Risk Analysis: Introduction of Bluetongue Virus-infected *Culicoides* sp. into Ireland from the UK in November 2007 (1 November 2007)

1. Disease report

On September 22nd 2007, laboratory tests confirmed that Bluetongue Virus serotype 8 (BT 8) was present in a native-born rare breed bovine animal on a farm in Suffolk. The farm had no history of livestock imports from Bluetongue affected countries in Europe. Since then, further cases were confirmed on different premises in Suffolk by laboratory testing and infected animals culled. Defra confirmed on September 28th that BT 8 was circulating between *Culicoides* vectors and livestock in East Anglia and from September 29th the temporary bluetongue control area was replaced by a Bluetongue Control Zone extending from Lincolnshire to Sussex. Since then, bluetongue has spread in southern England and the control zone extends from the north Norfolk coast to the south coast of Kent and Sussex and extends westwards into Cambridgeshire. The Protection Zone covers the greater part of England from East Riding in Yorkshire to the Welsh border and from the Isle of Wight eastwards along the south coast. Surveillance and epidemiological investigations are continuing.

2. Situation assessment

The origin of infection in the UK has yet to be determined but windborne vectors from the BT restricted areas in northwestern Europe are the most likely source of infection. This conclusion is based on epidemiological investigations of the 2006 outbreak in this part of Europe showing that temperatures were ideal for rapid multiplication of the virus and that wind trajectories were consistent with the direction of spread of the epidemic (Gloster *et al*., 2007a, b). There are ample historical precedents for wind-borne dispersion of infected *Culicoides* over long distances, particularly across water, as the primary mode of epidemic propagation in several parts of the world (reviewed in Gloster *et al*., 2007a, b; Ducheyne *et al*., 2007). Spread of infection from continental Europe to the UK in August-September 2007 would require the following factors to have been present:

- a source of infected *Culicoides* sufficiently close to the coast,
- climatic conditions favourable to midge survival and dispersal by wind,
- susceptible livestock at landfall in the UK.

The first of these conditions was fulfilled by the rapidly propagating BT 8 epidemic in Belgium, the Netherlands, Luxembourg, France and Germany since July 2007 (ADNS data). The warm humid weather in that part of Europe and southern England would also have favoured midge survival and replication of the virus within the vectors. Furthermore, wind trajectories for August through September have indicated that air masses originating in or traversing the restricted zone in Europe could have entered the eastern counties of England before and during the time infection was confirmed there (Eoin Sherlock, MET Eireann). The southeastern counties of England also have significant populations of domestic ruminants and free-ranging deer. Large numbers of sheep are found in East Sussex and on the Romney Marshes in Kent while Norfolk has a high density of dairy cattle (Defra). Thus, it would appear that sufficient susceptible hosts are present for establishment and propagation of an outbreak.

2.1. Bluetongue Transmission

Bluetongue virus is almost exclusively transmitted during feeding by adult females of certain competent *Culicoides* (Diptera: Ceratopogonidae) midge species. Females require a blood meal within 24 hours of emerging from the pupae and will continue to blood feed every three to four days throughout their life (Kitching 2006). The life span of adults is at most a few weeks under ideal laboratory-controlled conditions (13°C to 30°C) but more likely to be less than 10 days under natural field conditions (Birley and Boorman 1982; Mellor *et al*., 2000; Kitching 2006). When an uninfected female feeds on a viraemic ruminant host the virus requires an *extrinsic incubation period* within the insect to become infectious. In other words, transmission is not simply a mechanical transfer of virus from one host to another (Dr. P. Mellor, IAH Pirbright). Viral incubation within the midge is optimal around 28 to 30°C, negligible below 15°C, and is prevented below 10°C for serotypes of bluetongue transmitted by *Culicoides imicola,* the vector in southern Europe. There are no comparable data on the vectors in northern Europe and incubation requirements for BT 8. Clearly temperatures in the low 20's have been sufficient in the UK to have permitted transmission in September 2007.

Transovarial transmission of the virus in *Culicoides* midges is thought to be unlikely although genome segments of BTV have been found in over-wintering larvae of vectors in the US, no infectious virus has been found in larvae (Mellor 1990; Jones and Foster 1971; Purse *et. al*. 2005). Therefore, the eggs or larvae of *Culicoides* that may be inadvertently transported in garden compost, plants, vegetables, on machinery, or in vehicles used to carry livestock are unlikely to spread infection. These life stages of midges will not be considered further in this assessment.

2.2. Introduction of Bluetongue into Ireland

The following diagram broadly outlines potential conceptual pathways or routes by which BT 8 could enter Ireland on the basis of current understanding of the epidemiology of infection with respect to the virus, hosts, and the environment (Fig. 1). These consider legal movements of livestock and wild susceptible ruminants (such as zoo animals) including biological products (e.g. semen/ova/blood products/vaccines). Another possibility is arrival of infected midges via wind dispersal or accidental transportation. Illegal importation of susceptible animals or their products also risk introduction of the virus but this in not considered further here.

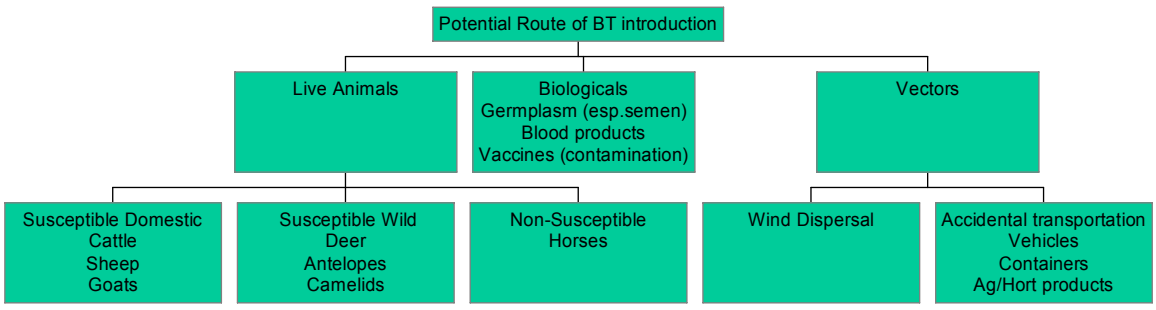

Figure 1: Potential routes for introduction of Bluetongue

Based on the introduction of bluetongue (various serotypes) into previously uninfected areas of Europe since 1998, epidemiological investigations enable a ranking of the importance of the various routes of transmission from the UK to Ireland from high to low probability.

High Risk routes of introduction:

- Importation of infected ruminants whether domestic or exotic species,
- Wind-borne infected vectors.

Moderate Risk routes in introduction:

- Importation of semen from viraemic bulls.

Low Risk routes of introduction:

- Contaminated blood products made from viraemic animals,
- Embryos from viraemic donors,
- Live vaccines that may be contaminated with the virus in the laboratory,
- Transportation of parous infected *Culicoides* on non-host species such as horses,
- Transportation of parous infected *Culicoides* in vehicles or containers,
- Transportation of parous infected *Culicoides* with agricultural or horticultural products such as hay, straw, or plants.

3. Risk mitigation

A. Bluetongue susceptible livestock:

Susceptible live ruminant species from Great Britain are banned from export to Ireland because of Foot and Mouth Disease until December 15th, 2007[1]. There is consequently no risk of importing BT infected livestock from England until after that date. From December 15th, the importation of susceptible livestock from Great Britain, and other member states affected by BT, will be subject to regulations on intra-community trade[2]. Import of susceptible species from BT-free member states or areas is permitted.

From November 1st, susceptible animals may be imported into Ireland from restricted zones but must be accompanied by a health certificate indicating compliance with the provisions in Commission Regulation 1266/2007/EC.

DAF is currently carrying out post-import testing of susceptible species imported from BT-free areas in affected member states. To date 1,512 cattle and 59 sheep have been tested and all results have been negative for antibodies to BT. When foot and mouth disease restrictions are lifted and the export of susceptible species from BT-free areas in GB recommences, these animals will be post-imported tested.

With the regulation of susceptible live animal imports as outlined above and compliance with health certification, there is a low risk of importing an infected animal from other member states. The low risk is associated with importation of an animal that originated in an area previously outside, but adjacent to, a restricted zone. Bluetongue may have spread into the area days or even weeks before becoming

clinically apparent or detected by sentinel surveillance in the newly affected area. Alternatively an infected animal could possibly have been moved from a restricted zone to a free zone within a member state and then illegally entered intra-community trade. Such animals are sampled for BTV antibodies at the farm of destination up to a week after arrival in Ireland. As seroconversion may not occur for 10 days to 2 weeks post infection, there is a low risk that an animal in early viraemia could escape detection if tested by serology within the first few days of arrival. Such animals could act as a source of infection if further risk mitigation steps are not undertaken (see conclusions below).

Conclusion: Introduction of infection to Ireland by legal importation of susceptible livestock under the current regulations carries some risk of importing viraemic animals from free areas adjacent to restricted zones or from the restricted zones themselves. The risk could be reduced further by undertaking the following measures with susceptible livestock imported into Ireland during the season of vector activity in Ireland between **March 1st and October 31st**:

(i) Treatment with an approved insecticide (www.bluetongue.ie) on arrival at the farm of destination. One treatment is sufficient for sheep or goats but cattle should have 3 treatments at 2-week intervals.

(ii) Where possible, housing imported animals during periods of greatest midge activity (dawn and dusk) for two weeks in the case of sheep and 60 days for cattle.

(iii) Strategic use of insect repellents or insecticide around animal housing to discourage entry of midges.

(iv) Removal of potential midge breeding sites such as dung from areas around animal housing at frequent intervals (at least twice weekly).

These measures are not required outside the stated period because climatic conditions in Ireland from November to March are generally unsuitable for *Culicoides* midges.

B. Imported germplasm (semen, ova and embryos):

Germplasm may be imported from donor animals in restricted zones subject to specific conditions and accompanied by a health certificate (see footnote 2 above).

Virus may be excreted intermittently in bull semen during the initial viraemic period and this is more likely if there is inflammation of the reproductive tract. Although infection of susceptible cows has occurred by this route it is thought to be an insignificant mode of viral transmission (Osbourn 1994; Kitching 2006).

Similarly, the risk of bluetongue transmission through embryo transfer from infected cattle or sheep is very low if the embryos are washed to International Embryo Transfer Society (IETS) standards (Sutmoller and Wrathall 1997; Singh *et al*., 1997).

Conclusion: Imported germplasm is highly unlikely to be a source of BTV with current regulations and health certification. No further control measures are required.

C. Wind dispersal of infected vectors from the UK:

This is theoretically possible provided the wind trajectories and velocities from the affected area are optimal, ambient temperatures sufficient for survival of infected parous female *Culicoides*, ambient climatic conditions suitable at landfall, and susceptible hosts present at landfall. As wind dispersal of *Culicoides* is greater over water than land masses, the localization of the current outbreak in eastern England would mitigate against dispersal as far as Ireland. Furthermore, from August 1st to mid October there were only 6 days when south-easterly winds flowed over Ireland from the UK but for most of those the airflow was probably not strong enough to advect particles (such as infected midges) from the UK to Ireland (S. O'Reilly, Met Eireann). Since mid October, wind trajectory models have continued to show airflow from the UK towards Scandinavia and continental Europe. Furthermore, modelling of wind trajectory paths originating in the outbreak area of Suffolk have shown that wind from that area did not reach Ireland at any time during August, September or October (Eoin Sherlock, Met Eireann). However, if the outbreak propagates in the UK as quickly as it has in continental Europe, infection may spread further west towards Wales. In that case the level of risk to Ireland would increase only slightly given the low temperatures currently prevailing in Ireland in late October. This assessment applies to the current situation only and is an ongoing process that will be constantly reviewed and updated as necessary.

Survival of the adult insects is highly dependant on temperature and humidity and at the present time (last week of October) ambient temperatures in Ireland are consistently at the lower end of tolerance for adult *Culicoides*. The last weeks of September saw a marked decline in trapped *Culicoides* in Ireland to less than 10 per trap per night. However, numbers increased with milder weather during the first two weeks of October giving a cumulative total of 14,000 midges caught for the 34 trap sites. Since then, temperatures have dropped significantly with several nights of frost in inland areas resulting in low catches comparable to those obtained in the last week of September. Thus, the seasonal patterns of midge activity are clearly affected by weather conditions. However, midges may remain active in locally favourable habitats and biting activity has been recorded in October (Dr. Kieran McCarthy, NUIG).

Thus, with bluetongue currently limited to eastern England, adult midges would be unlikely to survive the journey across the UK land mass and Irish sea and be unlikely to blood feed should they be blown here at this time of year. Lower ambient temperatures will also lengthen the extrinsic incubation period for the virus, which combined with a lower survival rate for parous females at lower temperatures, will greatly reduce the number of infective competent vectors. The risk of windborne introduction would be further reduced by the predominantly westerly flow of air since September. At this time of year, easterly winds are now more likely to be cool and dry and less favourable to *Culicoides* survival. As these parameters are all natural climatic variables and phenomena, they are not amenable to control.

Conclusion: No action is required on the part of the competent authority other than to monitor climatic conditions on an ongoing basis.

D. Importation of blood products or other biologicals:

This has never been demonstrated in any bluetongue outbreak worldwide. Importation of such products from reputable companies with good quality control should be sufficient to prevent introduction by this route. Nevertheless, a theoretical risk of importing the virus in contaminated bovine serum or live vaccines that may have been contaminated in a laboratory cannot be excluded.

Conclusion: No further control measures are required at this juncture.

E. Non-susceptible species:

Equidae are hosts for many of the known *Culicoides* sp. vectors of bluetongue although horses, and related species, are not infected by Bluetongue virus and do not act as a reservoir for infection. There is a low but theoretical risk that horses originating in restricted zones could be attacked by parous female midges that had previously blood fed on a viraemic ruminant, remained on the horse while in transit to Ireland, survived the journey, survived long enough in Ireland to require another blood meal, and then fed on a susceptible ruminant within flight distance of the point of arrival in Ireland. Furthermore, the ambient temperature and humidity in Ireland would have to be high enough to allow extrinsic incubation of the virus in the vector (15^{o}C minimum), and allow the vector itself to survive long enough for this sequence of requirements to occur.

Conclusion: Currently it is unlikely that horses would facilitate successful introduction of infective midges. Thus, further mitigation procedures are not warranted at this juncture.

F. Transportation of parous female midges in vehicles or containers:

There is a low but theoretical risk that parous blood fed and infected midges could be accidentally enclosed in a shipping container or vehicle such as and aircraft originating the restricted zone. Long distance transport has been documented for mosquito vectors of malaria via containers and shipping but this has generally been eggs and larvae (Tatem *et al*., 2006 a, b). Eggs and larvae are not known to be infected with bluetongue virus and pose no such risk. Adult Chironomids (species undetermined) have also arrived in containers from Japan to New Zealand (Biosecurity NZ). However, adult *Culicoides* are particularly sensitive to ambient temperature and humidity because of their small size (1.5 mm length) and parous infected females are even more susceptible to adverse conditions. It is therefore unlikely that at this time of year, vehicles or containers originating in the restricted zone would arrive in Ireland with infected female *Culicoides* ready to blood-feed on arrival.

Conclusion: It is considered that treatment of vehicles or containers with insecticide would not be justified on a risk basis at this juncture.

G. Carriage of parous infected Culicoides in horticultural or agricultural produce:

There is a low but theoretical risk that blood fed female midges may roost on cut flowers or pot plants originating in a restricted zone, remain on the plants during harvesting and packaging, survive the cooling during shipping, and arrive in Ireland. However, there is no evidence from the literature that such accidental transportation of *Culicoides* has ever occurred or that parous female midges could survive the transport conditions. Such a method of introduction was hypothesised for the original introduction of BT 8 into Europe in 2006 but no evidence was forthcoming to support the claim. Furthermore, the Netherlands is a much greater market source of horticultural produce for the world market and given that BT 8 has been present in the Netherlands at least since June/July 2006 without plant-borne spread to any other country, it is highly improbable that infected midges would be imported to Ireland by this route.

Conclusion: No further mitigation or control measures would be required.

H. Hay and straw

Hay and straw are by definition dry materials that must be stored and shipped dry. Adult *Culicoides* are dependant of a high relative humidity for survival and it is therefore unlikely that they could survive sufficiently long in a dry substrate to arrive alive in Ireland from the nearest BT restricted areas, particularly if transported by road and sea. Straw used as bedding for livestock in transport vehicles would become soiled by urine and faeces and disturbed by trampling. As such, it would not be a suitable habitat for adult *Culicoides*. Bedding materials contaminated with dung may provide a suitable substrate for *Culicoides* eggs or larvae but there is a negligible risk that these life stages carry bluetongue virus.

Conclusion: Further control measures are therefore unwarranted for this material.

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