Ref: VITT1200/HPAI – Spring migration

Version No.:	1
Date:	17 February 2006

SPRING MIGRATION

AND

THE LIKELIHOOD OF THE INTRODUCTION OF HIGHLY PATHOGENIC AVIAN INFLUENZA (H5N1) INTO THE UNITED KINGDOM

A COMMENTARY
Working Document

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Suggested reference for this publication:

Defra, (2005). Spring migration and the likelihood of the introduction of Highly Pathogenic Avian Influenza (H5N1) into the United Kingdom – A Commentary (Authors: Sabirovic, M., Wilesmith, J., Kingston, A., Coulson, N., Landeg F.), 1A Page Street, London, SW1P 4PQ, United Kingdom. Version 1, **Released 17 February 2006, pp.24.**

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1 Summary

In our previous risk assessments, we have concluded that the overall likelihood of further geographical spread or detection of the highly pathogenic avian influenza (HPAI) H5N1 virus was high. We also concluded that an overall risk of the virus introduction from Asia and Eastern Europe to the UK is increased but still low. These conclusions took into account the existing uncertainty and the fact that the HPAI H5N1 virus had been detected over broad geographic areas within a few months. We also concluded that an overall risk of the virus introduction from Asia and Eastern Europe to the UK is increased but still low.

We have also highlighted that many uncertainties remain about species susceptibility and ecology of the virus in many parts of the world. The routes by which the virus may be introduced and its dissemination in the affected regions still remain uncertain.

Migration is a natural phenomenon. Given the uncertainties, this risk assessment considers that the spring migration does not significantly alter the outcome of our previous risk assessments regarding the likelihood of possible introduction of the virus to the UK. At the time of writing, this is based on the considerations outlined below.

1.1 Overall conclusion

The latest epidemiological developments suggest that the HPAI H5N1 virus has been detected over broad geographic areas within a few months. However, it still remains uncertain how widespread the virus may be in Asia, Europe, Africa or beyond or whether it has already been present but remained undetected.

The most recent detection of the virus in a commercial poultry operation in Nigeria is the first reported detection of the virus in any country in Africa. This development in Africa, considered in the context of the currently affected regions in eastern Europe does not significantly alter our previous conclusion that the overall risk of introduction of the virus to the UK is increased but still low.

Nevertheless, with specific reference to spring migration:

1.2 Wild birds

It largely remains uncertain whether any species of migratory birds that may be infected with the virus would successfully commence and complete migration in the first instance. The epidemiological evidence, albeit circumstantial, suggest that wild birds may have a role to play.

1.2.1 Spring migration from Western Africa

At this stage we consider that there is an increased but still low likelihood that spring migration from Western Africa would result in the introduction of the virus to the UK.

The virus has been detected in a commercial poultry layers operation in Nigeria. There are currently no reports of the detection of H5N1 virus in migratory birds in any part of Africa. It remains uncertain to what extent east to west movements and mixing of many species of migratory birds that have arrived in Africa from ‘infected’ (eastern

Europe and Asia) flyways may occur while on ‘feeding’ grounds. This would also include intra-African migrants. Although the movement of individual birds cannot ever be ruled out, it remains uncertain whether there are any direct migratory routes from Southern Siberia to Western Africa (including Nigeria).

Whilst substantial numbers of wading birds will migrate from Western Africa to the coasts of the UK, in the spring they will generally be restricted to these areas during the spring staging period. After 'refueling', most waders will migrate onwards to the arctic, although very small numbers stay in the UK to breed, mostly in the north of Scotland. It is unlikely that these birds will have contact with domestic poultry owing to their use of different habitats. However, it is likely that these birds may have limited contact either with other potential birds which could that act as a secondary link to infect domestic poultry.

However, there is a possibility that the frequency of H5N1 virus detection in wild birds may increase in Europe in time to come. Should this be the case, the experts consider that H5N1 virus may arrive to the UK at some point in the future because of the potential for limited mixing at some contact points between the existing waterbirds populations in Europe.

1.2.2 Spring migration from Eastern Europe, Mediterranean basin and Eastern Africa

There is a low likelihood that some species of waders and passerines (perching birds) that migrate to the UK during spring from Eastern Europe, Mediterranean and East Africa regions would be infected with the virus. According to expert ornithologists only one passerine species (i.e. Lesser Whitethroat) is likely to come to the UK. Other species do not come to the UK from Eastern Mediterranean in any numbers.

The virus has now been confirmed in a small number of dead swans in northwestern Bulgaria. Our previous risk assessments have concluded that at some point in the future there will be an increased but still low likelihood that the virus may be introduced from Eastern Europe to the UK by migratory waterfowl. The virus has also now been confirmed in a very small number of dead swans in north Greece and south Italy (Sicily).

At the moment of writing, we consider that these developments do not significantly alter our previous conclusion that there is an increased but still low likelihood that the virus may be introduced from the affected locations in Eastern Europe to the UK. This is because of the potential for limited mixing at some contact points between the existing wild waterbirds populations from Eastern Europe with the populations in the EU.

This risk assessment acknowledges that these conclusions are based on much uncertainty and sketchy but emerging epidemiological evidence. These conclusions will be subject to scrutiny when more structured epidemiological information becomes available in the future from studies that are now in progress. Defra continues to monitor developments and assess the situation.

2 Introduction

The information on HPAI H5N1 outbreaks has been received from the European Commission (European Commission, 2006) and the World Organisation for Animal Health (OIE, 2006a) unless otherwise stated. The information on outbreaks presented in this paper is current as of 18 February 2006 at 10.00am. However, the situation has been changing rapidly and further developments are likely.

This update and commentary builds up on previous qualitative risk assessments carried out by Defra (http://www.defra.gov.uk/animalh/diseases/monitoring/index.htm) since January 2004. These risk assessments considered several pathways by which HPAI H5N1 may be introduced to the UK.

These assessments concluded at the time that a likelihood of further geographic spread or detection of HPAI H5N1 virus was high on the basis of evolving situation and availability of information. An overall likelihood of the virus introduction from the affected regions in Asia and Eastern Europe to the UK was considered to be increased (but still low). On a pathway by pathway basis, the likelihood of the virus introduction to the UK was considered to range from negligible to increased, but still low.

The EU and the UK have banned legal imports of risk commodities (live poultry, captive and wild caught birds, pet birds, unprocessed feathers) from the affected regions. The ban on trade in captive birds and wild caught and pet birds has been extended to include all Third Countries. The EU has extended the ban on imports of unprocessed feathers from other countries in the wider region (Georgia, Armenia, Azerbaijan, Iran, Iraq and Syria).

As with all disease agents, illegal imports from infected countries worldwide give rise to a constant, background risk of infection, subject to the survival of the infectious agent in the illegally imported product. The risk of transmission of viable virus in non-commercial poultry meat is difficult to quantify. This emphasises the need to continue to enforce measures at the border to mitigate this type of risk.

Humans could also transmit disease by mechanically transferring infected bird faeces (on footwear for example) or through themselves being infected. This likelihood is difficult to quantify and such potential is difficult to control.

3 Hazard identification

Our previous risk assessments recognised that the emerging epidemiological evidence, although circumstantial so far, points to the virus continuing to be detected in dead migratory waterfowl and non-commercial domestic poultry in the wider geographic regions since May 2005. The virus was detected mainly in areas that potentially provide for some contact between domestic and wild birds.

3.1 Disease reports

3.1.1 Domestic poultry

Recently, the H5N1 virus has been reported mainly in village poultry in many geographic locations in Europe (Romania, Turkey, Ukraine, southern districts of

Western Russia and north Cyprus). These are within the areas that are covered by the southward bird migration flyways from southern Siberia. There are no reports as yet on detection of the virus in domestic poultry from parts of Asia or east Africa that may be covered by these flyways. We do not rule out that undisclosed disease may be present in these regions.

Most recently (beginning of February 2006), HPAI H5N1 virus was reported in a commercial poultry layer operation in Nigeria. This is the first time the virus was reported in Nigeria. This is also the first time that the virus was reported in commercial poultry in any country in Africa. At this stage, we are not aware of any reports on the detection of the virus in village poultry or wild birds either in Nigeria or commercial and village poultry and wild birds in any other African country. Again, we do not rule out that undisclosed disease may be present in wider areas in Africa.

3.1.2 Migratory birds

Most recently, HPAI H5N1 virus has been reported confirmed in a small number of dead swans in Bulgaria, Greece, southern Italy (Sicily) and Azerbaijan and a wide range of wild birds in Turkey.

Within the past few weeks HPAI H5N1 virus has been confirmed in dead swans in several geographic locations in western Asia (i.e. Azerbaijan southern Russia, Iran), eastern Europe (Bulgaria, Romania) and some EU Member States (Greece, southern Italy, the German island of Ruegen in the Baltic sea, Austria).

The H5 virus has been confirmed in dead swans in two provinces in southern Italy (mainland), north Slovenia and southern Hungary. Further tests are underway. Unofficial reports suggest that dead swans have also been found in a few locations in Croatia and the Danish islands (Falter and Bornholm). The Danish island of Falter is geographically very close to the German island of Ruegen where HPAI H5N1 virus has recently been confirmed in dead mute swans and a raptor.

3.2 Autumn migration (year 2005)

We previously estimated that the likelihood of the introduction of HPAI H5N1 to the UK by migrating birds from Eastern Europe during the autumn migration had increased but remained low. This estimate was based on the assumption that wild birds may become infected and takes into account circumstantial evidence and the official information that is currently available.

3.3 Spring migration (year 2006)

At this stage there is evidence of HPAI H5N1 virus in several geographic locations in eastern Europe and western Asia and a number of locations in EU Member States in wild birds. We are not aware of any detections of the virus in domestic poultry associated with the swan deaths, so far.

It remains unknown whether the virus may have been introduced to other un-affected areas in Europe. It remains uncertain whether the geographic extension of outbreaks is a recent occurrence or whether the virus has already been present in these areas or even wider but has remained undetected so far. EU wide targeted surveillance of wild migratory birds detected no HPAI H5N1 in any of more than 25,000 samples collected from wild birds so far.

It also remains unknown whether HPAI H5N1 virus may have been introduced to Africa, or whether it may have already been present in Africa but remains undetected. There are no reports of virus presence in wild birds in Africa. A project is underway to monitor wild birds for avian influenza in Africa, Middle East and eastern Europe (Food and Agriculture Organisation, 2006).

The bulk of spring migration in Europe takes place between the beginning of March and end of May. It would be expected that birds that have migrated in autumn to East Africa will return in spring over Eastern Europe to their breeding grounds in southern Siberia. On the other hand, the birds from West Africa will return over Europe to their breeding grounds in Arctic areas and over Mediterranean basin to their breeding grounds in North Russia. However, this risk assessment recognises that this is very much a broad approach and that uncertainty remains about how much it may differ in reality.

A concern has been raised that spring migration may increase the risk of virus introduction to the UK. This concern is based on hypothetical comments that the birds that may have migrated in autumn from southern Siberia to East Africa may potentially be infected and could mix with birds that migrated from northern Russia over the Mediterranean basin to West Africa. At the same time, the concern has been raised that birds that may have migrated from Western Europe to Eastern Europe may be returning through infected areas in Eastern Europe.

Therefore, spring migration has been identified as a hazard for consideration in this risk assessment.

4 Risk assessment

This risk assessment attempts to consider spring migration on the basis that mixing of birds may occur during spring migration to their breeding grounds and that may increase the risk of the introduction of HPAI H5N1 virus to the UK.

This risk assessment recognises that there are several possible pathways by which HPAI H5N1 virus can be introduced to the UK from the currently affected regions including Africa (e.g. illegal imports; mechanical transmission by people). Nevertheless, this risk assessment will specifically focus on spring migration as one potential pathway identified for consideration.

4.1 Release Assessment

4.1.1 Terms and definitions

This release assessment considers the likelihood of the introduction of HPAI H5N1 virus to the UK from Africa and the affected or potentially affected countries in Eastern Europe. For the purpose of the release assessment (Section 4.1) the following definitions will apply:

Term	Definition
HPAI	*"HPAI viruses have an IVPI in 6-week-old chickens greater than 1.2 or, as an alternative, cause at least 75% mortality in 4-to 8-week-old chickens infected intravenously. H5 and H7 viruses which do not have an IVPI of greater than 1.2 or cause less than 75% mortality in an intravenous lethality test should be sequenced to determine whether multiple basic amino acids are present at the cleavage site of the haemagglutinin molecule (HA0); if the amino acid motif is similar to that observed for other HPNAI isolates, the isolate being tested should be considered as HPNAI"* (OIE, 2005a)
Waterbirds	*"Means those species of birds that are ecologically dependant on wetlands for at least part of their annual cycle…"* (UNEP, 2005)
Spring Migration	*Movements of wild migratory birds to their breeding grounds during spring*
Flyways	*"A "flyway" is the total area used by (groups of) populations or species of birds, throughout their annual cycle, including the breeding areas, migration stop-over and non-breeding (wintering) sites. Many of these sites tend to be highly productive and are thus also of importance to non-migratory birds and other biodiversity"* (UNEP, 2005).

For the purpose of the release assessment (Section 4.1) the following terminology* will apply (OIE, 2004):

Term	Definition
Likelihood	Probability; the state or fact of being likely
Likely	Probable; such as well might happen or be true; to be reasonably expected
High	Extending above the normal or average level
Highly	In a higher degree
Low	Less than average; coming below the normal level
Negligible	Not worth considering; insignificant
Remote	Slight, faint

* This risk assessment uses the OIE recommended terminology. Defra consider that this important to maintain consistency in expressing estimates. Defra is aware of some concerns that have been expressed about the appropriateness of this terminology for practical purposes (ie. clarity for the purpose of understanding by wider non-technical audience). Defra will consider this issue in the near future.

NOTE: Our qualitative risk assessments are undertaken to assist the process of identifying appropriate safeguard measures to prevent the introduction of HPAI H5N1 virus to the UK via legal trade among other pathways specified. Any such measures must maintain appropriate level of protection without unduly restricting trade.

The UK appropriate level of protection is that legal importation of live animals or their products from EU Member States or Third Countries must present a negligible likelihood that the diseases of concern will be introduced.

Migration is a natural phenomenon that cannot be controlled. Nevertheless, if the likelihood is identified as low or high this would indicate that certain practical measures in the UK may be undertaken.

4.2 Specific aspects of HPAI H5N1 in wild birds

4.2.1 Detection in wild birds

It is important to recognise that the virus was either isolated from single dead birds or a very small proportion of samples collected from bird flocks where mortalities were detected.

In May 2005, the H5N1 virus was detected in dead migratory waterbirds (e.g. Ruddy shelduck, Bar-headed geese, Great black-headed and Brown-headed gulls, great cormorants) in China. In August 2005, H5N1 was confirmed in a few dead wild waterbirds (Bar-headed geese and a Whooper swan) in the northern part of Mongolia close to the Russian border. Subsequently, it has been confirmed in a few dead wild birds in eastern Romania (Whooper swans, geese, heron), Croatia (swans – species not stated), Turkey (one swan and one cormorant – species not stated, including some other wild birds), Bulgaria (Mute swans), Azerbaijan (swans – species not stated), Greece (two Mute swans and one red-breasted goose), Italy (species not stated), the German island of Ruegen (Mute swans), Austria (species not stated). Its presence in now suspected in one swan in Slovenia (Mute swans), three swans, Hungary (species not stated) and swans in Iran.

The emerging epidemiological evidence, although circumstantial so far, points to the virus continuing to be detected in dead migratory waterfowl and non-commercial domestic poultry in the wider geographic regions since May 2005. However, it remains uncertain whether any differential diagnostic laboratory tests were carried out in dead wild birds to exclude other potential causes of death (e.g. other diseases, poisoning, natural die-off or some other natural ecological impact) or whether samples from unaffected cohorts were tested.

According to the OIE World Reference laboratory for Avian Influenza (Veterinary Laboratories Agency, Weybridge, UK) the virus isolates from the recently affected countries show close similarity to the virus isolate obtained from dead wild birds in China in May 2005.

4.2.2 Epidemiology of the disease in wild birds

4.2.2.1 Infectious dose and incubation period

There is no information in available literature on infectious dose, incubation period and pathogenesis of the virus in wild birds exposed to the virus in field conditions.

4.2.2.2 Transmission

There is an absence of evidence on how effectively and quickly the virus may transmit within an affected flock and other flocks in field conditions.

Experimental studies in juvenile mallard ducks suggest that the respiratory rather than digestive tract may be the main replication site for HPAI H5N1. This could also suggest that respiratory route, rather than faecal-oral route, may have become to be the primary transmission path (Sturm-Ramirez and others, 2005). While some experimental studies consider that the virus may have the ability to transmit between susceptible juvenile mallards (Sturm-Ramirez and others, 2005), this was not observed in other studies (Chen and others, 2004).

Table 1 is provisional and this risk assessment recognises that this table is not complete because some information is not available to us through official sources of information.

Table 1. H5N1 in wild birds

Country	Species	Samples	Population	(+) ve Test
Hungary	3 dead swans	3	Unknown	H5
Germany (island of Ruegen)	10 dead swans, one raptor	11	Unknown	H5N1
Austria	A dead swan	1	Unknown	H5
Slovenia	A dead swan	1	Unknown	H5N1
Italy mainland (southern)	Two dead swans	2	Unknown	H5
Italy (Sicily)	Dead swans	1	Unknown	H5N1
Greece	Two dead swans, one red-breasted goose	3	Unknown	H5N1
Iran	Dead swans	Unknown	Unknown	H5
Azerbaijan	Dead swans	pooled	Unknown	H5N1
Bulgaria	dead wild birds (several spp.)	Many	Unknown	None
Croatia	4 swans	4	Ca. 265	2 (AI)
Croatia	26 shot ducks	26	Unknown	None
Croatia	3 shot Swans	3 (1 sick)	Ca. 280	1 (H5N1)
Croatia	13 shot waterfowl (coots, grebes, ducks)	13	Unknown	None
Croatia	15 swans	2	Ca. 1500*	2 (H5)
Croatia	7 swans	7	Ca. 1500*	7 (H5N1)
Croatia	3 shot shorebirds 1 shot cormorant	4	unknown*	None
China	519 dead migratory birds	unknown	Unknown	Unknown (H5N1)
China	20 dead wild birds (magpies and other spp.)	unknown	Unknown	Unknown (H5N1)
Mongolia	80 dead migratory waterfowl (ducks, geese & swans)	unknown	Unknown	4 (H5N1)
Mongolia	9 dead migratory waterfowl (ducks, geese & swans)	unknown	Unknown	Not tested ?
Russia	1 dead wild duck	1	Unknown	1 (H5N1)
Romania	1 dead heron	1	Unknown	1 (H5N1)
Romania	2 dead geese 1 dead swan	3	Unknown	3 (H5N1)
Romania	1 dead water hen 7 dead swans	8	Unknown	8 (H5)
Turkey	1 pigeon, 1 swan, 1 cormorant	3	Unknown	H5N1
Turkey	3 pigeons	3	Unknown	H5N1
Turkey	1 sparrow	1	Unknown	H5N1
Hong Kong	1 dead Oriental magpie robin	1	unknown	H5N1
Hong Kong	1 dead peregrine falcon	1	Unknown	H5N1
Hong Kong	1 dead grey heron	1	Unknown	H5N1
Hong Kong	1 dead grey heron – observed sick day before it died	1	unknown (>1200?)	H5N1
Hong Kong	wild birds – 2004 routine surveillance	7,433	Unknown	None
Hong Kong	1 dead Chinese pond heron	1	unknown (>200)	H5N1

Table 1 shows that the virus was detected in a very small number of birds found dead in the wild. It also shows that, so far, the virus has not been detected in healthy birds that have been shot for surveillance purposes.

We are also aware that all EU Member States are conducting targeted surveillance of wild birds. So far, we have no indication that HPAI H5N1virus has been detected in any of the samples collected.

4.2.2.3 Clinical signs

So far, HPAI H5N1 has been detected in dead wild birds found in the wild. Nevertheless, unpublished data by Lvov and others (2006), currently subject to peer review, suggest that the virus has been detected in samples obtained from live healthy wild birds in southern Russia close to where outbreaks occurred in village poultry. The virus has been detected in approximately 0.03% to 0.13% of samples collected from apparently healthy wild migratory ducks in China during the period between October 2003 and March 2005 (Chen and others,2006).

The closest we can learn about the possible pathogenesis of the virus in waterfowl are rare field and experimental studies. In field conditions, decrease in egg production and feed consumption rates were observed although ducks showed no apparent clinical signs or mortality (Lee and others, 2005). In experimental conditions infected domestic ducks showed no apparent clinical signs and shed the virus (Nguyen and others, 2005).

The virus has been detected in apparently healthy domestic geese at two separate live bird markets in Vietnam. In experimental conditions, these isolates have been shown to cause deaths in chicken within two to five days following intra-nasal exposure. In contrast, these geese isolates did not cause any clinical signs or death in ducks following intra-nasal exposure (Nguyen and others, 2005). These findings would be in correlation with experimental findings that suggest that the virus may replicate efficiently in juvenile mallards (Sturm-Ramirez and others, 2005).

In contrast, other experimental studies show that domestic ducks may be highly susceptible. Following intra-nasal exposure to the virus isolates obtained from dead wild birds in Hong Kong in 2002, all inoculated ducks died within 5-6 days. These ducks shed the virus via cloacal (at low titres) and respiratory tract (at higher titres) from the day 1 following exposure to the time of death. In dead ducks, the virus was also detected in the lungs, kidneys, muscle and brain (Nguyen and others, 2005).

4.3 General aspects of migration

There are several general aspects that need to be considered in this risk assessment. They are:

4.3.1 Spring migration to the UK

Different species return to the UK at different times in the spring. A few species start appearing in March (Chiffchaff, Sand Martin, Wheatear, Little Ringed Plover), with increasing numbers of species through April (e.g. Swallows from early April, Whitethroat mid April and many species tending to make first appearance in late April) and some species not arriving in large numbers until May (e.g. Swift). Some species pass through the UK on their way to breeding grounds further north, notably various species of wader such as Turnstone, Bar-tailed Godwit and Ringed Plover, although most of these are highly coastal in nature.

4.3.2 Flyways

Populations of migratory birds simultaneously use a network of sites ('flyways') that are connecting breeding and wintering areas (Davidson & Pienkowski 1987; Hötker and others 1998; Schekkerman and others, 2003). Erni and others (2005) consider that large ecological barriers such as oceans and deserts have considerably shaped the migratory strategies of birds. On the other hand, the most ‘direct’ routes from breeding to feeding areas may not be energy efficient, so the birds may take one or more stopovers to moult or regain fat-reserves.

Different bird taxa may use different flyways between breeding and wintering areas. Waders, for example, use three main flyways that are defined by the region as East Atlantic, Black Sea/Mediterranean, and West Asian/East African. The flyways used by many *Anatidae* species appear to be less clear. While a small number of *Anatidae* may reach south into Africa, large numbers move on a north-east - south-west Eurasian axis. Populations of geese and swans tend to have highly discrete flyways and segregated populations which use traditional breeding and non-breeding ranges (Madsen and others 1999; Davidson and Stroud, 2004).

For passerines and other groups, flyways are a less useful concept, either because the wider habitat tolerances of the species mean they can disperse over a wider range in a more continuous manner, or because the species are less easily studied than waterbirds and the migration routes and wintering grounds are less well understood. For example, there are no sub-Saharan recoveries of UK Cuckoos yet, although we assume they do cross the Sahara.

For the purpose of this risk assessments the following flyways have been considered using information mainly available from Scott and Rose (1996) and Wernham and others, 2002), unless otherwise stated:

4.3.2.1 East Atlantic flyway

This flyway covers the area on the Northeast-Southwest axis between Western Europe and South Africa (Piersma and others 1987; Smit & Piersma 1989). This flyway is frequented by various bird taxa such as waders, waterfowl and birds of prey.

4.3.2.1.1 Waders

Stroud and others (2004), on the basis of most recent estimates, calculated that 14.4 million waders migrate twice a year through the area between their breeding grounds ranging from northern Canada and Greenland in the west to northern Scandinavia and Siberia in the east and their wintering areas as far south as West and South Africa. On this voyage, the Dutch-German-Danish Wadden Sea is considered as the most important staging and moulting area for water birds on the East Atlantic Flyway (van de Kam and others 2004).

The most abundant taxa on the East Atlantic Flyway are: Plovers and Calidrine sandpipers (31% and 33% of all waders respectively), the former largely owing to the very large Lapwing *Vanellus vanellus* population (2.3 million birds) estimated as wintering in Western Europe, and Woodcock *Scolopax rusticola* and snipes (11%) (Stroud and others 2004).

It has also been estimated that at least 3.5 million of these waders are wintering along the West African coast. Coastal wetlands in Mauritania and Guinea-Bissau are known to hold the majority of these birds. The Banc d’Arguin area in Mauritania is considered as an important wintering site for about 2 million waders. The Bijagos Archipelago in Guinea- Bissau has also been recognised as important wintering site for about one million migratory water birds of over 50 species (Frikke and others, 2002; Stroud and others 2004).

Many waders have their breeding grounds in the Arctic tundra (i.e. sandpipers such as the Curlew Sandpiper *Calidris ferruginea*) or inland Northern Europe i.e. (Dunlin *Calidris alpina*) and move south to near exclusively coastally habitats in the winter. Whilst most of these wintering grounds are in west or North Africa some birds move to Southeast Europe and the Caspian Sea. Their spring return route brings many of these birds through UK coastal areas before dispersing to their inland breeding areas. But virtually none of these West African wintering waders nest in the UK, and those that do (e.g. Whimbrel) are very northerly in UK, nesting mostly in Shetland, say.

4.3.2.1.2 Wildfowl

With regard to wildfowl (Anatidae), the following species have been considered:

4.3.2.1.2.1 Greylag goose *Anser anser*

The northwest Europe/Spain and North Africa wintering populations are concentrated at a few sites, with the Iberian peninsula holding the majority (60%) of the population and the other key sites being further north (the major delta region at the west Atlantic coast). The North Africa wintering population can be found entirely at Lac Ichkuel in Tunisia. These populations do not migrate to the UK.

Note: Ringing recoveries have shown that there is some interchange between the western and central European populations.

4.3.2.2 Black Sea/Mediterranean flyway

The Alps, the Mediterranean Sea, and the Sahara seem to be the major ecological barriers that prevent most long-distance migrants from flying on a direct southward course from Europe to Africa (Erni and others, 2005) and probably vice versa during spring migration.

This flyway links arctic and boreal breeding areas in Northern Russia with feeding areas in the Mediterranean basin and west Africa (Davidson & Pienkowski 1987; Hötker and others 1998; van der Have 1998). Within this flyway, the main migration routes are (Siren Conservation Education, 2003):

a) **The Eastern leg** (from southern Siberia and Eastern Europe across Bosphorus and the Middle East to eastern Africa) is a large-scale crossing along major rivers and is favoured by raptors, soaring birds and passerines.

b) **The Central leg** (from southern Europe across Southern Italy, Malta, Tunisia across to Northern Africa) is a narrow but longer crossing. It is mainly favoured by birds that use flapping flight including swallows and goldfinches including smaller raptors such as the honey buzzard, kestrel and red-footed falcon.

c) **The Western leg** (from southern Europe across southern Spain, Gibraltar, Morocco to south Mauritania) is a large-scale crossing, and the only narrow crossing point for soaring birds (e.g. honey buzzard, white stork) from Western Europe. **Note:** The western leg would fit squarely within what the waterbird community consider to be the east Atlantic flyway (Stroud, D.A. – personal communication, February 2006)

4.3.2.2.1 Waders

Stroud and others (2004) calculate that 25.9 million waders used the Black Sea/ Mediterranean Flyway. The large numbers of waders on the Black Sea/ Mediterranean Flyway (relative to other African-Eurasian Flyways is in large part due to the very large (but very poorly defined) population size estimates for Woodcock *Scolopax rusticola* and snipes on this flyway, which account for 68% of waders on the flyway. Tringid sandpipers (16% of total numbers) are the next most numerous group..

4.3.2.2.2 Passerines (perching birds)

The majority of migratory passerines (perching birds) such as warblers spend the winter in south western Europe or north and west Africa (Wernham and others 2002). However the Lesser Whitethroat moves through the eastern Mediterranean. Their dispersal in inland habitats makes it unlikely that there will be close contact with waterfowl.

4.3.2.2.3 Wildfowl

The following Anatidae have been considered to be important from the point of spring migration:

4.3.2.2.3.1 Common Shelduck - *Tadorna tadorna*

There is evidence to suggest that large numbers of birds from the Black Sea/east Mediterranean move into the west Mediterranean during severe winters. The wintering population in North Africa (large numbers in Algeria) are likely to be birds forced out of the Black Sea region by hard weather. Although there is a potential for considerable intermixing between the northwest European and the west Mediterranean birds, it remains uncertain to what extent it may happen.

Note: All populations are dispersed while breeding but come together in autumn, spring and during moult at a few extremely important sites. In winter they are more dispersed and rather mobile.

4.3.2.2.3.2 Gadwall - *Anas strepera*

There are three main wintering groups:

(1) Northwest Europe,
(2) Central Europe/Baltic Sea/Mediterranean
(3) Southwest Asia/northeast Africa.

Note: the population (3) has an estimated total ~ 130,000 birds and very few of these birds reach northeast Africa.

4.3.2.2.3.3 Mallard - *Anas platyrhynchos*

Five populations of the nominate form are recognised based on the main wintering regions:

(1) Northwest European group;
(2) West Mediterranean group;
(3) Black Sea/east Mediterranean group
(4) Southwest Asian group.

Note: Some mallards breeding in central Europe remain through winter if suitable weather conditions prevail but the majority are migratory to the northern Mediterranean coast. Some birds may migrate further south-eastwards along the Danube and intermix with birds from further east in the Black sea.

4.3.2.2.3.4 Northern Pintail - *Anas acuta*

There is a considerable amount of overlap on the breeding grounds between all wintering groups in Western Eurasia and Africa, and perhaps as birds move in response to hard weather in northwest Europe or severe drought in the Sahel. Thus no populations are identifiable, therefore this overlap suggests that a single West African/Mediterranean wintering population is involved.

The key wintering sites for the Mediterranean/West Africa wintering population is difficult to assess because of the year to year variation in the use of West African wintering areas.

Note: The total number of birds estimated for this population [Northeast Europe/Black Sea/Mediterranean/West Africa (east to Chad)] is 1,200,000. Birds from the Western Siberia/Southwest Asia/northeast and eastern Africa flyway are estimated to total ~700,000 and of these ~50,000 birds are thought to winter in northeast and eastern Africa.

4.3.2.2.3.5 Eurasian Wigeon - *Anas penelope*

Based on ringing data there are three different sub-populations:

(1) A sub-population breeding in Scandinavia and Russia which winters in northwest Europe;
(2) A sub-population breeding further east which winters in the Black Sea-Mediterranean region.

Note: The wintering ranges of these two sub-populations are almost completely separate, with few exchanges occurring between them except in Spain where, during hard winters, the populations may mix.

(3) A large wintering sub-population identified in Southwest Asia (~250,000) is concentrated mainly in the south Caspian region, Iran and Iraq.

Note: A small number of birds (~15,000 – 60,000) wintering in northeast Africa south to Kenya should be added to these. Birds from population (2) have been known to extend to West Africa (~ 300 to Lake Chad).

4.3.2.2.3.6 Garganey - *Anas querquedula*

There are two populations identified for the Garganey;

(1) A population passing through Europe (NB very scarce in UK) and the eastern Mediterranean and wintering mainly in West Africa east to Chad (~2,000,000 birds). This population passes along the north Sinai coast bound for West Africa.

(2) A population passing through Southwest Asia and wintering mainly in eastern Africa (~100,000 – 200,000 birds).This population occasionally pass off the tip of Sinai, though most of the birds enter Africa across the Red Sea.

Note: There may be a limited opportunity for these two populations to mix.

4.3.2.2.3.7 Northern Shoveler - *Anas clypeata*

There are three populations identified for the Northern Shoveler:

(1) Northwest Europe;
(2) Black Sea/Mediterranean/West Africa;
(3) Southwest Asia/northeast and eastern Africa.

Note: Birds from population (2) show very large fluctuations in numbers (~20,000) wintering in West Africa (mainly Senegal) and it is suggested that these birds arrive in West Africa as a result of "overspill" from a much larger population to the north. Birds from population (3) total ~400,000 and an estimated ~100,000 – 240,000 birds are thought to winter in northwest and eastern Africa, mainly Ethiopia, Kenya and Tanzania.

4.3.2.2.3.8 Common Pochard - *Aythya ferina*

No discrete populations are identifiable. It is thought that the birds wintering in the Mediterranean have the same origin as those wintering in northwest Europe, and there appears to be considerable overlap in the breeding areas of birds wintering in the Black Sea/east Mediterranean region and those wintering in Southwest Asia, with many of these birds breeding in southern Siberia and central Asian republics.

Note: The central Europe/Black Sea/Mediterranean birds cross the Sahara into West Africa and the Southwest Asia birds winter in northeast Africa (excluding Egypt), mainly Sudan and Ethiopia.

4.3.2.2.3.9 Tufted Duck - *Aythya fuligula*

Three populations are recognised based on major wintering areas:

(1) Northwest Europe,
(2) Central Europe/Black Sea/ Mediterranean,
(3) Southwest Asia.

Note: There is extensive overlap between these three groups on their breeding ground. Small numbers of birds of population (2) reach West Africa (Senegal, Nigeria and Chad) (~ 200 birds). Birds of population (3) winter in northeast Africa (Sudan and Ethiopia) (~ 5,000 birds) and probably less than 100 birds arrive in East Africa.

4.3.2.3 West Asian/East African flyway

This flyway links the central Siberia tundra with the Caspian Sea, the Middle East (especially the gulf Region) and eastern and southern Africa (Summers and others 1987).

Stroud and others (2004) calculate that 22.8 million waders used the West Asian/East African flyway. The flyway is also dominated by Woodcock *Scolopax rusticola* and snipes (43%) with Tringid (23%) and Calidridine sandpipers (16%) and plovers (13%) also relatively abundant.

4.3.3 Bird migration – physiological preparation and other aspects

Successful bird migration is a combination of a number of complex physical and ecological factors. Broadly, these are (Schekkerman and others, 2003; van der Kam and others 2004):

a) Character of the bird (size, flight characteristics, state-dependency of predation risk)

b) Staging sites (rates of energy expenditure and gain, predation risk)

c) Conditions en route (wind).

Another important component for successfully completing migration is general health status of birds in order to 'navigate' and sustain flight over various distances in a most effective way. Hedenstrom (2004, p52) considers that "*the mechanical power is produced by the cyclical contraction of flight muscle and the total flight cost is estimated by assuming conversion efficiency for metabolizing fat to produce the mechanical power output to the surrounding air by the beating wings*".

According to radar data from North America, spring migration appears to be several miles per hour faster than in the autumn with less diverse directions than in the autumn suggesting that less time is lost during travel. For example, herons, hawks, crows, and smaller birds appear to cover 100 to 250 miles per day in a sustained flight of 10 hours. In the same period, ducks and geese appear to cover as much as 400 to 500 miles. Shorebirds might travel about 45 miles per hour for several hours. Songbirds might travel around 30 miles per hour. To conserve energy, some birds appear to reduce flight speed in proportion to the degree of assistance from a tailwind. Nevertheless, it seems probable that most migratory birds appear to travel at a slow rate of flight and would usually take a month or more to cover a straight-line distance of between 1000 to 3000 miles (Lincoln and others, 1998). We are unsure whether these data for waterfowl and waders would apply in the flyways we described, although we see no particular reason why they would differ significantly. In general, it is considered that many species are "in a hurry" to get to the best breeding sites in the spring, whereas the autumn migration can afford to be more leisurely.

4.4 Spring migration - General commentary

4.4.1 HPAI H5N1 virus infection in wild birds

The recent detection of the virus in a number of countries in eastern Europe coincides with the autumn southward migration. What remains uncertain is how the disease may have been introduced into the affected countries and what may have contributed to the disease spread within the affected countries.

The virus effectively kills affected wild birds. The virus has been isolated from a very small number of dead, and in a couple of individual cases, moribund migratory birds. There is currently absence of evidence that the virus may have been isolated from live healthy wild birds. However, using polymerase chain reaction (PCR) alone, Lvov and others (unpublished data currently subject to peer review) detected the virus in 19 out of 54 samples collected from wild ducks (18 samples positive out of 45 collected from mallards – *Anas platyrhynchos* and pochards – *Aythya ferina*) and great crested grebe (*Podiceps cristatus*) (1 sample positive out of 2 collected) during the outbreaks in Novosibirsk region in July 2005. Five samples collected from coot and two samples collected from common tern tested negative. Chen and others (2006), tested approximately 13,000 samples collected from apparently healthy wild migratory ducks in China during the period between October 2003 and March 2005. The HPAI H5N1 virus was detected in approximately 0.03% to 0.13% of samples.

It is also known that migration requires birds to be in top condition to complete it successfully. Field and experimental data indicate that domestic poultry (chicken and ducks) appear to be highly susceptible to infection. These data also indicate that the virus caused significant pathological changes in respiratory tract, skeletal muscle and brain of dead birds (Nguyen and others, 2005). These organs are of vital significance for successful migration and questions on how efficient would such birds be at travelling over any substantial distance have been raised in our previous risk assessments.

According to Reed and others (2002) physiologic stress associated with migration is a known factor for immunosupression and increased susceptibility to infectious diseases and for some birds may lead to reactivation of otherwise latent infection. Should it be the case, this would be in correlation with the observed small number of deaths in wild birds and the circumstantial evidence that the virus was isolated from apparently healthy wild birds.

However, the notion that latent infection with HPAI H5N1 may be possible on a larger scale would not be in correlation with targeted surveillance in wild birds which is carried out on a large scale in many countries yielding no positive finding. Therefore, if the virus is present in wild birds, it is highly likely to be present at such a low level that would be impossible to detect unless vast majority of the entire wild birds populations are tested worldwide using standardised tests. In practice, this would be impossible to achieve.

The spread of HPAI H5N1 virus southwards occurred within a relatively short period of time over large geographic areas. This would be contrary to what may be expected for contiguous spread of infection. Reed and others (2002) consider that in case of some other diseases their spread may have been the result of birds having ecliptical migration routes.

The virus has also been detected in other wild birds (e.g. swallows, pigeons). As it currently stands, there is no field evidence to support the fact that swallows play a role as a reservoir host. There is no strong field evidence that pigeons play a significant role as a reservoir host. In experimental conditions carried out in the past they have been shown to be refractory to infection.

At this stage it appears that migratory birds may have a role to play in the virus introduction over large geographic areas. However, this would have to be viewed in the context of other possible pathways which may provide for a single point introduction (e.g. legal trade, illegal trade, mechanical transmission). It is hoped that further genetic studies will provide more information on genotypes of the virus isolates from different countries.

4.4.2 International initiatives - Early detection and prevention of AI

In line with the FAO/World Organization for Animal Health (OIE) Global Strategy for the Progressive Control of Highly Pathogenic Avian Influenza (HPAI), several projects have been initiated. The primary objective of proposed projects is to strengthen the capacity for generating and sharing HPAI disease intelligence and using this to mount emergency preparedness planning against the eventuality of HPAI being introduced into the region, specifically in relation to migration of and trade in wild birds (FAO, 2005). Table 2 lists key sites selected by Wetlands International & FAO for wild bird HPAI surveillance in spring 2006.

Table 2. HPAI Spring surveillance

	Danube Delta – **Rumania**
Eastern Europe & Caucasus	Askania-Nova Biospheric reserve – **Ukraine**
	Uluabat Lake, Kizilirmak Delta & Gediz Delta - **Turkey**
Middle East	**Iran**?
	Souss Massa – **Morocco**
Northern Africa	a. Lacs de barrages : El Ogla, Oued Rmel (Gouvernorat de Zaghouan) 100 km de Tunis;
	b. Lacs de barrages Lebna, Oued El Hjar (Gouvernorat de Nabeul) 120 km de Tunis – **Tunisia**
	Senegal Delta Casamance – **Senegal**
West Africa	Niger Delta – **Mali**
	Lake Tchad Complex – **Chad**
	Rift Valley - **Ethiopia**
Eastern & Southern Africa	Am Gar – **Sudan**
	Lake Ol-Bolosot – **Kenya**
	Lake Chilwa – **Malawi**

4.4.3 Potential for mixing of birds in Africa

Reed and others (2002) consider that bird species that reside in favourable climate, especially tropics and subtropical forest often live their entire lives within a few miles of where they were hatched.

It would be reasonable to assume that subtropical and tropical climate would prevail in the main ‘feeding grounds’ in Africa. However, it remains uncertain to what extent they would use a network of sites throughout Africa during the course of the non-breeding season. That is, it remains uncertain to what extent these movements would result in mixing of birds that have arrived via various flyways from HPAI H5N1 affected regions in western Asia and eastern Europe during the autumn migration.

4.4.3.1 Migratory flyways

Only East Atlantic flyway provides direct route for migratory birds (mainly waders and small numbers of waterfowl) arriving to the UK from west Africa during spring migration.

It is likely that the other two flyways will result in significant numbers of waterfowl returning to their breeding grounds northwards in Europe and southern Siberia.

4.4.3.1.1 East Atlantic Flyway

Many species of waterbirds that come to the UK have a marine distribution during spring. They will remain at sea and are therefore highly unlikely to come into contact with farms or domestic birds.

A substantial number of waders from west Africa visit the coasts of the UK in spring during their migration further north.

It is, however, highly likely that this journey will be interrupted with at least one or two stop-overs and will take days, if not weeks, to complete.

4.4.3.1.2 Black Sea/Mediterranean flyway

The majority of migrating waterfowl (Anatidae) appear to be traveling from northeast Africa to their breeding grounds in northern Russia through Mediterranean, central Europe and Baltic Sea region. This flyway appears to offer more opportunities for various populations to come in closer contact in these regions and potentially mix on their way northwards. It is also likely that this journey will be interrupted several stop-overs and will take weeks to complete.

There appear to be no major or direct routes to the UK from this flyway.

Nevertheless, significant numbers of these birds arrive in UK from northwest Europe, Baltic and western Russia during the autumn/early winter period and then move later in the winter period to some parts of the EU, some Mediterranean countries and North Africa. It is likely that some of these birds may have limited ‘mixing’ at some contact points with birds from eastern Russia. Little is known of their return movement during spring migration, however, there is the possibility that some of these ‘in-contact’ birds may arrive the UK at some point in the future.

4.4.3.1.3 West Asian/East African Flyway

The majority of migrating waterfowl (*Anatidae*) appear to be traveling from eastern Africa to their breeding grounds in southern Siberia through Arabian Peninsula and Caspian Sea region. This flyway appears to offer limited opportunities for mixing with birds from Black Sea/Mediterranean flyway. It is also likely that this journey will be interrupted several stop-overs and will take weeks to complete. There appear to be no major or direct routes to the UK from this flyway.

5 Conclusions

In our previous assessment we have highlighted that many uncertainties remain with respect to the potential presence of species susceptibility and ecology of the virus in many parts of the world, The routes by which the virus may be have been introduced and its dissemination in the affected regions still remain uncertain.

For the purpose of this assessment, it is assumed that migrating waterbirds may at least have a part to play in the introduction of the virus into affected areas. Nevertheless, other pathways such as legal trade, illegal trade or mechanical transmission would also have to be considered.

Once the virus is introduced into domestic poultry in an affected country, it would be likely that local practices contribute to the dissemination of the virus within the affected country. This local spread could also increase opportunities for wild birds to become exposed to the virus from infected domestic poultry.

Given the uncertainties, this risk assessment considers that the spring migration does not significantly alter the outcome of our previous risk assessments. This is based on the following considerations that are possible at this stage regarding spring migration:

5.1 Wild birds

It largely remains uncertain whether any species of migratory birds that may be infected with the virus would successfully commence and complete migration in the first instance. The epidemiological evidence, albeit circumstantial, suggest that wild birds may have a role to play.

5.1.1 Spring migration from western Africa

At this stage we consider that there is an increased but still low likelihood that spring migration from western Africa would result in the introduction of the virus to the UK.

The virus has been detected in a commercial poultry layer operation in Nigeria. Although the situation may be evolving, there are currently no reports of the detection of H5N1 virus in village poultry or migratory birds in Nigeria. There are also no reports of the detection of H5N1 virus in commercial poultry, village poultry or migratory birds in any other country in Africa. It remains uncertain to what extent east to west movements and mixing of many species of migratory birds that have arrived in Africa from ‘infected’ flyways may occur while on ‘feeding’ grounds.

Whilst substantial numbers of waders will migrate from western Africa to the coasts of the UK, in the spring they will generally be restricted to these areas during the spring staging period. After 'refueling', most waders will migrate onwards to the arctic, although some will stay in the UK to breed. It is likely that these will have limited contact either with other potential ‘spillover’ birds which in turn could infect domestic poultry or with domestic poultry owing to their use of differing habitats. These birds could conceivably come into contact with resident wild birds (e.g.

Mallards, Canada Geese, gulls) that could act as a secondary link to poultry. The manner in which wild birds interact with farmed poultry remains still uncertain.

5.1.2 Spring migration from Eastern Europe, Mediterranean and eastern Africa

There is a low likelihood that some species of waders and passerines (perching birds) that migrate to the UK during spring from eastern Europe, Mediterranean and east Africa regions would be infected with the virus.

However, our previous risk assessments have concluded that at some point in the future there will be an increased but still low likelihood that the virus may be introduced to the UK by migratory waterfowl. This is because of the potential for limited 'mixing' at some 'contact' points between the existing wild waterbirds populations from eastern Europe with the populations in the EU.

This risk assessment acknowledges that these conclusions are based on much uncertainty. Nevertheless, these conclusions will be subject to scrutiny when more structured epidemiological information becomes available in the future from epidemiological and surveillance studies that are now in progress. Defra continues to monitor developments.

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