AFRICAN HORSE SICKNESS:

POTENTIAL RISK FACTORS AND THE LIKELIHOOD FOR THE
INTRODUCTION OF THE DISEASE TO THE UNITED KINGDOM

Working Document

Dr Mirzet Sabirovic
Mauricio López
Kulin Patel
Andrew Kingston
Simon Hall

DISCLAIMER: IAH reserves the right to update this publication and make changes to the outcomes at any time if new information becomes available following this release. The update will be carried out without prior notice. This publication or any related updates are published at the Defra’s website above. This publication and any subsequent update, if available, may be used free of charge in any format or medium provided it is used accurately and not used in a misleading context. The material must be acknowledged as crown copyright and the title of the publication specified.

Suggested reference for this publication:


©Crown copyright
Copyright in the typographical arrangement and design rests with the Crown
Table of Contents

1 Summary..................................................................................................................3
2 Introduction ............................................................................................................4
3 Risk question .........................................................................................................4
4 Scope.....................................................................................................................4
4.1 Inclusion..............................................................................................................4
5 Hazard identification ............................................................................................5
6 Risk assessment ....................................................................................................6
6.1 Definitions ..........................................................................................................6
6.2 Terminology .......................................................................................................6
6.3 Key criteria ..........................................................................................................7
6.3.1 Uncertainties .................................................................................................7
6.3.2 Starting assumption ......................................................................................8
6.4 Release assessment ...........................................................................................9
6.4.1 Legal trade and imports ................................................................................9
   6.4.1.1 Third Country imports ..........................................................................10
   6.4.1.1.1 Live equidae ....................................................................................10
   6.4.1.1.2 Equine semen, ova and embryos ....................................................13
   6.4.1.1.3 Authorised biologicals ..................................................................14
   6.4.1.1.4 Research samples (including equine sera) ....................................15
   6.4.1.1.5 Meat and by-products ...................................................................15
   6.4.1.1.6 Exotic ungulates ...........................................................................15
   6.4.1.1.7 Import of plants from countries where AHS virus may be present. ..16
   6.4.1.2 Intra-Community trade ........................................................................17
   6.4.1.2.1 Live equidae ...................................................................................17
   6.4.1.2.2 Semen, ova and embryos of equidae .............................................19
6.4.2 Illegal movements .........................................................................................19
6.4.3 Epidemiological considerations .....................................................................20
   6.4.3.1 The virus ..............................................................................................21
   6.4.3.2 The host ................................................................................................21
   6.4.3.3 The environment ..................................................................................27
   6.4.3.3.1 AHS - geographic distribution ......................................................27
   6.4.3.3.2 Biological vectors ...........................................................................28
7 Conclusions ..........................................................................................................30
8 References .............................................................................................................31
1 Summary

This qualitative risk assessment specifically addresses the potential likelihood of the introduction of African Horse Sickness virus (AHS) from abroad to the UK via various pathways. Should the disease be introduced to the UK, we consider that it would have a significant impact on its horse industry. Therefore, this specific aspect of disease dissemination in the UK has only briefly been considered in this document as it is subject to comprehensive consideration by another team.

With regard to the introduction of AHS from abroad, we currently consider that:

a) The likelihood of the introduction of AHS virus to the UK via legal trade in horses and other equidae is considered very low. On the basis of official reports, the AHS virus currently appears to be confined to sub-Saharan continental Africa. Only certain categories of equidae from EU approved Third Countries are authorised for legal import into the EU. In this context, testing for AHS under quarantine conditions is required for equidae being imported into the EU from Third Countries with areas at risk due to presence of the disease in the country or in neighbouring infected countries.

b) The likelihood of the introduction of AHS virus to the UK via legal trade of equine semen, ova and embryos, their meat and specified biologicals is considered negligible.

c) Although possible, the likelihood of the introduction of the virus via illegal or non-compliant movements of equidae is difficult to quantify. It is also impossible to quantify the likelihood of introduction of virus by as yet unrecognised routes.

Should the virus be introduced to the UK, we consider that:

a) The local spread would depend on the presence of optimal conditions such as equine density and abundance of competent vectors.

b) Awareness and familiarity of owners, keepers of horses and veterinarians with AHS clinical signs would facilitate early detection as a key limiting factor to potential wider dissemination of the disease in the UK.

With regard to availability of vaccines for AHS, we consider that:

a) There are reservations about the use of live attenuated vaccines in non-endemic areas, such as the EU, in the face of an epizootic. Nevertheless, their use in the current absence of any other type of vaccine would have to be further considered.

b) The potential use of modern recombinant vaccines would have to be considered because of their safety and their role in distinguishing vaccinated from infected animals.

c) Consideration should also be given to the potential for creation of an international vaccine bank for AHS.
2 Introduction

This qualitative risk assessment considers the likelihood of the introduction of African horse sickness (AHS) virus via various pathways to the United Kingdom. It builds on our previous assessments following official reports on confirmed cases of AHS in Third Countries.


This document primarily addresses the likelihood of the introduction of AHS from abroad to the UK (see diagram to the left).

We acknowledge that the introduction of the disease to the UK may have serious consequences for our equine industry. However, this is currently being considered by another team in close co-operation with industry sector.

3 Risk question

"Given the known geographical distribution of AHS, what is the likelihood of the introduction of African horse sickness (AHS) virus to the United Kingdom via various pathways?"

4 Scope

4.1 Inclusion

This qualitative risk assessment covers:

- All serotypes of African horse sickness virus (types 1 to 9);
- Biological and other potential pathways for the introduction of the virus;
- Equidae as defined by EU rules;
- Products of equidae.
5 Hazard identification

The hazard of interest is African horse sickness virus as defined in the scope of this risk assessment.

Key assumptions:

a) AHS virus causes significant impact on health of horses;

b) AHS has a significant impact on international trade in equidae and their products;

c) Predicted climate changes could create potential for northward distribution of the main known biological vector (i.e. Culicoides imicola) in Europe. Nevertheless, other natural and human related factors would also have to be considered to ensure more balanced assessment of potential risks;

d) There are concerns that existing Culicoides spp that are present in Europe may favour the spread of the disease should it be introduced.

Supporting evidence

AHS is a non-contagious viral disease of equidae. Nine different serotypes (AHSV 1-9) have been recognised. Horses are most susceptible to all AHS serotypes with a mortality rate ranging between 70-95%. The disease is endemic in sub-Saharan continental Africa from where it occasionally spreads to other suitable areas. AHS does not affect human although it has a significant impact of international trade in live equidae and their products. Following the pandemic spread of AHS-9 through the Middle East in late 1950s and early 60s, exports of equidae from South Africa have been virtually banned until late 1990s.

AHS is a disease that is considered to have a significant impact on international trade in live equidae and their products. The existing EU rules provide mechanisms for risk mitigation measures related to legal trade of equidae and their products.

The disease is mainly transmitted by midges of the genus Culicoides. Mosquitoes and biting flies may also act as biological or mechanical transmitters of the virus. However, the possibility of iatrogenic dispersion via contaminated needles would have to be further considered.

Potential changes in ecological situation in southern Europe have raised concerns as they may favour further expansion of areas in Europe where vectors considered to be competent are currently known to be present, thus creating favourable conditions for the spread of the disease should it be introduce. Changes in climate are always occurring because of natural factors and the term ‘climate variability’ is often used to refer to this natural component (Chan and others, 1999).

The issue of climate change remains controversial because of uncertainties as to what extent this is a natural phenomenon or is influenced by a global change caused...
by human activities. The international scientific community generally accept that human activities, particularly during the last century, have impacted on climate change and may serve as a catalyst for future developments in this area (Suthers, 2004). The emergence of diseases may be an evolutionary response to various global changes. These changes may be in the environment, including anthropogenic factors such as new agricultural practices, urbanisation and globalisation, as well as climate change (Slingenberg and others, 2004).

6 Risk assessment

6.1 Definitions

For the purpose of the release assessment, the following definitions will apply:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equidae</td>
<td>Means wild or domesticated soliped mammals of all species within the genus Equus of the family Equidae, and their crosses (European Commission, 2008)</td>
</tr>
<tr>
<td>Trade</td>
<td>Means intra-Community trade between EU Member States</td>
</tr>
<tr>
<td>Importation</td>
<td>Means temporary admission, re-entry after temporary export, and imports from Third Countries to the EU (including the UK)</td>
</tr>
</tbody>
</table>

6.2 Terminology

For the purpose of the release assessment, the following terminology will apply (OIE, 2004; EFSA, 2006):

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>So rare that it does not merit to be considered</td>
</tr>
<tr>
<td>Very low</td>
<td>Very rare but cannot be excluded</td>
</tr>
<tr>
<td>Low</td>
<td>Rare but does occur</td>
</tr>
<tr>
<td>Medium</td>
<td>Occurs regularly</td>
</tr>
<tr>
<td>High</td>
<td>Occurs very often</td>
</tr>
<tr>
<td>Very high</td>
<td>Events occur almost certainly</td>
</tr>
</tbody>
</table>
6.3  Key criteria

6.3.1  Uncertainties

In general terms, estimating the likelihood of the effects of factors such as globalization connected with increased movements of animals and vectors in cargo holds of aircrafts, climate change and emergence and dissemination of pathogens in new areas is a complex task. Whilst our knowledge of many aspects of these factors is improving, our understanding of responses to the full complement of these factors needs further examination (Dukes and Mooney, 1999), particularly in the area of animal health. Consequently, further work is necessary to consider and assess the interactive effects of the drivers of climate change and global change on animal health.

In this document we use some elements of a holistic approach (Fig.1) which we have developed from a number of related published papers (Brown, 2004; Chan and others, 1999; Chevalier and others, 2004; Hunter, 2003; Morse, 2004; Slingenbergh and others, 2004; Sørensen and others, 2006; Sutherst, 2004;). These papers broadly cover aspects of climate change, global change and its impact on emerging diseases and animal health. These aspects should not be considered mutually exclusive (Morse, 2004) because several major factors (Fig.1) may contribute to changes in the risks to animal health in the UK.

![Fig.1. Conceptual considerations – national and international factors influencing potential risks to animal health in the UK](image)

A very similar principle may be applied when assessing the potential risk of the introduction of AHS virus and its subsequent dissemination. This approach would allow an integrated assessment of important and complex direct and indirect effects on animal health and production.
determinants that influence the introduction, or emergence, and establishment of pathogens (including AHS) in new areas, including the UK, taking into account a varying degree of uncertainty that could be associated with any of the factors listed.

Therefore, this risk assessment acknowledges that our current understanding of worldwide distribution and the epidemiology of AHS and potential pathways for the introduction and further dissemination has a number of limitations and any inferences made have a degree of uncertainty.

6.3.2 Starting assumption

Even when EU rules for trade are fully complied with, there is an inherent risk that infectious live equidae or their products may be consigned in good faith from an EU approved Third Country. In addition, a possibility that equidae may be infected while in transit cannot be excluded. Also, a possibility of illegal movements of live equidae and their products, windborne influx of infected midges, or movement of infected midges in cargo holds of aircrafts cannot be excluded.

Therefore, the starting assumption in this risk assessment is that undisclosed infection may be present in live equidae or their products that may be imported to the UK (and other EU Member States) via legal trade or illegal movements.

Very broadly, the likelihood of the introduction of AHS into unaffected areas will depend on:

a) the prevalence of infection in the country of origin;

b) other possible human activities and risk reduction measures that may affect legal trade;

c) favourable environmental conditions and presence of the virus in sufficient quantities to initiate infection in countries authorised for imports into the EU;

d) illegal movements;

e) any other unknown mechanism.
6.4 Release assessment

This assessment recognises that there are broadly two major groupings of pathways (i.e. legal and illegal) by which the AHS virus may be introduced to the UK (Fig. 2).

6.4.1 Legal trade and imports

Diagram 1 outlines possible scenarios for the introduction of AHS via legal trade and imports.

The diagram assumes that infected equidae or their products may be directly imported to the UK or arrive to the UK being imported via another EU Member State.
6.4.1.1 Third Country imports

6.4.1.1.1 Live equidae

**Conclusion:** There would be a very low likelihood that AHS may be introduced to the EU via legal trade in live equidae from approved Third Countries, including via triangulation. Nevertheless, if transhipment (e.g. for refuelling) through an AHS virus infected country is permitted, the possibility that some equidae may become infected by exposure to AHS virus infected insect vectors while in transit is considered remote but cannot be excluded.

**Key assumptions:**

a) Currently, AHS virus appears to be confined to many countries in sub-Saharan continental Africa;

b) Legal imports of live equidae or their products are not permitted from any sub-Saharan continental African country to the EU. The EU has established a group of exporting countries that are free but at risk and to which specific preventive measures are applied in case of imports of equidae into the EU;

c) We are aware that the only two exceptions to the rule under ‘b’ above are:

- imports of registered horses and their products from a defined area in South Africa (AHS free zone), if not banned because of an outbreak;

- transhipment of live equidae from South America via Dakar airport in Senegal*

d) The OIE (and the EU) significantly tightened international trade standards and rules for AHS in early 1990s. Subsequently, we are not aware of any cases of AHS being reported in any country around the World where the disease is considered exotic that is attributed to legal trade in equidae and their products;

e) All imported equidae are immediately subject to veterinary checks at Veterinary Border Inspection Post approved for the species in the EU;

f) It is highly likely that any infected horse would be detected during the residency period during triangulation in the approved Third Country;

g) The infection of certain equidae with AHS virus due to exposure to AHS infected vector insects while in transit is considered as a chance event subject to fulfilment of optimal conditions for infection to occur.

* Note: Senegal is not included in the approved EU list for horses. Transhipment without unloading is permitted provided that horses are not exposed to risk. There is
Supporting evidence

**Note:** All maps are for visual purposes only

According to the official reports, AHS appears to be confined to sub-Saharan continental Africa (see map below) (OIE, 2008) with occasional excursions into areas further north such as Mauritania or Mali. However, the situation in many countries in the region remains uncertain and the barrier function of the Sahara is no longer as solid as it appeared to be prior to the 1999 FMD outbreak in Algeria caused by a West African sub-Saharan virus strain.

![Map of African Horse Sickness Outbreaks](image)

EU rules permit the import of live equidae, and semen, ova and embryos of the equine species from approved Third Countries or their territories (European Commission, 2004). Current EU import rules distribute Third Countries, authorized for imports of certain categories of equidae, into different sanitary groups on the basis of the potential animal health risk they pose. Furthermore, live equidae are also categorised in accordance to their final import purpose (re-entry, temporary admission, slaughter, and breeding and production) (European Commission, 1992 and 1993, 1993a & 1993b). As an example, the map below shows the different groups of countries authorized for imports of registered horses and horses for breeding and production to the EU.
Note: Legend explains that each of these groups will have slightly different risk management requirements for AHS for the purpose of entry to the EU.

Equidae from the approved countries must meet country and zone freedom requirements from AHS. That is, live equidae and their products may only come from countries or areas that are recognised as free from AHS, based on minimum 2 years absence of disease and 12 month no vaccination. The certificate also requires a statement on the vaccination status of the imported live equidae, to verify post-import checks and future certification and to ensure that live attenuated vaccines have not been used 60 days prior to import.

Registered horses as defined in Article 2 (c) of Regulation 504/2008 (European Commission, 2008) are considered to be subject to close monitoring and management by their owners or designated handlers. It is unlikely that AHS would be introduced into the UK by registered horses because of the usually short incubation period and severity of the disease in naïve horses. However, this may not necessarily be the case with some other equidae. Mules and descendents of the African donkey (European and Asian donkeys) are less susceptible while African donkeys and zebras rarely demonstrate clinical disease. However, depending on the risk associated with the exporting approved Third Country, for example countries with high risk areas due to the history of disease in the country or neighbouring infected countries, testing for AHS under quarantine conditions is required.

EU rules also make specific reference for import of registered horses, mainly for racing and competition, and breeding horses from the AHS free area in South Africa (i.e. the Metropolitan area of Cape Town). These horses must be accompanied by a certificate stating that they have remained for at least 40 days in pre-export isolation in an approved quarantine station under certain strict vector proof conditions. This certificate also includes a statement on their vaccination status and mandatory testing.
EU rules require that all imported equidae from Third Countries are checked (i.e. documentary, physical and identity checks) at the port of entry to the EU (Border Inspection Post - BIP). Post-import testing of equidae from all approved Third Countries is subject to a risk assessment by the BIP veterinary inspector at the time of inspection.

EU rules also allow for *triangulation*. That is the way by which an equidae from a non approved Third Country may be imported into the EU by spending a certain period of time in an approved Third Country allowing the equidae to be legally certified for imports into the EU. It is considered that any horse infected with AHS show signs of the disease during the compulsory residency period prior to entry into the EU.

In line with Commission Decision 2004/211/EC, the UK does not approve transhipment with unloading of equidae through any non-approved Third Country prior to import to the UK (European Commission, 2004). These rules do not specifically ban transhipment through non-approved Third Countries without unloading but, because no legal provision is made for verification of what takes place during the transhipment, the UK only approve such practice where no alternative routing is feasible and information (such as airports located away from vector risk areas) is available to ascertain that the risk is minimal.

It should also be considered that the use of modern, fully vector-proof jet stalls completely closed with mesh and sprayed with insecticide effective against midges would mitigate the risk of horses transiting these non approved Third Countries. Furthermore, these horses normally travel with a veterinarian or a specifically trained groom.

However, horses that may have been transhipped through AHS virus infected countries or zones may subsequently arrive to the UK via another EU Member State that permits such practice for a wider range of non-approved Third Countries. Some EU Member States allow this practice on the basis of a written declaration from the captain of the aircraft declaring that the horses do not leave the aircraft. Nevertheless, some uncertainty remains whether this could be fully achieved at all times. Therefore, it is considered that imports of such horses should be subject to some sort of official supervision at the transhipment airport and be supplied with official documentation providing assurances that management measures to mitigate the risk are used at all times.

### 6.4.1.1.2 Equine semen, ova and embryos

**Conclusion:** There would be a negligible likelihood that AHS virus may be introduced to the EU via legal trade in equine semen, ova or embryos from approved Third Countries.
Key assumptions:

a) The existing risk management measures are considered proportionate to mitigate against possible exposure of live equidae to AHS virus via these pathways;

b) While it could be expected that virus may be present in blood circulation during viraemic phase, we are not aware of any publication that actually contain data on the presence (or detection) of the virus in semen, ova or embryos.

Supporting evidence

EU rules require that approved semen collection centres (European Commission, 1994) must be situated in AHS free areas in listed Third Countries. Specific requirement also apply to donor stallions, semen (European Commission, 1996), and ova and embryos (European Commission, 1996a).

6.4.1.3 Authorised biologicals

Conclusion: There would be a negligible likelihood that AHS virus may be introduced to the EU via legal trade in specified biologicals.

Key assumptions:

a) Import of such products is permitted from approved Third Countries subject to official certification;

b) The virus may be present in specified biologicals if raw material is sourced from equidae incubating the disease;

c) Processing of such products is also considered sufficient to destroy the virus.

Supporting evidence

Limited data suggest that AHS virus can be transmitted between horses by parenteral inoculation of infective blood or organ suspensions (Henning, 1956).

EU rules (European Commission, 2004) permit imports of the blood of equidae from approved countries or subject to specified conditions (e.g. heat-treatment, irradiation) to ensure controlled collection and the destruction of the virus, if present. According to the same EU rules, raw sera from equidae may be imported from approved Third Countries under specified conditions.
6.4.1.1.4 Research samples (including equine sera)

**Conclusion:** There would be a negligible likelihood that AHS virus may be introduced to the EU via research samples.

**Key assumptions:**

a) Such import is subject to licence or authorisation;

b) Such samples are handled in laboratory conditions subject to licensing or authorisation conditions that require handling according to good laboratory practices.

6.4.1.1.5 Meat and by-products

AHS virus can survive in frozen meat, but it is inactivated at temperatures greater than 60°C. Due to pH fluctuations, the virus is also rapidly destroyed in carcasses that have undergone rigor mortis. Dogs are susceptible to infection being severely infected by the virus, usually by eating infected horsemeat. There is no known risk to public health.

6.4.1.1.6 Exotic ungulates

**Conclusion:** There would be a very low likelihood that AHS virus may be introduced to the EU via legal trade in exotic ungulates.

**Key assumptions:**

a) Currently, there are no harmonised EU rules for imports of exotic ungulates;

b) A new EU Directive will allow Member States to develop national rules if no harmonised rules are available.

**Supporting evidence**

Antibodies to the AHS virus have also been detected in some other wildlife (e.g. rhinoceros and elephants) (Davies and Otiento, 1977; Fisher-Tenhagen and others, 2000). However, the potential role of these species in the epidemiology of the disease remains unclear.

The Balai Directive 92/65/EEC sets out rules for intra-Community trade and imports of ‘other animals’ not covered by EC legislation for domestic species, such as cattle, sheep, pigs, horses, etc. (Council of the European Communities, 1992). Specific
rules are also set out for intra Community movement of a small number of species of animals and their semen, ova and embryos.

The virus may have the ability to pass from larva to nymph and from nymph to adult camel tick (*Hyalomma dromedari*) (AUSVETPLAN, 1996). However, we are not aware of any publications where this tick was implicated in the introduction of the disease.

No rules are set out for imports of other animals or semen, ova and embryos from Third Countries. We understand that there are differing views as to whether absence of harmonised rules meant that the Member States may make their own legislation. A new Council Directive 2008/73 (which came into force on 3 September 2008) (Council of the European Communities, 2008) amends the Balai Directive to permit Member States to prepare national rules in event of no harmonised rules.

At present, an amendment to revision 14 of a new EC Proposal establishing harmonised rules for ‘other animals’ including ungulates is awaited from the Commission.

### 6.4.1.1.7 Import of plants from countries with AHS

**Conclusion:** There is a theoretical possibility that infected midges may inadvertently introduced by import of plants from countries where AHS virus is present

<table>
<thead>
<tr>
<th>Key assumptions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Many insect species are associated with plants where they breed or on which they feed and consequently may be transported with them;</td>
</tr>
<tr>
<td>b) This is not generally known to be the case for the <em>Culicoides</em> vectors of BTV and AHS. However, we are not aware of any publication on this type of investigation;</td>
</tr>
<tr>
<td>c) The proximity of AHS infectious animals, therefore potentially infected midges, to crops of plants intended for imports into the EU would have to be considered in the context of existing EU rules.</td>
</tr>
</tbody>
</table>

**Supporting evidence**

According to Meroc and others (2006, p.9) who considered this possibility as a part of the EFSA assessment of BTV-8 introduction to Europe, “such *Culicoides* would have to be infected adults, since BTV has not been shown to be transmitted transovarially. Adult *Culicoides* associate much more closely with their mammalian hosts than with plant species such as the ones normally dealt with in the export trade”. We were unable to find any publication in available literature that addresses this issue.

At the same time, countries exporting plants to the EU have to comply with EU rules for such imports.
6.4.1.2 Intra-Community trade

6.4.1.2.1 Live equidae

**Conclusion:** Currently, there is a negligible likelihood that AHS virus may be introduced to the UK via legal trade in equidae and their products from other EU Member States as no disease is known to be present in the EU. Nevertheless, this conclusion should be considered in the context of a very low likelihood that may be associated with imports of certain equidae that may have arrived to another EU Member State before entering the UK.

**Key assumptions:**

a) The whole of the EU is currently known to be free from AHS;

b) The last recorded outbreak of AHS in the EU was in early 1990s in the Iberian Peninsula.

c) The aspects of potential climate change, global change and its impact on emerging diseases and animal health would have to be considered mutually inclusive (see 6.3.1).

**Supporting evidence**

Movement of equidae into the UK from some EU Member States in 2007 is given in the map below. *(Note: The map is for visual purposes only)*
Trade of equidae between EU Member States is harmonized (European Commission, 1990). Trade of semen, ova and embryos of the equine species is also harmonized (European Commission, 1992). In this context, the UK recognizes two major streams of trade:

The Tripartite Agreement (TPA) exists between the UK, Ireland and France (see map) and provides for movements of live horses (i.e. for racing, breeding and production), and asinines. These equidae must have passports to be allowed to move without an official certificate. This Agreement does not cover zebras.

Under this Agreement, the UK, France and Ireland are obliged to notify each other of confirmed cases of listed diseases. This relates to any significant developments in equine health status, including AHS.

Once the horses enter the EU, there are no residence restrictions and they may travel to any Member State subject to a statement that they are clinically healthy. There is no specific reference to AHS in this statement. However, the certification requirement does not apply in the case of Tripartite Agreement.

Movement of equidae between Member States is subject to veterinary certification stating that they have not come from the territory or part of the territory of a Member State subject to specified disease restrictions. This includes AHS.

Should a case of AHS be detected in any of the Member States, the specific requirements may apply to allow for the movement of equidae. These requirements are subject to EC approval and include vector proof quarantine, testing, vaccination.
statement, clinical inspection and shipment during the specified period in the year that where vector activity is considered to be low.

6.4.1.2.2 Semen, ova and embryos of equidae

**Conclusion**: There would be a negligible likelihood that AHS virus may be introduced to the UK via legal trade in equine semen, ova or embryos from another EU Member State.

**Key assumptions**:

a) While it could be expected that virus may be present in blood circulation during viraemic phase, we are not aware of any publication that actually contain data on the presence (or detection) of the virus in semen, ova or embryos;

b) The existing risk management measures are considered proportionate to mitigate against possible exposure of live equidae to AHS virus via these pathways.

**Supporting evidence**

EU rules require semen collection centres to be situated in the AHS free areas or territory on the day the semen is collected until the date of dispatch, or until the 30 days mandatory storage period for frozen semen elapsed. These also apply to semen used for production of embryos. In the case of ova and embryos, donor mares must be located in AHS free areas on the day of collection.

6.4.2 Illegal movements

**Conclusion**: There would be an undeterminable likelihood that AHS virus may be introduced to the EU via illegal movements of equidae and/or their products.

**Key assumptions**:

a) Illegal activities may pose the risk of the introduction of AHS virus into any non-affected country;

b) This would be considered as a chance event subject to fulfilment of optimal conditions for infection to occur.
Supporting evidence

We are not aware of any evidence to suggest introduction of the AHS virus to non-affected countries due to illegal activities. However, as demonstrated with some other disease introductions, this possibility cannot be excluded.

This again emphasises the importance of maintaining appropriate enforcement measures at the border and raising awareness among horse owners and industry of potential risks that may be associated with illegal activities.

6.4.3 Epidemiological considerations

Broadly, any occurrence of a disease is subject to specific interactions between multiple factors (determinants) which include a susceptible host, pathogen, environment (Thrusfield, 1995) and sustainable management to address these factors and interactions (Sutherst, 2004) (Fig. 3). This may also include biological vectors, if applicable. In addition, other determinants such as genetic constitution, nutrition and toxic agents may also contribute and impact on animal health and production (Thrusfield, 1995). Exotic diseases are more usually associated with ‘changing’ environments, while endemic diseases are usually linked with ‘static’ environment (Slingenbergh and others, 2004). In endemic areas, a specific disease is characterised by the presence of a pathogen; the immunological background and density of hosts and local environmental factors (Chevalier and others, 2004), including potential vectors.

Epidemiology of AHS is highly dependant on the interaction between the infected host, a competent vector and susceptible non-infected equidae under favourable environmental conditions. Once the disease has been introduced, cyclic outbreaks (usually during the late summer through late autumn) would coincide with the availability and abundance of the competent vector(s).

In the context of the potential exposure of horses to infection with AHS virus, the following has been considered:
6.4.3.1 The virus

**Conclusion:** All types of AHS virus are capable of causing infection of susceptible equidae under optimal conditions.

**Key assumptions:**

a) There are nine types of AHS virus, each of which is capable of infecting susceptible equidae under optimal conditions;

b) Stability of the virus is influenced by different biological, physical and environmental factors.

**Supporting evidence**

AHS virus is classified in the genus *Orbivirus* in the family *Reoviridae*. It is similar in morphology to, and shares many properties with other orbiviruses such as bluetongue virus and equine encephalosis virus (Coetzer & Erasmus, 1994). There are nine different types of AHS virus (type 1-9) with marked genetic heterogeneity being recognised within each type (MacLachlan and others, 2007).

The virus appears to be relatively stable at ambient temperatures and could survive at 37°C/37 days. AHS virus was demonstrated to be stable at pH between 6.0 and 10.4 and quickly inactivated below pH 5.9 and above pH of 10.9 (Parker, 1975). It is also inactivated at 50°C/3 hours and 60°C/15 minutes and 1% formalin/48 hours (OIE, 2002). Due to pH fluctuations, the virus is rapidly destroyed in carcasses that have undergone rigor mortis. However, AHS virus can survive in frozen meat if meat is harvested from animals that have not undergone rigor mortis.

6.4.3.2 The host

**Conclusion:** Morbidity and mortality will depend on the species of host infected and the type of AHS virus involved. Early detection of index case, prompt notification, and action by the authorities, the proximity to/density of susceptible host population and the availability of competent vectors will have an impact on the incidence of the disease.

**Key assumptions:**

a) Infection with different types of AHS virus may result in varying morbidity and mortality;

b) Infectious dose under natural conditions is not known;

c) While incubation periods usually vary from 3-14 days, the virus is present in blood of infected equidae during the febrile phase of the disease which may last from 1 to 10 days in most instances;
d) The introduction of the virus to the EU would be a random event resulting from importation of equidae incubating the disease that may have become infected during an exceptionally narrow period of time to escape detection;

e) No case of suspected AHS has been reported to Defra for the past decade. Increased awareness, particularly among horse owners, keepers and veterinary practitioners may contribute to early recognition of the disease and limiting the risk period of further dissemination of the virus over wider geographic areas;

f) Following the initial introduction, further transmission of the virus from infected equidae to non-infected equidae is highly likely to occur during the febrile phase, mostly by competent biological vectors, and to a lesser extent by mechanical and iatrogenic transmission;

g) Historic evidence suggests that further transmission is likely to result in local clustering of individual cases and would be a function of the proximity to, and the density of a susceptible equidae population, and the ability of competent biological vectors to initiate infection;

h) It is highly likely that further geographical dissemination of the virus in the UK would occur due to movement of equidae incubating the disease until it is detected and movements of horses stopped and traced;

i) The extent of this risk period would depend on the time it would take to recognise and confirm the disease.

j) There are a number of live attenuated vaccines against AHS manufactured in the world. Most of them commercialise in mono or polyvalent vaccines to be used in endemic situations. Currently, there are no commercially available inactivated or recombinant vaccines.

Supporting evidence

AHS is a non-contagious, insect-borne disease of primarily equine animals (horses, mules, donkeys and zebras). Other species (e.g. dogs, camels) may also become infected but are not considered to play a significant role in the epidemiology of the disease (Mellor and Hamblin, 2004).

Zebras are considered to be the natural vertebrae host and reservoir of the virus. It is possible that the virus is maintained in endemic areas as a result of a continuous cycle between insect vectors and wild or domestic equines or other wild reservoir hosts.

Horses are regarded as an indicator host. AHS types 1-8 are considered to be highly pathogenic for horses and infection results in high mortality (90-95%). The type 9 AHS virus appears to be less pathogenic and infection may result in lower mortality (70%). Mortality in mules may reach 50% while in donkeys it is around 10% (OIE, 2002). The incubation period depends on the virulence of the virus and the infective dose. Infective dose in natural conditions is not known. Horses that recover from the disease do not remain carriers.
In experimental conditions, the incubation period in horses usually varies between 5 and 7 days. However, it may be as short as 2 days and rarely longer than 10 days (Coetzer & Erasmus, 1994). The longest recorded viraemia in horses was 21 days, and about 40 days in the case of zebras. The World Organisation for Animal Health specifies that the maximum infective period for horses is 40 days (OIE, 2007).

AHS virus may be isolated from blood of affected equidae during the early febrile stage. This febrile stage usually lasts from 1-2 days (peracute form), 3-6 days (cardiac form) and 5-8 days (mild form) (OIE, 2008). Therefore, equidae in the febrile phase of the disease are most likely to serve as a source of the virus for transmission to other susceptible equidae.

In a naïve population, infected horses will show clinical signs of the disease resulting in mortality rate ranging between 70 and 95%. This would depend on the type of virus involved. Broadly, clinical disease may manifest in four different forms:

a) The “peracute (pulmonary) form” has a short incubation period of only 3 to 5 days. Clinical disease is manifested by high fever, severely laboured breathing, coughing and profuse discharge from the nostrils. The mortality rate is very high with up to 95% of infected horses dying within a week. The pulmonary form is also the usual form in dogs;

b) The “subacute oedematous (cardiac) form” has an incubation period of 7 to 14 days. Clinical signs are characterised by swellings over the head and eyelids, lips, cheeks and under the jaw. The mortality rate is 50 to 60 % and death results from heart failure;

c) The acute (mixed) form” is the most common form being a combination of the above two types. It has an incubation period of 5 to 7 days and the disease shows itself initially by mild respiratory signs followed by the typical swellings of the cardiac form. The mortality rate in horses affected by this form is around 70%;

d) The mildest form is the “horsesickness fever”, characterised by a fever with the lowest temperatures in the morning rising to a high peak in the afternoon.

Mules are less likely than horses to exhibit clinical signs resulting in a mortality rate ranging between 50 to 70%. African donkeys and zebras are unlikely to show clinical signs of the disease (Coetzer & Erasmus, 1994). Nevertheless, donkeys in areas outside endemic areas may exhibit clinical signs (OIE, 2002).

Other diseases, such as anthrax, equine infectious anaemia, equine viral arteritis, trypanosomiasis, equine encephalosis, piroplasmosis and purpura haemorrhagica should be considered as differential diagnosis (OIE, 2002).

Some studies in South Africa suggested that AHS virus showed high levels of variation in transmission between districts within the same province, particularly in areas of intermediate transmission. These data emphasised the focal nature of this virus (Lord and others, 2002).
Defra received no reports on suspected AHS for the past decade. Therefore, the risk period would greatly depend on the time taken to recognise the disease and put in place disease control measures. Effective detection of infection would greatly depend on the serology and virus detection tests used. Over the past few years, a number of screening and confirmatory tests have been introduced for the detection of specific antibodies and the virus (OIE, 2008).

As already mentioned, AHS is not a contagious disease. The disease introduction is usually attributed to movements of either infected vertebrate hosts or infected biological vectors. Once introduced into a susceptible host, the virus is primarily transmitted to other susceptible hosts by competent biological vectors (i.e. midges of the genus Culicoides) (see Fig.4). While Culicoides imicola is considered to be the most important biological vector, other Culicoides spp. have also been found to have some potential in the transmission of the virus (Meiswinkel and Paweska, 2003; Mellor and others, 1990).

Mosquitoes may also be implicated as another biological vector in transmitting the disease. To a lesser extent, mechanical transmission by biting flies from the genera Stomoxys and Tabanus may also be possible.

Historical records suggest that the number of infected horses may vary greatly. Optimal conditions, such as when infected equidae during febrile phase are mixed with other susceptible equidae, will create potential for transmission of the virus, which in natural conditions would be on a random basis. The level of randomness would depend on the proximity of other susceptible equidae to a donor equidae and population levels of equidae and competent vectors.

In local conditions, it is likely that a high number of holdings with susceptible equidae will experience a case where a certain percentage of the naïve equidae population may be expected to become infected. According to available literature, this percentage may vary greatly (~0.6% to 13%), depending on the region from where the outbreaks were reported. What is usually evident from the available literature is the lack of information on the common measures of morbidity (i.e. prevalence, cumulative incidence and incidence rate) on the basis of which a meaningful interpretation of the potential effect of the disease on the local population could be drawn.
In Africa, historic reports from Nigeria suggest that 97 (12.3%) out of 786 imported polo horses became infected with AHS virus and 84 (86.6%) of these died. Similar morbidity and mortality was reported from Zimbabwe in late 1970s (Blackburn and Swanepoel, 1988). In South Africa, an estimated 500 horses died in the 1996 outbreak of AHS (Meiswinkel, 1998).

The most recent outbreak of AHS in Europe was reported in the Iberian Peninsula in 1990s. The AHS virus (type 4) was considered to be introduced to Spain by importation of zebras from Namibia in 1987. The disease was successfully contained and eradicated by a combination of disease control measures (i.e. destruction, movement control and vaccination) (Rodrigues and others, 1992). Regardless, the disease got spread to Portugal (1989) and Morocco (1989-1991) (authors cited by Sailleau and others, 2000).

During the outbreak of AHS in Portugal in late 1980s, 137 outbreaks were recorded on 104 farms. In total, 206 equidae died or were slaughtered (81.5% were horses, 10.7% were donkeys and 7.8% were mules). Following the vaccination of a total equine population in Portugal in 1990 (total of 170,000 equidae), 82 animals (0.04%) died or were slaughtered due to suspected or confirmed AHS. At that time, the total cost of eradication was estimated to be US$1,955,513. (Portas and others, 1999). The 206 horses that died or were slaughtered represent only 0.12% of the reported total horse population of 170,000.

In Spain, the first in a series of outbreaks of AHS (type 4) virus was recorded in horses in Madrid, Toledo and Avila in September 1987. The table below summarises the outbreak situation in Spain between 1987 and 1990 (Sanchez-Vizcaino, 2004).

Table 1: Outbreaks of AHS in Spain (Sanchez-Vizcaino, 2004)

<table>
<thead>
<tr>
<th>Month/year</th>
<th>Affected area</th>
<th>Died</th>
<th>Sacrificed</th>
<th>Vaccinated/Affected areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept/1987</td>
<td>Madrid, Toledo, Avila</td>
<td>250</td>
<td>n/a</td>
<td>38,000</td>
</tr>
<tr>
<td>Oct/1987</td>
<td>Vejer de la Frontera (Andalucia) Cadiz</td>
<td>110</td>
<td>75</td>
<td>34,768</td>
</tr>
<tr>
<td>July/1988</td>
<td>Cadiz, Huelva Sevilla y Cordoba</td>
<td>157</td>
<td>845</td>
<td>161,672</td>
</tr>
</tbody>
</table>

Note: If the number of horses that were reported to have died from AHS was considered in the context of the total number of horses that were subsequently vaccinated, this outbreak would indicate that a very small proportion of horses (0.09% to 0.66%) were actually affected during this episode in Spain. If horses that have been sacrificed (not clear whether because of the disease or as part of disease control measures implemented) are taken into account, the percentage of the population affected still remained very low (~ 0.53% to 0.62%). Similarly, a very small percentage of horses in Portugal were affected (~0.12% of the total population).
Three types of vaccine for AHS can be considered: live attenuated, inactivated and recombinant. Currently, a live attenuated vaccine manufactured in South Africa is available. This vaccine requires 2 doses three weeks to one month apart (vial 1 – types 1,3,4 and vial 2 – types 2,6,7,8). The combination of serotypes makes use of cross protection between certain serotypes (notably the serotypes 6 and 9, and 5 and 8). (Note: Type 5 has not been included in the vaccines for the past decade; Type 9 is not included as it is considered to be rare in South Africa and that the type 6 would provide sufficient cross-protection). Nevertheless the effectiveness and efficiency of these live attenuated vaccines in preventing the disease have often been questioned (various authors cited in MacLachlan and others, 2007). However, it remains uncertain to what extent ignorance of, or non-compliance with recommended vaccination procedures (e.g. use of professional services to administer vaccine; cold chain maintenance, application of vaccine during the low risk period) may have contributed to these issues. Inactivated vaccines are considered to be effective; however, they are not commercially available (MacLachlan and others, 2007).

Current live attenuated vaccine may prevent the disease. However, it does not prevent low level viraemia in vaccinated horses, which is thought to be below the threshold ($10^4$ TCID/50ml) necessary to infect competent biological vectors.

There are also some concerns about the safety and efficacy of the live vaccines that are produced in various countries across Africa. An animal with a high stable titre of neutralising antibody against a particular serotype is likely to be protected against that serotype. There is some evidence also that full protection from live vaccines may only be achieved after multiple vaccinations. Therefore, it remains uncertain whether 100% assurance of no infection against the homologous serotype through vaccination can be achieved. However, mortality is probably much reduced as vaccinated animals would have some protection and would not react to infection as naive animals.

One of the potential constraints in the development of a more efficacious vaccine could be that global distribution of AHS virus appears to be limited. While inactivated vaccines may become commercially available, it is highly likely that a number of logistical problems would be encountered to produce sufficient quantities in case of any outbreak as live virus would have to be handled. Producing efficacious recombinant vaccines may be the way forward, however, this would depend on a number of factors such as better understanding of the molecular biology of the virus (MacLachlan and others, 2007) and market demand for this type of AHS vaccine. Therefore, development and production of recombinant vaccines may require joint international effort to create a market which would allow vaccine manufacturers to carry out necessary research. The creation of an international vaccine bank may contribute to provide the necessary market demand for laboratories to increase the funding for developing new vaccines.
6.4.3.3 The environment

6.4.3.3.1 AHS - geographic distribution

**Conclusion:** While AHS remains confined to known affected areas in sub-Saharan continental Africa, there is indication of possible incursion of new serotypes.

**Key assumptions:**

a) Global distribution of AHS virus remains limited;

b) Limited evidence suggests incursion of new serotypes in previously known affected areas;

c) Introduction and spread of AHS virus into non-affected areas is usually attributed to uncontrolled movement of infected equidae or wind dispersion of infected competent vectors;

d) Long-term persistence of the virus outside known affected areas has not been demonstrated.

**Supporting evidence**

Contrary to the global distribution of various types of bluetongue virus, the global distribution of AHS virus is considerably more limited, probably because its vertebrate hosts are restricted to the equidae whose populations tend to be small and scattered (Mellor, 2002). The frequency, extent and severity of outbreaks in Southern Africa has also declined significantly over the last century. This may coincide with a major decrease in the horse and zebra populations in this part of the World and the introduction of AHS vaccines (Mellor & Hamblin, 2004).

As already mentioned, the disease currently remains confined to sub-Saharan continental Africa. AHS has been reported to the OIE since 1993 from Botswana, Burkina Faso, Cape Verde, Eritrea, Ethiopia, Gambia, Lesotho, Malawi, Mozambique, Namibia, Nigeria, Republic of South Africa, Senegal, Swaziland and Zimbabwe.

Historically, only two AHS viruses (Types 4 and 9) have been found in West Africa (Sánchez-Vizcaino, 2004). In recent years some other types of AHS virus were reported for the first time in sub-Saharan Africa. That is, AHS virus type 6 was identified for the first time in Ethiopia in 2003 (Zeleke and others 2005). AHS type 2 virus was also confirmed in Senegal and Nigeria in 2007. Until this report, type 2 virus was apparently confined to southern Africa where a high prevalence of AHS virus type 2 in zebras with a lower prevalence of serotypes 4, 1, 6 and 9 was reported in mid 1990s (Bremer and others, 2000). It still remains uncertain how type 2 virus was introduced into Senegal and Nigeria, whether as an extension in range of the vector infected with this type of the virus or otherwise (i.e. movements of infected equidae). Nevertheless, the most recent report suggested further eastward expansion of the virus which was reported from Ethiopia for the first time. Eleven
outbreaks were reported (OIE, 2008a) (see map). Of the total reported susceptible population (46,451 equidae), 4000 cases (8.6%) with 2128 deaths (54.6%) were recorded. This percentage of observed deaths may usually be observed in endemic areas where circulation of the virus may provide a certain level of protection of the population in the affected areas; therefore, it is uncertain when this introduction may have occurred.

The spread of the infection outside the endemic region is usually attributed to either transportation of infected horses or other equidae or dispersal of infected vectors (*Culicoides* species). Historically, outbreaks of AHS outside sub-Saharan Africa have been reported from North Africa, the Iberian Peninsula, the Middle East, Cyprus, Turkey, Pakistan, Afghanistan and India. The infection, however, has not persisted in these areas although it has caused massive outbreaks associated with substantial mortality.

### 6.4.3.3.2 Biological vectors

**Conclusion:** Different populations of *Culicoides* spp may vary in their susceptibility to AHS virus and ability to transmit the virus to susceptible equidae.

**Key assumptions:**

a) AHS virus is transmitted when an infected competent vector (*Culicoides* spp.) feeds on a susceptible host;
b) In natural conditions, not all *Culicoides* spp are equally capable of transmitting the infection to susceptible equidae;

c) Sufficient quantities of the virus must be generated by a competent vector for the infection to be transmitted/initiated in a susceptible equidae;

d) Although a very low infection prevalence (0.003%) was demonstrated in a competent vector in natural conditions, it is considered that successful transmission would be compensated for by the superabundance of the vector;

e) While mechanical transmission of the virus by non-biological vectors in field conditions may be a theoretical possibility, we are not aware of any publication where this type of transmission has been demonstrated in field conditions.

The AHS virus is thought to be maintained in endemic areas as a result of a continuous cycle between insect vectors and infected wild or domestic equines or other wild reservoir hosts (Coetzer & Erasmus, 1994). Epidemics of AHS tend to occur at cyclic intervals, and are often associated with drought followed by heavy rain presumably giving rise to large numbers of competent vectors.

As mentioned, AHS virus belongs to the same family as bluetongue virus. AHS virus tends to be transmitted by the same species of *Culicoides* as bluetongue virus. Along those lines, the following figure demonstrates barriers that the virus would have to overcome to develop a fully patent infection and be available for oral transmission see Fig.5 from Mellor (2004).

![Figure 5](image-url)

**Figure 5**

Barriers to the infection and transmission of arboviruses by insect vectors
Route of virus dissemination in the *Culicoides*-BTV system highlighted in red.
While intrathoracic inoculation and incubation at 26°C, of *C. variipennis* resulted in the transmission of the virus after 4 days of incubation (Mellor and others, 1975), this may not have any epidemiological significance given that the intrathoracic infection of midges with the virus in field conditions is highly unlikely.

We are not aware of any publication demonstrating whether vertical transmission of AHS virus in a competent vector is possible.

It has been demonstrated that AHS virus is present at a very low infection prevalence (0.003%) in infected competent vectors during an outbreak. However, the transmission to susceptible equidae is compensated by the superabundance of the competent vector (Venter and others, 2006). Nevertheless, it remains uncertain to what extent the detection of the virus in a competent vector would depend on the expression of outer coat gene used for viral detection.

While in natural conditions both AHS type 1 and AHS type 7 were detected in competent vectors during an outbreak in South Africa in 2004, only type 1 was detected in dead and sick horses (Ventor and others, 2006).

### 7 Conclusions

Overall, the likelihood of the introduction of AHS virus from abroad to the UK via legal trade in horses and other equidae is considered very low. The existing risk management measures appear to be appropriate to mitigate the potential for the introduction of the virus. However, it remains uncertain to what extent proportionate risk management measures to mitigate against the risk of possible vector exposure may be applied by other EU Member States that allow for transhipment of equidae through AHS virus infected countries or zones.

The likelihood of the introduction of AHS virus to the UK via legal trade in equine semen, ova and embryos, their meat and specified biologicals is considered negligible.

The likelihood of the introduction of the virus via illegal or non-compliant movements of equidae is difficult to quantify. These movements may be direct to other EU Member States and then to the UK (or the UK direct) or through listed Third Countries to other EU Member States and then to the UK (or the UK direct).

The likelihood of introduction of virus by as yet unrecognised routes is impossible to quantify.

It is likely that the introduction of AHS virus to the UK would result in local spread under optimal local conditions (i.e. mixing with other equidae, abundance of competent vectors). To what extent this event may result in wider distribution of the virus in the UK would greatly depend on early recognition of the disease by owners and veterinary practitioners, the movements of initially infected but undiagnosed equidae and any other in-contact equidae that may become infected.

It is likely that the use of recombinant vaccines would be effective in preventing the disease. Their use could be much preferred because of their safety and their role in distinguishing between vaccinated and infected animals. However, development and production of such vaccines would depend on a number of factors such as better
understanding of the molecular biology of the AHS virus and market demand for this type of vaccines. This effort may require joint international effort to create a market which would allow prospective vaccine manufacturers to carry out necessary research.

Our ability to assess risk would also greatly benefit from systematic studies providing more information on global, natural and human related factors. For example the distribution of the disease in endemic areas and the type of virus involved; the distribution of potential competent vectors in Europe; the reliability of surveillance systems; information on the pathogenesis and ecology of the virus and; possible pathways of introduction and dissemination of the AHS virus. Such an approach would assist in reducing uncertainties and ensuring that regulatory risk management measures are regularly reviewed by taking into account the most recent scientific and surveillance evidence.

8 References


