that water acts as an environmental vector of EHV-1. In controlled experiments, the presence and infectivity of the virus were confirmed over 21 days (Dayaram et al., 2017; Bonassies et al., 2019).

Fomites are recognised as an important source of indirect infection of EHV-1, as demonstrated in case of spread of infection from isolated infected horses to horses or captive zoo equids housed in close stables (Slater, 2014; Dayaram et al., 2017, 2021; Azab et al., 2018).

In general, there is a growing evidence of the importance of indirect contact in EHV-1 transmission.

These findings support the importance of the application of appropriate cleaning and disinfection and biosecurity measures in EHV-1 outbreaks management.

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)

EHV-1 transmission occurs by direct and indirect contact with nasal secretions of diseased or healthy horses. The main route of transmission of EHV-1 is the direct contact through the respiratory tract (Allen, 2002a). The horse gets infected through the nasal epithelium after contact with aerosolised infective droplets. The virus is present in nasal secretion 24 h after experimental infection and shedding lasts for 7–14 days (Gibson et al., 1992; Slater et al., 1994; Allen, 2002b; Gryspeerdt et al., 2010). The importance of aerosol transmission depends on the amount of infectious virus released by the horse, climatic conditions and distance among horses (van Maanen et al., 2002). The transmission can occur over limited distances (Kohn et al., 2006).

Contact with aborted fetuses and placenta tissues represents an important source of infection in stud farms. EHV-1 is also horizontally transmitted to other mares by direct contact with large virus loads present in aborted fetuses, fetal membranes, and placental fluids (van Maanen et al., 2002; Ma et al., 2013; Slater, 2014). EHV-1 can cause abortion with or without infecting the fetus, depending on the level of uterine endothelial cells damage. A massive EHV-1 infection of uterine endothelial cells can lead to a detachment of fetal membranes, causing an abortion of a virus-negative fetus (Smith et al., 1992; van Maanen et al., 2002). If the cell damage is minor, EHV-1 is able to invade the fetus, causing lesions in lungs, spleen and umbilical cord and abortion of a virus-positive fetus (Smith et al., 1997).

The exposure of horses to EHV-1 frequently occurs in young foals before 2 years of age from infected mares and the virus establishes a lifelong infection (Slater, 2014; OIE, 2019b). Like other herpesviruses, EHV-1 can undergo latency and reactivate at any time under stressful conditions promoting clinical disease and virus shedding (Khusro et al., 2020). Existence of a latent status compromises efforts to control EHV-1 and explains why outbreaks may occur in closed populations of horses.

The infection can also occur by ingestion or inhalation of droplets from surfaces (Slater, 2014). Indirect virus transmission through contamination of human hands, feed, water and other fomites is also possible (Allen, 2002b).

In few published studies, EHV-1 nucleic acid was detected by PCR in the semen of stallions (Tearle et al., 1996; Hebia-Fellah et al., 2009; Walter et al., 2012). However, it was possible to isolate the virus only in one case, thus limiting the probability that venereal transmission plays a role in EHV-1 infection.

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

Not applicable (EHV-1 infection is not a zoonosis).

Speed of transmission

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

The incidence (number of new cases/population at risk) of the infection of EHV-1 is hard to define and calculate as stated in Section 2.1.

In two large seroprevalence studies performed in breeding farms, the crude incidence in a naive exposed population, i.e. unweaned foals from 30 to 150 days of age, was 40% (Gilkerson 1999 b). This rate was confirmed by a following study, where 35% of foals were found positive at 27 days of age (Foote et al., 2006).

The extreme variability in vaccination status, the impossibility to determine whether the infection was new or a reactivation of a latent one, the different biosecurity measures applied, do not allow to calculate a reliable incidence rate.

After experimental infection with the so-called neuropathogenic strains, an incidence of neurological sign of 25% (9/36), 36% (5/14) or 38% (3/8) was found (Allen, 2008; Brosnahan et al., 2012; Holz et al., 2019), but the small number of involved horses can bias the results.

Parameter 4 – Transmission rate (beta) (from R0 and infectious period) between animals and, when relevant, between animals and humans

The only available information on transmission rate was found in a thesis investigating and comparing epidemiological dynamics of two outbreaks of EHV-1 in the USA (Meade, 2012). Estimates of R0 were 10 and 3, respectively, for the so-called neuropathogenic and non-neuropathogenic strains of EHV-1 isolated in two outbreaks. Interestingly, a Reed–Frost model constructed for each EHV-1 indicated that the prevention of EHV-1 neurological illness requires a higher level of herd immunity than EHV-1 respiratory illness (Meade, 2012).

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

Presence and distribution

Parameter 1 – Map where the disease is present in EU

The EHV-1 infection is widely present and is considered endemic in the EU (Table 3). The infection is notifiable to OIE, while not to EU. When the disease is reported as absent or no information is available from OIE, evidence of disease presence can be found in published papers or in grey literature. Some MSs have a surveillance programme or can list the infection with EHV-1 as subject to compulsory notification to the Veterinary Authorities at national level.

Table 3: Report of EHV-1 and EHV-4[(a)] presence in EU MSs[(b)]

Member state	OIE six monthly and annual reports and immediate notification and follow-up reports (January 2014–December 2020)	Outbreaks reported by the International Collating Centre (ICC) (1/1/2019–31/5/2021)[(c)]	Literature demonstrating presence*	Grey literature demonstrating presence**
Austria	No information	No report	Engels et al. (1986)	https://www.pferderevue.at/aktuelles/gesundheit/2021/03/herpes-ausbruch-auch-in-oesterreich.html
Belgium	Present	25 repro. EHV-1 1 repro. EHV-1/4 6 repro. EHV-4 10 EHM cases 24 resp. EHV-1 16 resp. EHV-4	Not available	Not available

Member state	OIE six monthly and annual reports and immediate notification and follow-up reports (January 2014–December 2020)	Outbreaks reported by the International Collating Centre (ICC) (1/1/2019–31/5/2021)[c]	Literature demonstrating presence*	Grey literature demonstrating presence**
Bulgaria	absent	No report	Martinov et al. (2000)	Not available
Croatia	Present	No report	Not available	Not available
Cyprus	No info	No report	No information	No information
Czech Republic	Absent	No report	Molinkova et al. (2004), Molinkova (2012)	Not available
Denmark	Present	1 repro. EHV-1 1 resp. EHV-1	Not available	Not available
Estonia	Present	No report	Not available	Not available
Finland	Present	No report	Not available	Not available
France	Present	Cf. details below	Not available	RESPE (réseau d'épidemio-surveillance des pathologies équines)
Germany	Present	21 repro. EHV-1 9 EHM EHV-1 1 EHM EHV-4 17 resp. EHV-1 7 resp. EHV-4	Not available	Not available
Greece	No info	No report	No information	No information
Hungary	Present	No report	Not available	Not available
Ireland	Present	10 repro. EHV-1 1 repro. EHV-4 10 resp. EHV-1 5 resp. EHV-4	Not available	Not available
Italy	Present	11 resp. EHV-1 2 resp. EHV-4 9 EHM EHV-1 1 EHM EHV-4	Not available	Not available
Latvia	Absent	No report	No information	No information
Lithuania	Absent	No report	Liutkevičien et al. (2006)	
Luxembourg	Absent	No report	Not available	https://chronicle.lu/category/at-home/35858-equine-virus-detected-in-luxembourg
Malta	Absent	No report	No information	No information
Netherlands	Present	13 repro. EHV-1 6 resp. EHV-1 24 resp. EHV-4 9 EHM EHV-1	Not available	Not available
Poland	No information	No report	Stasiak et al. (2020), Płoszay et al. (2012)	Not available

Member state	OIE six monthly and annual reports and immediate notification and follow-up reports (January 2014–December 2020)	Outbreaks reported by the International Collating Centre (ICC) (1/1/2019–31/5/2021)[c]	Literature demonstrating presence*	Grey literature demonstrating presence**
Portugal	Present	No report	Not available	Not available
Romania	Absent	No report	No information	No information
Slovakia	Absent	No report	No information	No information
Slovenia	Present	No report	Not available	Not available
Spain	Present	2 resp. EHV-1 1 resp. EHV-4 2 EHM EHV-1	Not available	Not available
Sweden	Present	13 repro. EHV-1 14 resp. EHV-1 12 resp. EHV-4 4 EHM EHV-1	Not available	Not available

*: Only in the absence of report to OIE or no information.
**: Only in the absence of report to OIE or no information and no literature demonstrating presence available.
(a): EHV-1 and 4 are often notified together as Equine Rhinopneumonitis.
(b): In ICC reports, an outbreak is defined as a premise with at least one animal displaying clinical signs of disease and EHV infection confirmed by diagnostic analysis.
(c): https://equinesurveillance.org/iccview/; resp: respiratory; repro: reproductive

Equine disease surveillance is variable between MSs, in terms of network, activity and/or focus. As a consequence, EHV-1 and EHV-4 outbreaks are likely to be underreported in most EU countries. Equine herpesvirus outbreaks have been the focus of attention in recent years in France. Due to the size and geographical cover of the French equine pathology epidemiological surveillance (RESPE; https://respe.net/) network (i.e. around 800 sentinel equine veterinarians taking part to the surveillance effort) and the size of the French horse population (i.e. around 1,000,000 equids), surveillance data obtained in France by the RESPE may provide a picture of EHV-1/4 outbreak prevalence closer to the reality (Table 4). From 2013 to 2017, 119 EHV-1 outbreaks were reported to the RESPE. In 2018, a surge of EHV-1 outbreaks was reported (56 in total) leading to a significant disruption of the French equine industry in the first semester of the year (cf. Section e). Between 2019 and 2021 (June), 89 outbreaks were reported.

Table 4: Number of individual EHV-1 outbreaks in France (organised by disease type) reported to RESPE from 2013 to 2018 (extracted from Sutton et al., 2019 and RESPE website). An outbreak is defined here as a premise with at least one animal displaying clinical signs of disease associated with EHV-1 or EHV-4 infection. In the case of respiratory disease inducted by EHV-1, mild cases are likely to be largely underreported

Year	Respiratory	Abortion	Neurological	ND[1]	Total
2013	1	1	3	0	5
2014	14	10	3	0	27
2015	11	16	1	0	28
2016	11	8	7	3	29
2017	5	9	6	3	23
2018	15	18	5	20	58
2019	6	8	8	5	27
2020	10	5	0	0	15

Year	Respiratory	Abortion	Neurological	ND(1)	Total
2021 (up to JUN21)	33	6	5	3	47
Total	106	81	38	34	259

(1): ND = clinical form of disease not defined or reported.

In the last 5 years, 423 EHV-4 outbreaks were reported to the RESPE (55 in 2017, 122 in 2018, 107 in 2019, 63 in 2020, 76 in 2021 to date), including 10 cases of EHV-4 inducing abortion.

The decrease in the number of EHV-1 and EHV-4 outbreaks reported in 2020 is likely associated with lockdown measures implemented during the COVID-19 epidemic and resulting in a reduction of horse movements, equestrian events, veterinary visits and reporting.

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

EHV-1 is considered endemic in the horse population worldwide as well as in the EU, with horses being latently infected (Allen, 2002b; Patel et al., 2005; Perkins et al., 2009; Gryspeerdt et al., 2011; OIE, 2019b), while outbreaks with clinical disease are infrequent (Allen, 2002a).

Abortion caused by EHV-1 can be sporadic at population level and epidemic in a breeding farm, as already presented in Section 2.1. The unexpected presentation of several abortions in apparently healthy mare groups in late-term pregnancies is often called 'abortion storm'.

The EHM is reported with a rare, sporadic frequency or as a re-emerging disease (USDA, 2008; Perkins et al., 2009; Pronost et al., 2012; Negussie et al., 2017b), as already presented in Section 2.1.

Given the magnitude and importance of the epidemic occurred in early 2021 in Valencia (Spain), detailed information about that event is reported below:

2021 Europe epidemic (Sunshine Tour in Valencia, SP)

In 2021, Europe experienced the most severe EHV-1 epidemic outbreak of the last decades. An EHV-1 outbreak originated in an International Horse Jumping Event hold in Valencia (Spain), called Sunshine Tour, rapidly spread around Europe due to horse movements and led to the cancellation of sport and racehorse events in 12 European countries by the Fédération Equestre Internationale (FEI) and competent bodies. Over 400 horses were congregated at the Valencia venue and the majority were housed together in a tented facility. After movement restrictions were implemented, 159 horses were present and 114 showed illness or resulted positive to RT-PCR.[3] In the following weeks, at least 18 horses died in the Spanish venue or after the return to their holdings (www.fei.org). The geographical spread included 10 countries: Belgium, Denmark, Spain, France, Germany, Italy, Qatar, Slovakia, Sweden and Switzerland. Over 30 affected premises were linked directly to the Sunshine Tour through secondary spread by horses returning from the affected venues and tertiary spread arose from horses travelling from Germany to Doha. The genome sequencing of five horses with EHM returning from the Valencia outbreak to Belgium and France showed that the involved strain was similar to the ones already circulating in Belgium and UK (Vereecke et al., 2021). Preliminary results currently available seem to indicate that the virus strain implicated in the Valencia-related outbreaks is not a new EHV-1 variant but a strain endemic in Europe. The genomic analysis of isolates revealed that the causative strains were not the so-called neuropathogenic strains (Vereecke et al., 2021). If these findings are confirmed in further studies, no new or more pathogenic variant would be involved in the 2021 epidemic. The possible delay in diagnosis and application of biosecurity measures could be identified as the possible trigger for virus spread. The epidemiological pattern observed during this epidemic was similar to other outbreaks reported in last decades in Europe (Goehring et al., 2006; Gryspeerdt et al., 2011; Pronost et al., 2012; Walter et al., 2013; van Galen et al., 2015; et al., 2019) and worldwide (Henninger et al., 2007; Tsujimura et al., 2011; Burgess et al., 2012; McFadden et al., 2016; Negussie et al., 2017b; Pusterla et al., 2020) with movements of horses carrying the infection to other premises from the index one.

[3] https://www.rfhe.com/wp-content/uploads/2021/03/Informe-foco-rinoneumonia-MAPA-17-03-21.pdf

Risk of introduction

Parameter 3 – Routes of possible introduction

The main route of introduction of EHV-1 infection into free areas is the introduction of infected horses, which can be healthy latently infected animals. However, the risk of introduction of EHV-1 is not a considerable concern in the EU, since the infection is already widely present in EU MSs (Table 3) at least at latent stage, and no countries claim freedom of EHV-1. Taking into account the epidemiological characteristics of the virus (latency, widespread infection, prevalent subclinical infection), it may be assumed that EHV-1 is present in all the MSs, including in countries where the disease is not officially reported.

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

No data available.

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

The infection is lifelong. The virus can survive in a contaminated environment for a period ranging from 7 to 42 days (Doll et al., 1959).

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

The sensitivity of EHV-1 diagnostic methods is variable, but a latent infection cannot be detected. A quarantine of 21 days is usually applied to ensure that a horse is not shedding virus.

If an outbreak has been notified, horses entering in a premise from a risk area must be physically separated from other horses' buildings by at least 10 metres. A double (10 days apart) serological test is often applied to exclude recent seroconversion. Paired (10 days apart) direct testing through RT-PCR of nasopharyngeal swab can also be collected. Cleaning, disinfection and biosecurity measures have to be applied. Separate staff should attend isolated and non-isolated horses. All horses on the premises, including those that have not travelled in a risk area recently, must have close clinical monitoring with twice-daily temperature recording and avoid further travel and participation to race or equestrian events.

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

Latent infection is the common status of an infected animal and it is lifelong (Edington et al., 1994).

Parameter 8 – Risk of introduction (by entry route)

Given the above-mentioned patterns (i.e. the latency of the infection and the difficulties to detect latently infected animals), the risk of introduction of EHV-1 into free areas is very high, when horses' shipping occurs.

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

Diagnostic tools

Parameter 1 – Existence of diagnostic tools

Numerous diagnostic methods and tools are available and used to confirm cases of EHV-1 or EHV-4 infection (e.g. PCR, virus isolation, measures of seroconversion). These methods are detailed in section (d).1. However, it is not possible to differentiate infected from vaccinated animals (DIVA) at the current time, which could impair disease control strategies and efforts.

> Furthermore, the relevant target condition with a diagnosis does not appear to be fixed. For example, a large proportion of the horses may have lifelong infection. Yet, an event like the international horse jumping event lead to an epidemic described above (Sunshine Tour in Valencia, SP). The diagnostic accuracy of available tests for different target conditions, i.e. new infection, infection at risk of re-activation, or re-activated infection could differ greatly, simply because of the targets and their relevance for different purposes.

Control tools

Parameter 2 – Existence of control tools

Surveillance: Epidemiological surveillance is an essential tool to control equine infectious diseases, as regularly demonstrated in the case of equine influenza (e.g. in 2007–2008 in Australia, and in the

EU and the UK since the early 1990s). However, the level of surveillance of EHV outbreaks is highly variable between MSs and further complicated by the absence of notification requirements. The absence of compulsory notification may lead to underreporting and skipping the application of containment measures (e.g. movement restrictions), thus making disease control more difficult. As EU rules do not require compulsory notification of the disease, information on the presence of the disease and of the clinical outcome of outbreaks is not easily and readily available, and it is delegated to equestrian federations, websites, news and publications. Consequently, information, when present, is at national level and often not in the English language.

The control is therefore often at farm level, where private veterinary practitioners and, where relevant, local veterinary authorities are in charge of managing outbreaks. An example of EHV outbreak management attempted at the national level was in France in 2018 and in 2021, when the RESPE activated an EHV crisis group to coordinate the release of information and advice for the management of the EHV-1 outbreaks (Cf. section d.4. for examples).

Vaccination: The prevention of the outbreak occurrence is difficult because of the carrier status of many asymptomatic horses. When available, an effective measure for preventing equine infectious diseases is the use of proper vaccination. While several EHV vaccines are commercially available in the EU, their efficacy and effectiveness against the different forms of disease induced by EHV-1 or EHV-4 are variable. EHV vaccines reduce clinical signs of disease and virus shedding, but may not prevent infection and/or reactivation. EHV vaccination is detailed in section (d).2.

Management, movement restrictions and biosecurity measures: Management practices in holdings and sport events such as quarantine and isolation, segregation of horses into small groups, stress reduction in order to avoid reactivation of latent EHV, diagnostic testing and fomites disinfection are recommended. Recommended biosecurity measures and movement restrictions to prevent/control EHV-1/4 outbreaks are detailed in section (d).4 and (d)5, respectively.

Limitation of existing tools for the control and eradication of EHV-1 disease, when compared to other equine infectious respiratory disease: Regretfully, the level of protection induced by currently available EHV vaccines and the absence of DIVA ability would make eradication of EHV-1 or EHV-4 difficult. Due to the endemic presence of EHV-1 or EHV-4 in the European horse population, the absence of EHV vaccines with DIVA ability and the absence of diagnostic tools able to identify latently infected horses, eradication of EHV-1 or EHV-4 would be extremely difficult to achieve in the EU, at the current time. Eradication of EHV1 has not been attempted in any country.

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

As the EHV-1 infection is endemic worldwide in the horse population, at least as latent infection, it is possible to assume that in all MSs the disease is present, although a different magnitude can be supposed (Table 3). The presence of the disease is documented from at least 21 MSs, either in official reports to the OIE or in the scientific literature. From Cyprus, Greece, Latvia, Malta, Romania and Slovakia, there is no information available (Table 3). In some MSs, control measures such as the compulsory notification of ER (cause by EHV-1 and/or EHV-4) and the actual level of its implementation, biosecurity measures applied in case of an outbreak, the level of horse industry organisation, the quantity of horses vaccinated against the disease, the number of horses subject to international and national movements for sport or trade purposes, can modify the level of the incidence/prevalence of the disease. Nevertheless, insufficient data are available to determine the degree of EHV-1 presence. At least in Austria, Belgium, France, Germany, Ireland, Italy, Netherlands, Poland, Portugal, Slovakia, Spain, Sweden and other countries where equestrian sports and horse breeding are common, EHV-1 represents a threat for the equine industry (https://inside.fei.org/fei/ehv-1).

The loss of production of the disease

Parameter 2 – Proportion of production losses (%) by epidemic/endemic situation (milk, growth, semen, meat, etc.)

The losses due to of EHV-1 infection for horses depend on the horse sector in each MS and the value of horses being affected by some of the possible sequelae of the disease. The losses linked to EHV-1 are due to the factors and stressors leading to reactivation of the latent infection or new infections. This can generate the clinical forms (respiratory disease, abortion, EHM) which may severely affect the equine industry worldwide, although few data are available about quantification of these losses (Moreau et al., 2012; OIE, 2019b; Oladunni et al., 2019; Khusro et al., 2020). The respiratory disease causes a reduction of the sport performance of horses, interruption to training regimes and failure to participation to competition, but it is usually transient and not severe if not complicated by secondary infections.

EHV-1 abortion or perinatal death is an economic problem, especially in breeding farms. Covering fees and the related potential value of a foal in some horse breeds such as Thoroughbred can be very high, up to 290,000€.[4] The mares that abort due to herpesvirus have usually no reproductive problems in the following reproductive managements and pregnancies (Dunowska, 2014). EHV-1-induced abortion may have a significant impact on breeding operation in the absence of preventive and biosecurity measures. For example, EHV-1-induced abortion storms were reported in the USA. The highest incidence of EHV-1-associated abortions reported in Central Kentucky was 17.3/1,000 pregnant mares in 1963 but decreased to < 2/1,000 in 2002 (D. Powell, Gluck Equine Research Centre). EHV-1-induced abortions are still reported nowadays, but EHV-1 vaccination is usually required for breeding operation (both stallion and mare).

EHM can cause the death or the lack of performance in horses, the significance of which depends on the economic value of the horse. Horses can die or being euthanised, while horses that recover can return to a normal sport activity after some weeks of convalescence (Allen, 2002a; van Maanen et al., 2002). The occasional outbreak of EHM may result in the cancellation of equestrian and racehorse events with a huge economic impact for the sector.

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

No evidence of human-to-human transmission is available for EHV-1 infection, no human form of the disease has been ever observed; thus, no impact has ever been recorded.

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

In the context of experimental infection of Welsh mountain ponies (i.e. target species) with EHV-1 conducted for the purpose of EHV-1 vaccine efficacy evaluation (e.g. clinical trials conducted for marketing or regulatory purposes in the UK), the respiratory form of the disease was classified as being of moderate severity under the Home Office Project Licensing system (Animal Scientific Procedure Act (ASPA) 1986 of the United Kingdom) (Paillot R., Home Office Project Licence Holder, personal communication). Both EHV-1-induced abortion and EHM would be classified as severe under the same system, if authorised under the Animal (Science Procedures) Act 1986 of the United Kingdom. In the field, cases of EHM may require euthanasia on welfare grounds (e.g. recumbent animal and/or distress associated with paralysis). The level of recovery from EHM is variable, with the possibility of permanent neurological deficits, and would depend of the extent of the damage induced by infection. Mares recover after EHV-induced abortion, with no impact on reproductive capacities. EHV-induced respiratory disease is mild to moderate but could lead to serious and life-threatening secondary bacterial infection.

In EHM cases, scrupulous attention to horse welfare must be observed. When neurological signs develop and fatalities occur in horses, the horse welfare is severely affected. In all the cases in which euthanasia of horses is unavoidable, this must be performed with full respect for the horse welfare (sedation and complete anaesthesia before euthanasia).

[4] www.bloodhorse.com/horse-racing/thoroughbred-breeding/sire-lists?year=2021&listType=g&racingArea=eur&standingRegion=europe&surface=all&sortColumn=earnings

3.1.2.4. Article 7(b)(iii) 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

EHV-1, EHV-9 and a recombinant virus among them have been associated with a wide range of infections in several species, most of them in captive animals, causing from asymptomatic disease to fatal outcome with neurological or reproductive disorders (Göltenboth et al., 1996; Fischer-Tenhagen et al., 2000; Donovan et al., 2009; Wohlsein et al., 2011; Greenwood et al., 2012; Abdelgawad et al., 2014; Guo et al., 2014; Abdelgawad et al., 2016; Azab et al., 2018; Camara Falcao, 2020). In Table 5, the species where Equid herpesviruses were found and that IUCN classified from 'near threatened' to 'extinct in the wild' are reported. Other susceptible wild species are listed in Section 1.1.

It is important to note that some breeds of domestic horses are endangered, as for example the Desert Arabian Horse.

Table 5: IUCN status of wild animal species with reported EHVs infection

Order	Family	Species	Common name	IUCN status	IUCN reference
Perissodactyla	Equidae	*Equus africanus asinus*	African Wild Ass	Critically endangered	Moehlman PD, Masseti M, de Smet K, Yohannes H, Teclai R and Kebede F, 2010. *Equus africanus*. *The IUCN Red List of Threatened Species* 2010: e.T7949A12873963
		Equus hemionus	Onager (Asiatic Wild Ass)	Near threatened	Kaczensky P, Lkhagvasuren B, Pereladova O, Hemami M and Bouskila A, 2020. *Equus hemionus* (amended version of 2015 assessment). The IUCN Red List of Threatened Species 2020: e.T7951A166520460. https://doi.org/10.2305/IUCN.UK.2020-1.RLTS.T7951A166520460.en
		Equus hemionus ssp. *onager*	Persian Onager	Endangered	Hemami M, Kaczensky P, Lkhagvasuren B, Pereladova O and Bouskila A, 2015. *Equus hemionus* ssp. *onager*. The IUCN Red List of Threatened Species 2015: e.T7966A3144941. https://doi.org/10.2305/IUCN.UK.2015-4.RLTS.T7966A3144941.en
		Equus ferus	Przewalski's Horse	Endangered	King SRB, Boyd L, Zimmermann W and Kendall BE, 2015. *Equus ferus* (errata version published in 2016). The IUCN Red List of Threatened Species 2015: e.T41763A97204950. https://doi.org/10.2305/IUCN.UK.2015-2.RLTS.T41763A45172856.en
		Equus quagga	Plain Zebra	Near threatened	King SRB and Moehlman PD, 2016. *Equus quagga*. The IUCN Red List of Threatened Species 2016: e.T41013A45172424. https://doi.org/10.2305/IUCN.UK.2016-2.RLTS.T41013A45172424.en
		Equus grevyi	Grévy's Zebra	Endangered	Rubenstein D, Low Mackey B, Davidson ZD Kebede F and King SRB, 2016. *Equus grevyi*. The IUCN Red List of Threatened Species 2016: e.T7950A89624491.

Order	Family	Species	Common name	IUCN status	IUCN reference
					https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T7950A89624491.en
		Equus zebra	Mountain Zebra	Vulnerable	Gosling LM, Muntifering J, Kolberg H, Uiseb K and King SRB, 2019. *Equus zebra* (amended version of 2019 assessment). The IUCN Red List of Threatened Species 2019: e.T7960A160755590. https://doi.org/10.2305/IUCN.UK.2019-1.RLTS.T7960A160755590.en
		Equus zebra ssp. *hartmannae*	Hartmann's Mountain Zebra	Vulnerable	Gosling LM, Muntifering J, Kolberg H, Uiseb K and King SRB, 2019. *Equus zebra* ssp. *hartmannae*. The IUCN Red List of Threatened Species 2019: e.T7958A45171819. https://doi.org/10.2305/IUCN.UK.2019-1.RLTS.T7958A45171819.en
		Equus zebra ssp. *zebra*	Cape Mountain Zebra	Least concern	Hrabar H, Birss C, Peinke D, Novellie P and Kerley G, 2019. *Equus zebra* ssp. *zebra*. The IUCN Red List of Threatened Species 2019: e.T7959A45171853. https://doi.org/10.2305/IUCN.UK.2019-1.RLTS.T7959A45171853.en
	Rhinocerotidae	*Diceros bicornis*	Black Rhinoceros	Critically endangered	Emslie R, 2020. *Diceros bicornis*. *The IUCN Red List of Threatened Species* 2020: e.T6557A152728945. https://doi.org/10.2305/IUCN.UK.2020-1.RLTS.T6557A152728945.en
		Ceratotherium simum	White Rhinocerus	Near threatened	Emslie R, 2020. *Ceratotherium simum*. *The IUCN Red List of Threatened Species* 2020: e.T4185A45813880. https://doi.org/10.2305/IUCN.UK.2020-1.RLTS.T4185A45813880.en
		Rhinoceros unicornis	Indian Rhinocerus (Greater One-horned Rhinocerus)	Vulnerable	Ellis, S and Talukdar B, 2019. *Rhinoceros unicornis*. The IUCN Red List of Threatened Species 2019: e.T19496A18494149. https://doi.org/10.2305/IUCN.UK.2019-3.RLTS.T19496A18494149.en
	Tapiridae	*Tapirus indicus*	Malayan Tapir	Endangered	Traeholt C, Novarino W, bin Saaban S, Shwe NM, Lynam A, Zainuddin Z, Simpson B and bin Mohd S, 2016. *Tapirus indicus*. *The IUCN Red List of Threatened Species* 2016: e.T21472A45173636. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T21472A45173636.en
Carnivora	Ursidae	*Ursus maritimus*	Polar Bear	Vulnerable	Wiig Ø, Amstrup S, Atwood T, Laidre K, Lunn N, Obbard M, Regehr E and Thiemann G, 2015. *Ursus maritimus*. The IUCN Red List of Threatened Species 2015: e.T22823A14871490. https://doi.org/10.2305/IUCN.UK.2015-4.RLTS.T22823A14871490.en

Parameter 2 – Mortality in wild species

EHV-1 was considered the cause of death or of a severe infection that required euthanasia after neurological signs in black bear (*Ursus americanus*), Thomson gazelle (*Eudorcas thomson*) and Indian rhinoceros (*Rhinoceros unicornis*) (Wohlsein et al., 2011; Abdelgawad et al., 2014). Death was reported also after EHV-1 experimental infection of llama (*Lama glama*) (House et al., 1991). An infection by herpesvirus was also suspected for the sudden death of a tapir and a black rhinoceros (*Diceros bicornis*) (Göltenboth et al., 1996).

The EHV-1 close related EHV-9 was considered the cause of death in Thomson gazelle (*E. thomson*) and polar bear (*U. maritimus*) (Kennedy et al., 1996; Yanai et al., 1998; Donovan et al., 2009; Greenwood et al., 2012).

In zebra species, both EHV-1 and EHV-9 are responsible of neurological disease, but it is not clear whether they can be associated with mortality (Abdelgawad et al., 2016).

Environment

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

Several studies demonstrated that EHV-1 can survive and be infective in straw, glass, iron, wood, paper, rope, plastic, polyester-cotton tissue, wood shavings and leather for several days, as reported in Section a 5.2. Faeces and water also can play a role (Dayaram et al., 2017; Seeber et al., 2019). Fomites are recognised as an important source of indirect infection of EHV-1 (Slater, 2014), as demonstrated in case of spread of infection from isolated infected horses to horses or captive zoo equids housed in a close stable (Greenwood et al., 2012; Abdelgawad et al., 2014; Dayaram et al., 2021).

In zoos, non-sympatric species are kept in close settings, facilitating pathogen transmission among susceptible or accidental hosts. This possibility was demonstrated between zebras and rhinoceros where only aerosols, fomites or rodent vectors were hypothesised to be responsible of the cross-species transmission (Abdelgawad et al., 2014).

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

Parameter 1 – Listed in OIE/CFSPH classification of pathogens

Infection by EHV-1 is listed by the OIE (https://www.oie.int/en/disease/equine-viral-rhinopneumonitis-caused-by-ehv-1/). EHV-1 is not listed by CFSPH.

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

EHV-1 is not listed in the Encyclopaedia of Bioterrorism Defence of Australia Group.

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

None identified.

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

The main points related to EHV-1 infection are:

- Effective, well-established diagnostic tools are available.
- Vaccines are a useful aid to prevent abortion and respiratory disease, but there is no evidence of efficacy against neurological disease;
- Spread between premises is almost always associated with horse movement; thus, temporary movement restrictions are highly effective.

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

Availability

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

The OIE Reference Laboratories use quantitative real-time PCR assays such as those targeting heterologous sequences of major glycoprotein genes to distinguish between EHV-1 and EHV4.

Additionally, OIE Reference Laboratories use in-house strain typing methods for virus strain characterisation (to date, these methods are not internationally validated).

Direct detection of the pathogen: As indicated in the OIE Terrestrial Manual, the recommended method for detection and identification of EHV-1 (and the closely related EHV-4) is the PCR (direct detection of the virus nucleic acids). PCR results could be supported by virus isolation in cell culture.

Reference and diagnostic laboratories usually employ quantitative real-time PCR (qRT-PCR) assay targeting the genes of several surface glycoproteins, such as glycoprotein B (gB) (Wagner et al., 1992; Borchers and Slater, 1993; Kirisawa et al., 1993; McCann et al., 1995; Diallo et al., 2006; Hussey et al., 2006; Diallo et al., 2007; Pusterla et al., 2009; El-husseini et al., 2016; Hu et al., 2014), glycoprotein C (gC) (Sharma et al., 1992; Lawrence et al., 1994; Carvalho et al., 2000) or glycoprotein H (gH). Other genes such as ORF30 (DNA polymerase) or thymidine kinase are also targeted (Sharma et al., 1992; Carvalho et al., 2000). A multiplex qRT-PCR targeting glycoprotein B gene of EHV-1 and EHV-4 was described by Diallo et al. (2007).

ORF30 PCR and 'neuropathic' marker (ORF30 typing): The PCR method described by VanDevanter et al. (1996) is still in use (VanDevanter et al., 1996). This method uses degenerated primers targeting the ORF30 of mammalian herpesviruses. In the case of a positive result, ORF30 sequencing is subsequently required to identify the herpesvirus detected. In 2006, Nugent et al. identified a single nucleotide mutation at position 2254 (A2254G) that was initially thought to be associated with the development of the different forms of secondary diseases (i.e. infectious abortion (A2254 mutation) or EHM (G2254 mutation, also called neuropathic marker) (Nugent et al., 2006). PCR assays have been adapted to differentiate EHV-1 strains based on this 2254 mutation (Allen et al., 2007; Smith et al., 2012). To date, the importance of the 2254 mutation as a 'neuropathic' marker is arguable (Vissani et al., 2009; Pronost et al., 2010; Fritsche and Borchers, 2011; Stasiak et al., 2015; Garvey et al., 2019; Sutton et al., 2019; Pusterla et al., 2020). While EHV-1 strains carrying the A2254 mutation are frequently (but not exclusively) isolated from abortion cases, EHV-1 strains isolated from EHM cases are carrying either mutation. Recently, a third 2,254 mutation (C2254) was isolated from a large outbreak in France, which raised further questions on the prognostic importance of this marker (Sutton et al., 2020). A specific SNP single nucleotide polymorphism marker present in the EHV-1 strains involved in the 2021 EHV-1 outbreak in Valencia (Spain) was recently identified and used to trace infected horses (Sutton et al., 2021).

Whole ORF 30 sequencing (Sutton et al., 2019), whole genome sequencing (Bryant et al., 2018) and multilocus strain typing (MLST) have been recently used to better understand the EHV-1 phylogenetic evolution. The EHV-1 MLST was first described by Garvey et al. (2019) and involves the analysis of 37 loci in 26 ORFs (based on non-synonymous changes identified between the reference EHV-1 strain Ab4 and V592 protein coding regions) (Garvey et al., 2019). This MLST was recently used by Sutton et al. (2019) to confirm that the surge of EHV-1 outbreaks in France in 2018 involved numerous EHV-1 strains, including a new ORF30 variant (C2254) (Sutton et al., 2019, 2020). These methods are not currently fully adapted for diagnostic analysis but a better phylogenetic characterisation of circulating EHV-1 strains remains a frequent demand from equine practitioners in the field.

Point-of-care tests for the detection of EHV-1/4 in respiratory secretion are currently being developed or commercialised (e.g. Enalees Epona test in France) (Thibault et al., 2019). While such tests represent an advance in terms of veterinary medicine and care (faster detection, biosecurity measure implementation and treatment), their potential detrimental impact on field surveillance (e.g. reduced reporting, reduced sample availability for subsequent virus strain characterisation and isolation) remains to be evaluated.

Cell culture isolation of EHV-1 is used to titrate live infectious EHV-1. Typical cytopathic effect (CPE) is usually observed 1–3 days after cell infection. Several cell lines are used to isolate EHV-1 from nasal/nasopharyngeal swab samples and/or peripheral blood mononucleated cells (PBMC) (i.e. Rabbit Kidney cell line (RK13), Equine Dermal cell line (E. Derm), Equine Embryonic Kidney cell line (EEK), Baby Hamster Kidney cell line (BHK-21), Madin-Darby Bovine Kydney cell line (MDBK), Pig Kidney cell line (PK-15) (Balasuriya et al., 2015). The cell culture tropism of EHV-4 is more limited than EHV-1. Unlike EHV-1, EHV-4 cannot be isolated or propagated in RK13 cells (OIE, 2019b). To date, cell culture isolation is not a primary diagnostic method but is usually conducted in the context of EHV-1/4 surveillance and research.

Direct immunofluorescent detection of EHV-1 and/or EHV-4 antigen could be conducted on cryostat sections of tissues from aborted fetuses and placenta (in the case of abortion). This diagnostic method is not frequently used and laboratories providing this service are limited. Post-mortem examination of placenta and tissues from aborted fetuses, perinatal foal death and EHM cases could be conducted in

order to support a diagnostic finding (if the presence of histopathological lesions typical of EHV infection is confirmed by macroscopy and/or microscopy/histology observation).

EHV-antibody detection and measure of seroconversion: Several serological assays could be used to demonstrate EHV-induced seroconversion in blood serum samples. A fourfold or greater rise in virus-specific antibody titre by either virus neutralisation (VN) assay or complement fixation (CF) test is indicative of recent infection (Thomson et al., 1976). Limitations of serological assays: due to the prevalence of EHV-1 and most importantly EHV-4 infections in the field that induce detectable levels of EHV-specific antibodies in serum and the lack of type specificity of both VN and CF tests, the use of a single blood sample is insufficient to confirm a recent infection. Paired blood samples should be taken at least 2 weeks apart (e.g. acute and convalescent samples) in order to document seroconversion. In the case of a single blood sample available or for epidemiological studies and field surveillance, the CF test may be preferentially used as the CF antibody response is considered to be short-lived (around 3-month duration) and an elevated CF antibody titre could be indicative of a recent contact with EHV. The VN antibody response is considered to last around 6 months. The VN assay is preferentially used to measure and demonstrate EHV-vaccine immunogenicity. A type-specific (EHV-1/4) enzyme-linked immunosorbent assay (ELISA) is also commercially available. However, its use in the field is limited (Crabb and Studdert, 1995; Hartley et al., 2005).

Effectiveness

Parameter 2 – Sensitivity and specificity of diagnostic tests, positive and negative predictive values

EHV-1/4 diagnostic is usually required by veterinarians when confronted with an animal displaying signs of disease that could be attributed to EHV-1/4 infection (i.e. respiratory disease, abortion and/or neurological signs of diseases) and/or if there is a suspicion of contact with a confirmed case of EHV infection.

Requirements for reliable confirmation of EHV-1/4 infection: EHV-1 or EHV-4 infection is confirmed by the detection of the virus in the respiratory tract (indicative of virus shedding), in blood cells (indicative of cell-associate viraemia), in the aborted fetus and/or placenta (indicative of infectious abortion, with the caveat that abortion could be the result of anoxic death; in this case, the aborted fetus may be negative) and in cerebrospinal fluid (CSF; EHV-1 infection could not be ruled out if negative). In the case of EHM, EHV-1 detection could be performed on post-mortem brain and spinal cord samples. CF seroconversion or high antibody titre is usually indicative of a potential contact with EHV-1 or EHV-4 in the preceding 3 months but is not sufficient by itself to confirm EHV infection.

The detection of the pathogen by qRT-PCR methods, as described above, remains the most suitable method to confirm the involvement of EHV-1/4 during an outbreak. Positive diagnosis could be confirmed by seroconversion (fourfold increase or greater) when post-infection serum samples are compared with pre-/acute infection samples, when available. This could be complicated by the endemic nature of EHV-1 and EHV-4 and their cross-reactivity. Measure of seroconversion is adapted for retrospective epidemiological survey and control of biosecurity measures effectiveness.

Suitability of diagnostic tools for surveillance purpose: The surveillance of EHV is conducted by dedicated teams and networks with either integrated diagnostic capacities or seconded by diagnostic laboratories using validated methods. Data collected by EHV surveillance networks are obtained with the diagnostic methods described in Sections 45 and 46, which are suitable to ensure reliable and robust demonstration of the involvement of EHV-1/4 in clinical cases. EHV virus strain characterisation and typing assays have improved in recent years. They could be used to provide epidemiological links, but this still remains infrequent in the field. The increasing use of point-of-care tests may have some negative impacts on the surveillance of equine infectious diseases in the field in the coming years. As mentioned in Section 45, serological assays have limitations and EHV vaccines do not possess DIVA ability, which tend to complicate the sero-epidemiological surveillance. However, the OIE recommends VN or ELISA for the prevalence of infection surveillance and they are suitable for this purpose in unvaccinated populations. Current diagnostic tools are not adapted to identify latently infected animals.

Sensitivity and specificity: Little information is available about the sensitivity and specificity of the different assays used by diagnostic laboratories. As indicated in the OIE Terrestrial Manual, a panel of blinded samples is available from OIE reference laboratories in order to determine the sensitivity and specificity against each target when developing a new assay. Perkins et al. (2008) reported the sensitivity and specificity of a qRT-PCR targeting the EHV-1 gB when compared with virus isolation (which was the most frequently used methods at the time of the study). The sensitivity of the qRT-

PCR reached 97% and the specificity was only 27% (detection of EHV-1 in nasal swabs). As discussed by the authors, the specificity was artificially poor due to a greater ability of the method to detect positive samples, while found negative with the virus isolation method. Hussey et al. (2006) demonstrated the sensitivity of a qRT-PCR targeting EHV-1 gB by the detection of as few as six gene copies of gB in a sample (Hussey et al., 2006). Balasuriya et al. (2017) have recently reported the development of an insulated isothermal polymerase chain reaction (iiPCR) assay with a sensitivity of 100% and a specificity of 90.2% when compared to conventional qRT-PCR methods (Balasuriya et al., 2017). The agreement between the two methods was 95.2% with an index of agreement of 0.9. This assay targets ORF30. For the point-of-care tests currently commercialised in France, the information about their use and effectiveness in the field, specificity and sensitivity remains limited.

It is important to note that EHV-1 is more closely related to EHV-8 and EHV-9 than to EHV-4. As a consequence, EHV-8 and EHV-9 have caused infections that were reported in the past as EHV-1, due to the low specificity of diagnostic essays (Garvey et al., 2018). For example, an EHV-8 strain was isolated from a donkey nasopharyngeal sample initially identified as being positive for EHV-1 using a usual diagnostic PCR assay. As a consequence, 199 EHV samples (taken from French horses between 2002 and 2018) initially identified as EHV-1 were subsequently screened and checked in order to determine the frequency of misidentification. Four EHV-8 strains were identified (i.e. a misidentification frequency of 2.5%) (Paillot R. personal communication).

Sample timing: The timing of collection of the sample after infection with EHV-1 or EHV-4 is of the outmost importance. EHV-1 shedding in the respiratory tract could be detected by qRT-PCR from 1 day after infection to 2–3 weeks, depending of the level of infection and immunological status at the time of infection (Figure 1). Cell-associated viraemia could be detected by qRT-PCR in blood around 5 days after infection, up to 2–3 weeks depending of the level of infection and immunological status (Figure 1).

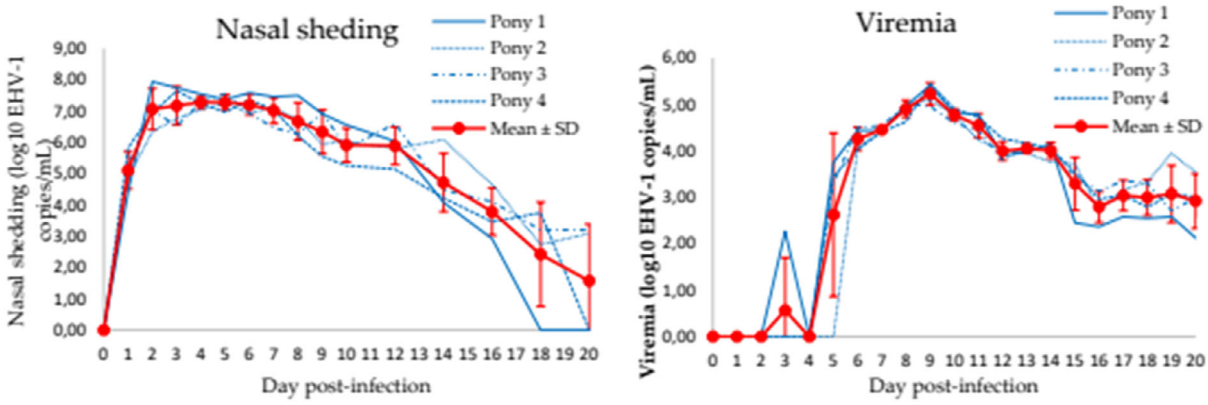

Figure 1: Kinetics of EHV-1 shedding (left) and cell-associated viraemia (right) in Welsh mountain ponies experimentally infected with EHV-1. EHV-1 was detected using the gB quantitative RT-PCR (Sutton et al., 2020)

Tissue from aborted fetus (i.e. lung, spleen, liver, adrenal gland or thymus) usually present high EHV-1 load. EHV-1 could also be detected in the placenta (Gardiner et al., 2012). Placenta could be difficult to retrieve due to predation when abortion occurs in the field, out of the stable. In some cases, abortion could be the result of a premature separation of the placenta from the endometrium, with subsequent anoxic death of the fetus. In this case, EHV-1 may not be detected in the aborted fetus. Some foals may be infected during pregnancy but survive birth. In general, foals succumb to the infection in the days following birth (the samples collected are similar to samples collected from aborted fetus). Typical virus-induced lesions are detectable by post-mortem macroscopy and/or microscopy examinations. EHV-1 is usually detectable in tissue samples from internal organs.

In the case of EHM, cerebrospinal fluid (CSF) could be taken for analysis, but the detection of EHV-1 in CSF is variable and a negative result should not preclude EHV-1 as the cause of disease. As mentioned earlier, post-mortem brain and spinal cord sample could be used for diagnosis.

To date, latent infection is difficult to confirm with the methods currently available.

Feasibility

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

Virus shedding: Nasopharyngeal swab is the most suitable sample to detect virus shedding in nasal secretion. A nasal swab could also be used but the amount and duration of virus shedding detection could be reduced, as previously described for equine influenza in the context of a laboratory clinical trial in the target species (Paillot et al., 2013). However, a field study conducted during an EHV-1 outbreak in the USA has reported that nasal swabs are a viable alternative when compared to the less tolerated nasopharyngeal swabs (Pusterla et al., 2008). Nasopharyngeal lavage is another possible sample matrix although it has no advantage when compared to nasal/nasopharyngeal swabs, and is less tolerated by horses. As such, lavage is not frequently used in the field if there is a suspicion of EHV infection.

Cell-associated viraemia: Blood samples (as little as 2 mL (Sutton et al., 2020), with or without further purification of peripheral blood mononucleated cells) is the matrix of choice to detect cell-associated viraemia. Peripheral blood mononucleated cells could be used for direct detection of EHV-1 and/or co-culture on permissive cell lines.

Other matrices: In the case of EHV-induced abortion, EHV-1 (and EHV-4) could be detected in tissue samples from aborted fetus (e.g. lung tissue samples) or in the placenta. In the case of EHM, cerebrospinal fluid (CSF), post-mortem brain and spinal cord samples could be taken for analysis.

Timing of sampling: EHV-1 is usually detectable in lung, liver, spleen, adrenal or thymus of aborted fetuses and dead neonatal foals. Foals born alive can be diagnosed by real-time PCR of nasopharyngeal swabs and blood samples. Samples from EHM cases should be collected shortly after the presentation of neurological signs. The condition is diagnosed by PCR on nasopharyngeal swabs and blood sample. If the animal is dead, PCR is performed on the spinal cord and brain tissue.

3.1.4.2. Article 7(d)(ii) Vaccination

Availability

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

EHV vaccines available worldwide are mostly whole inactivated vaccines, either monovalent EHV-1 vaccine or multivalent EHV-1 and EHV-4 vaccines (cf. Table 6; EHV vaccines available in the EU are indicated in bold text). Several EHV vaccines commercialised in the USA are also combined with other equine infectious valences, such as equine influenza virus (EIV), Eastern, Venezuelan & Western Equine Encephalomyelitis viruses (EEE, VEE and WEE, respectively), West Nile Virus (WNV) and tetanus toxoid. Several live-attenuated EHV-1 vaccines are commercially available, but their use is usually limited (e.g. prevaccinole is only commercialised and authorised in Germany).

Table 6: EHV vaccines available worldwide. The EHV vaccines available and authorised in the EU or in some EU countries are indicated **in bold**

Vaccine type	Vaccine Name	Vaccine strains	Manufacturer
Inactivated	**Pneumequine**	EHV-1	Boehringer Ingelheim
	Pneumabort K®+1B*	EHV-1	Zoetis
	Equip® EHV 1,4 (formerly Duvaxyn EHV-1/4)	EHV-1/4	Zoetis (EU)
	Flu-Vacc Innovator®6	EHV-1/4 and EIV	Zoetis (US)
	Equivac innovator® EHV-1/4	EHV-1/4	Zoetis (US)
	Vetera®2XP	EHV-1/4 combined with EIV	Boehringer Ingelheim (US)
	Vetera®5XP	EHV-1/4 combined with EEE, WEE and tetanus	
	Vetera®6XP	EHV-1/4 combined with VEE, EEE, WEE and tetanus	
	Vetera® EHVXP 1/4	EHV-1/4	
	Vetera® GoldXP	EHV-1/4 combined with EIV, EEE, WEE, WNV and tetanus	
	Calvenza®-03 EIV/EHV	EHV-1/4 combined with EIV	

Vaccine type	Vaccine Name	Vaccine strains	Manufacturer
	Prodigy®	EHV-1	Merck Animal health
	Prestige®2	EHV-1/4 combined with EIV	
	Equine Rhinopneumonitis Inactivated Vaccine	EHV-1	Nisseiken
	Bioequin H*	EHV-1	Bioveta a.s
Live attenuated	**Prevaccinol®**	EHV-1	Intervet/MSD
	Rhinomune	EHV-1	Boehringer Ingelheim
	Equine Rhinopneumonitis Vaccine	EHV-1	Nisseiken

Equine Influenza Virus (EIV); Eastern, Venezuelan & Western Equine Encephalomyelitis viruses (EEE, VEE and WEE, respectively); West Nile Virus (WNV).

*: The EHV vaccine Pneumabort K + 1B (Boehringer Ingelheim) and Bioequin H (Bioveta a.s) obtained a temporary authorisation to be commercialised in France in 2016 (similar authorisations may have been granted in other MSs).

To date, no EHV vaccine has DIVA ability.

Parameter 2 – Availability/production capacity (per year)

EHV vaccine availability has been impaired at several occasions in recent years. Between 2015 and 2017, several European countries (including France, Ireland, the United Kingdom) have reported a shortage of EHV-1/4 vaccines due to manufacturing issues with vaccine batch production and release (Pneumequine and Equip EHV-1/4, Merial Animal Health and Zoetis, respectively). In some MSs such as France, Sweden, Netherlands, Ireland and Czechia, both companies obtained temporary authorisation to import and commercialise substitute EHV-1 vaccines (Pneumabort K+1B produced by Zoetis in the USA and Bioequin H produced by Bioveta and supplied by Merial). Both substitute vaccines were monovalent EHV-1 vaccines. The number of doses available were limited (e.g. 150,000 doses of Bioequine H provided for 2016) (Paillot et al., 2017).

The innocuousness of the Bioequin H vaccine was subsequently questioned, due to numerous anecdotal or official reports of serious side effects. A retrospective study conducted by ANSES confirmed the safety concern (i.e. Proportional Reporting Ratio, anaphylaxis PRR of 9.10, $p < 0.001$; mortality PRR of 5.22, $p < 0.001$) (S. Rougier, ANSES France, oral presentation, AVEF 2019; no abstract available).

In early March 2021, following the outbreak in Valencia, the ANSES reported that about 90,000 doses were sold in France in less than a week, which is usually the amount of EHV vaccine sold in a 3- to 4-month period in normal year. This surge in sales and requests led to some delivery difficulties and shortage for 2–3 weeks in March and a subsequent backlog of orders. It is reported that a similar situation was observed throughout Europe. It is reported that around 95,000 doses were made available to French equine practitioners at the end of March, more than 100,000 doses scheduled for April and May (ANSES, 2021). In response to the shortage of vaccines in the face of the Iberian outbreak 10,000 doses of Pneumabort-K and Equivac by Zoetis, were authorised for importation from the USA to Ireland and made available to all sectors of the industry at cost (Cullinane, personal communication).

Effectiveness

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

It is acknowledged that protection against EHV-1 after vaccination requires an effective antibody and cellular immune response. The humoral antibody response primarily protects against epithelial infection and subsequent respiratory disease, virus shedding and spread of the disease to other horses. Cell-mediated immunity is required to reduce cell-associated viraemia, which is a necessary step for the development of abortion in pregnant mare and EHM (both a consequence of EHV-1 systemic dissemination in the host). While EHV-1-specific humoral response is usually well documented after EHV vaccine immunisation (VN and CF antibody response), cell-mediated immunity stimulation is usually more difficult to measure due to technical challenges (e.g. frequency of EHV-specific cell effectors).

According to the European Pharmacopeia (Equine herpesvirus vaccine (inactivated) 1,613), all EHV vaccines have to be tested for efficacy against experimental infection in the target species in order to be registered in the EU. In this context, the severity of disease, duration and amount of EHV shedding in nasal secretion need to be significantly reduced in vaccinated horses when compared with unvaccinated controls (no specific value or range indicated). Several independent studies have been conducted to confirm vaccine efficacy against EHV-1 infection. For example, the whole inactivated EHV-1/4 vaccine Duvaxyn EHV-1/4 has shown a significant reduction in clinical signs of diseases in foals after experimental infection with EHV-1 or EHV-4 (from a total clinical score of 69 $\pm$ 16 in controls to 51 $\pm$ 18 in vaccinates for EHV-1, 63 $\pm$ 14 to 36 $\pm$ 14 for EHV-4 (Heldens, 2001). Duration of both EHV-1 shedding (10.0 $\pm$ 3.2 days in controls when compared with 5.2 $\pm$ 1.6 days in vaccinates) and cell-associated viraemia (4 of 5 control foals when compared with 3 of 10 vaccinates) were also reported as significantly reduced (Heldens et al., 2001). Virus shedding was also reduced in vaccinated mares. The incidence of EHV-1-induced abortion was significantly lower (1 of 5) in vaccinated mares when compared with unvaccinated (4 of 4) (Heldens et al., 2001). When used in yearlings (8 mixed breed ponies per group), a modified live-attenuated EHV vaccine (MLV) and a whole inactivated EHV vaccine have shown to induce a significantly reduction in clinical signs of disease (controls were on average 13 and 3 times more likely to have a high clinical score when compared with the MLV and inactivated vaccine groups, respectively), virus shedding (controls were on average 2 and 1.5 times more likely to shed EHV-1 when compared with the MLV and inactivated vaccine groups, respectively) and cell-associated viraemia (control group = 13 positive day; MLV group = 5 days and killed inactivated group = 3 days). In this study, yearlings were experimentally infected 24 days after the third immunisation (Goehring et al., 2010).

The effectiveness of EHV vaccines is more difficult to evaluate in the field. EHV-1 infection remains a reality despite the broad use of whole inactivated EHV-1 vaccine in numerous countries. A study carried out in Australia measured the seroconversion of 159 mares and 101 foals after immunisation with an inactivated whole EHV-1/4 vaccine (3 administrations). Less than 30% of mares and 50% of foals seroconverted (Foote et al., 2002) and the infection of foals continued to occur despite vaccination of mares during pregnancy (Foote et al., 2003, 2004, 2006). These studies tend to indicate that acquisition of maternal antibodies from vaccinated mares is not enough to prevent EHV-1 seroconversion associated with EHV infection. Brown et al. (2007) reported that three foals born from EHV-vaccinated mares seroconverted to EHV-1 during the first month of life (Brown et al., 2007). Measure of seroconversion in the field is complicated by three factors: (1) the endemic circulation of EHV-1 and EHV-4 in horse populations, which means that animals may have a highly variable antibody baseline at the time of vaccination, with either potential interference with the vaccine and immunisation process and/or difficulty to meet the seroconversion criteria (i.e. fourfold increase of the antibody titre), (2) the cross-reactivity between EHV-1 and EHV-4 and (3) the semi-quantitative nature of the EHV serological assays.

However, the effectiveness of EHV-1 vaccination against abortion tends to be better documented. It is largely accepted in the EHV scientific community that the frequency of abortion storms due to EHV-1 infection has decreased since the introduction of EHV vaccination in the late 1980s, alongside increased implementation of biosecurity measures. Historical data provide some picture of the prevalence of EHV-1-induced abortion before the use of vaccine. EHV-1 was involved in 0.4–2.6% equine abortion in Kentucky (USA) between 1940 and 1979 (prior to implementation of vaccination). In Germany, it was estimated that 0.65% of equine abortions were related to EHV-1 between 1968 and 1992 (reported by van Maanen et al., 2000). The same author reported that 24% and 44% of fetuses sent for analysis to the Dutch Animal Health Service (Deventer) for the 1986–1990 period and in 1991, respectively, were positive for EHV-1 (Van Maanen et al., 2000). The highest incidence of EHV-1-associated abortion reported in Central Kentucky was 17.3/1,000 pregnant mares in 1963 (baseline rate of abortion) but decreased to < 2/1,000 in 2002 (Dr. D. Powell, Gluck Equine Research Centre). In their review, Kydd et al. (2006) reported the result of a large-scale, 5-year long, field vaccination trial conducted in the late 1970s (inactivated vaccine Pneumabort K). The reported accumulated incidence for EHV-1 induced abortions was 0.16% (14/8638) in vaccinated Thoroughbred mares when compared with an incidence of 0.68% (140/30732) in the remainder of the study population (Kydd et al., 2006). A recent report from Stasiak et al. (2020) presents EHV-1-abortion incidence data from an Arabian stud in Poland with around 30 mares. The authors report that all mares were routinely vaccinated against EHV-1/4 (Equip EHV-1,4) until 2015–2016. The reported prevalence of abortion was around one per year, with the exception of early 2013 when three mares aborted and no abortions were reported between mid-2013 and 2016. EHV-1/4 vaccination was not

implemented during the 2016–2017 breeding season. In early 2017, eight abortions and one EHV-1-induced neonatal death were reported (30%) (Stasiak et al., 2020).

Clinical experience has demonstrated that vaccination can be useful for reducing clinical signs of respiratory disease and incidence of abortion; however, none of the vaccines protects against neurological disease (OIE, 2019a) (mostly due to the absence of a robust model of the disease).

Emergency vaccination: Report of EHV-1 outbreaks is usually associated with an increase of vaccination, but the implementation of emergency vaccination against EHV-1 and EHV-4 remains a controversial subject, with no clear guidelines or recommendations. The HBLB (Horserace Betting Levy Board) code of practice and the EHV-1 consensus statement from the American College of Veterinary Internal Medicine (ACVIM) do not statute on naive animals (not previously immunised) vaccination in face of an increased risk of contact with EHV-1 (Lunn et al., 2009; HBLB, 2021). An increased risk of EHM has been reported in recently EHV-1-vaccinated horses (Henninger et al., 2007; Ivens, 2014). The American Association of Equine Practitioners (AAEP) mentions the possibility to vaccinate horses that have not been exposed and/or new arrivals in order to stimulate an anamnestic response in previously vaccinated horses (AAEP, 2021).

EHV-1/4 cross-protection: The level of cross-protection between EHV-1 and EHV-4 remains largely unknown in the field. Experimental infection with EHV-4 has been shown to stimulate both antibody and cell-mediated immune response. EHV-4 induced effector cytotoxic cells can lyse EHV-1-infected target cells in vitro (O'Neill, 1995) and a similar cross-priming could exist for the humoral response (Allen and Bryans, 1986; Crabb and Studdert, 1990). However, differences seem to exist after EHV-1 or EHV-4 immunisation. A foal immunised with an inactivated EHV-1 vaccine has been shown to develop a type-specific antibody response, whereas this response was cross-reactive after immunisation with inactivated EHV-4 (Fitzpatrick et al., 1984). CMI induced by a modified live EHV-1 seems to be more cross-reactive in vitro (Ellis et al., 1997).

Parameter 4 – Duration of protection

Onset of immunity (OOI) usually appears 2 weeks after the second immunisation. Duration of immunity is variable depending of the vaccine used. However, most EHV vaccines recommend regular boost immunisation, every 6 months to 1 year (depending of the vaccine; cf. Table 7 Immunisation schedule). A 6-month duration of immunity against clinical signs of disease was reported after immunisation with an inactivated whole EHV-1/4 vaccine adjuvanted with carbomer (Minke et al., 1998; Heldens et al., 2001). Pregnant mares require three immunisations during pregnancy (usually at the 5th, 7th and 9th month of pregnancy), on top of the primo-vaccination and subsequent boost (outside the reproduction programme).

Table 7: Immunisation schedule for the EHV vaccines commercially available in the EU

Vaccine	Claim	Schedule	Administration
Equip® EHV-1,4	• Rhinopneumonia • Infectious abortion	• V1–V2: 4–6 weeks apart • Boost: every 6 months to 1 year	Intra-muscular
Pneumequine® EHV-1	Rhinopneumonia	• V1–V2: 1 month apart • V3: 6 months later	Intra-muscular
Prevaccinol®	Rhinopneumonia	• V1–V2: 3–4 months apart • Boost: every 6 months	Intra-muscular

Feasibility

Parameter 5 – Way of administration

Most EHV vaccines are administered intramuscularly. The schedule of vaccination usually requires two immunisations 4–6 weeks apart (primo-vaccination) and a third immunisation (4–6 months later). Subsequent boost immunisations are recommended every 6 or 12 months, based on the vaccine and/or activity requirement (e.g. FEI rules).

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

Availability

Parameter 1 – Types of drugs available on the market

While numerous antiviral compounds have been tested and found active against EHV-1 and EHV-4 *in vitro* (Thieulent et al., 2019), no antiviral treatment are currently authorised or commercially available against EHV-1 and/or EHV-4 in the EU. Acyclovir and valacyclovir have been tested in natural or experimental infection with EHV-1, with no or little success in terms of protection against clinical signs of disease (Henninger et al., 2007; Maxwell et al., 2008; Goehring et al., 2010; Estell et al., 2015). The use of valacyclovir and valganciclovir against experimental infection with EHV-1 *in vivo*, in the target species, was associated with a reduction of clinical signs of disease and cell-associated viraemia (Maxwell et al., 2017) (Paillot personal communication). There is some report of valacyclovir used in the treatment of EHM in the field.

Parameter 2 – Availability/production capacity (per year)

No antiviral treatment is currently authorised or commercially available against EHV-1 and/or EHV-4 infection in the EU.

Effectiveness

Parameter 3 – Therapeutic effects on the field (effectiveness)

There is some report of acyclovir/valacyclovir use in the field during EHV-1 outbreaks, out of any marketing authorisation, but effectiveness is not known. However, the use of antiviral compounds against EHV-1 in the field is likely to be limited due to the duration of treatment (daily administration for 1–2 weeks), the need to administered antiviral before or at the onset of infection and the associated cost.

Feasibility

Parameter 4 – Way of administration

When used in the context of clinical trials in the target species, valacyclovir and valganciclovir were administered orally, twice daily, mixed with apple puree (Maxwell et al., 2017) (Paillot personal communication). Typical valganciclovir treatment consists in 6.5 mg/kg body weight of valganciclovir three times the first day (D0) and twice daily during 13 days (Paillot et al, personal communication).

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

Availability

Parameter 1 – Available biosecurity measures

EHV-1 and EHV-4 are respiratory pathogens. Horses are usually infected through direct horse-to-horse contact (e.g. nose-to-nose), ingestion of contaminated substances/water, indirect contamination (e.g. inhalation of infectious aerosols or droplets) or contact with fomites (e.g. placenta from aborted fetus, stud farm, etc.). All classical biosecurity measures available for equine pathogens are likely to have a beneficial impact on the spread of EHV-1 and EHV-4. Examples of biosecurity/preventive measures suggested by stakeholders of the horse sector and equestrian organisations include:

- Health monitoring and testing (PCR of nasoparyngeal swabs) of new equids for EHV-1/4 shedding prior to introduction in a new herd;
- Isolation of new equids for at least 3 weeks on arrival in a new premise and/or herd, with regular health monitoring (e.g. rectal body temperature monitoring) and appropriate testing if required;
- Reduced stress. Stress associated with weaning, commingling, poor health (e.g. parasitism) and transportation are recognised as known risk factors for the reactivation of latent EHV-1 and EHV-4;
- Segregation of population at specific risk or separation in small group (e.g. pregnant mares, cf. Section 4.3 for specific details);
- Limitation of contact between visiting and resident equids;
- Classical biosecurity protocols and hygiene measures (e.g. disinfection, dedicated equipment) for personal involved, resident staff and visitors included (e.g. farrier, veterinarians);

- Vaccination of all resident horses;
- Awareness of the epidemiological situation, locally and nationally (e.g. through surveillance network);
- Isolation of animals developing clinical signs of infectious diseases, with appropriate veterinary health care and testing.

Examples of biosecurity measures from different organisations are presented below, for different situations or for different horse categories, e.g. outbreaks, competitions sites, breeding centres, foaling mares.

Example of biosecurity measures in the event of outbreaks:

The following measures of prevention were recommended to horse owners, transporters and event organisers by the RESPE in the context of the surge of EHV-1/4 outbreaks in France in 2018 and following the EHV-1 outbreak in Valencia (Spain) in 2021 (RESPE, 2021a, 2021b, 2021c, 2021d):

- Prior to the event/movement:
  - Establishment of a health certificate including regular recording of the rectal temperature in the 48 h prior to movement;
  - Isolation of any horses with clinical signs of respiratory diseases;
  - Disinfection of all vehicles and avoid transportation of horses from different premises in the same vehicle;
  - Check of vaccination status[5];
  - Avoid attending events with known cases;
- On the event site:
  - Clinical examination on arrival (including rectal temperature monitoring);
  - Limitation of horse density on site (depending on the facilities available) and reduction of contact between horses;
  - Dedicated team/equipment per group or horses;
  - Regular disinfection/cleaning of the premises;
  - Use of personal protective equipment and appropriate hygiene measures for personal directly involved with horses, such as farriers, veterinarians, etc.;
  - Use of disinfectant footbath for personal and vehicles if in the presence of a suspicious case;
  - Census of the horses present in the venue (resident and guest);
  - Standstill of movement in and out the infected venue for at least 21 days from the last EHV-1 case.

Example of existing biosecurity measures recommendations specific to breeding centres:

The following measures were recommended by the RESPE to breeding centres for visiting mares (RESPE, 2021e,f):

- Increase awareness for clients about vaccination recommendation and movement limitation in the 2 weeks preceding the arrival in the breeding centre;
- Implement a visit schedule to limit/avoid mares/horses interaction on site;
- Require a health certificate from mare's owners;
- Check vaccination status and requirements (i.e. up to date vaccination if required);
- For mares with foal at foot, keep the foal in the vehicles, if possible;
- Organise the flow of animals on the premise to avoid unnecessary interaction;
- Hygiene measures and disinfection for the personal and equipment used;
- Dedicated equipment for each mare, if possible.

[5] Vaccination is recommended, not mandatory, thus no action is performed if the animal is not vaccinated. The vaccine does not cover 100% of clinical forms, so there is no 'strength' to impose it as a mandatory measure. In addition, there are also recurring supply problems linked to low demand. The FEI requires vaccination records to be provided for all in-contact horses during an outbreak, in order to further evaluate the severity of the horses' clinical symptoms in relation to their vaccination status. Usually, in the EU and USA, the mandatory vaccination for FEI and race horses is only against equine flu and tetanus.

Example of existing biosecurity measures recommendations specific to pregnant mares:

The following biosecurity measures are summarised from the HBLB code of practice and the RESPE and specifically focused on the prevention of EHV-1 infection in pregnant mares:

- Pregnant mares should be kept separate from all other horses. If possible, pregnant mares at similar stage of pregnancy should be kept together;
- In order to reduce the risk of disease transmission, pregnant mares should be kept on pasture and group should be as small as possible;
- Where possible, mares should foal at home and go to the stallion with a healthy foal at foot;
- If foaling at home is not possible, pregnant mares should go to the stallion or boarding stud at least 28 days before foaling is due. These mares should be placed in quarantine for 2 weeks and then isolated in small groups;
- Pregnant mares should not travel with other horses, particularly mares that have aborted recently;
- Any horse arriving on the premise should be grouped and isolated away from pregnant mares. These horses are more likely to have recently mixed with other animals of unknown EHV infectious and vaccination status;
- Stallions should where possible be housed in premises separate from the mare and should be attended by separate dedicated staff with strict biosecurity measures;
- Strict biosecurity measures should be adopted to minimise indirect transmission of infection between different horse groups on the premise;
- Full vaccination of all resident horses on a premise is recommended (cf. Section 2, Vaccination). Pregnant mares should be vaccinated at 5, 7 and 9 months of gestation.

Example of biosecurity measures recommended at competition sites by FEI:

- Check and record the body temperature of the horse twice daily. Any temperature over 38.5°C should be reported immediately to the FEI Veterinary Authorities;
- Assess the horses' general condition: appetite, drinking, behaviour, breathing rate, heart rate, urination and defecation, eye or nose discharges, how the horse is standing and moving, swollen legs;
- Have dedicated tack/equipment for each horse and disinfect the bit after riding;
- Do not share buckets, no common water troughs;
- Wash and disinfect hands;
- Do not let horses sniff each other, limit contact as much as possible, including human contact, apart from rider and regular groom.

Advice for FEI Organising Committees:

- If local horses are kept at the event site, assess the EHV status of these horses. Ask a veterinarian to sample 10–20% of these horses approximately 10 days before the event;
- Clean and disinfect the stables and other facilities where FEI horses will be;
- Examination on arrival must always be carried out before horses are allowed to enter the FEI stables. It is advised that the temperatures of the arriving horses are recorded;
- Under the current conditions, it is critical that the FEI Veterinarian is given the requested resources in terms of space, possibility to wash and disinfect hands, personnel and resources to run the isolation stable;
- A health certificate of every horse arriving at the venue that is issued within 48 h of departure from the stable of origin is highly recommended. The certificate should state the following:
  - Identity of the horse
  - Identity, contact information and signature of the issuing veterinarian
  - Date and place of issue
  - Statement that the horse has been located at a stable where there have been no signs of EHV infection for the last 14 days;
- Control the density of horses in the warm-up arena. Too many horses on a limited area increases the risk for transmission of the disease;
- Provide hand washing facilities and hand disinfection gel for everyone handling horses.

A temporary measure in place until December 2021 requires, for any event with more than 400 horses of any category, to provide proof of a negative PCR test for EHV-1 taken no earlier than 120 h prior to arrival at the event.

FEI guidelines for horse isolation

The best types of stables to use for isolation are those:

- located outside rather than in a barn;
- located away from other horses;
- which have solid walls from floor to ceiling to create a physical barrier and eliminate shared airspace.

The material from which the stables are made should also be considered as this can impact the ability to clean and disinfect them effectively.

Wooden stables have porous, rough surfaces, which make cleaning and disinfection very difficult. Modifications can be carried out, such as filling holes and knots in the wood with plastic wood products or caulking, and applying marine varnish. This results in a smooth, waterproof surface that is easy to clean and disinfect.

Concrete blocks also have porous, rough surfaces, which can trap organic matter. Appling enamel or heavy duty outdoor paint results in surfaces that can be easily cleaned and disinfected.

Compact and concrete floors and surfaces can be washed and disinfected easily. Sand, dirt or compacted clay floors cannot be adequately cleaned.

Isolation unit access

Only personnel who are looking after the horses in the isolation unit should be given access. This is to prevent the possibility of disease transmission to other horses. Physical barriers constructed around the isolation unit can help to set clear boundaries and prevent inadvertent access.

Always make sure that any other horses are not walked in close proximity to the isolation unit.

Stabling of horses

When planning the stabling of horses in isolation, there are a number of key actions and considerations to be aware of:

- If possible, stable horses in the groups in which they travel and refrain from stabling the horses directly next to each other. It is useful to identify dedicated storage areas for the belongings of each horse to avoid them from being mixed up and used on other horses;
- Attach a clipboard containing the FEI's Temperature Monitoring Record outside each stable for the recording of rectal temperatures;
- Identify a changing area near the entrance of the isolation stables so that clothing and footwear worn in the restricted area are not worn elsewhere;
- Provide hand washing facilities as well as hand disinfection gel for everyone handling horses. Make sure you provide separate protective clothing and footwear for those handling and treating sick horses;
- Communal water troughs must not be used;
- Keep a map of where each horse is stabled in the isolation unit and the dates during which the horse was stabled there. This is particularly helpful information for your veterinarian should any of the horses become ill.

Effectiveness

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

There is limited experimental data or study available to objectively measure the prevention of EHV-1 or EHV-4 introduction on a premise. However, Goerhing et al. (2010a,b) described the management of an EHV-1 outbreak in the equine hospital of the James L. Voss Veterinary Teaching Hospital. The authors reported that once EHV-1 transmission in the hospital was identified and the initial cluster isolated, the implementation of strict biosecurity measures supported by appropriate testing, as described above, allowed to contain the infection (i.e. none of the horse in the in-patient area of the hospital displayed clinical signs of disease or seroconverted) (Goehring et al., 2010d).

Feasibility

Parameter 3 – Feasibility of biosecurity measures

All these biosecurity measures are recommendations. It is not possible to evaluate the level of implementation and compliance in the field as it is highly variable from one event/premise to another. Biosecurity measures as quarantine and segregation of horses in sport events are hardly feasible. Equestrian and race sport events last from one day to more than one week, thus limiting the possibility to apply quarantine.

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

Availability

Parameter 1 – Available movement restriction measures

As the EHV-1 is considered endemic in the European MSs with high prevalences, restrictions of movement can be applied only to animals that could shed the virus and not to animals latently infected that are presumably not contagious. It has to be considered also that the detection of infected animals that hold the virus in latency is not possible and represents a considerable diagnostic challenge (Slater, 2014). Nasal/nasopharyngeal swabs analysed in RT-PCR are used to exclude that a horse is shedding the virus (Lunn et al., 2009) and viral reactivation and consequent shedding can happen after the testing with exposure to any stressors. Serology gives a valuable effect in longitudinal surveillance considering that serological screening with two samples collected in a period of 21 days can detect a seroconversion (i.e. recent exposure to EHV-1; considered positive with an increase of antibodies titre of at least four folds).

Due to latent infection and frequent circulation, it is difficult to find horses that are seronegative for EHV-1 (and EHV-4 also complicates the picture). It is also complicated by the fact that only a few reactivating factors are known, such as transportation stress and some anti-inflammatory treatment). Latent infection is probably one of the reasons that horses have always detectable low levels of antibody against EHV-1. Active infection with EHV-1 associated with recent exposure is strong enough to increase titre in a measurable and meaningful way.

No specific measures are mentioned in the EU legislation for EHV-1 outbreak control. The OIE Code recommends that horses to be moved should not present clinical signs of EHV-1 infection and have been kept for the 21 days prior to shipment in an establishment where no case of EHV-1 infection was reported during that period (OIE, 2019a). In addition, even if vaccination against EHV-1 does not provide a complete protection against the infection, vaccinated horses could be moved with less concern.

During an active EHV-1 outbreak, horses in contact or sharing personnel or facilities with affected (diseased or laboratory test-positive animals) should be considered exposed to the virus and at risk of being infected. They should remain confined and a strict movement standstill in and out the premise must be implemented. Healthy animals could be admitted in the affected premise only if an isolated and separate facility can host the horse. The quarantine will end 21–28 days after the last case occurrence (Allen et al., 2004). Horses leaving the affected premise can be place in 14 days quarantine at the arrival in a new premise.

After an EHV induced abortion in a stud farm, Codes of practice of Horse Associations and Bodies (https://codes.hblb.org.uk/index.php/page/76) usually recommend the following:

- pregnant mares due to foal in the current season must stay on the premises until they foal a healthy foal;
- mares that have aborted must be isolated from other horses for 28 days after abortion and from pregnant mares due to foal that season and mares in early pregnancy for the remainder of that season;
- mares that return home pregnant from premises where abortion occurred the previous season should foal in isolation at home.

Effectiveness

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

The ban of animal movements for at least 21–30 days (van Maanen and Cullinane 2002; Allen et al., 2004; Khusro et al., 2020) from the resolution of clinical signs in all horses in an EHV-1 outbreak is effective in avoiding further spread of the disease from an infected premise. Ban on movement into

an infected premise avoids the infection of new susceptible animals. Therefore, restriction to horse movements can be efficiently applied in the control of an outbreak. The spread of EHV-1 between premises is unusual, but it can happen as a result of movement of horses before the infection is diagnosed or, more rarely, in case owners move horses from affected premises. Dispersal of horses from an equestrian event such as the Valencia venue can result in wide geographic disease spread.

The efficacy of this measure could be weakened by the under-reporting of the disease due to the lack of compulsory notification in EU legislation. Compulsory notification has an inherent risk in that it may result in reluctance to investigate neurological cases and submit samples for laboratory analysis.

Feasibility

Parameter 3 – Feasibility of restriction of animal movement

The restriction of horse movement appears to be hardly feasible for the frequent movements of sport and race horses in short-term events. It can be more easily applied in breeding farms or long-period horse movements where a quarantine procedure is more practicable. In case of an active outbreak during an equestrian or race events, like the one in Valencia, movement restrictions must be applied also if hardly feasible and horses must be kept on the affected premise.

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

Availability

Parameter 1 – Available killing of animal measures

Due to the endemic presence and circulation of EHV-1 and EHV-4, and the establishment of latency after a primo-infection, killing of equids naturally infected with EHV-1 or EHV-4 is not conducted in the field. However, due to the establishment of latency after infection with EHV-1 and the risk of subsequent reactivation, rehoming is not recommended for horses experimentally infected with EHV-1 in the context of EHV-1 vaccine and challenge trials or other clinical studies. As a consequence, euthanasia is usually applied to experimental horses in order to avoid litigation in case of reactivation (R. Paillot, personal communication).

Effectiveness

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

Due to the endemic nature of EHV infection and the establishment of latent infection, killing EHV-1- or EHV-4-infected animals is not conducted at premise level and is unlikely to have any impact on the spread of the disease.

Feasibility

Parameter 3 – Feasibility of killing animals

Not carried out as a control measure for EHV-1, only in case of EHM animals may be euthanised.

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

Availability

Parameter 1 – Disposal options available

Aborted fetus and fomites are known source of EHV-1 or EHV-4 contamination. The conventional methods of biological material disposal, such as incineration, should be applied.

Effectiveness

Parameter 2 – Effectiveness of disposal options

Incineration of carcasses is the conventional method of disposal applied during terminal (i.e. no re-use or rehoming of experimental animals) vaccination/challenge clinical trials.

Feasibility

Parameter 3 – Feasibility of disposal options

Existing equid carcass removal and cremation services are appropriate.

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 indirectcosts for the affected sectors and the economy as a whole

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

Prevention cost: EHV vaccine and veterinary costs will vary from country to country. A horse will require three immunisations in the first year of vaccination (primo-vaccination) and subsequent boost every 6 months to one year depending of the country, regulation and activity. This would mean at least 75 euro for only the cost of the vaccine in the first year, excluding visit cost of the veterinarian. A pregnant mare specifically requires three immunisations during pregnancy (usually at the 5th, 7th and 9th months of pregnancy), on top of the primo-vaccination and subsequent boost (outside the reproduction programme).

EHV-1/4 outbreak cost: Due to the multiple forms of disease that could be induced by EHV-1 and EHV-4 infection (respiratory, abortion and EHM) and the variable value of the horses on the affected premise, the cost of control is difficult to calculate and little information is available, although the highest impact of EHV outbreak control is largely represented by economic losses induced by movement restriction in case sport events or competitions have to be cancelled. The cost report associated with an EHV-1 outbreak that occurred in a Thoroughbred breeding centre in France in 2009 (Moreau et al., 2012) could be used as an example. This breeding centre housed 169 horses (60 broodmares, 44 with and 16 without a foal and 65 yearlings) at the time of the EHV-1 outbreak. Overall, two EHM cases, 23 cases of respiratory disease and four abortions were reported over a period of nine and a half months (Sutton et al., 2019). The cost details (in 2009) were reported as follows:

- Cost associated with EHM cases:
  - Mare A (died):
    - Medical treatment: €1,400
    - Estimated cost of the lost mare: €300,000 (insurance value)
    - Post-mortem examination: €160
  - Mare B (survived):
    - Medical treatment: €1,500
- Cost associated with the respiratory cases (**per diseased foal, 23 foals affected in total**):
  - Diagnostic testing:
    - Sampling (swabs and blood): €80
    - PCR diagnostic: €43
  - Medical treatment: €15 to €40
- Infectious abortion (**per abortion; 4 abortions in total**):
  - Examination, sampling and medical treatment: €200 to €400
  - Diagnostic: free as conducted in the context of RESPE (French surveillance programme) but would have costed around €43 otherwise
  - Post-mortem examination of the fetus: €30
  - Estimated cost per lost foal: from €20,000 to €100,000 € (insurance value)
- Other cost (no value reported):
  - PPE, CCTV camera installation for stable monitoring. Two teams for night shift, movement restriction on the premise, etc.

All costs presented here applied to France in 2009 for a total of around €8,000 for this specific breeding centre alone, excluding the insured value of lost animals. For reference, France registered 47,666 equid births in 2018 (IFCE, 2019a) and 34,702 breeders in 2019 (CCN, 2019).

The running cost of quarantine procedure at the premise level is dependent of numerous factors, such as the size of the premises, the number of new arrivals, etc. The Redwing Horse Sanctuary (United Kingdome) quarantine procedure for new arrival could be used to evaluate the cost of such

operation. Redwing Horse Sanctuary is the largest UK horse sanctuary with around 1,500 equids and conducts a strict quarantine for all new arrivals (around 200 equids every year). This quarantine is primarily targeting strangles, a bacterial respiratory infection of equids but most procedures in place would be applicable to EHV. Redwing Horse Sanctuary reported that the costs of running their quarantine facilities, including disinfectant, PPE, diagnostic tests for new arrivals and yard staff time was £7,814 per month (around €9,130 per month) in 2016 (Redwing Horse Sanctuary, 2017).

Parameter 2 – Cost of eradication (culling, compensation)

EHV-1 and EHV-4 are endemic in most EU countries. At the current time, eradication is not feasible for EHV-1 or EHV-4 but for reference, the cost of controlling and eradicating equine influenza (the other major equine respiratory disease) in Australia during the major 2007 outbreak, was estimated to have reached US$1 billion. The control and eradication strategies included movement interdiction and restriction, vaccination, tracing, testing and surveillance (Paillot et al., 2016).

Parameter 3 – Cost of surveillance and monitoring

The cost of the establishment/running of a surveillance network for equine disease is significant. Such surveillance network involves a dedicated core team, the voluntary participation of sentinel equine practitioners (for reference, the RESPE involved around 800 sentinel veterinarians in France) and designated diagnostic laboratories. In the UK, the equine influenza surveillance programme was funded by the Horserace Betting Levy Board (HBLB, 2020). In 2019, the HBLB applied some £357,000 (around €415,000) for this operation alone and the same amount was announced for 2020 (HBLB, 2020). For reference, the HBLB has given £1.3 million (around €1.5 million) since 2013 for equine welfare research (surveillance operation excluded). Beyond staff and running charges, the cost of equine disease surveillance is primarily associated with the shipment of samples and diagnostic analyses. In France, the RESPE covers 50% of the diagnostic cost (cf. Section 69) for up to three cases on a premise. In the UK, equine influenza samples were covered at 100% by the surveillance network. The Department of Agriculture Food and the Marine contributes €250,000 annually to the running of the OIE reference laboratories for equine rhinopneumonia and equine influenza at the Irish Equine Centre. This assists with surveillance, testing during outbreaks nationally and internationally, virus typing and the supply of reference standards, diagnostic reagents and proficiency tests to MS and other OIE member countries (Cullinane, personal communication).

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

Not relevant.

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

The horse sector is complex and diverse and ranges from high-value sport horses with a remarkable income to backyard horse with no economic, but important emotional value. Therefore, economic impact is highly variable depending on the horse sector, but many authors reported it as notable (Reed and Toribio, 2004; Ma et al., 2013; Slater, 2014; Oladunni et al., 2019). The losses associated with respiratory disease due to lost training time and poor sport performance are unquantified (Gilkerson et al., 1999), but have to be considered. Late-term abortion can have a major impact in the breeding sector. The neurological form of the disease can lead to horse death, training interruption, sport horse competitions cancelation and extensive movement restrictions. Recover from the disease and related expense for veterinary care, pharmaceutical treatment and the delay on horse training or use purpose can sum up to thousands of euros per horse (Oladunni et al., 2019).

In Europe, the disease is endemic and many outbreaks occur yearly in MSs, managed at sector level or farm level. As the outbreak is often self-limiting in the farm, they are often seen as a normal business risk. A thesis on commercial Dutch sector estimates the impact in two scenarios, a self-limited EHM outbreak in a Dutch riding school and a Belgian outbreak with more than a premise involved. An estimated cost of about 26,000€ and 85,000€ were calculated, respectively (Vollebregt, 2014).

In the EU (and United Kingdom), based on the World Horse Welfare and Eurogroup for Animals, the number of equids reached 7 million in 2018–2019 (Table 8).

Table 8: Number of equids in MSs (World Horse Welfare and Eurogroup for Animals, 2018/2019)

MS	Size of equine population	MS	Size of equine population
France	840,259 (1,106,000 according to J. Arthuis report 2018)	Finland	74,100
Romania	728,814	Greece	70,443
Spain	681,334	Czech Republic	33,175
Belgium	535,897	Lithuania	26,803
Germany	480,500	Croatia	24,300
Italy	468,851	Slovenia	23,000
Netherland	293,500	Latvia	11,000
Poland	276,188	Estonia	8,250
Sweden	229,000	Slovakia	7,372
Portugal	179,000	Cyprus	7,350
Ireland	159,200	Luxembourg	4,887
Denmark	121,500	Malta	1,860
Austria	103,250		
Bulgaria	97,500		
Hungary	77,180		
Other countries			
United Kingdom	796,000		

As mentioned earlier, the cost of an EHV outbreak is variable, depending on the clinical form of EHV-1 involved, the horse population affected and the extent of the outbreak and the type of measures applied. The economic burden of an outbreak of EHV-1 consists of medical treatment, biosecurity measures, lost time for training and performing and even death of the horse. As mentioned above and for example, the average number of equid birth by breeder in France is 1.4 (i.e. 47,666 births for 34,702 registered breeders in 2018–2019). This tends to indicate that a majority of breeders in France have only one–two births a year. In this condition, any EHV-1-related abortion is likely to have a major impact for a whole breeding season at the individual breeder level.

Example: the 2018 EHV outbreak in France:

A retrospective study conducted by the IFCE[6] (*Institut français du cheval et de l'équitation* (French Horse institute)) about the EHV-1/4 outbreaks in France in 2018 provides an idea of the importance of the disease for the French equine industry (IFCE, 2019a).

From 1 March to 30 June 2018:

- Type of equine centre affected (n = 39 premises, 73 cases reported to the RESPE) and associated loss:
  - Breeding centres: 8 affected, average loss of €22,039, total loss of €176,312.
  - Leisure centres: 3 affected, average loss of €47,400, total loss of €142,200.
  - Livery yards: 6 affected, average loss of €15,300, total loss of €91,800.
  - Unknown: 22 affected, average loss of €24,136, total loss of €530,992.
- Total loss of €940,000.

The costs mentioned in this report are limited to the EHV outbreak reported to the RESPE during this period and include veterinary care, travel/visit cost, sampling and diagnostic testing, loss due to centre shutdown or decreased activity. It is estimated that only half of the EHV outbreak were reported to the RESPE. Therefore, the overall cost is estimated to have reached €1,880,000 for the affected premises.

The number of events (all categories) taking in place in France during this same period was estimated at around 7,000. The cost of biosecurity measures, testing and health certificate (€23 per horse on average) specifically put in place during this period was estimated to have reached €1,100,000.

[6] https://www.ifce.fr/

Six hundred events were cancelled during this same period in link to the EHV crisis (with the caveat that not all cancellation can be solely attributed to EHV-1/4 infection and circulation).[7] The overall loss associated with events cancellation was €2,400,000 (€287,000 for the FFE (Fédération Française d'Equitation) and €2,154,000 for the event organisers).

Impact of the outbreak on local economies: based on data associated with equestrian events in three different French regions in 2017 (*CSO amateur et pro de Deauville*: 1,091 participants in 2017; *Jumping amateur et pro de Cabourg*: 2,805 participants in 2017 and *Concours de dressage international* *** de Saumur: 276 participants in 2017), it was estimated that impact on local economy was €1.87 for €1 of event organisation budget. Based on these data, the cost of the EHV outbreak for the local economy associated with these three major events was estimated to have reached €1,070,000.

The study authors concluded that the direct cost of the EHV outbreak ranged between €4,400,000 and €5,400,000, with an additional €1,070,000 on local economy.

For reference, in 2018, the French equine industry has generated €10,825 M (IFCE, 2019b):

- €9,737 M associated with horse racing (sales: €98 M; pension: €315 M; business: €176 M and betting: €9,148 M);
- €1,066 M associated with sport, leisure and work (reproduction: €8 M; pension: €878 M and business: €180 M);
- €22 M associated with the horse meat industry.

3.1.5.2. Article 7(e)(ii) Their societal acceptance

Horse owners can be reluctant to accept the horse movement standstill for at least 21 days in a sport or race horse venue, where an EHV-1 outbreak is notified.

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

Animal welfare is not affected by control measures applied for EHV-1 infection.

Parameter 2 – Wildlife depopulation as control measure

Wildlife depopulation is not implemented as a control measure for EHV-1.

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)

The possible environmental impact of residues of supportive pharmaceutical therapy to EHV-1 clinical diseased horse and environmental products for cleansing disinfection have to be considered, although there is no specific evidence available.

Biodiversity

Parameter 2 – Mortality in wild species

There are no reports on mortality in wildlife species due to control measures applied for EHV-1 infection.

3.2. Assessment of EHV-1 infection according to Article 5 criteria of the AHL on its eligibility to be listed

In Table 9 and Figure 2, the results of the expert judgement on the criteria of Article 5 of the AHL about EHV-1 are presented, including the estimated overall probability of EHV-1 infection fulfilling the criteria of Article 5 on its eligibility to be listed. The distribution of the individual answers (probability ranges) provided by each expert for each criterion are reported in Annex 6.2.

[7] Cancellations were a response of the EHV-1/4 epidemic, all disease types included, not just limited to EHM. There were 58 EHV-1 outbreaks reported in 2018 in France. Cancellation was the decision of event organisers in agreement with their veterinary structures. Such response was considered proportionate by the French Equine Industry representatives and Veterinary authorities.

Table 9: Outcome of the expert judgement on the Article 5 criteria

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		**Outcome**			
		Median range (%)	**Criterion fulfilment**	**Number of 'not applicable (n.a.)'**	**Number of experts**
A(i)	The disease is transmissible	99–100	Fulfilled	0	20
A(ii)	Animal species are either susceptible to the disease or vectors and reservoirs thereof exist in the Union	99–100	Fulfilled	0	20
A(iii)	The disease causes negative effects on animal health or poses a risk to public health due to its zoonotic character	95–100	Fulfilled	0	20
A(iv)	Diagnostic tools are available for the disease	99–100	Fulfilled	0	20
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	33–90	Uncertain	0	20
At least one criterion to be met by the disease: In addition to the criteria set out above at point 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	66–95	Fulfilled	0	20
B(ii)	The disease agent has developed resistance to treatments and poses a significant danger to public and/or animal health in the Union	10–33	Not fulfilled	17	20
B(iii)	The disease causes or could cause a significant negative economic impact affecting agriculture or aquaculture production in the Union	10–33	Not fulfilled	0	20
B(iv)	The disease has the potential to generate a crisis or the disease agent could be used for the purpose of bioterrorism	0–10	Not fulfilled	0	20
B(v)	The disease has or could have a significant negative impact on the environment, including biodiversity, of the Union	5–30	Not fulfilled	0	20

In Figure 2, the outcome of the expert judgement on the Article 5 criteria is graphically shown together with the overall probability for EHV-1 infection on its eligibility to be listed.

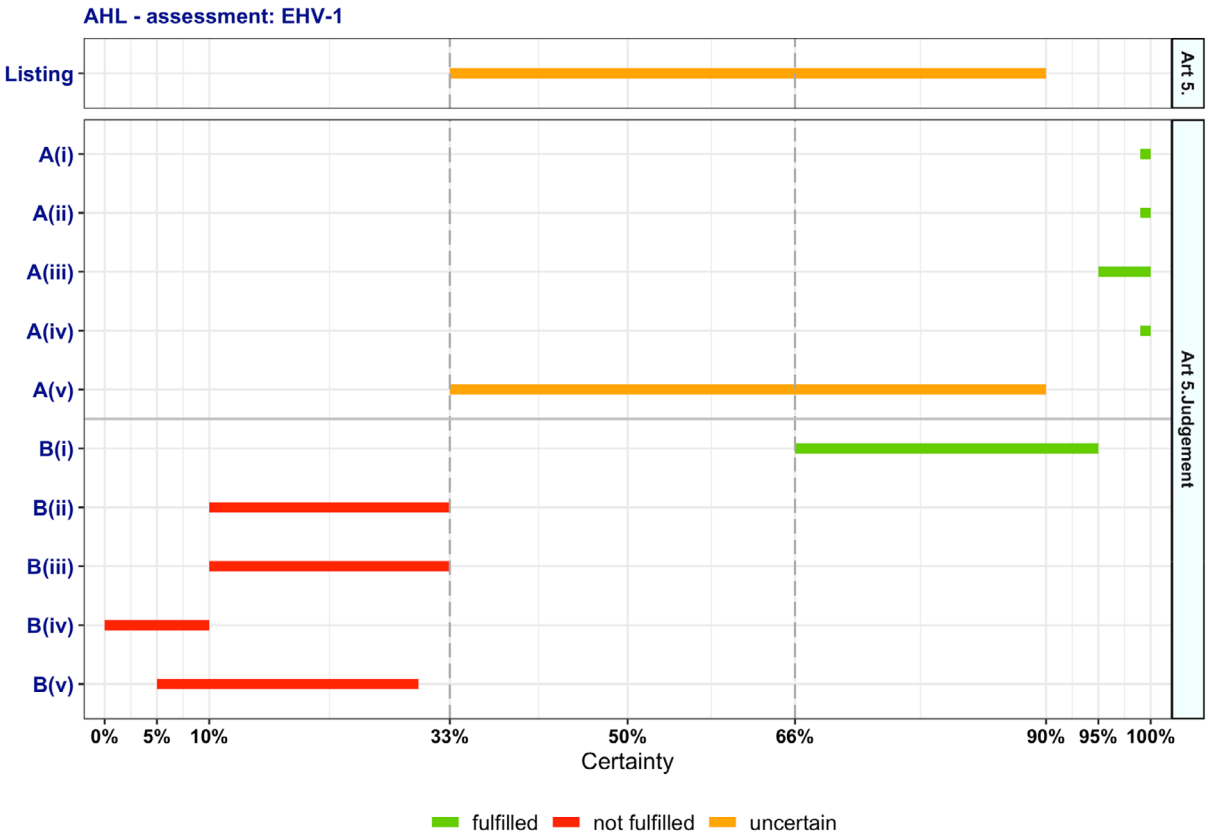

Figure 2: Outcome of the expert judgement on the Article 5 criteria and overall probability for EHV-1 infection on its eligibility to be listed. 'Listing': it is the overall outcome of the assessment, the probability of the disease to be listed according to criteria in Art. 5 of the AHL

3.2.1. Reasoning and arguments for uncertain assessment on criteria

Criterion 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

- Limited data are available about the effectiveness of risk-mitigating measures. At regional and national level, testing and movement restrictions may be considered, but because diagnostic testing is inaccurate in detecting latent infection and since factors for re-activation of the infection are not known, the effectiveness of these measures is uncertain. The measures appear to be at least relatively effective in reducing morbidity and fatality in naïve animals.
- There are no official control programmes and the level of surveillance of EHV outbreaks is highly variable between MSs. This is further complicated by the absence of notification requirements. The absence of compulsory notification may lead to underreporting and skipping the application of containment measures (e.g. movement restrictions). The control is therefore often at farm level, where biosecurity measures seem to be effective.
- Vaccination is not compulsory and availability of vaccines differs between MSs. The efficacy and effectiveness against the different forms of disease induced by EHV-1 or EHV-4 are variable.
- The clinical forms caused by EHV-1 are in general not too severe (apart from neurological forms) and the risks posed are relatively low. Therefore, the risk-mitigating measures may be proportionate to the risks posed by the disease.
- It is questionable whether the disease would fade out by itself without risk-mitigating measures in place.

3.2.2. Overall outcome

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, a criterion is considered fulfilled when the median range lays above 66%.

According to the results shown above, EHV-1 complies with four criteria (more than 95% certainty) of the first set (from A(i) to A(v)), but there is uncertainty (**33% to 90% certainty)** on the assessment on compliance with criterion A(v) that EHV-1 can be considered eligible to be listed for Union intervention as laid down in Article 5 of the AHL. The computed overall probability range for the disease being eligible to be listed is 33–90% (Figure 2).

3.3. Assessment of EHV-1 infection according to criteria in Annex IV for the purpose of categorisation as in Article 9 of the AHL

In Tables 10–14 and related graphs (Figures 3–5), the results of the expert judgement on EHV-1 infection according to the criteria in Annex IV for the purpose of categorisation as in Article 9 of the AHL are presented.

Table 10: Outcome of the expert judgement related to the criteria of Section 1 of Annex IV (category A of Article 9) for EHV-1

Criteria to be met by the disease: The disease needs to fulfil **all** of the following criteria		**Outcome**			
		Median range (%)	**Criterion fulfilment**	**Number of NA**	**Number of experts**
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	0–1	Not fulfilled	0	20
2.1	The disease is highly transmissible	33–66	Uncertain	0	20
2.2	There are possibilities of airborne or waterborne or vector-borne spread	10–33	Not fulfilled	0	18
2.3	The disease affects multiple species of kept and wild animals OR single species of kept animals of economic importance	95–99	Fulfilled	0	17
2.4	The disease may result in high morbidity and significant mortality rates	5–10	Not fulfilled	0	17
At least one criterion to be met by the disease: In addition to the criteria set out above at point 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	0–1	Not fulfilled	0	20
4	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	33–66	Uncertain	0	18
5(a)	The disease has a significant impact on society, with in particular an impact on labour markets	10–33	Not fulfilled	0	19
5(b)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	10–66	Uncertain	0	19
5(c)	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	5–10	Not fulfilled	0	19
5(d)	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	10–66	Uncertain	0	19

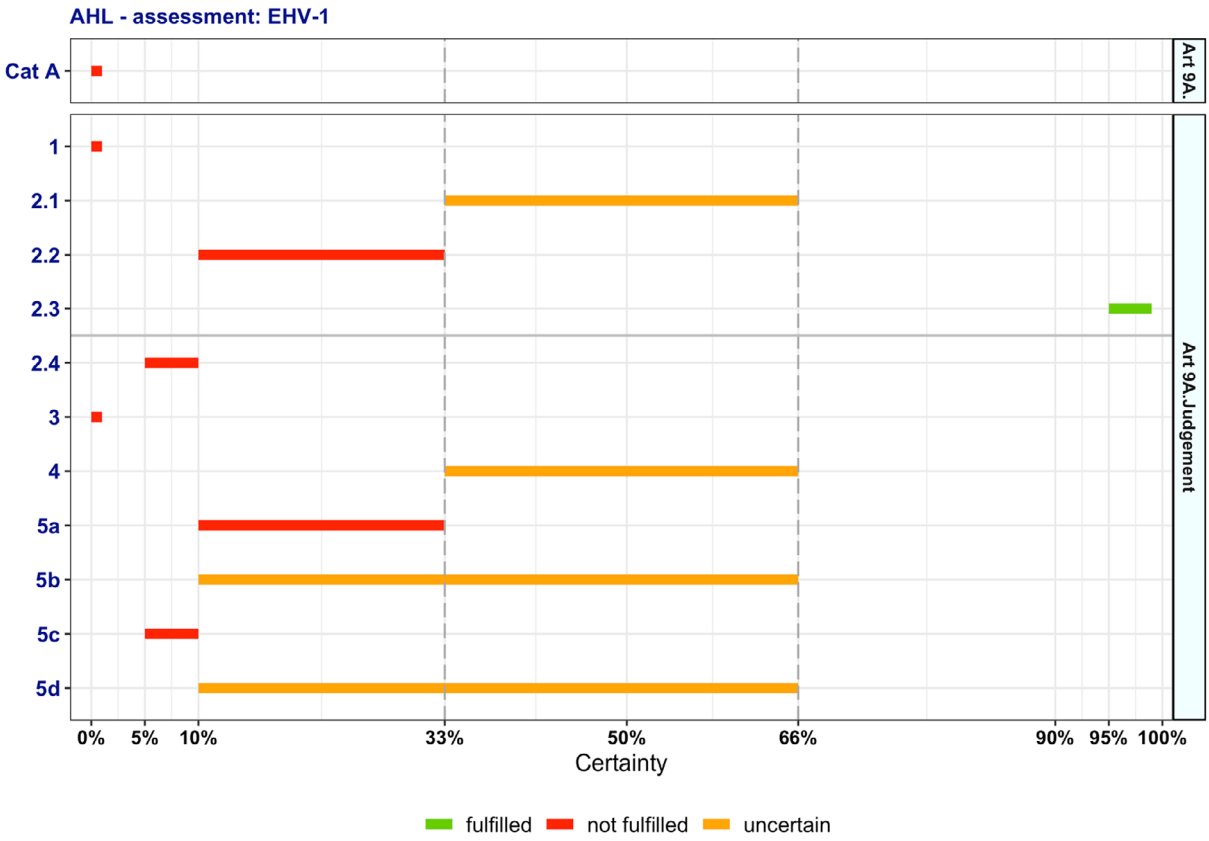

Figure 3: Overall probability range for categorisation of EHV-1 according to criteria of Section 1 of Annex IV (category A of Article 9) for EHV-1

3.3.1. Reasoning for uncertain assessment on criteria

Criterion 2.1: The disease is highly transmissible

- Transmissibility is variable with low transmission rates in the most common EHV-1 respiratory form (35% of foals were found positive at 27 days of age in a naïve exposed herd) and higher for the less common neurological illness (with high R0 of about 3–10).
- Given the widespread distribution, it seems likely that the disease is easily transmitted.
- The transmissibility can be high under certain circumstances, e.g. during large gatherings of horses, as at the outbreak in Spain in early 2021.

Criterion 4: 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

- Detailed information on the economic impact induced by EHV-1 infection in EU is lacking, although considering the whole economy of the Union, EHV-1 is not considered to have a major impact. There may be a significant impact when considering the horse sector alone.
- The major impact is due to risk-mitigating measures that may lead to cancellation of equestrian and racehorse events with a huge economic impact for the sector. On the other hand, the direct impact on health and productivity of animals is low, also due to low morbidity rates of clinical forms of EHV-1 infection.
- Outbreaks leading to abortion storms and mortality (perinatal death) have been reported, and this may be an economic problem, especially in breeding farms.
- If occurred frequently, outbreaks like the one reported in Valencia in 2021 may have a considerable economic impact because of high-value affected horses.

Criterion 5b: the disease has a significant impact on animal welfare, by causing suffering of large numbers of animals

- Proper estimates of clinical disease are lacking although prevalence of clinical infection is low, and no potential emergence of highly virulent strains is identified.

- In some cases, the disease can be serious (welfare impact is mainly due to abortions and EHM); therefore, there is large uncertainty. Horses with clinical signs can be treated and their pain can be relieved.
- In EHM cases, attention to horse welfare should be paid. When neurological signs develop and fatalities occur in horses, the horse welfare is severely affected. Cases of EHM may require euthanasia on welfare grounds (e.g. recumbent animal and/or distress associated with paralysis). EHV-induced respiratory disease is mild to moderate but could lead to serious and life-threatening secondary bacterial infection.

Criterion 5d: 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

- There is no information about possible impact on equine rare breeds in the EU, although donkeys may be impacted.
- There is no impact on wild animals in the EU. Zoo animals may be affected, but this has no impact on biodiversity in the EU. However, non-EU endangered species are susceptible to EHV infection.

Table 11: Outcome of the expert judgement related to the criteria of Section 2 of Annex IV (category B of Article 9) for EHV-1

Criteria to be met by the disease: The disease needs to fulfil all of the following criteria		**Outcome**			
		Median range (%)	**Criterion fulfilment**	**Number of NA**	**Number of experts**
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	1–5	Not fulfilled	0	20
2.1	The disease is moderately to highly transmissible	66–95	Fulfilled	0	19
2.2	There are possibilities of airborne or waterborne or vector-borne spread	10–33	Not fulfilled	0	18
2.3	The disease affects single or multiple species	95–99	Fulfilled	0	17
2.4	The disease may result in high morbidity with in general low mortality	66–90	Fulfilled	0	17
At least one criterion to be met by the disease: In addition to the criteria set out above at point 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	0–1	Not fulfilled	0	20
4	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	33–66	Uncertain	0	18
5(a)	The disease has a significant impact on society, with in particular an impact on labour markets	10–33	Not fulfilled	0	19
5(b)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	10–66	Uncertain	0	19
5(c)	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	5–10	Not fulfilled	0	19
5(d)	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	10–66	Uncertain	0	19

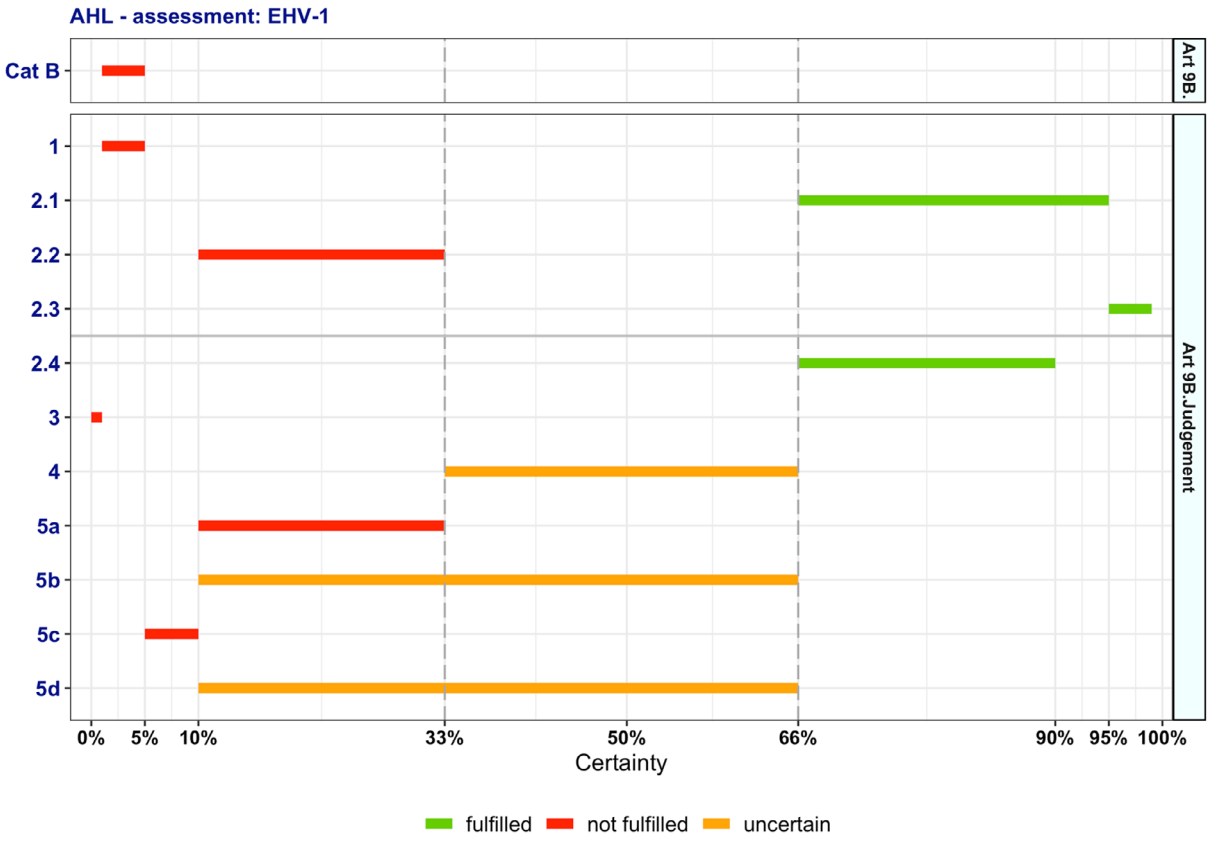

Figure 4: Overall probability range for categorisation of EHV-1 according to criteria of Section 2 of Annex IV (category B of Article 9) for EHV-1

3.3.2. Reasoning for uncertain assessment on criteria

Criteria 4, 5b, 5d:

Same criteria as in Section 3.3.1 above (category A).

Table 12: Outcome of the expert judgement related to the criteria of Section 3 of Annex IV (category C of Article 9) for EHV-1

	Criteria to be met by the disease: The disease needs to fulfil all of the following criteria	**Outcome**			
		Median range (%)	**Criterion fulfilment**	**Number of NA**	**Number of experts**
1	The disease is present in the whole OR part of the Union territory with an endemic character	95–99	Fulfilled	0	20
2.1	The disease is moderately to highly transmissible	66–95	Fulfilled	0	19
2.2	The disease is transmitted mainly by direct or indirect transmission	99–100	Fulfilled	0	20
2.3	The disease affects single or multiple species	95–99	Fulfilled	0	17
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	33–66	Uncertain	0	17
	At least one criterion to be met by the disease: In addition to the criteria set out above at point 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	0–1	Not fulfilled	0	20

	Criteria to be met by the disease: The disease needs to fulfil all of the following criteria	Outcome			
		Median range (%)	Criterion fulfilment	Number of NA	Number of experts
4	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	10–66	Uncertain	0	19
5(a)	The disease has a significant impact on society, with in particular an impact on labour markets	10–33	Not fulfilled	0	19
5(b)	The disease has a significant impact on animal welfare, by causing suffering of large numbers of animals	10–66	Uncertain	0	19
5(c)	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	5–10	Not fulfilled	0	19
5(d)	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	10–66	Uncertain	0	19

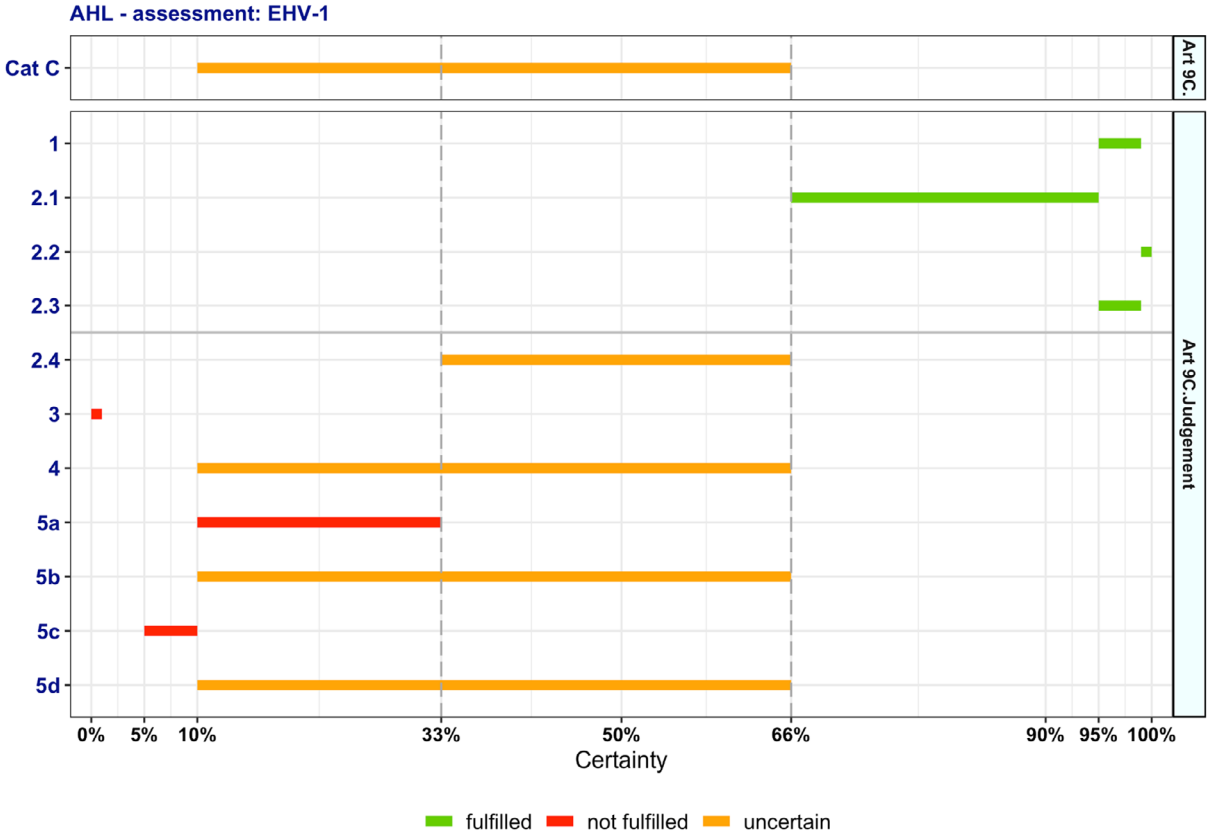

Figure 5: Overall probability range for categorisation of EHV-1 according to criteria of Section 3 of Annex IV (category C of Article 9) for EHV-1

3.3.3. Reasoning for uncertain assessment on criteria

Criterion 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

- There is a high variation in case morbidity of EHV-1 infection, depending on strain and other factors. Latent infection is in general widely present in equine populations (> 60% of horses infected worldwide), while clinical signs have a median morbidity of 10.6%, which though can

be considered high. Among these forms, the respiratory forms are the most common, followed by abortion and neurological forms. Mortality is in general low or negligible.
- Abortions and loss of foals as well as reduction in performance can be considered production loss.

Criterion 4 (C): 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

- Considering the whole horse sector as a type of production system, the impact of EHV-1 infection on the economy of the Union can be considered significant. However, only a very small part of the horse sector (equestrian and racehorse sector) may be affected.
- The disease affects horses in all keeping systems. The economic losses are likely larger in horses of higher value regardless the keeping system.
- Breeding farms, stables and riding schools may suffer economic losses when affected by EHV-1.
- Sport, race and exhibition events involving horses from many establishments may result in outbreaks that have significant impact.

Criteria 5b, 5d

See Section 3.3.1 above (category A).

Table 13: Outcome of the expert judgement related to the criteria of Section 4 of Annex IV (category D of Article 9) for EHV-1

Diseases in category D **need to fulfil criteria of Section 1, 2, 3 or 5 of Annex IV of AHL** and the following:		Outcome			
		Median range (%)	**Criterion fulfilment**	**Number of NA**	**Number of experts**
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	66–90	Fulfilled	0	19

Table 14: Outcome of the expert judgement related to the criteria of Section 5 of Annex IV (category E of Article 9) for EHV-1

Diseases in category E **need to fulfil criteria of Section 1, 2 or 3 of Annex IV of AHL** and/or the following:		Outcome	
		Median range (%)	**Fulfilment**
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 for being listed, consequently category E would apply.)	33–90	Uncertain

3.3.4. Reasoning for uncertain assessment on criteria

Since the assessment on category E depends on criteria of Article 5, see above for the reasoning related to criterion A(v).

3.3.5. Outcome

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 points (a) to (e) of Article 9(1) of the AHL) if it 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 10–14. According to the assessment methodology (Section 2), a criterion is considered fulfilled when the median range lays above 66%.

The overall outcome of the assessment of criteria in Annex IV for EHV-1 for the purpose of categorisation as in Article 9 of the AHL is presented in Table 15 and Figure 6.

Table 15: Outcome of the assessment of criteria in Annex IV for EHV-1 for the purpose of categorisation as in Article 9 of the AHL (green: criterion fulfilled, yellow: uncertainty; red: not fulfilled; the median range is provided)

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	0–1	33–66	10–33	95–99	5–10	0–1	33–66	10–33	10–66	5–10	10–66
B	1–5	66–95	10–33	95–99	66–90	0–1	33–66	10–33	10–66	5–10	10–66
C	95–99	66–95	99–100	95–99	33–66	0–1	10–66	10–33	10–66	5–10	10–66
D	66–90										
E	33–90										

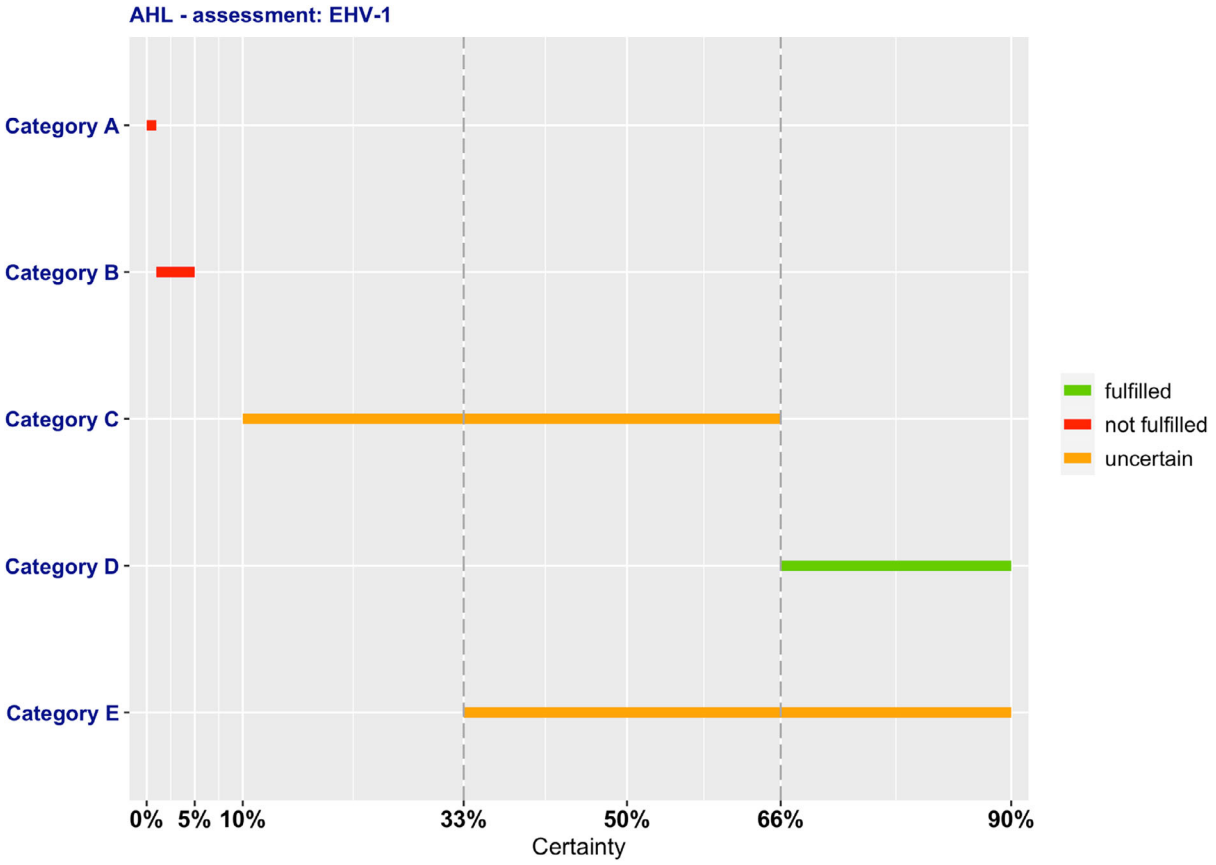

Figure 6: Overall probability range for categorisation of EHV-1 according to criteria in Annex IV for the purpose of categorisation as in Article 9 of the AHL

According to the assessment here performed, EHV-1 complies with the following criteria of 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, EHV-1 complies with criterion 2.3 (more than 95% certainty) but not with 1 (less than 1% certainty), 2.2 and 2.4 (5–10% certainty). The assessment was inconclusive on compliance with criterion 2.1 (33–66% certainty). For being eligible for category A, a disease needs to comply additionally with one of the criteria of the second set (3, 4, 5a-d), and EHV-1 does not comply with criteria 3, 5a and 5c. The assessment was inconclusive on compliance with criteria 4, 5b and 5d. Overall, it was assessed with less than 1% (almost impossible) certainty that EHV-1 may be assigned to category A according to criteria in Annex IV of the AHL for the purpose of categorisation as in Article 9.
2) For being 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, EHV-1 complies with criteria 2.3 (more than 95% certainty) and 2.4 but not with 1 (1–5% certainty) and 2.2 (10–33% certainty). For being eligible for category B, a disease needs to comply additionally with one of the criteria of the second set (3, 4, 5a-d), and EHV-1 does not comply with criteria 3 (less than 1% certainty), 5a (10–33% certainty), 5c (5–10% certainty). The assessment was inconclusive on compliance with criteria 4 (33–66% certainty), 5b (10–66% certainty) and 5d (10–66% certainty). Overall, it was assessed with less than 5% certainty (extremely unlikely) that EHV-1 may be assigned to category B according to criteria in Annex IV of the AHL for the purpose of categorisation as in Article 9.
3) For being 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, EHV-1 complies with criteria 1, 2.1, 2.2 and 2.3, but the assessment was inconclusive on compliance with criterion 2.4 (33–66% certainty). For being eligible for category C, a disease needs to comply additionally with one of the criteria of the second set (3, 4, 5a-d), and EHV-1 does not comply with criteria 3 (less than 1% certainty), 5a (10–33% certainty), and 5c (5–10% certainty). The assessment was inconclusive on compliance with criteria 4, 5b and 5d (10–66% certainty). Overall, it was assessed with 33–66% certainty (about as likely as not) that EHV-1 may be assigned to category C according to criteria in Annex IV of the AHL for the purpose of categorisation as in Article 9.
4) For being 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 EHV-1 complies (66–90% certainty).
5) For being 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, for which the assessment is inconclusive with a large uncertainty (33–90%).

3.4. Assessment of EHV-1 infection according to the criteria of Article 8

In this section, the results of the assessment on the criteria of Article 8(3) of the AHL about EHV-1 are presented. 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.[8] 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 animal species to be listed for EHV-1 according to the criteria of Article 8(3) of the AHL are as displayed in Table 16 (elaborated from data reported in Section 3.1.1.1).

Table 16: Animal species to be listed for EHV-1 according to criteria of Article 8

	Order	Family	Genus/species
Susceptible	Perissodactyla	Equidae	All
		Tapiridae	Indian tapir (*Tapirus indicus*)
		Rhinocerontidae	Indian rhinoceros (*Rhinoceros unicornis*)
			Black rhinoceros (*Diceros bicornis*)
	Carnivora	Ursidae	Polar bear *(Ursus maritimus*)
			American black bear (*Ursus americanus*)
		Felidae	Cat (*Felis catus*)
	Rodentia	Caviidae	*Cavia*
		Cricetidae	Syrian hamster (*Mesocricetus auratus*)
		Muridae	House mouse (*Mus musculus*)
	Artiodactyla	Bovidae	Domestic cattle (*Bos taurus*)
			Thomson's gazelle (*Eudorcas thomson*)
			Blackbuck *(Antelopa cervicapra*)
		Cervidae	European fallow deer (*Dama dama*)
		Camelidae	Llama (*Lama glama*)
			Alpaca (*Vicugna pacos*)
			Bactrian camel (*Camelus bactrianus*)
		Giraffidae	Reticulated giraffe (*Giraffa camelopardalis reticulate*)
	Lagomorpha	Leporidae	
Reservoir	Perissodactyla	Equidae	Domestic horse (*Equus caballus*)
			Zebra (*Hippotigris*)
			Donkey?
Vectors	None		

4. Conclusions

TOR 1: *to assess, following the criteria laid down in Article 7 of the AHL, the eligibility of EHV-1 infection of being listed for Union intervention as laid down in Article 5(3) of the AHL:*

- According to the assessment here performed, the EFSA Panel on animal health and welfare found with 33% to 90% certainty (ranging from 'as likely as not' to 'likely') that EHV-1 can be considered eligible to be listed for Union intervention as laid down in Article 5 of the AHL.

TOR 2: *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, the EFSA Panel on animal health and welfare estimated with less than 1% certainty (almost impossible) that EHV-1 fulfils 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.
- According to the assessment here performed, the EFSA Panel on animal health and welfare estimated with 1–5% certainty (extremely unlikely) that EHV-1 meets the criteria as in Section 2 of Annex IV of the AHL, for the application of the disease prevention and control rules referred to in point (b) of Article 9(1) of the AHL.

[8] 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.

- According to the assessment here performed, the EFSA Panel on animal health and welfare estimated with 10–66% certainty (ranging from 'unlikely' to 'as likely as not') that EHV-1 meets the criteria of as in Section 3 of Annex IV of the AHL, for the application of the disease prevention and control rules referred to in point (c) of Article 9(1) of the AHL.
- According to the assessment here performed, the EFSA Panel on animal health and welfare estimated with 66–90% certainty (likely) that EHV-1 meets the criteria as in Section 4 of Annex IV of the AHL, for the application of the disease prevention and control rules referred to in point (d) of Article 9(1) of the AHL.
- According to the assessment here performed, the EFSA Panel on animal health and welfare estimated with 33% to 90% certainty (ranging from 'as likely as not' to 'likely') that EHV-1 meets the criteria as in Section 5 of Annex IV of the AHL, for the application of the disease prevention and control rules referred to in point (e) of Article 9(1) of the AHL.

TOR 2: *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 animal species that can be considered to be listed for EHV-1 according to Article 8(3) of the AHL are species belonging to the family of Equidae, Tapiridae, Rhinocerontidae, Ursidae, Felidae, Caviidae, Cricetidae, Muridae, Bovidae, Cervidae, Camelidae, Giraffidae, Leporidae, as reported in Table 16 in Section 3.4 of the present document.

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Abbreviations

AHAW	Animal Health and Welfare
AHL	Animal Health Law
CSF	cerebrospinal fluid
EHM	Equine Herpesvirus Myeloencephalopathy
ER	Equine Rhinopneumonitis
EHV-1	equine herpesvirus-1
GHV	Gazelle herpesvirus
ToR	terms of reference

Annexes

A.1. Operations for the modified methodology of AHL assessment

A.1.1. Median aggregation

Let $R = \{r_1, r_2, \ldots r_n\}$ be the collection of outcomes from individual assessments involving n experts, where the response or assessment r_i of each expert is drawn from the EFSA approximate probability scale. The median of R is obtained as:

$$\text{median}(R) = \begin{cases} s_{\left(\frac{n+1}{2}\right)} & n \text{ is odd} \\ s_{\left(\frac{n}{2}\right)} & n \text{ is even} \end{cases} \quad (1)$$

where s_i is the i-th largest of elements in S obtained by reordering or ranking R in descending order.

Example 1: Let $R = \{r_1, r_2, \ldots r_7\} = \{50\%, 10\%, 66\%, 95\%, 66\%, 10\%, 95\%\}$ we have the following steps to calculate the median:

- Reordering or ranking R in descending order gives:

  $S = \{s_1, s_2, \ldots s_7\} = \{95\%, 95\%, 66\%, 66\%, 50\%, 10\%, 10\%\}$

- Since n = 7 then, median R = s_4 = 66%.

In the case where the r_i are uncertain probabilities or ranges, the median is calculated for both lower and upper bounds (Figure A.1–A.37).

Example 2

Question ID	Certainty range		Expert
	Lower bound %	Upper bound %	
2.1A	66	99	A
2.1A	33	66	B
2.1A	33	100	C
2.1A	1	5	D
2.1A	33	100	E
2.1A	0	1	F
2.1A	0	1	G
2.1A	95	99	H
2.1A	33	66	I
2.1A	33	66	J
2.1A	10	90	K
2.1A	10	33	L
2.1A	10	33	M
2.1A	5	10	N
2.1A	1	5	O
Median	**10**	**66**	

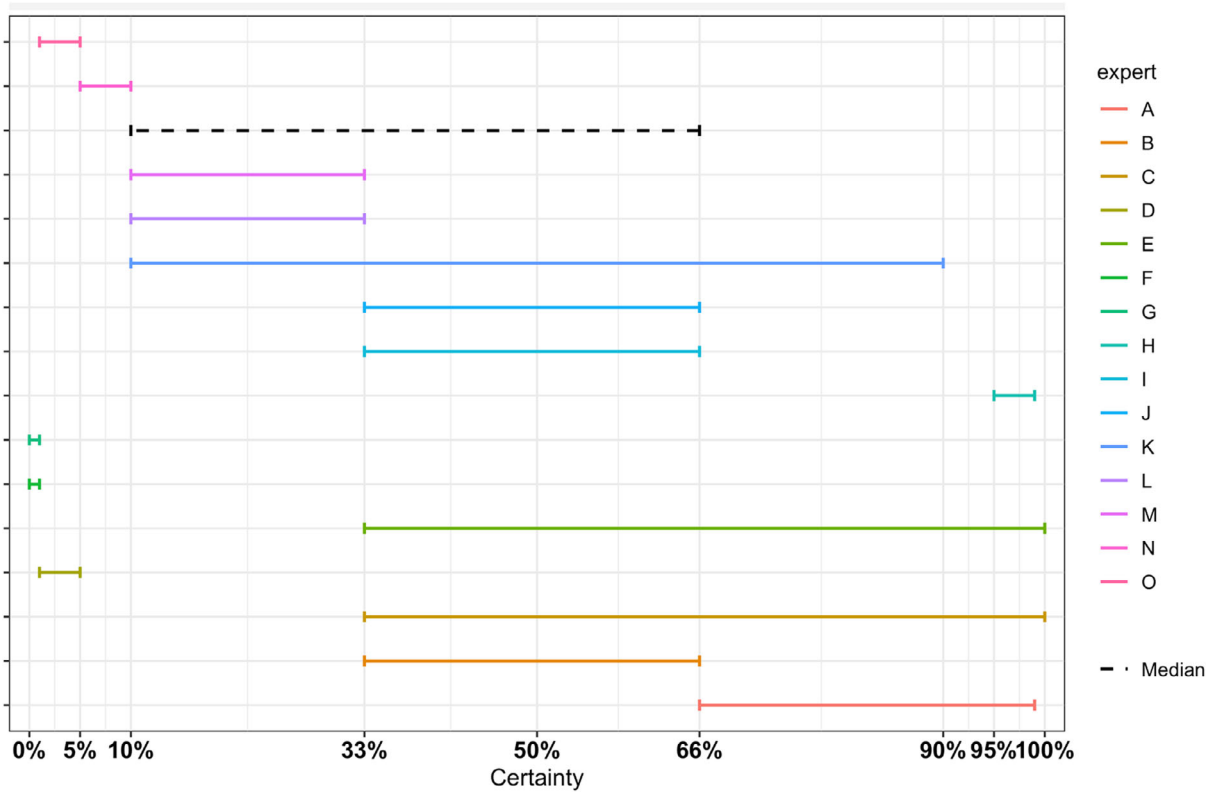

Figure A.1: Illustration of the median aggregation

A.1.2. Aggregation according to AHL categories

The general structure of Art. 5 and 9 of AHL can be summarised as in the Table below.

Questions		**AHL – aggregation**	
Set 1: all of them	r_1	$r^* = r_1 \wedge r_2 \wedge \ldots \wedge r_n$	Final result: **R = r* ^ s***
	r_2		
	⋮		
	r_n		
Set 2: at least one	s_1	$s^* = s_1 \vee s_2 \vee \ldots \vee s_m$	
	s_2		
	⋮		
	s_m		

$\wedge$ = AND operation; $\vee$ = OR operation
When r_i and s_i are uncertain probabilities or ranges, the aggregation is calculated for both lower and upper bounds.

In what follows, we will use:

$$\begin{cases} r_1 \wedge r_2 = \min[r_1, r_2] \\ s_1 \vee s_2 = \max[s_1, s_2] \end{cases}$$

Example 1: Art. 5

Questions		Certainty range		AHL – aggregation	
		Lower bound %	Upper bound %		
Set 1: all of them	A(i)	99	100	$r^*_{lb} = \min[99,\ 99,\ 95,\ 99,\ 93] = 33\%$	Final result
	A(ii)	99	100		$R_{lb} = \min[33,\ 66] = 33\%$
	A(iii)	95	100	$r^*_{ub} = \min[100,\ 100,\ 100,\ 110,\ 90] = 90\%$	$R_{ub} = \min[90,\ 95] = 90\%$
	A(iv)	99	100		$R = [33\%,\ 90\%]$
	A(v)	33	90		
Set 2: at least one	B(i)	66	95	$s^*_{lb} = \max[66,\ 10,\ 10,\ 0,\ 5] = 66\%$	
	B(ii)	10	33		
	B(iii)	10	33	$s^*_{ub} = \max[95,\ 33,\ 33,\ 10,\ 33] = 95\%$	
	B(iv)	0	10		
	B(v)	5	33		

A.2. Criteria where the expert panel reached consensus

A.2.1. A(i) The disease is transmissible

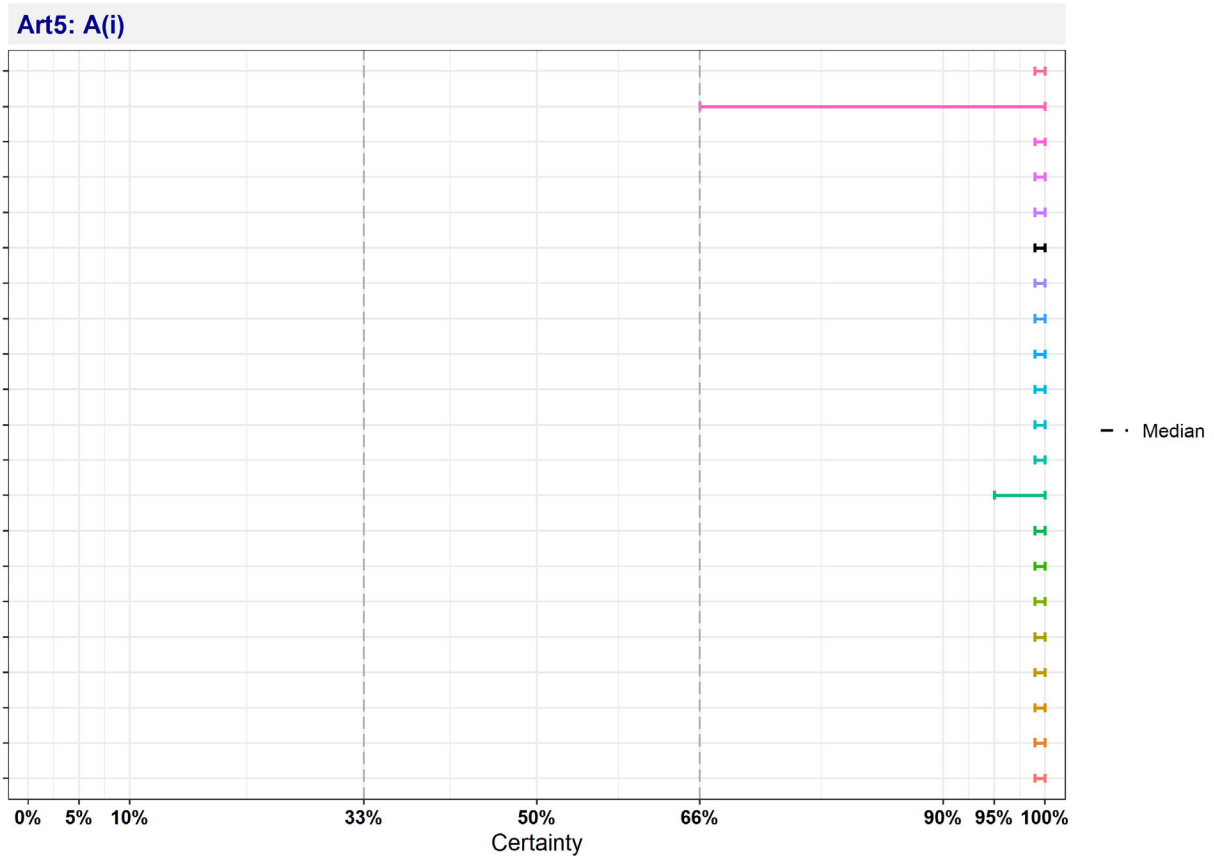

Figure A.2: Individual probability ranges reflecting fulfilment of criterion A(i) after the collective judgement

A.2.2. A(ii) Animal species are either susceptible to the disease or vectors and reservoirs thereof exist in the Union

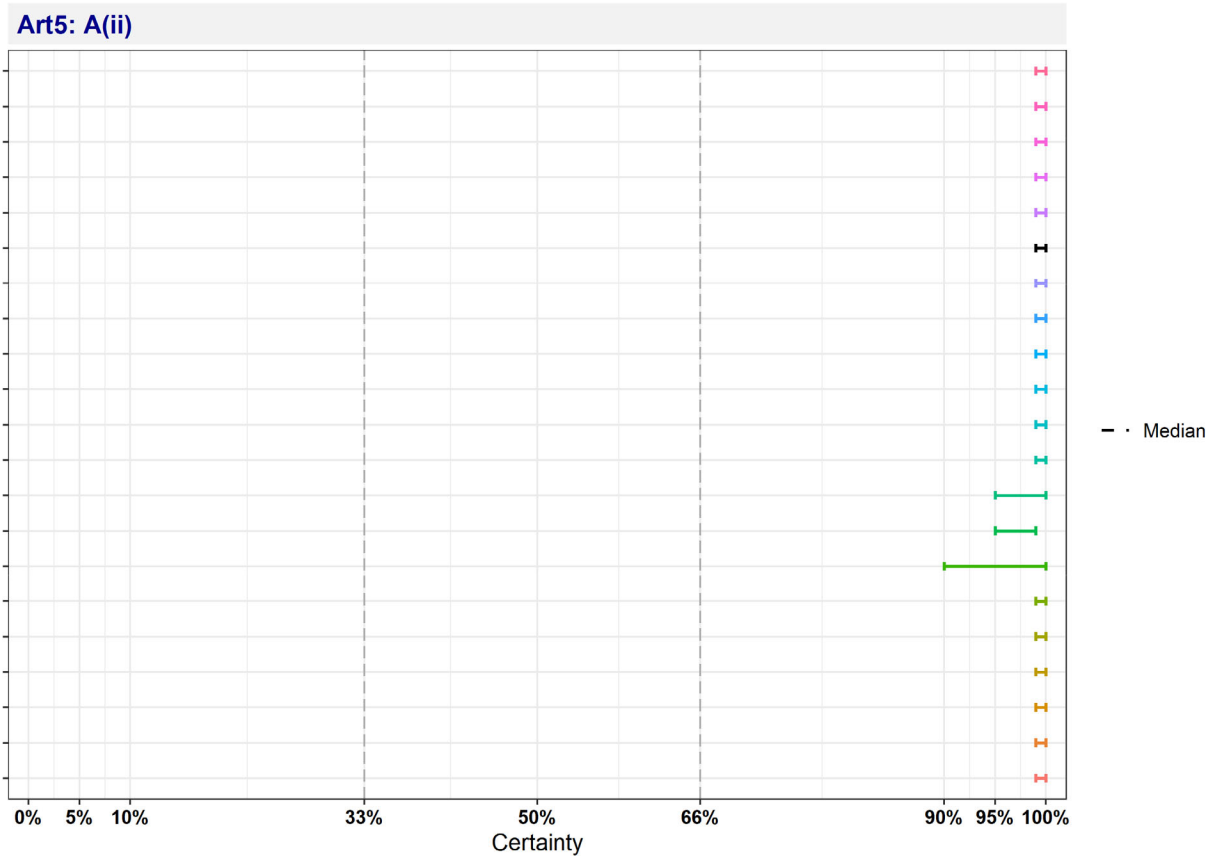

Figure A.3: Individual probability ranges reflecting fulfilment of criterion A(ii) after the collective judgement

A.2.3. A(iii) The disease causes negative effects on animal health or poses a risk to public health due to its zoonotic character

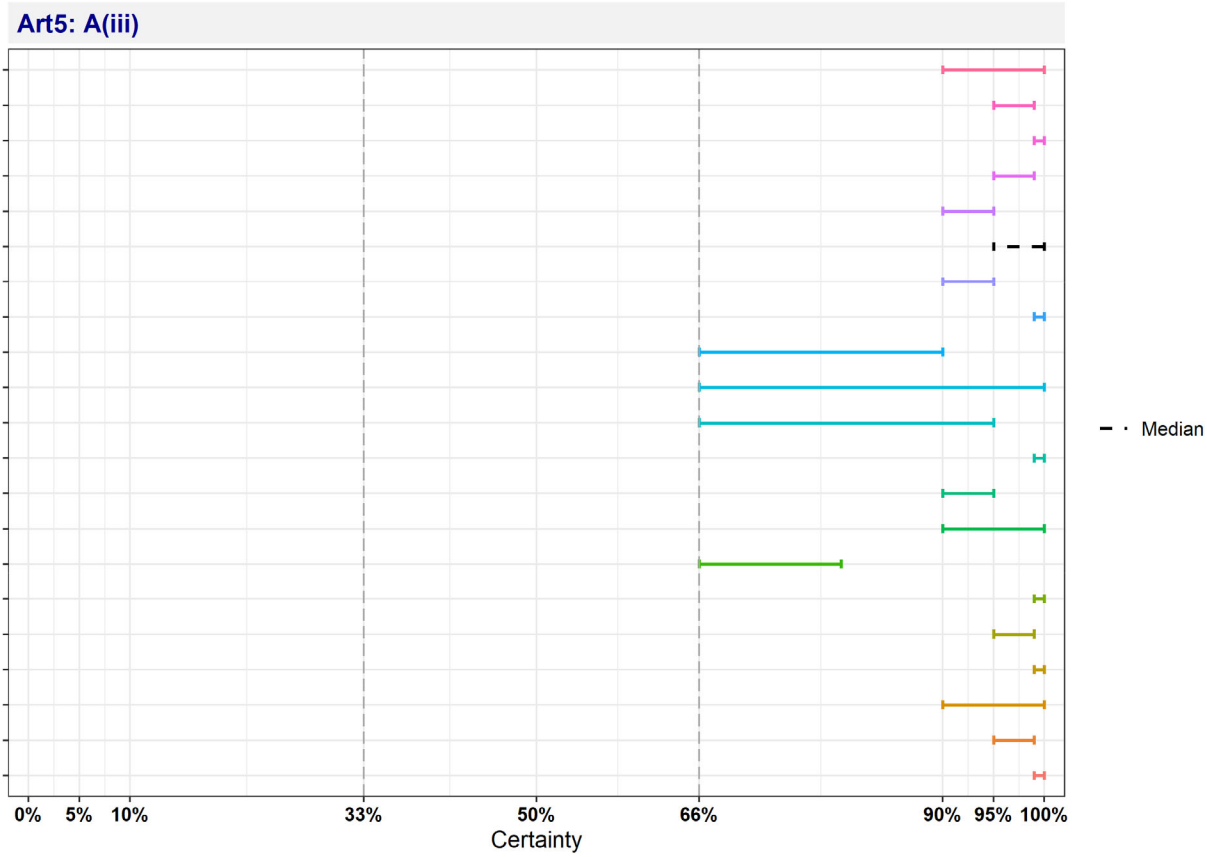

Figure A.4: Individual probability ranges reflecting fulfilment of criterion A(iii) after the collective judgement

A.2.4. B(ii) the disease agent has developed resistance to treatments and poses a significant danger to public and/or animal health in the Union

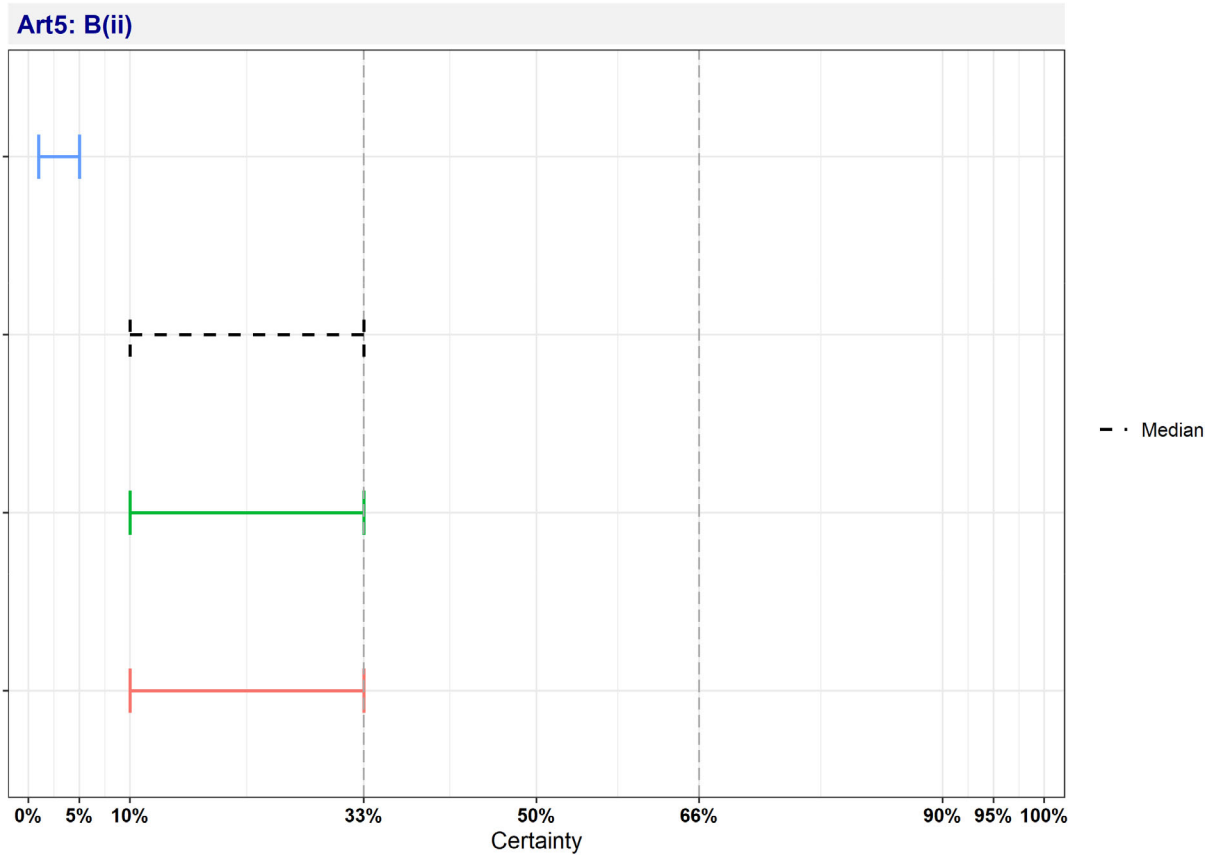

Figure A.5: Individual probability ranges reflecting non-fulfilment of criterion B(ii) after the collective judgement

A.2.5. B(iv) the disease has the potential to generate a crisis or the disease agent could be used for the purpose of bioterrorism

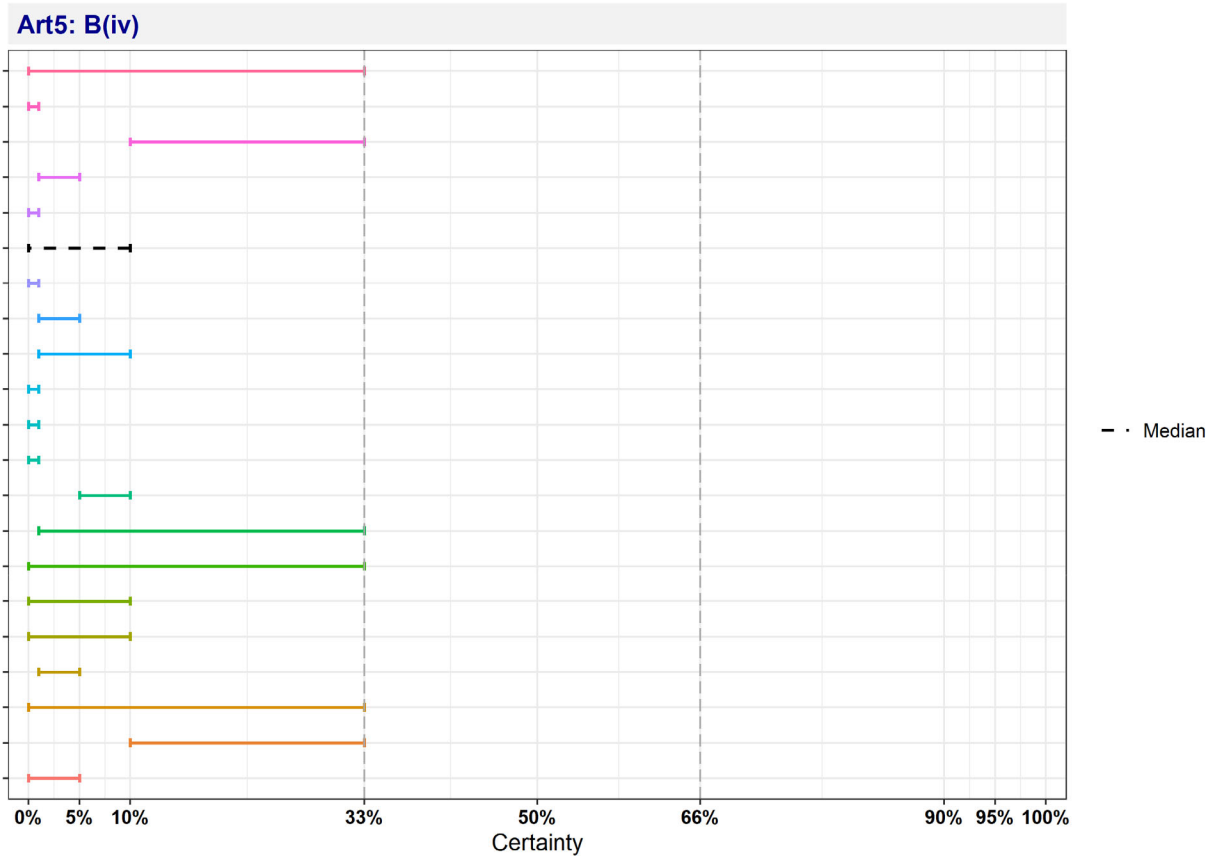

Figure A.6: Individual probability ranges reflecting non-fulfilment of criterion B(iv) after the collective judgement

A.2.6. 1A 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

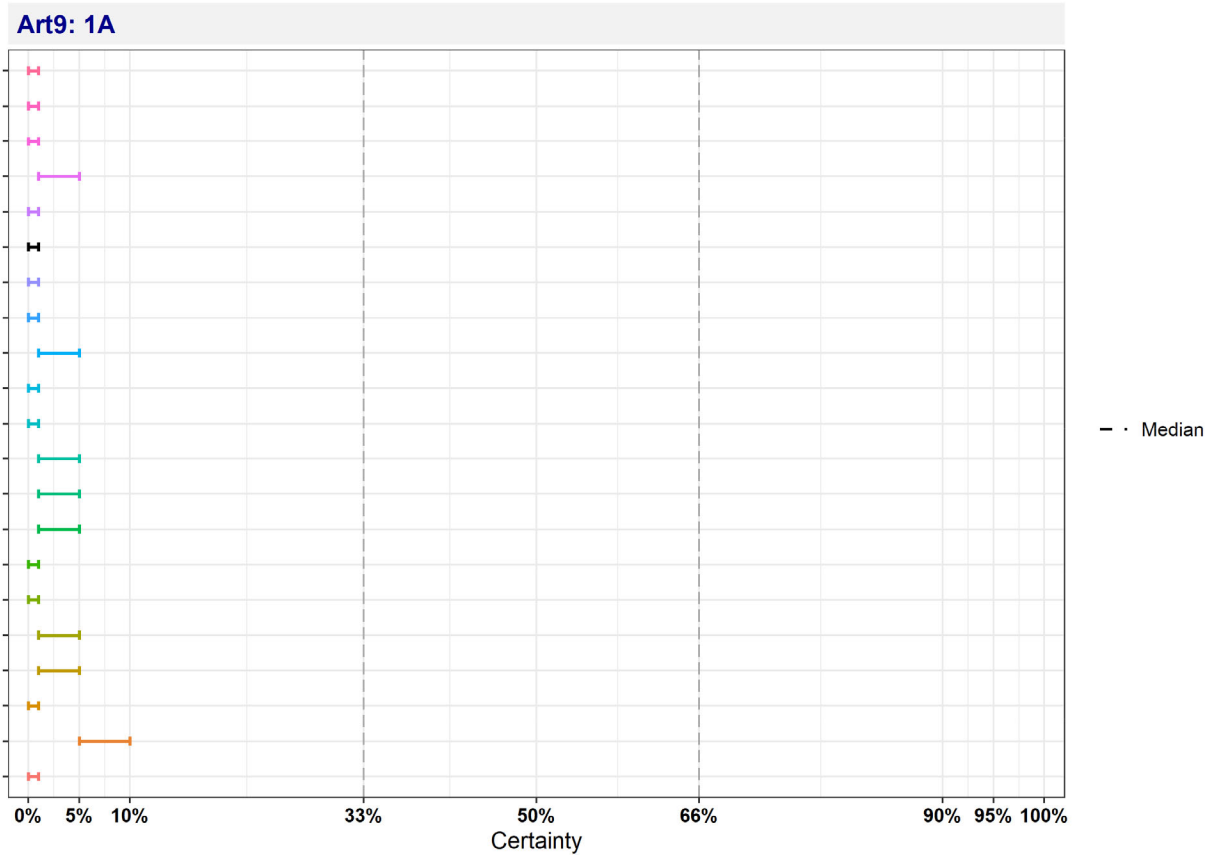

Figure A.7: Individual probability ranges reflecting non-fulfilment of criterion 1A after the collective judgement

A.2.7. 1B 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

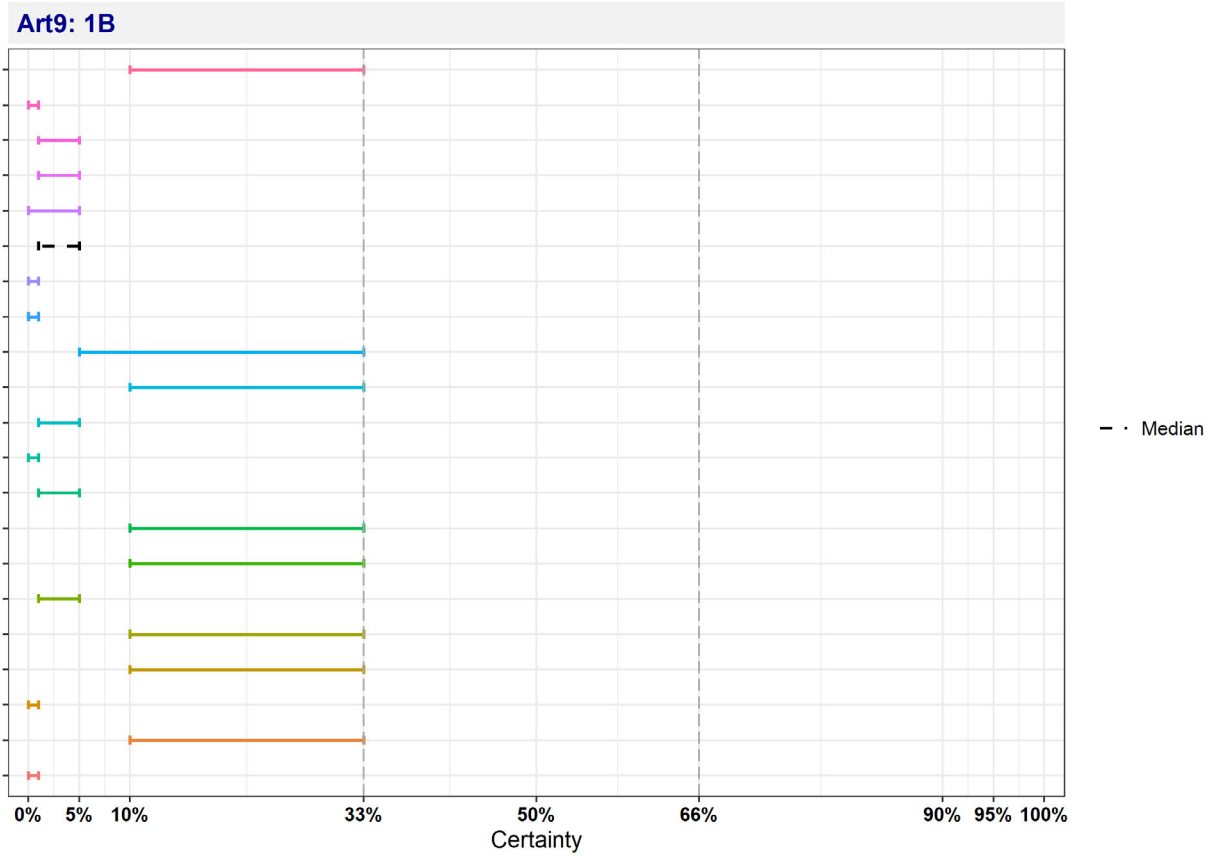

Figure A.8: Individual probability ranges reflecting non-fulfilment of criterion 1B after the collective judgement

A.2.8. 1C the disease is present in the whole OR part of the Union territory with an endemic character

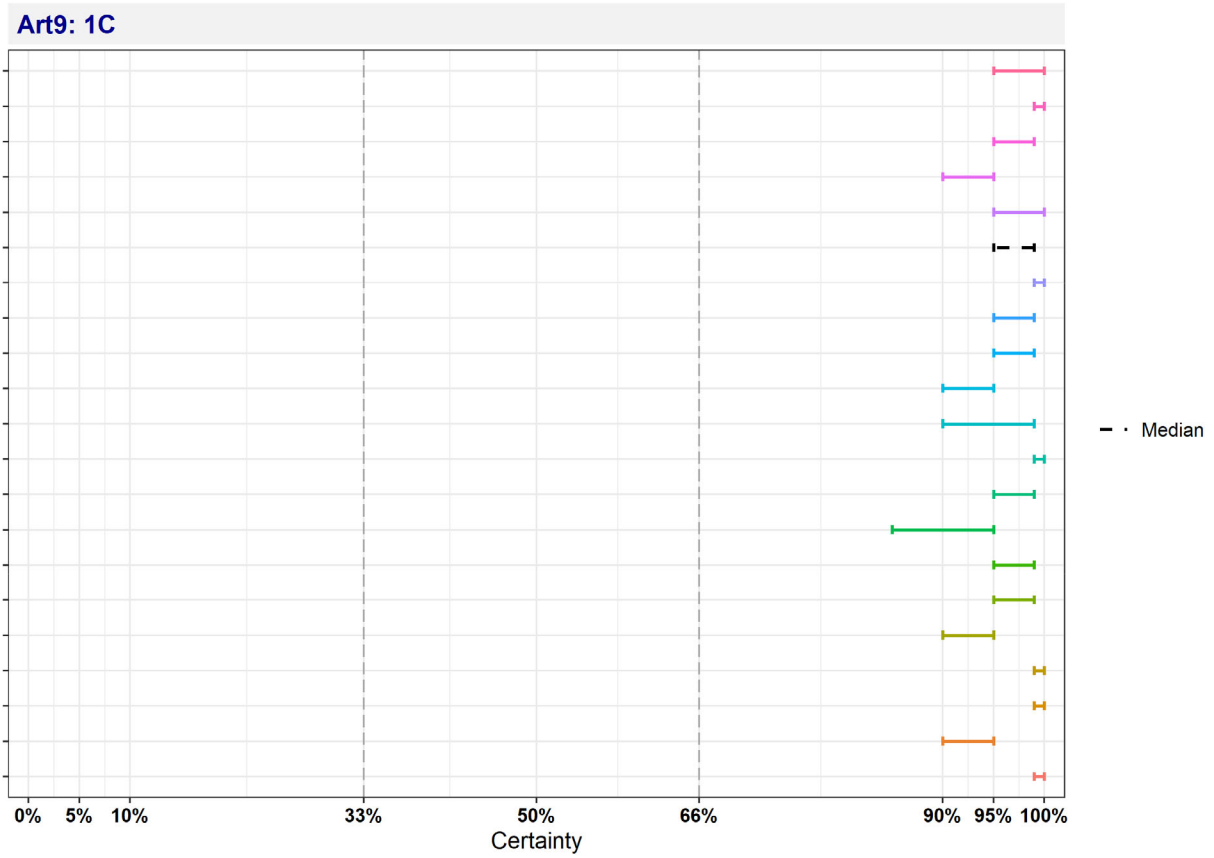

Figure A.9: Individual probability ranges reflecting fulfilment of criterion 1C after the collective judgement

A.2.9. 2.2AB there are possibilities of airborne or waterborne or vector-borne spread

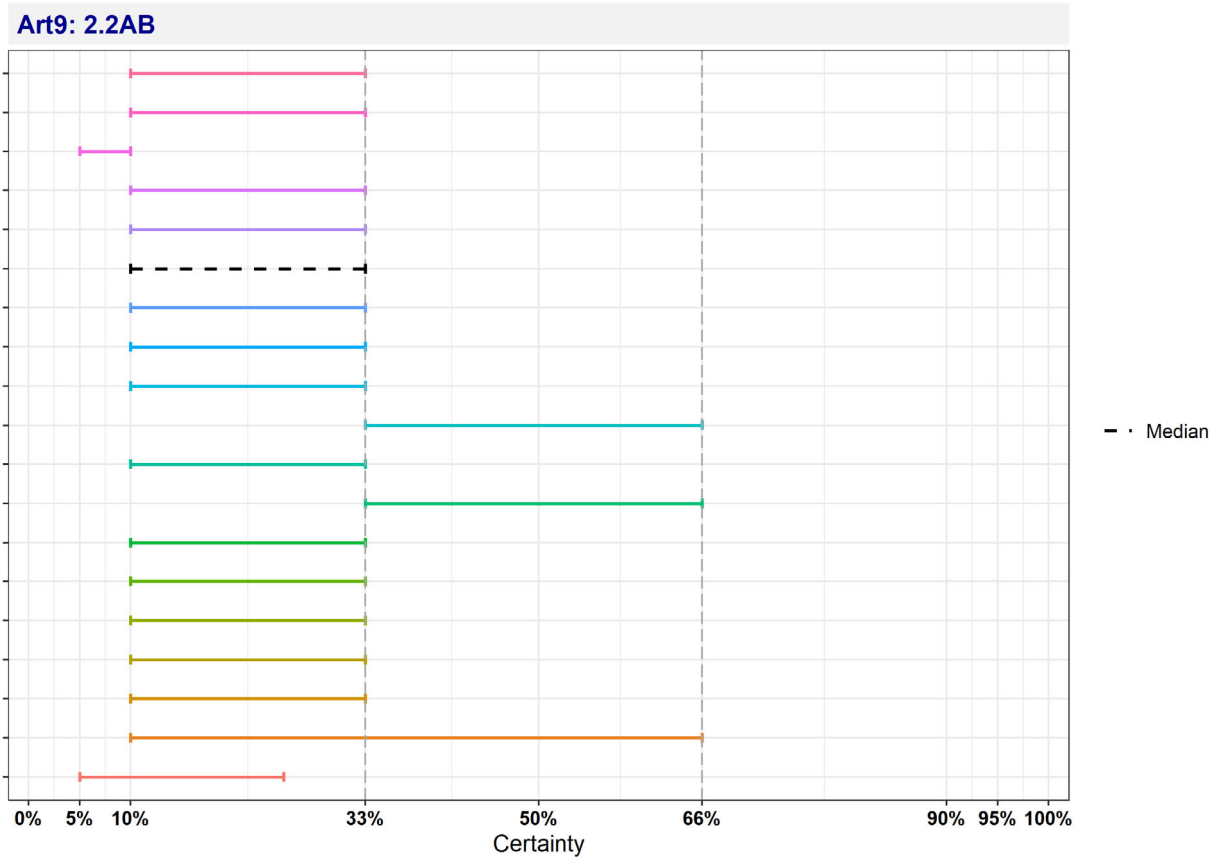

Figure A.10: Individual probability ranges reflecting non-fulfilment of criterion 2.2AB after the collective judgement

A.2.10. 2.3A the disease affects single or multiple species

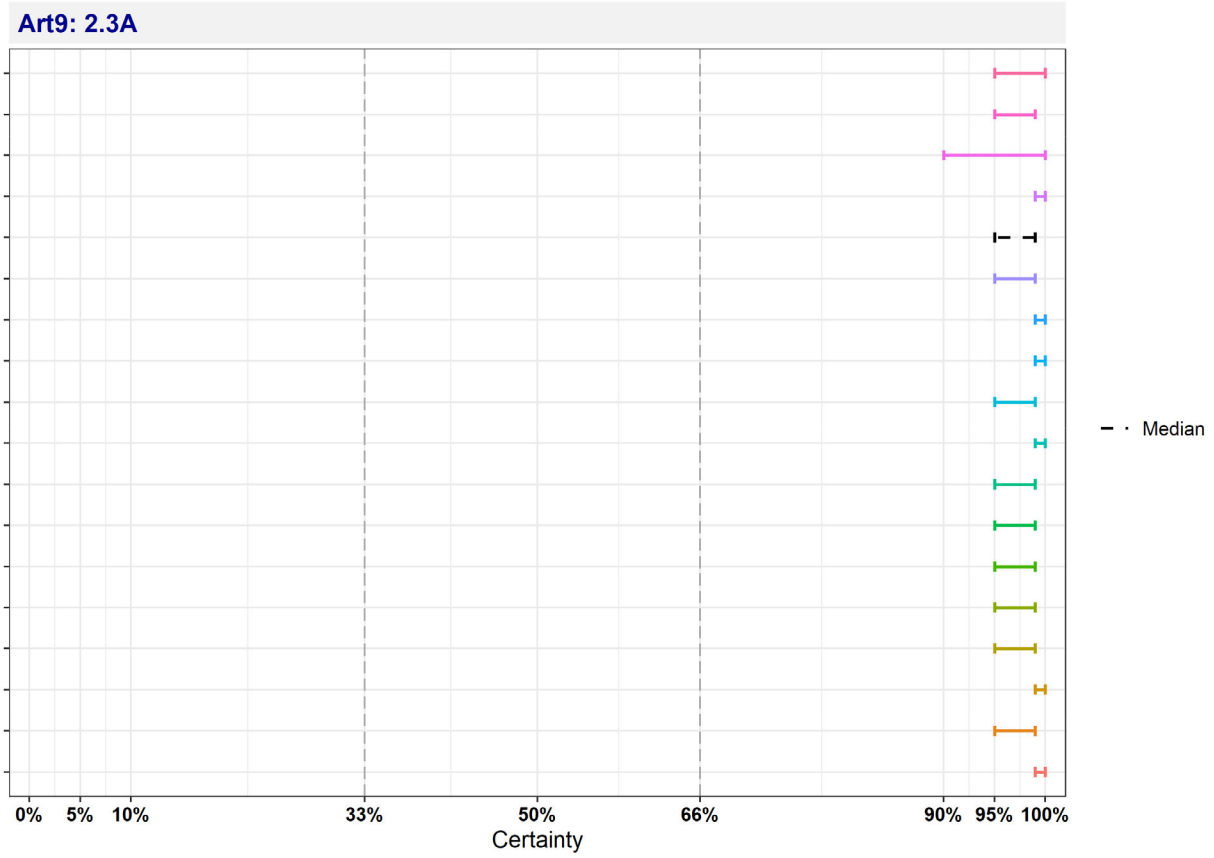

Figure A.11: Individual probability ranges reflecting fulfilment of criterion 2.3A after the collective judgement

A.2.11. 2.4A the disease may result in high morbidity and significant mortality rates

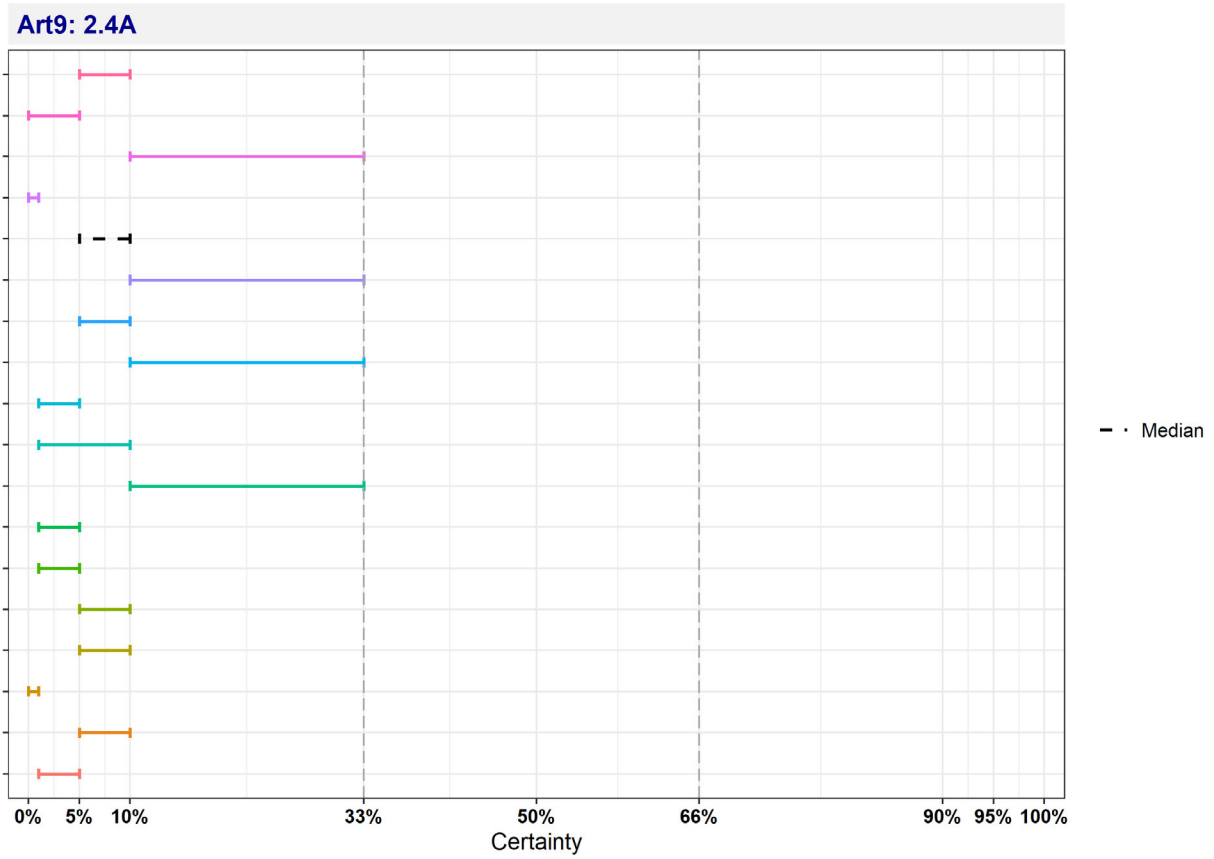

Figure A.12: Individual probability ranges reflecting non-fulfilment of criterion 2.4A after the collective judgement

A.2.12. 3A the disease has a zoonotic potential with significant consequences on public health, including epidemic or pandemic potential OR possible significant threats to food safety

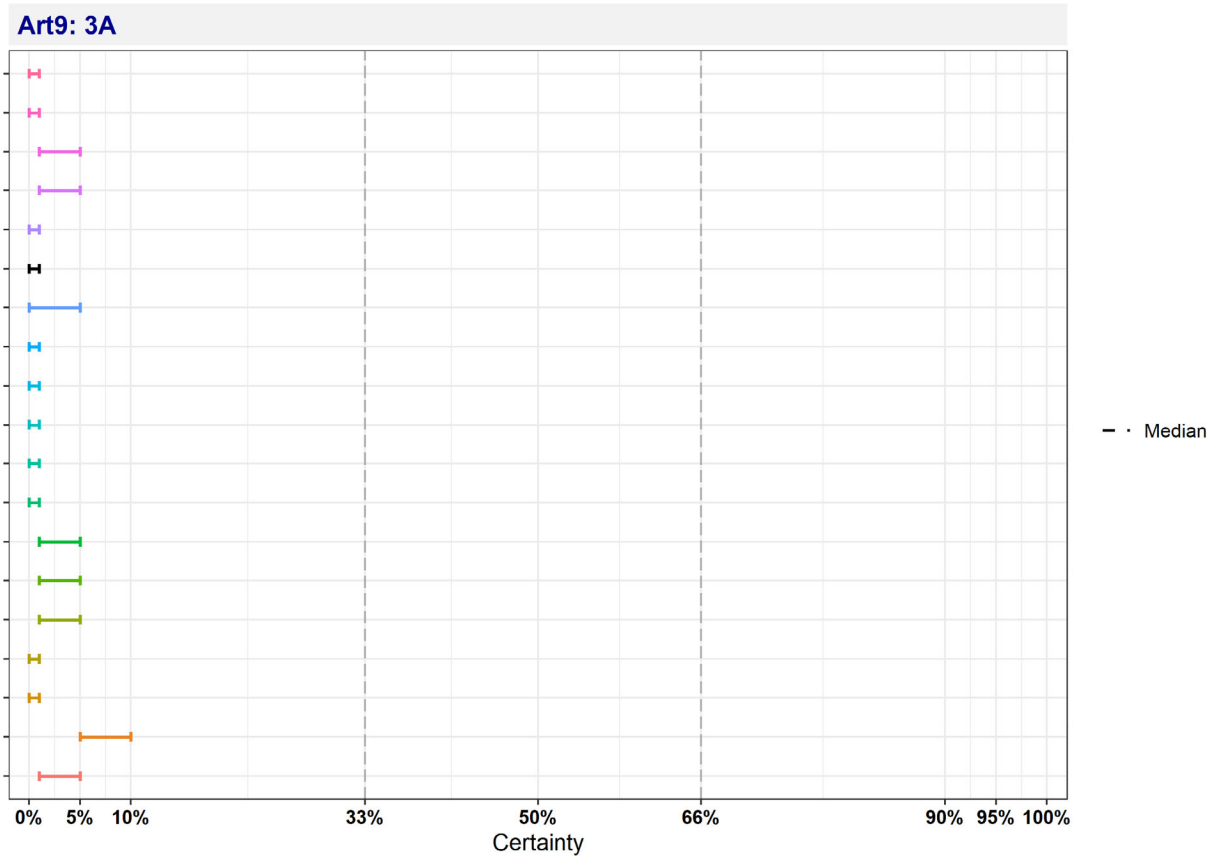

Figure A.13: Individual probability ranges reflecting non-fulfilment of criterion 3A after the collective judgement

A.2.13. 3AB the disease has a zoonotic potential with significant consequences on public health, including epidemic potential OR possible significant threats to food safety

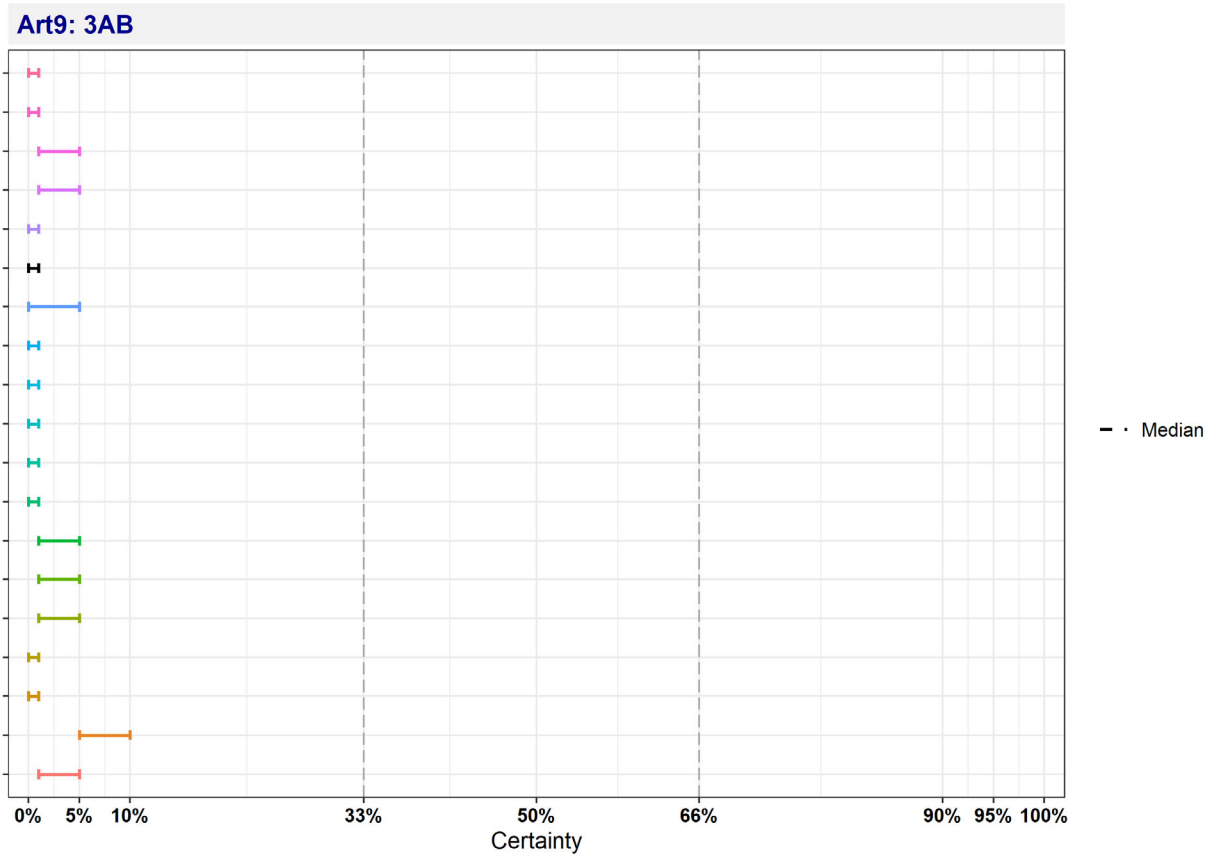

Figure A.14: Individual probability ranges reflecting non-fulfilment of criterion 3AB after the collective judgement

A.2.14. 3ABC the disease has a zoonotic potential with significant consequences on public health, or possible significant threats to food safety

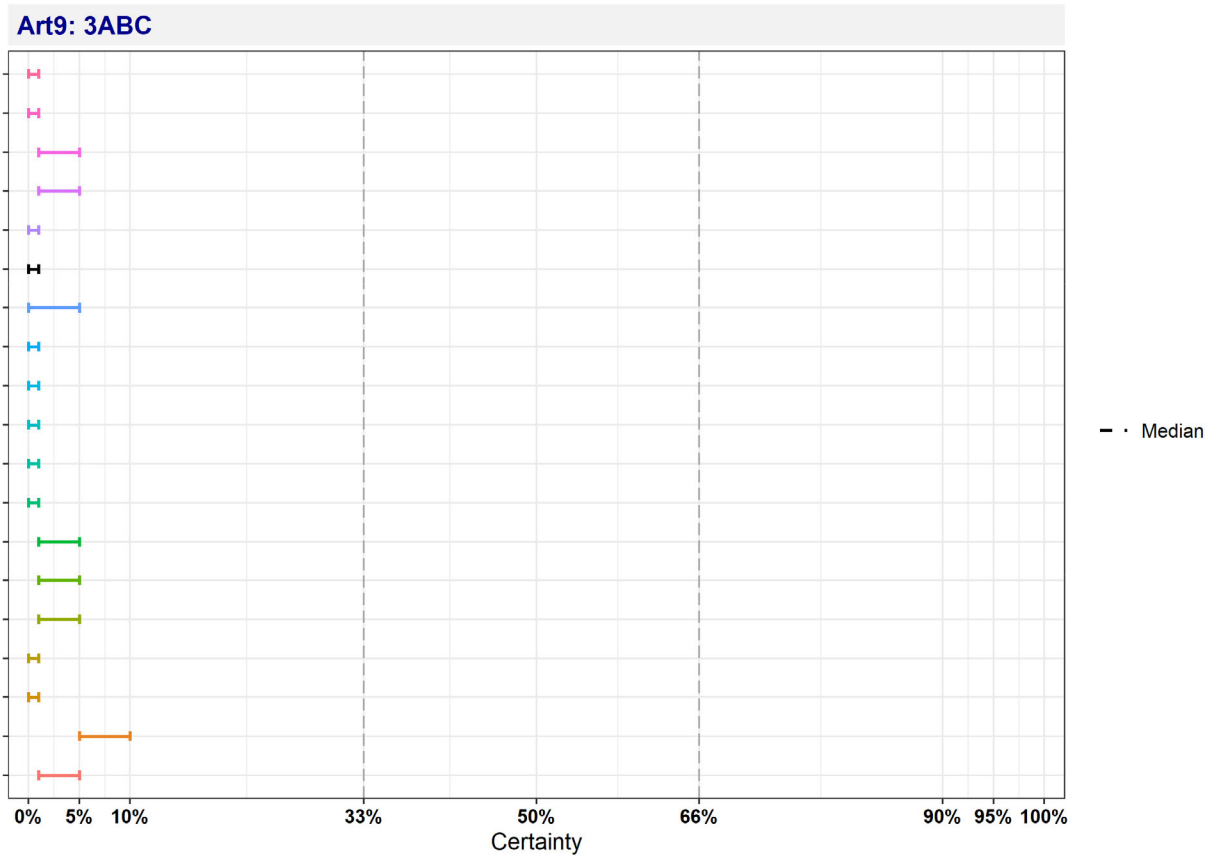

Figure A.15: Individual probability ranges reflecting non-fulfilment of criterion 3ABC after the collective judgement

A.2.15. 5A the disease has a significant impact on society, with in particular an impact on labour markets[9]

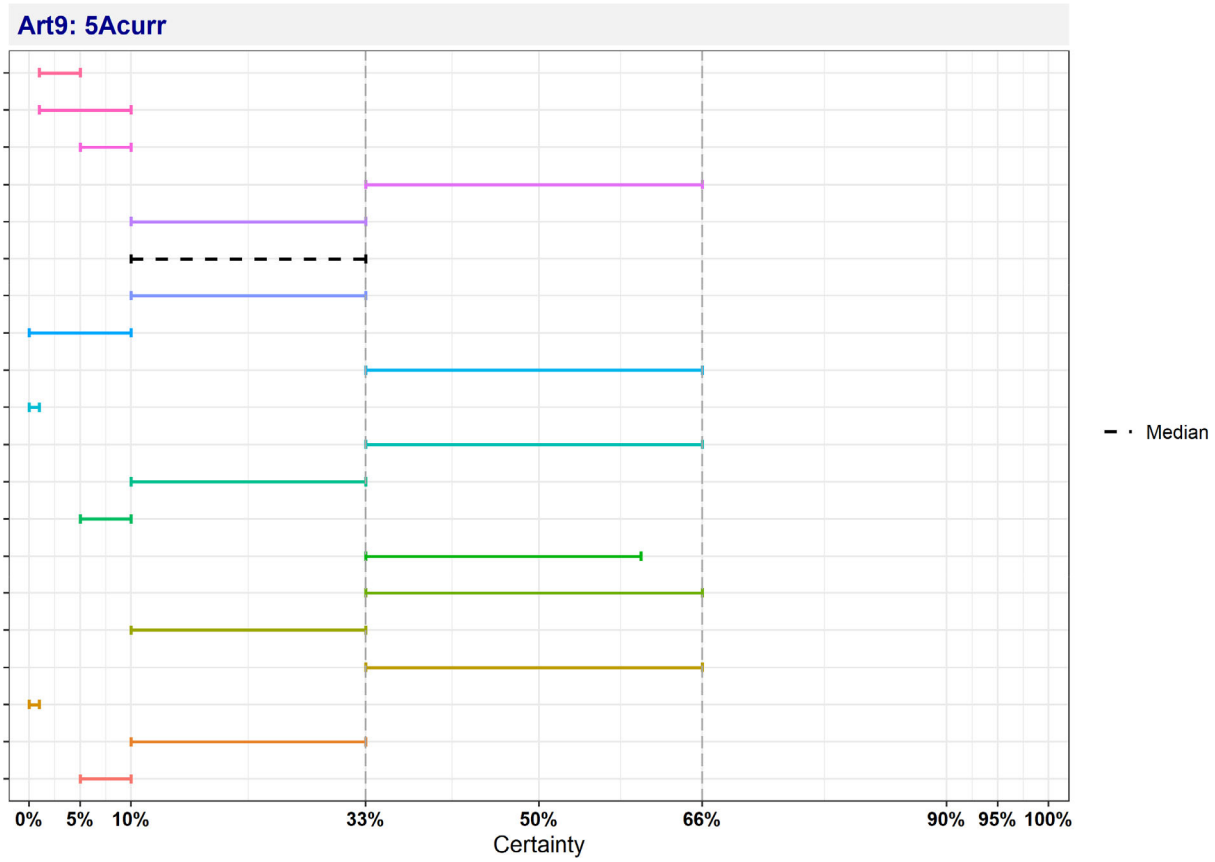

Figure A.16: Individual probability ranges reflecting non-fulfilment of criterion 5Acurr after the collective judgement

[9] As in the opinion on methodology (EFSA AHAW Panel, 2017), the criteria about impact are assessed both for the current (curr., see graph) and potential (pot., see graph) impact, then in the final results these are combined by taking the largest range of probability of the two.

A.2.16. 5C 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[13]

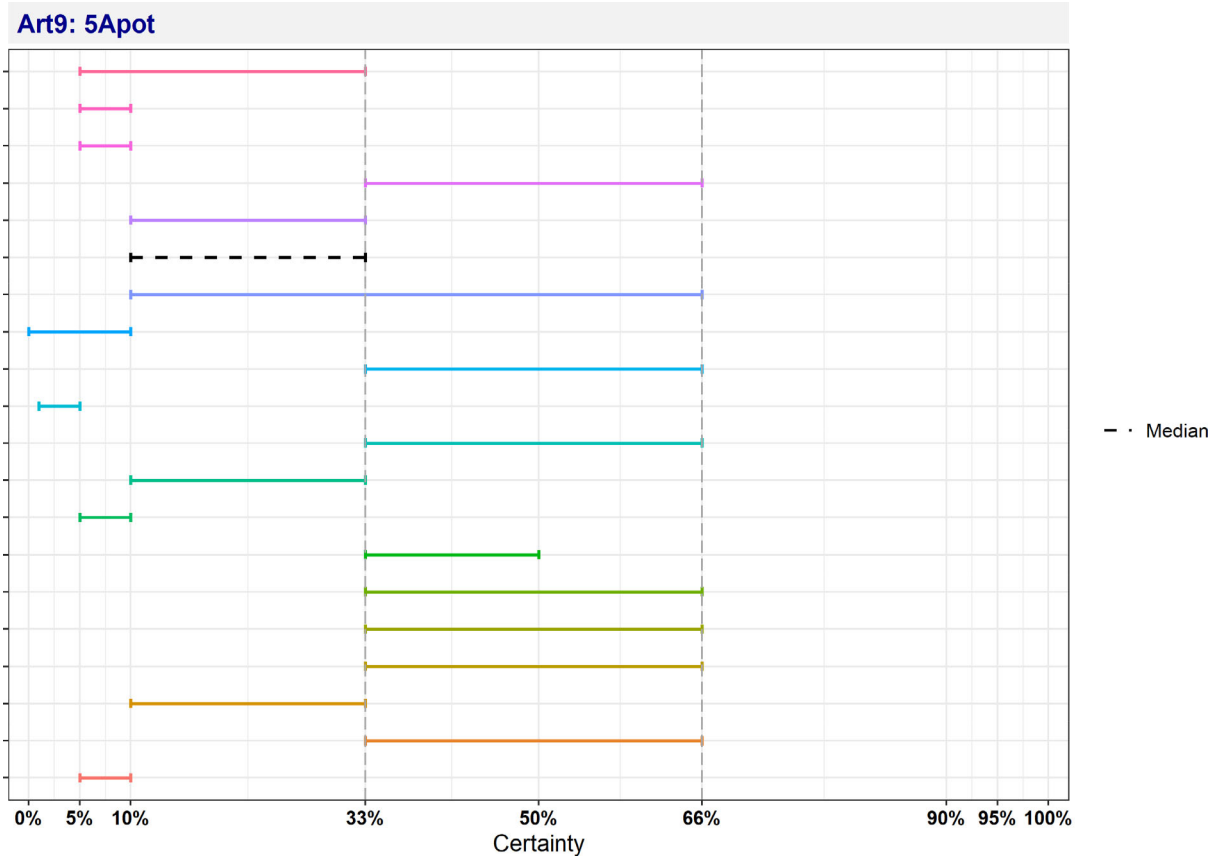

Figure A.17: Individual probability ranges reflecting non-fulfilment of criterion 5Apot after the collective judgement

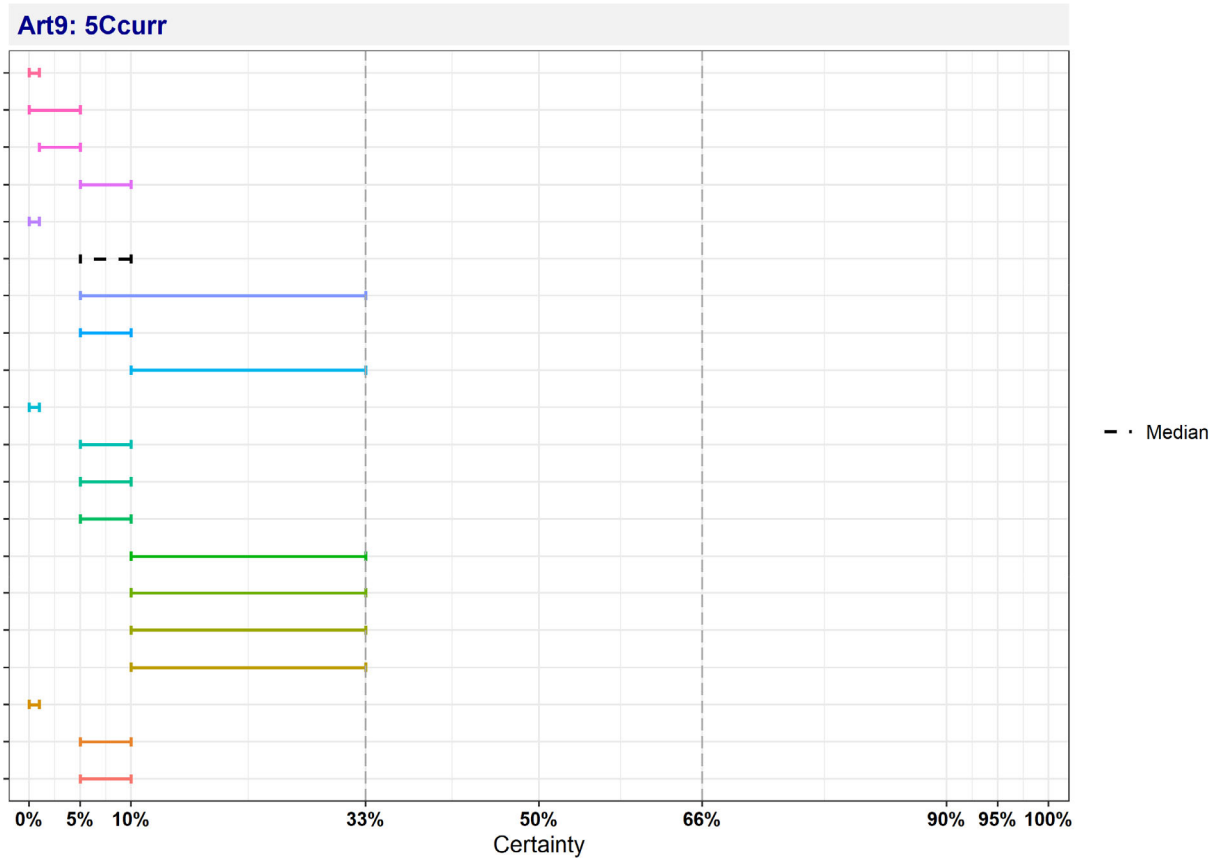

Figure A.18: Individual probability ranges reflecting non-fulfilment of criterion 5Ccurr after the collective judgement

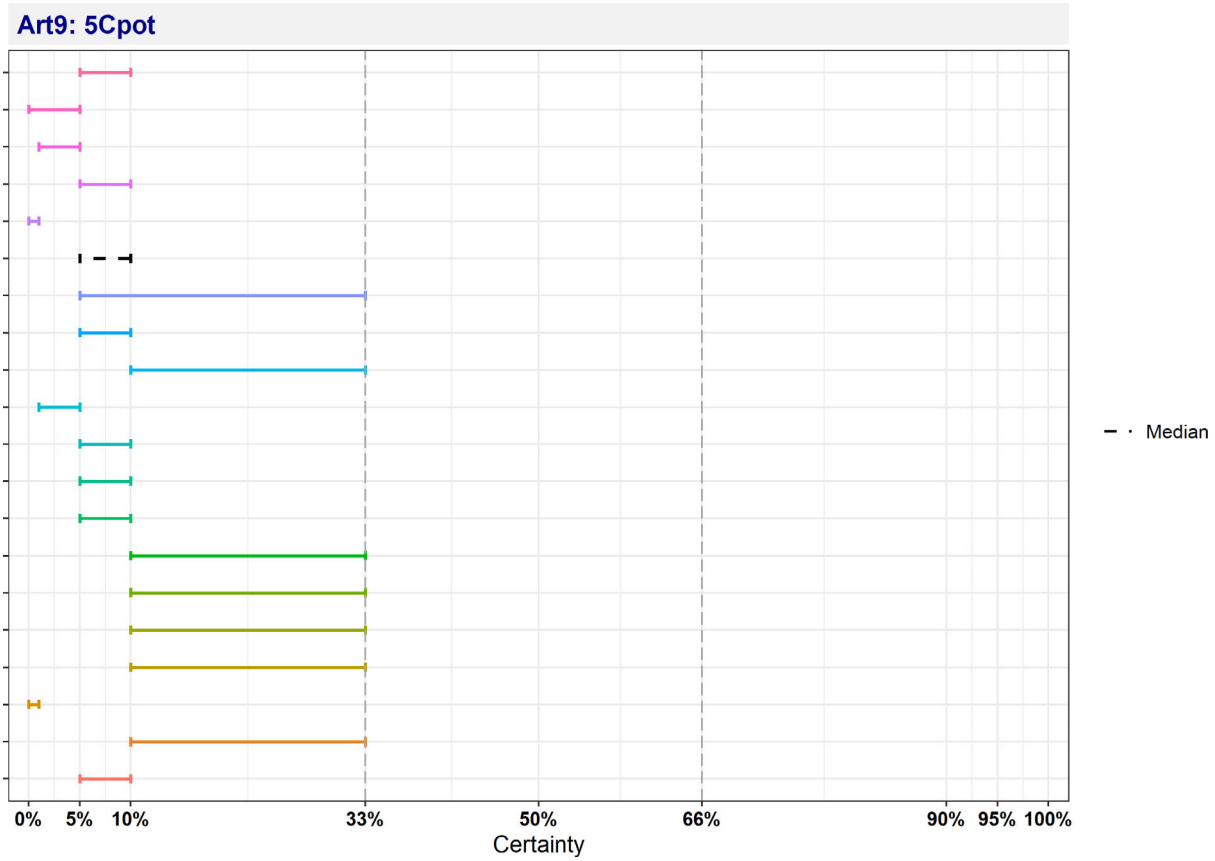

Figure A.19: Individual probability ranges reflecting non-fulfilment of criterion 5Cpot after the collective judgement

A.3. Criteria where the expert panel did not reach consensus

A.3.1. A(iv) Diagnostic tools are available for the disease

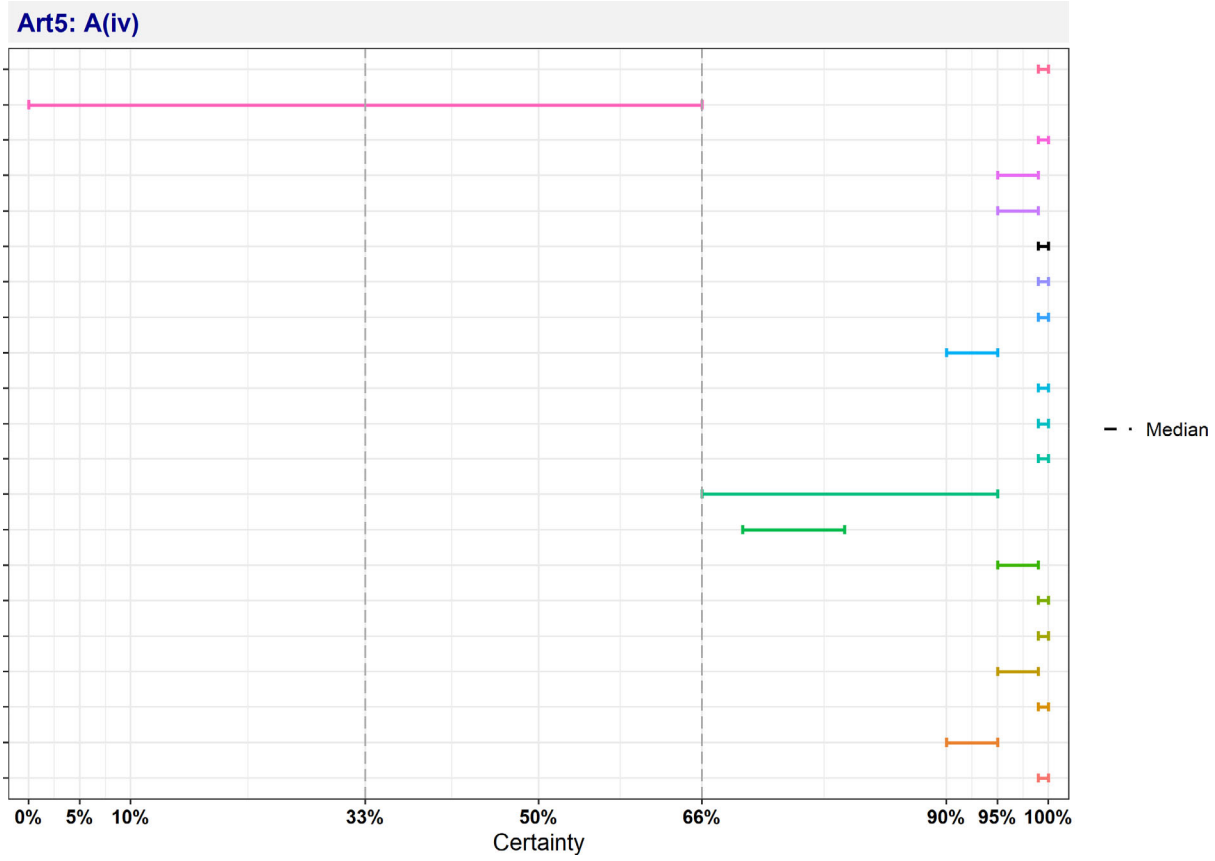

Figure A.20: Individual probability ranges reflecting fulfilment of criterion A(iv) after the collective judgement

Reasoning:

- There is a highly variable disease definition, and when this is the case, then it is not clear what should be detected, and what is relevant: clinical disease? Latent infection? Excretion of EHV-1? Most available diagnostic tools can detect EHV-1 only when these are excreted, but do so with high accuracy. Latent infection cannot be detected with high accuracy and this is crucial for control.
- Numerous diagnostic methods and tools (e.g. PCR, virus isolation, measures of seroconversion) are available and used to confirm cases of EHV-1 infection.
- Diagnostic tools are available but not suited for all epidemiological conditions (e.g. absence of DIVA tests for serological diagnosis of vaccinated horses). However, in these scenarios, available PCR and longitudinal testing approaches could be used. Alternatively, (non-vaccinated) sentinels could also be considered (if accepted by public opinion) as part of control and surveillance strategies.

A.3.2. 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

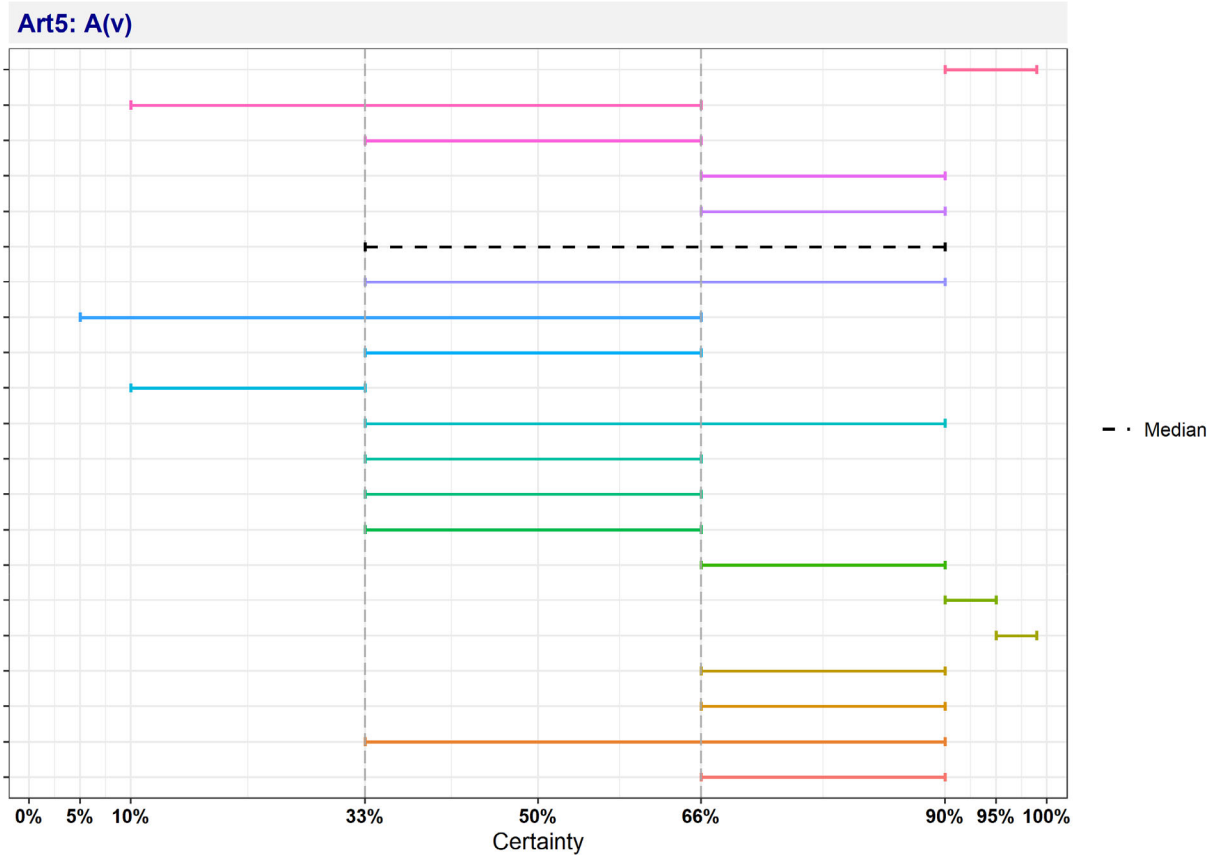

Figure A.21: Individual probability ranges reflecting uncertainty about fulfilment of criterion A(v) after the collective judgement

Reasoning:

- No data on the effectiveness of risk-mitigating measures exist. Furthermore, there is insufficient knowledge on the factors resulting in activation of latent infection leading to spread of the pathogen. Also, the effectiveness of vaccination to prevent spread of EHV-1 is not described or is variable. Lastly, on regional/national level, testing and movement restrictions may be considered, but because diagnostic testing is inaccurate and factors for re-activation are not known, the effectiveness of these measures are uncertain. Therefore, it seems unlikely (10–33%) that risk-mitigating measures will be effective.
- Risk-mitigating measures, including surveillance, are not effective in preventing the negative impact of the disease although the incidence of some clinical signs such as abortions can be reduced (scored as very unlikely). It is more uncertain whether or not they are proportionate.
- Risk-mitigating measures seem not to be effective given the wide spread of the disease and taking the outbreak in Spain as an example.
- There are no official control programmes and the level of surveillance of EHV outbreaks is highly variable between MSs. This is further complicated by the absence of notification requirements. The absence of compulsory notification may lead to underreporting and skipping the application of containment measures (e.g. movement restrictions). The control is therefore often at farm level. Biosecurity measures at this level seem to be effective.
- Vaccination is not compulsory and availability of vaccines differs between MSs. Their efficacy and effectiveness against the different forms of disease induced by EHV-1 or EHV-4 are variable. Vaccination and surveillance are expected to be more effective in the high-performance sector.

- It is questionable whether the disease would fade out by itself without risk-mitigating measures in place.
- Disease caused by EHV-1 is not too severe and the risks posed are relatively low. Therefore, the risk-mitigating measures are proportionate to the risks posed by the disease.
- Risk-mitigating measures are relatively efficient in reducing morbidity and fatality in competition horses. Therefore, they are at least effective in naïve animals.
- There are some tools that can be applied (e.g. vaccination, surveillance based on clinical signs, diagnostic tests, biosecurity), but these have important limitations (hard to detect asymptomatic infections, vaccination has limited efficacy).
- There is relatively extensive surveillance combined with risk-mitigating measures in some MSs.

A.3.3. 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

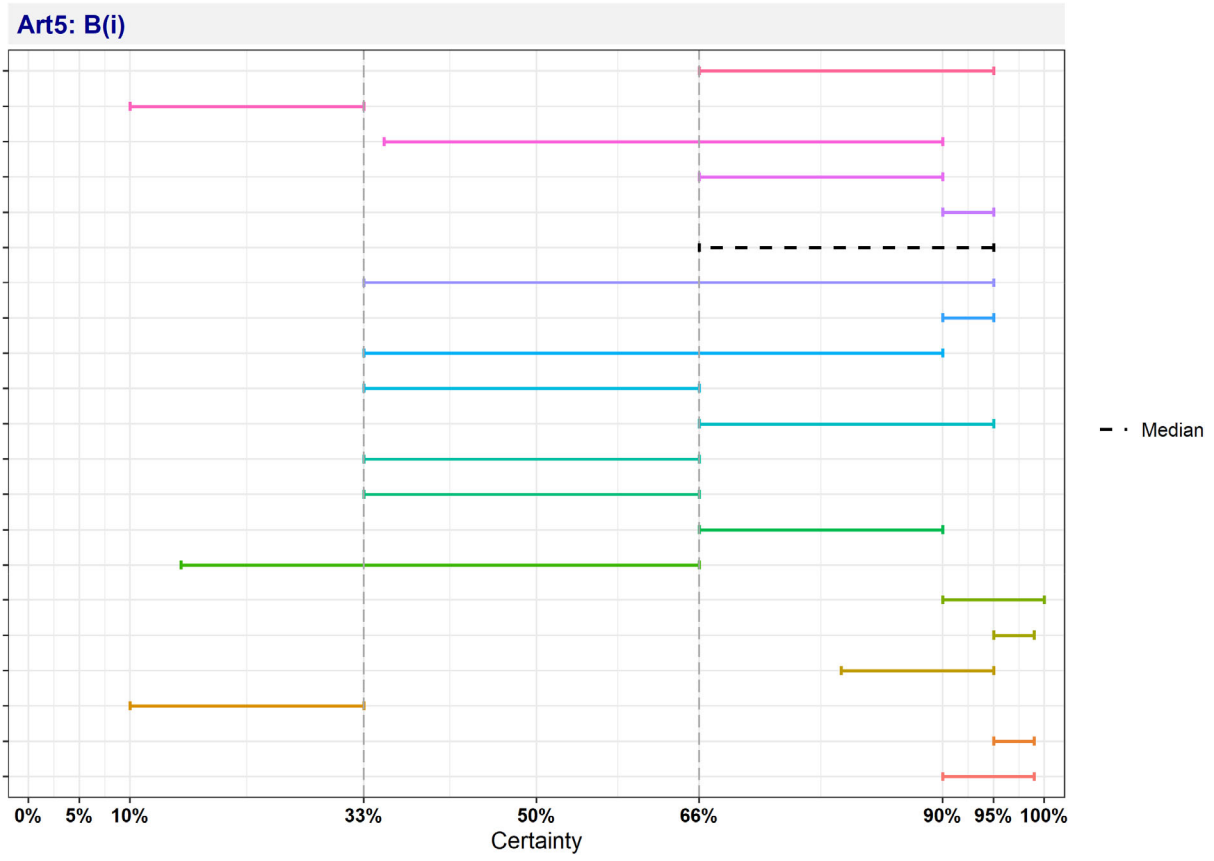

Figure A.22: Individual probability ranges reflecting fulfilment of criterion B(i) after the collective judgement

Reasoning:

- There is no systematic evidence that clinical disease (respiratory disease and abortions) occur to a level where it causes significant negative effects on animal health in the Union. Latent infections are very common but seem to rarely result in re-activation, and when re-activation occurs, it is not common that disease occurs.
- Case-morbidity and case-fatalities rates are very low in an enzootic situation. Therefore, there are no significant effects at population and Union level.
- Outcome in horses is very variable (from venereal to respiratory infection). It also depends on the strain and vaccination status.
- Latent prevalence is high (15–88%), but the presentation of clinical signs is reported as low at the population level. Respiratory disease is more common, while abortion and EHM are

sporadic. Higher incidence of abortions may happen in form of abortion storms. Mortality ranging from 0.5% to 10% has been reported.
- Infection can lead to serious disease in a small proportion of infected animals. Severity of the clinical form depends on many factors such as age, immune and health status, and virus strain involved.
- The outbreak in Spain caused significant negative effects due to the number of affected horses and how quickly the disease has spread across MSs.
- The disease will cause additional effects to animals compared to the situation, where the infection (disease) and risk-mitigation measures are not present.

A.3.4. B(iii) The disease causes or could cause a significant negative economic impact affecting agriculture or aquaculture production in the Union

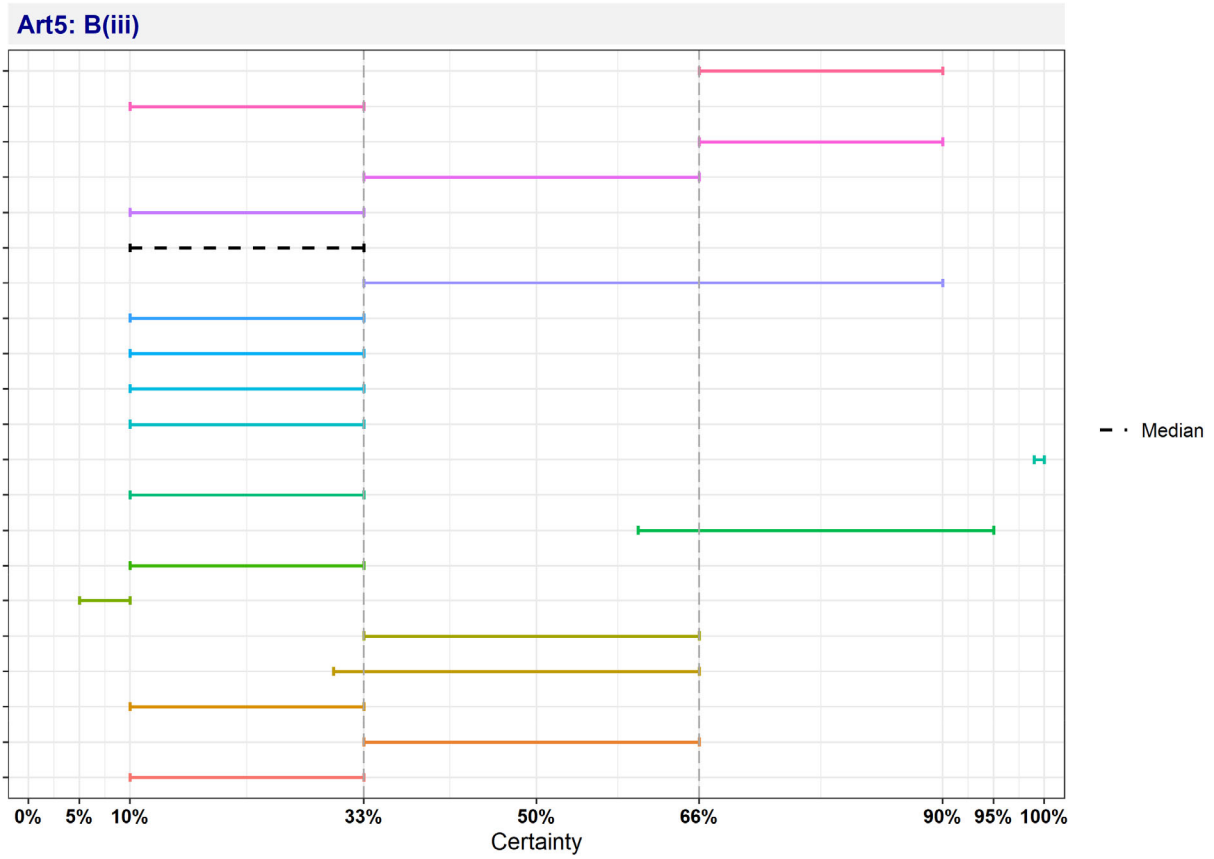

Figure A.23: Individual probability ranges reflecting non-fulfilment of criterion B(iii) after the collective judgement

Reasoning:

- There is no information about the economic impact at EU level.
- The disease may cause significant impact (almost certainly) on the horse industry but not on agriculture as a whole.
- EHV-1 is only reported to sporadically cause major outbreaks. Case-morbidity and case-fatalities rates are very low in an enzootic situation.
- Abortion storms or perinatal death is an economic problem for breeding farms. Those and the competition sector are mostly affected. Temporal effects on performance can also be counted towards losses.
- Stables and riding schools may need to stop activities temporally with high financial impact in the sector. However, this may not be the case for agriculture as a whole.

A.3.5. B(v) The disease has or could have a significant negative impact on the environment, including biodiversity, of the Union

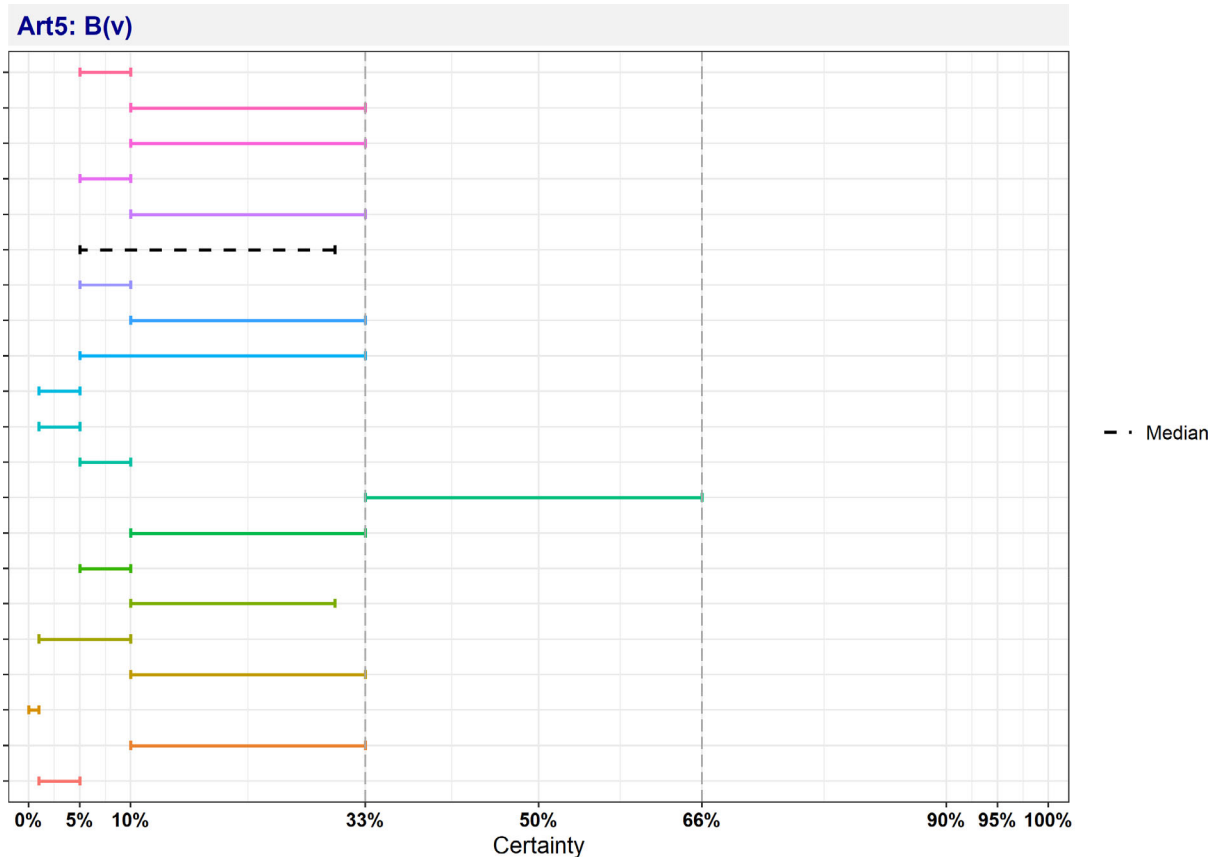

Figure A.24: Individual probability ranges reflecting non-fulfilment of criterion B(v) after the collective judgement

Reasoning:

- Data on mortality due to EHV-1 in wildlife occurring in the Union are sparse, but with a high prevalence of latent infection in horses, it would be expected that data existed if it was a major problem.
- The situation is uncertain, as no official control programmes exist and surveillance might be low.
- There is no significant number of wild equids in the EU and, therefore, a significant impact on biodiversity is very unlikely.
- Negative impact is very unlikely because affected animals are mostly asymptomatic, even for susceptible endangered species. Mortality has not been described in those species.
- Some rare and ancient breeds might disappear. There might be a risk for the Przewalski's Horse (in Eastern Europe), but this species is not known as highly susceptible to EHV. These species could be impacted by abortion storms.

A.3.6. 2.1A the disease is highly transmissible

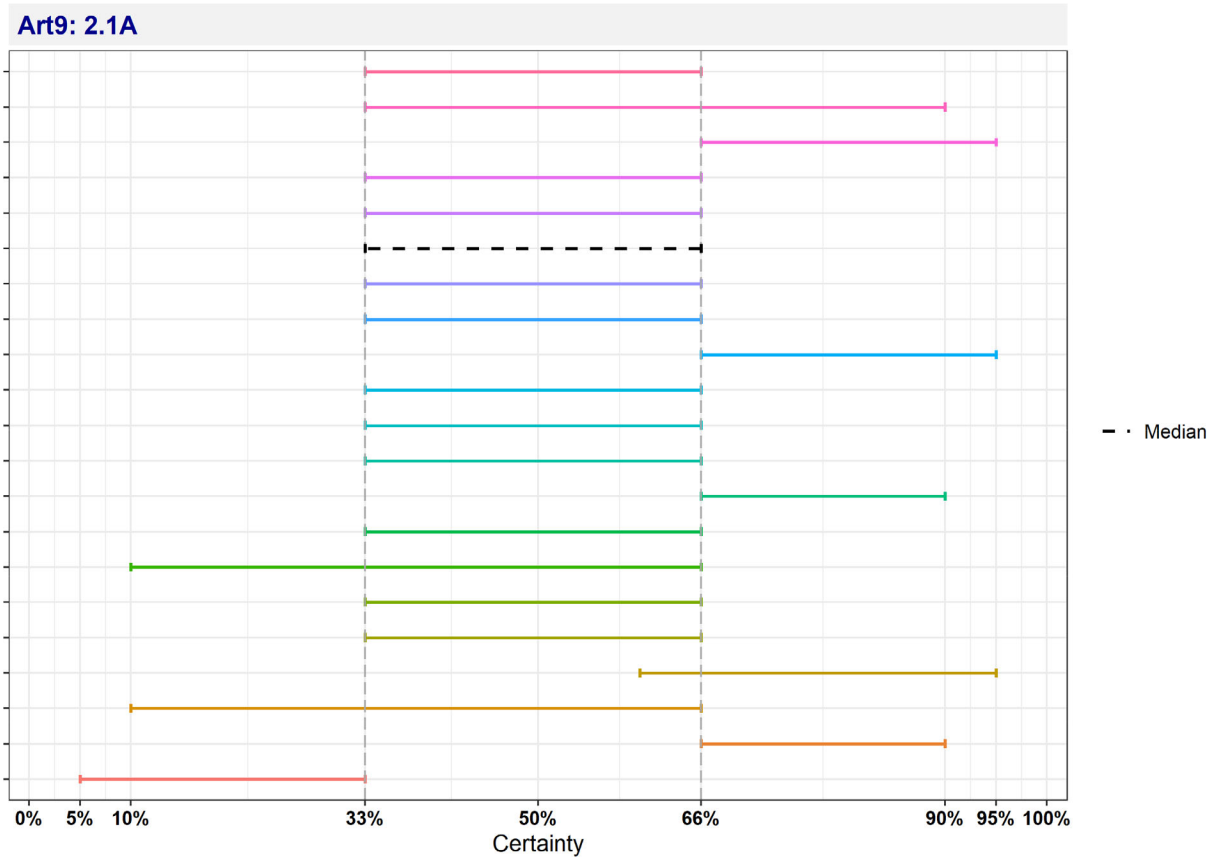

Figure A.25: Individual probability ranges reflecting uncertainty about fulfilment of criterion 2.1A after the collective judgement

Reasoning:

- Considering all transmission routes together, the disease is not highly transmissible.
- Transmissibility is different between EHV-1 respiratory (with low transmission rates of 35–40%) and neurological illness (with high R0 of about 3–10).
- For respiratory transmission, the reported incidence estimates allow to evaluate the transmissibility as only moderate (e.g. 35% of foals were found positive at 27 days of age in a naïve exposed herd).
- Given the widespread distribution, it seems likely that the disease is transmitted easily and with very high R0.
- R0 can be high under certain circumstances (e.g. the outbreak in Spain, large gatherings)

A.3.7. 2.1BC the disease is moderately to highly transmissible

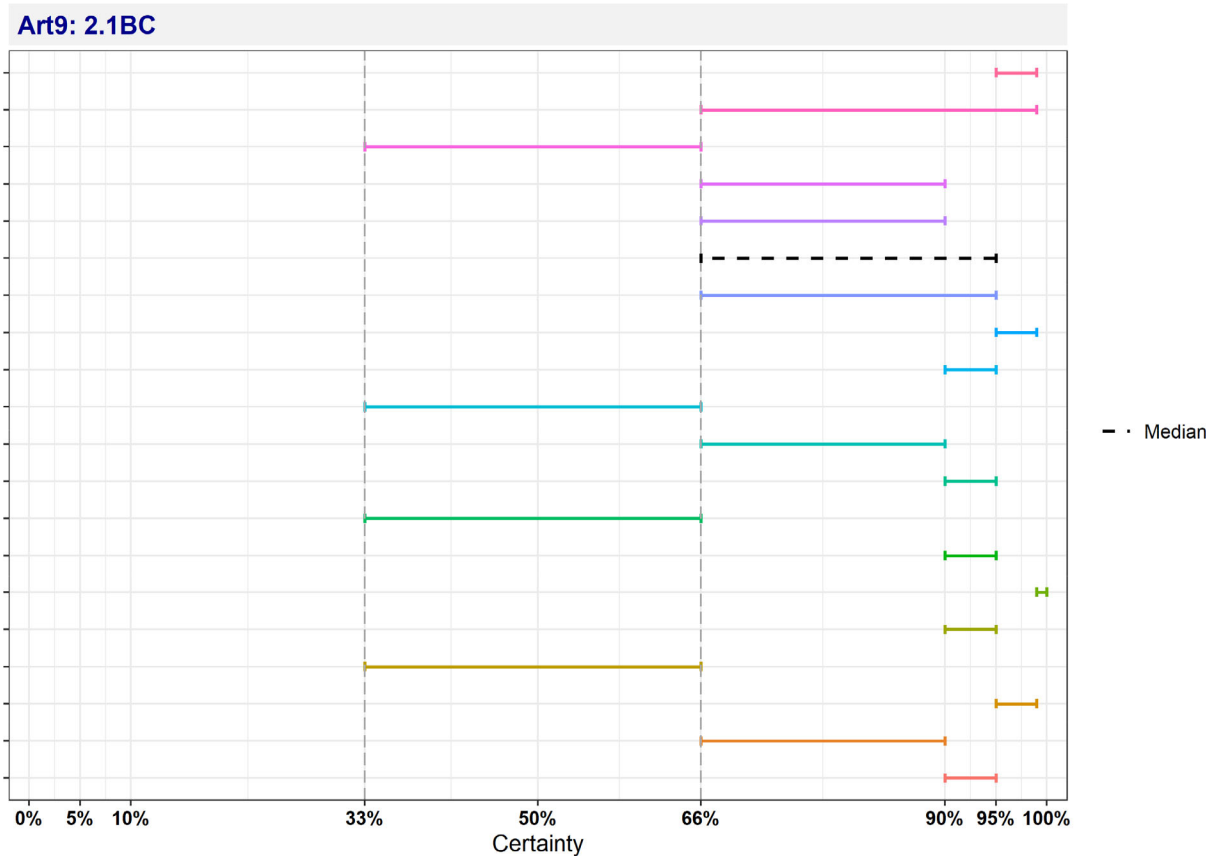

Figure A.26: Individual probability ranges reflecting fulfilment of criterion 2.1BC after the collective judgement

Reasoning:

- The evidence suggests that incidence is hard to estimate.
- There is strain variation in transmissibility, ranging from moderate (R = 3) to high (R = 10).
- Transmissibility is different between EHV-1 respiratory (with low transmission rates of 35–40%) and neurological illness (with high R0 of about 3–10).
- R0 can be high under certain circumstances (e.g. the outbreak in Spain, large gatherings). In other circumstances, it is moderately transmissible

A.3.8. 2.4B the disease may result in high morbidity with in general low mortality

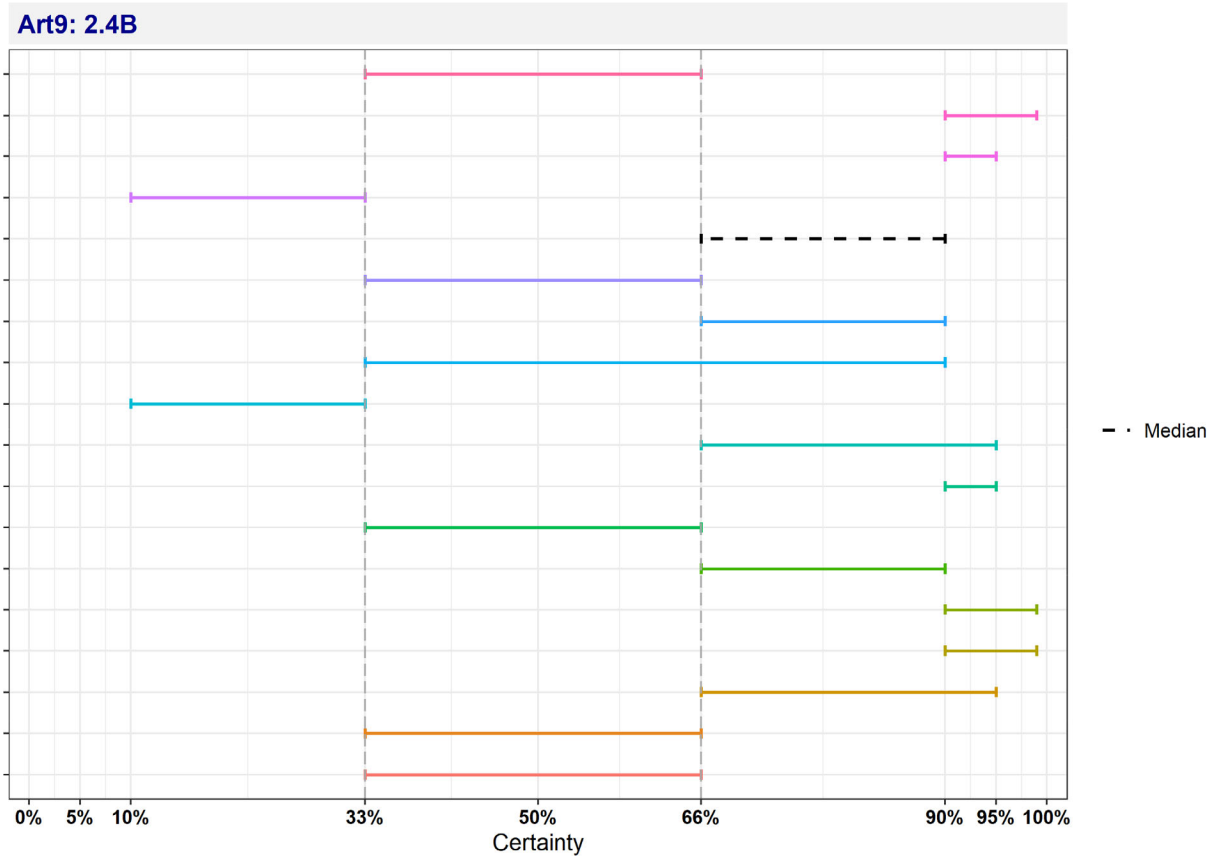

Figure A.27: Individual probability ranges reflecting fulfilment of criterion 2.4B after the collective judgement

Reasoning:

- Evidence suggests signs are rare (suggesting it is unlikely to see high morbidity) even if latent infection rates are high. There is some uncertainty about this because it is possible to have morbidity without noticeable signs.
- There is moderate morbidity and rather low mortality (ranging from 0.5% to 10%). Morbidity is strain-dependent.
- Some infections may result in respiratory or neurologic disease, or abortions, but this is more uncommon than common.
- There is high prevalence at herd level (74% and 90% in Spain and Poland, respectively) and the infection is widespread. Latent prevalence is higher than 60% in equine populations worldwide.
- The recorded median morbidity was 10.6% (Q1: 2.0%; Q3: 31.3%) and this can be considered high for abortions.
- Outbreaks with abortion storms and high mortality have been reported. Morbidity was 100% in some of those outbreaks. Therefore, the disease 'may' result in high morbidity.

A.3.9. 2.4C 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

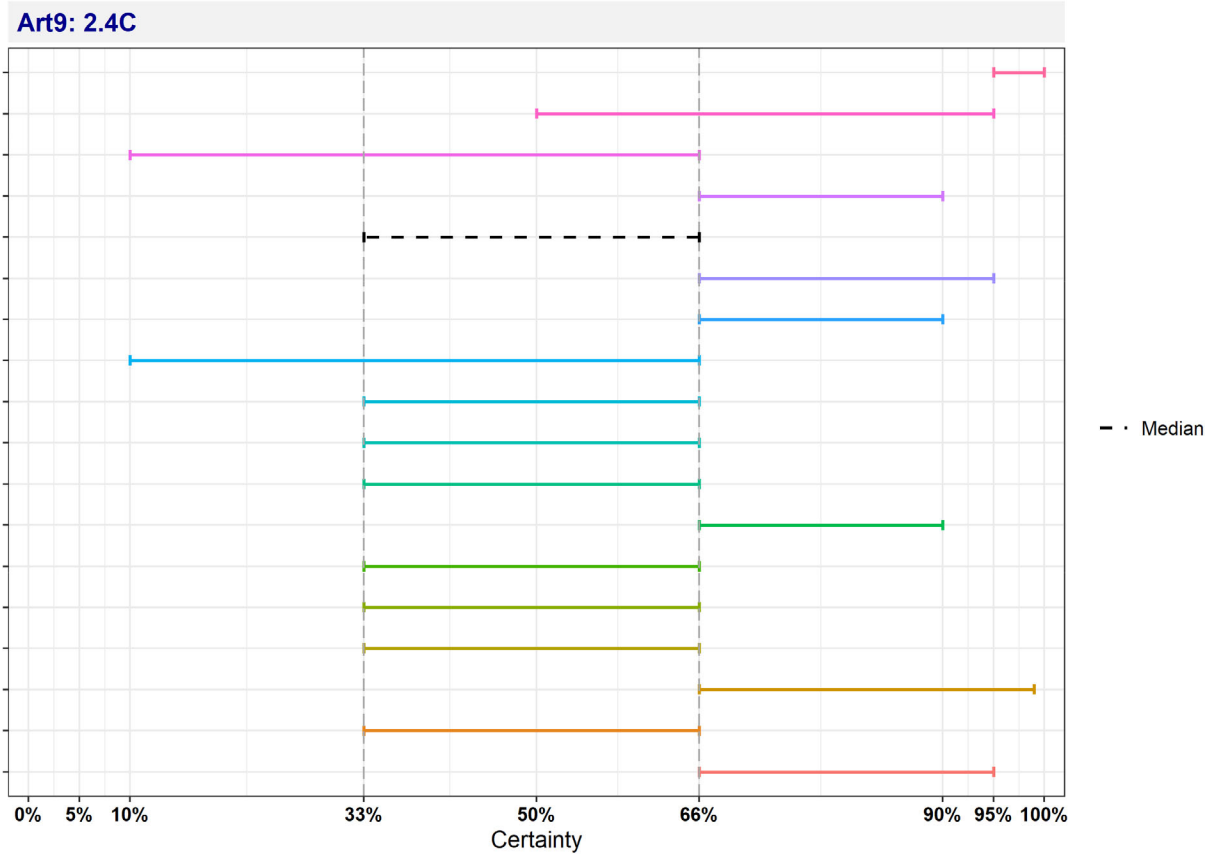

Figure A.28: Individual probability ranges reflecting uncertainty about fulfilment of criterion 2.4C after the collective judgement

Reasoning:

- There is a high variation in morbidity, depending on strain and other factors, but it seems high in general (> 60% latent infection in equine populations worldwide). Even if clinical signs are not common, a median morbidity of 10.6% can be considered high.
- Outbreaks with abortion storms, including mortality, have been reported.
- EHV-1 is endemic among horses and spreads easily.
- The majority of EHV-1 infected horses do not show clinical signs. Most infections are latent. Respiratory or neurologic disease and abortions are more uncommon than common. Prevalence and infection profile imply no or negligible mortality and only low to moderate morbidity.
- Abortions and loss of foals as well as reduction in performance can be considered production loss.

A.3.10. 4AB 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

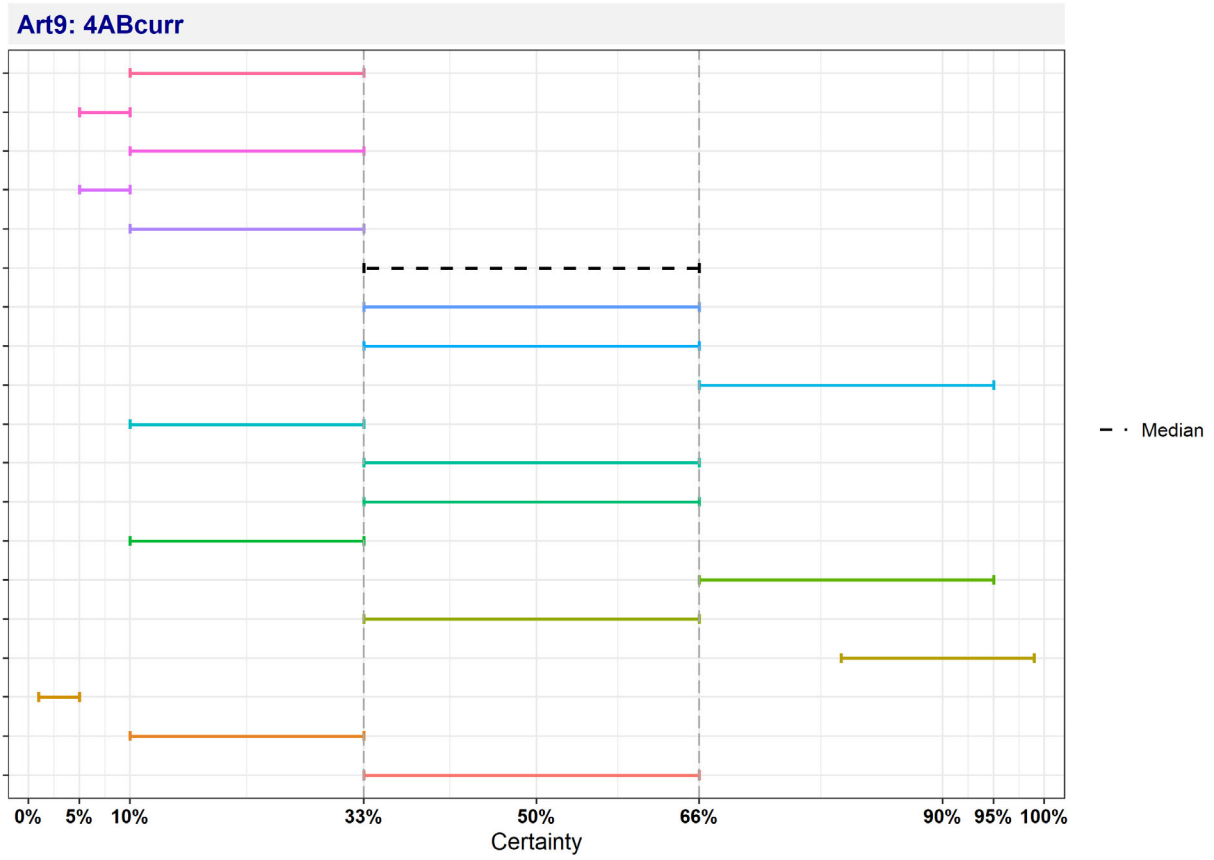

Figure A.29: Individual probability ranges reflecting uncertainty about fulfilment of criterion 4ABcurr after the collective judgement

Reasoning:

- There is a lack of data on the economic impact.
- Considering the whole economy of the Union, EHV-1 does not seem to have a major impact. However, there may be a significant impact on the horse sector.
- The major impact is through risk-mitigating measures and not through direct impact on health and productivity of animals.
- There is no major impact due to low morbidity rates.
- There is high latent prevalence and possibly a lot of underreporting. Outbreaks with abortion storms and mortality have been reported. Even if clinical signs are rare, they can still represent a non-negligible percentage of the infected populations, including relevant neurological presentations.
- EHV-1 abortion or perinatal death is an economic problem, especially in breeding farms. Covering fees and the related potential value of a foal in some horse breeds such as Thoroughbred can be very high, up to 290,000€. EHM can cause the death or the lack of performance in horses. The occasional outbreak of EHM may result in the cancellation of equestrian and racehorse events with a huge economic impact for the sector.
- There was a major impact for the recent outbreak in Spain and there might be more impact in future. Billions of € were involved, because affected horses often have a huge economic value.
- Even if the impact has been significant in only one MS, this would be considered EU. EHV-1 has caused significant impact in the Netherlands and Spain.

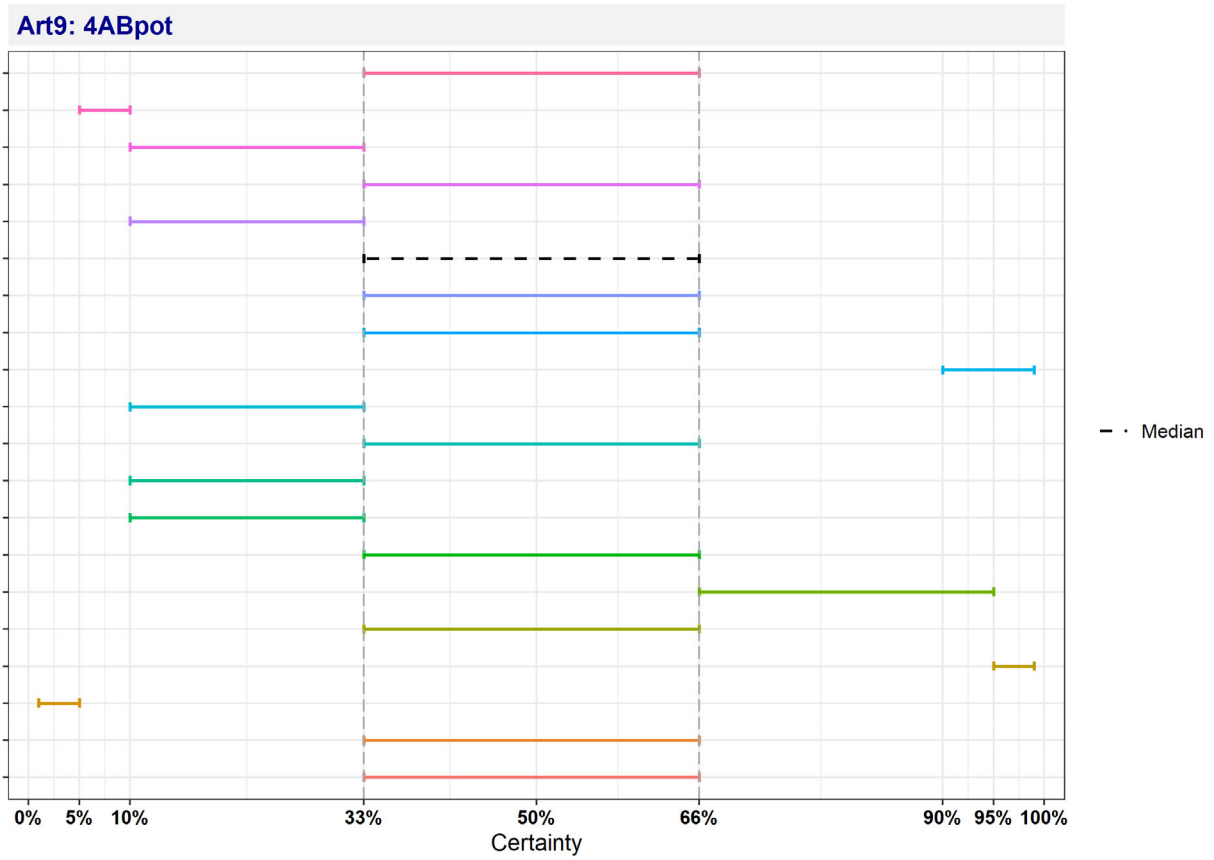

Figure A.30: Individual probability ranges reflecting uncertainty about fulfilment of criterion 4ABpot after the collective judgement

A.3.11. 4C 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

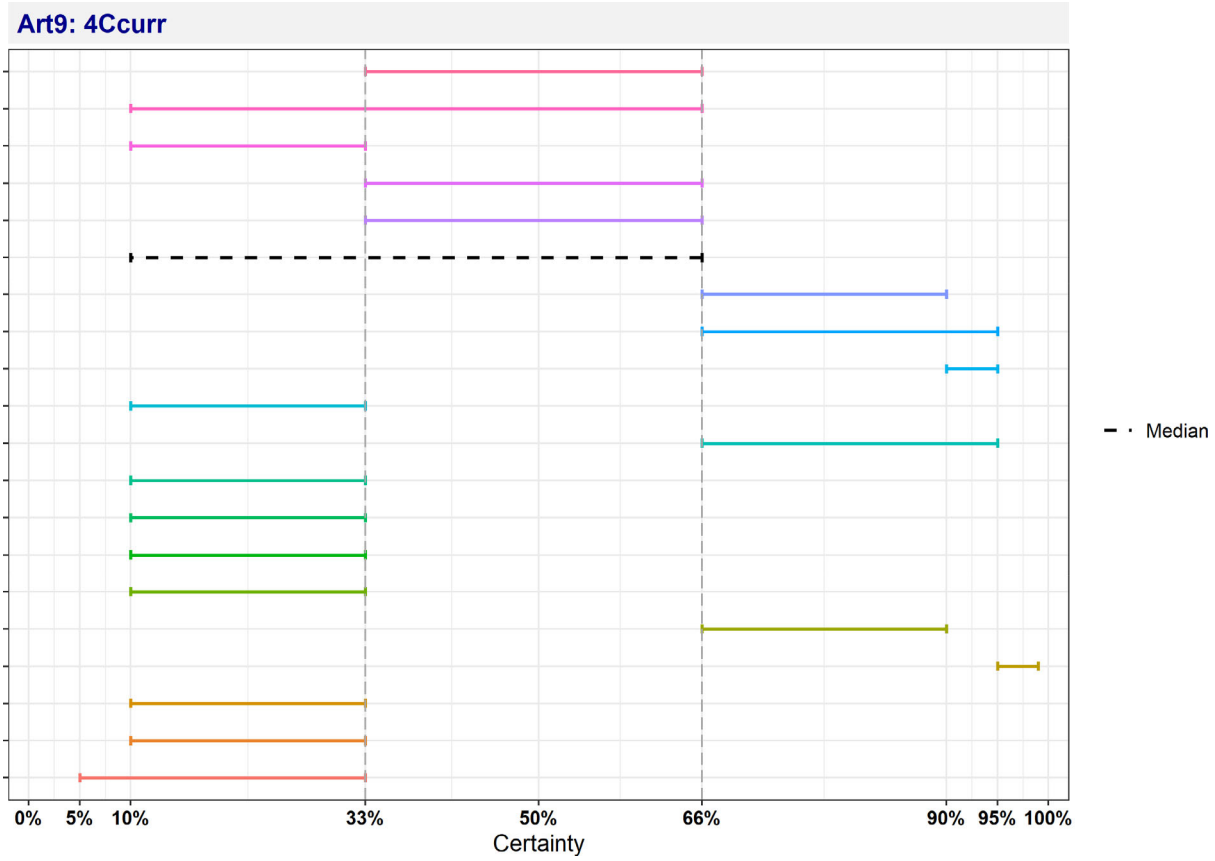

Figure A.31: Individual probability ranges reflecting uncertainty about fulfilment of criterion 4Ccurr after the collective judgement

Reasoning:

- Considering the whole horse sector as one certain type of production system, there is a significant impact on the economy of the Union. However, only a very small part of the horse sector may be affected.
- The effects of the disease are unlikely related to production system (keeping system) of horses. The disease affects horses in all keeping systems. The economic losses are likely larger in horses of higher value independent of keeping system.
- Breeding farms, stables, and riding schools may suffer economic losses.
- Sport, race and exhibition events involving horses from many establishments may result in outbreaks that have some impact.
- The disease can cause high economic losses to single privates when high-value animals are involved.

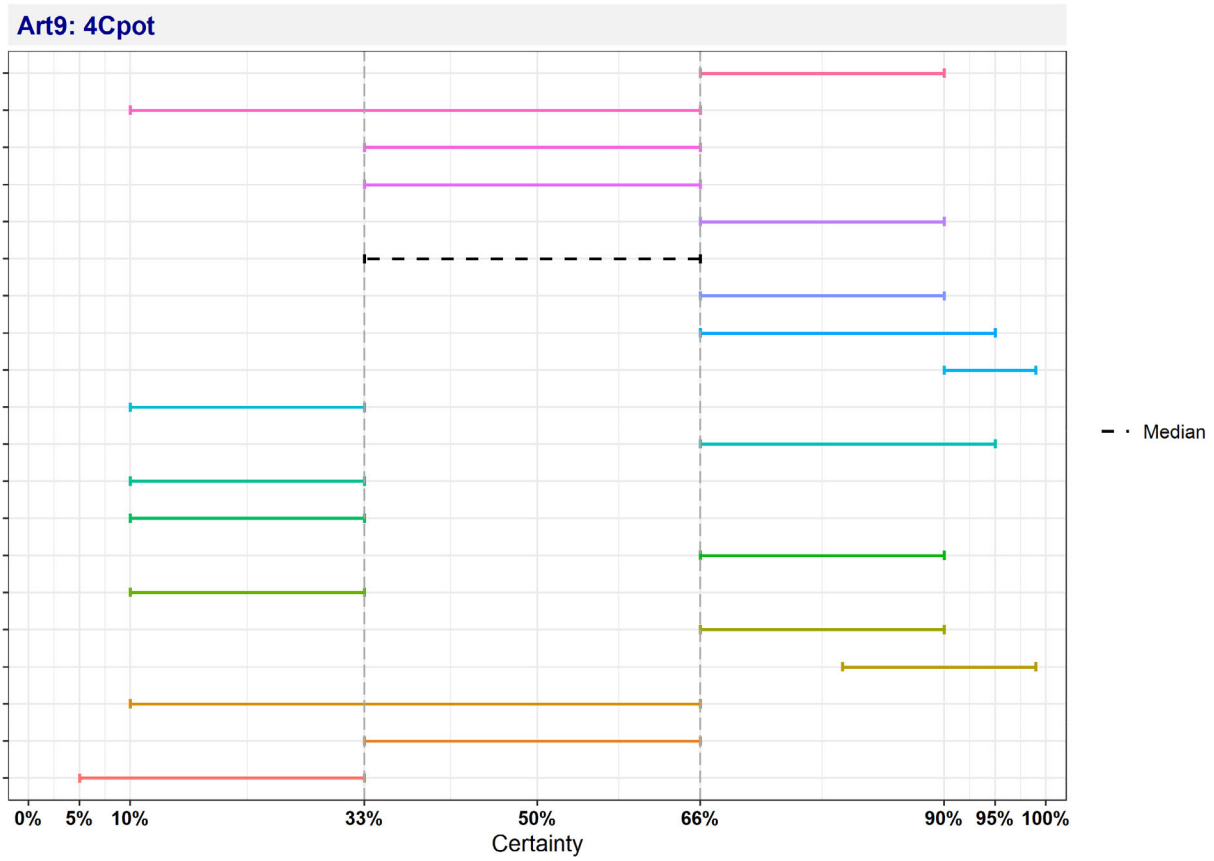

Figure A.32: Individual probability ranges reflecting uncertainty about fulfilment of criterion 4Cpot after the collective judgement

A.3.12. 5b the disease has a significant impact on animal welfare, by causing suffering of large numbers of animals

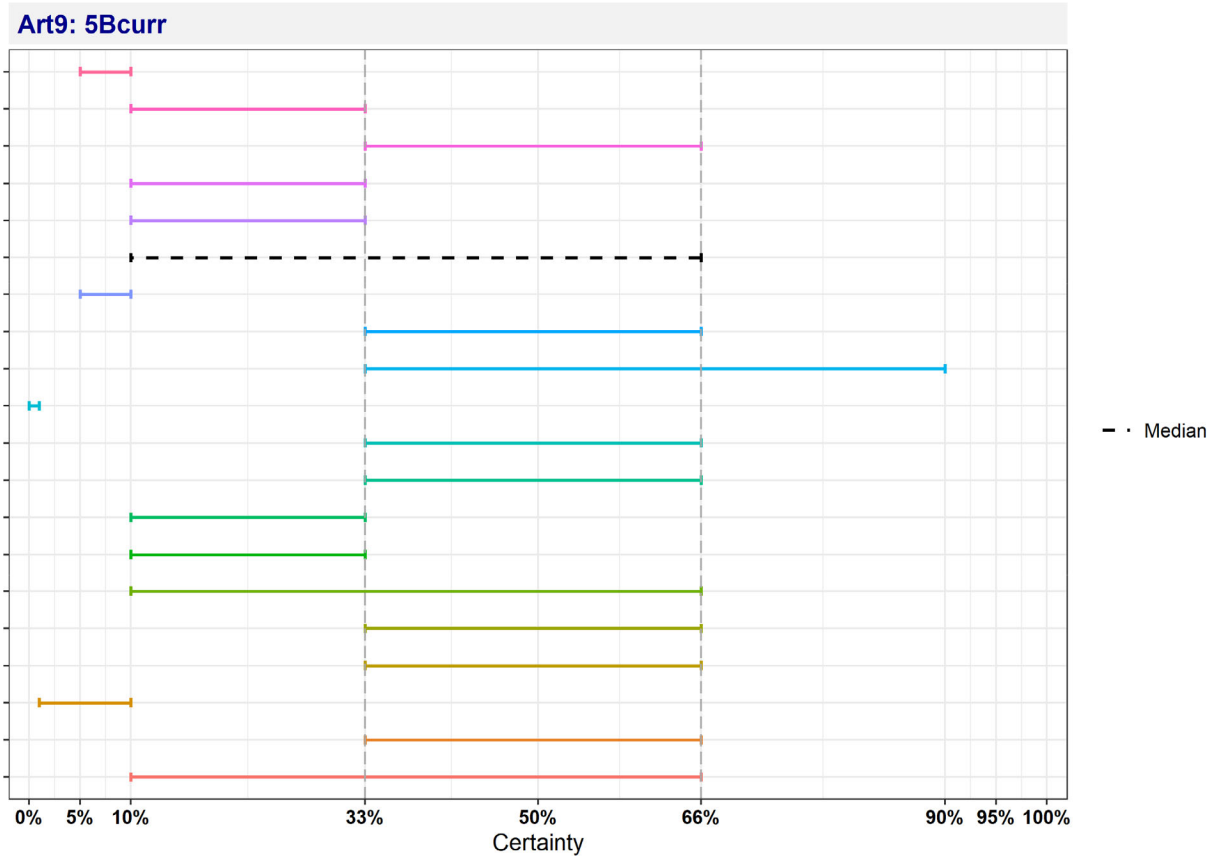

Figure A.33: Individual probability ranges reflecting uncertainty about fulfilment of criterion 5Bcurr after the collective judgement

Reasoning:

- Proper estimates of clinical disease are lacking although prevalence of clinical infection is low, yet in some cases the disease can be serious, therefore there is large uncertainty.
- No large numbers of animals are affected. The disease can be controlled by good biosecurity. Moreover, horses with clinical signs are treated and their pain can be relieved.
- There is low morbidity and the majority of the EHV-1 infected horses do not show any clinical signs.
- No potential emergence of highly virulent strains are identified.
- Welfare impact is mainly due to abortions (4–21% of the abortion cases) and EHM.
- Cases of EHM may require euthanasia on welfare grounds (e.g. recumbent animal and/or distress associated with paralysis). In EHM cases, scrupulous attention to horse welfare should be paid. When neurological signs develop and fatalities occur in horses, the horse welfare is severely affected. EHV-induced respiratory disease is mild to moderate but could lead to serious and life threatening secondary bacterial infection.

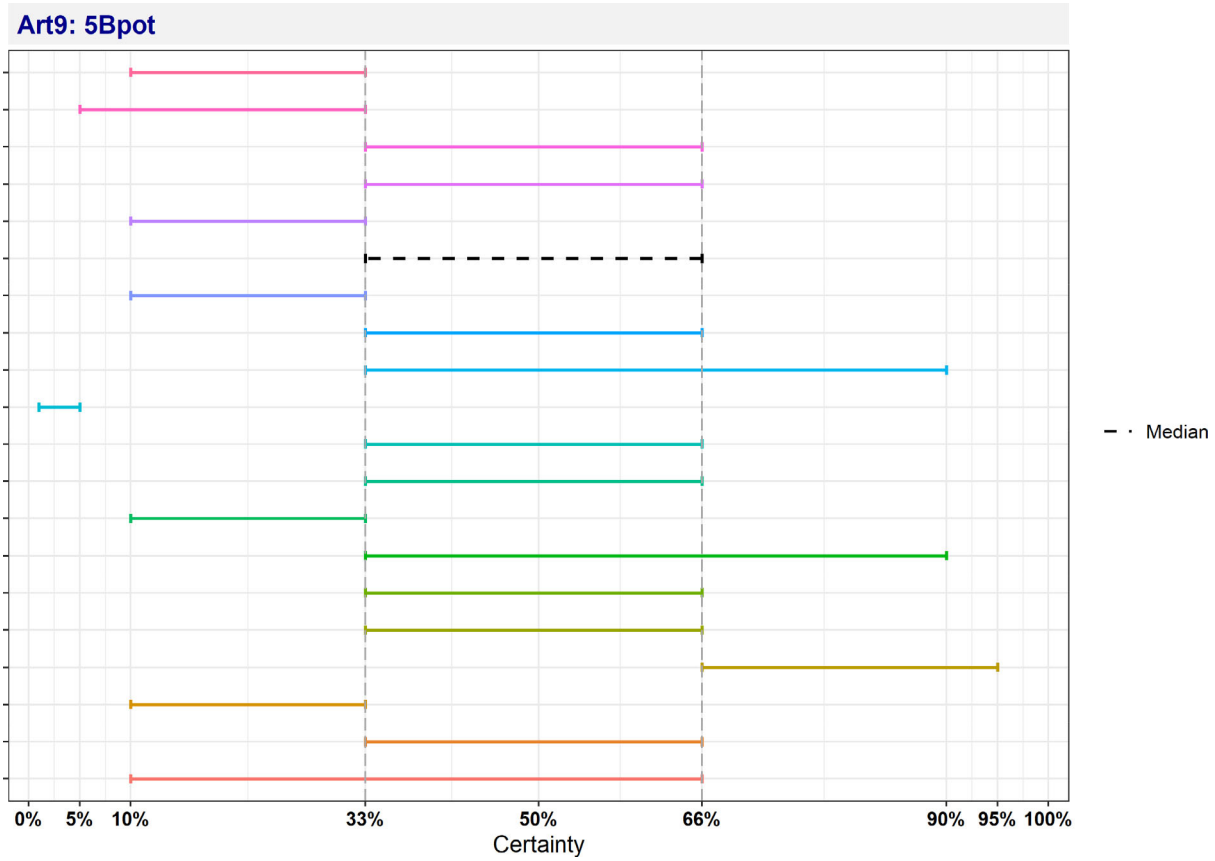

Figure A.34: Individual probability ranges reflecting uncertainty about fulfilment of criterion 5Bpot after the collective judgement

A.3.13. 5d 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

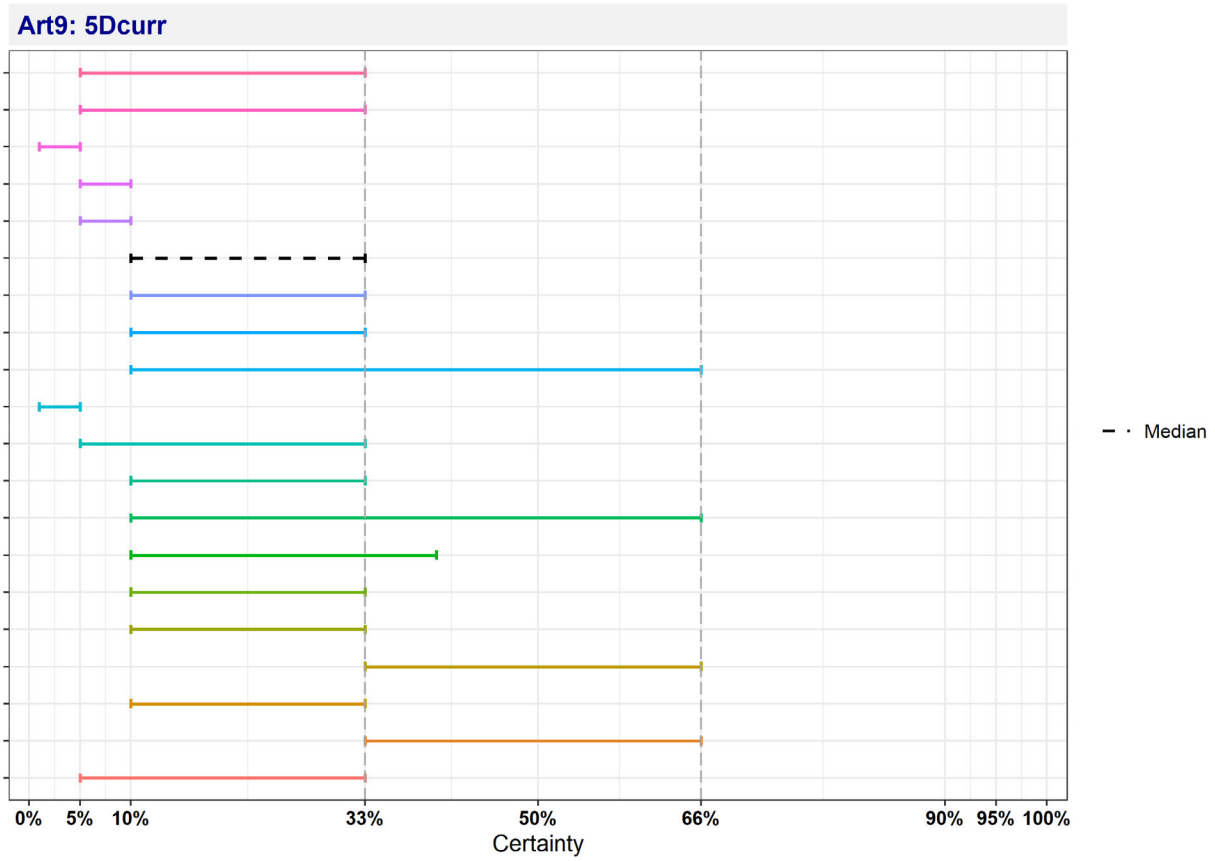

Figure A.35: Individual probability ranges reflecting non-fulfilment of criterion 5Dcurr after the collective judgement

Reasoning:

- There is no information about a possible impact on equine breeds in the EU. More evidence is required.
- Based on the evidence, it is not clear how this disease could have a significant impact on biodiversity/protection of endangered species or breeds, since it does not seem to be a major risk for endangered species (even if some are susceptible). There is no evidence that the disease is can cause high mortality in any of the affected species.
- There is no impact on wild animals in the EU. However, non-EU endangered species are susceptible to EHV infection.
- Zoo animals may be affected, but this has no impact on biodiversity in the EU.
- Some impact is expected, but it is not significant.
- Some rare breeds of wild horses and donkeys may be impacted.

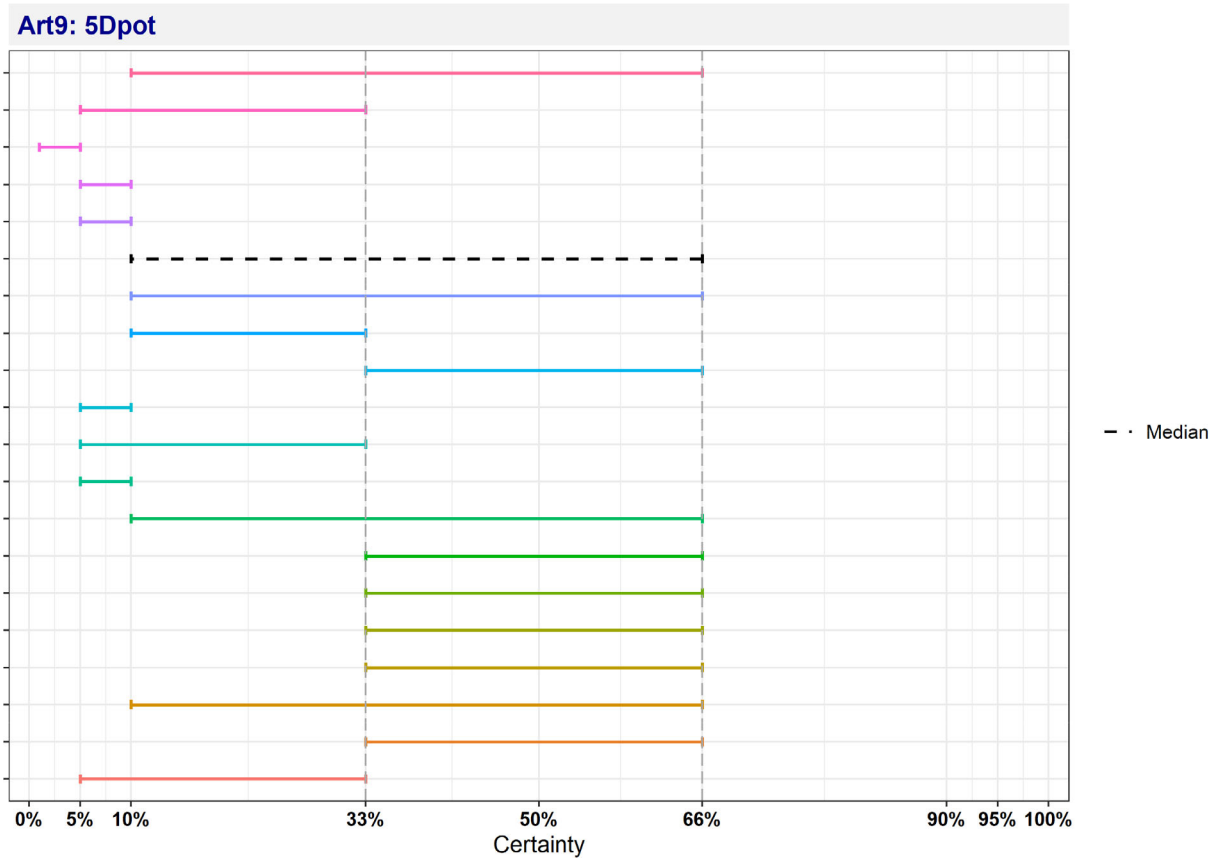

Figure A.36: Individual probability ranges reflecting uncertainty about fulfilment of criterion 5Dpot after the collective judgement

A.3.14. 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

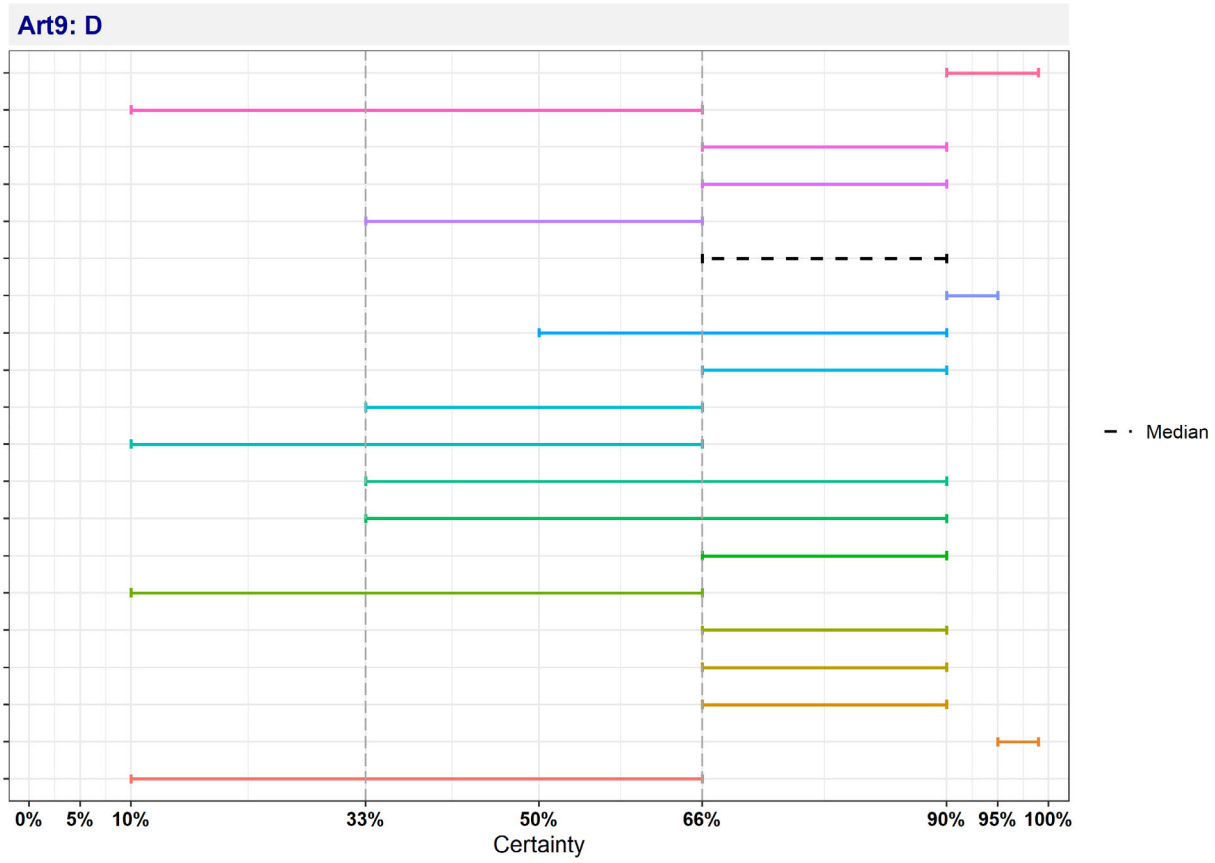

Figure A.37: Individual probability ranges reflecting fulfilment of criterion D after the collective judgement

Reasoning:

- Although movement restrictions are commonly applied, they target the animals that excrete the virus at the time of testing. With a majority of horses likely to be latently infected, and with limited information on factors that cause re-activation of infection, it is a major challenge to identify animals that should not be moved unless they are tested repeatedly (daily?) during movements and events.
- Because of the widespread nature of the infection, the limited performance of diagnostic tests in asymptomatic phases and difficulties interpreting test results, it seems difficult to contain the risk through movement restrictions. Many animals can be affected and go undetected. This would only serve in the case of symptomatic animals.
- Feasibility of movement restrictions may not be always effective.
- As EHV-1 is considered endemic in MSs with high prevalence rates, restrictions of movement can be applied only to animals that could shed the virus and not to animals latently infected that are presumably not contagious.
- The infection is endemic in the EU and latent with a high prevalence. It is not compulsory to report, but movement restrictions may be useful in case of outbreaks. However, they are difficult to implement systematically. Therefore, movement restrictions may be effective when considering outbreaks (disease) but unlikely when considering latent infection.

- Quarantine appears to be effective, also when implemented within farms during outbreaks. The ban of animal movements for at least 21–30 days (van Maanen, 2002; Allen et al., 2004; Khusro, 2020) from the resolution of clinical signs in all horses in an EHV-1 outbreak is effective in avoiding further spread of the disease from an infected premise.