The Royal Society of Edinburgh

Avian Influenza

An Assessment of the Threat to Scotland

A Report from The Royal Society of Edinburgh's Working Party on Avian Influenza

revised December 2007

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Foreword by Professor John Coggins FRSE

The incident at Cellardyke in Fife in April 2006 focussed public attention on the potential dangers that could result from an outbreak of avian influenza caused by the H5N1 strain.

The Royal Society of Edinburgh, recognising the need for independent advice, set up a Working Party to assess how well prepared Scotland is to handle an epidemic of avian influenza. In our Report we recognise the extensive work done to minimise the risk to both human health and agriculture. We make recommendations to improve both disease prevention measures and the capability of dealing with an outbreak, should this occur in Scotland.

This Report has been produced by an expert group, which also took evidence over several months from key people involved in this complex issue. We also have had the benefit of the extensive Inquiry undertaken by Sir John Skehel for the Royal Society of London and the Academy of Medical Sciences. That examined the extent to which scientific evidence has been incorporated into preparedness for a human flu pandemic in the UK. We endorse the findings of that study, but have not sought to cover the same ground. We commend the contingency planning underway in Scotland for another human influenza pandemic, recognising that it might not be caused by the H5N1 avian influenza virus.

It is important to recognise that avian influenza is a disease of birds and can spread to humans only in exceptional circumstances. There is no evidence to suggest that there is a risk to humans from the consumption of eggs or poultry meat, provided it has been properly cooked. There are many forms of the avian influenza virus, not least the H5N1 strain that is currently of concern, and these pose a significant threat to the poultry industry worldwide, including that in Scotland.

The only effective means of protection currently available to the Scottish poultry industry is to prevent the virus spreading to its poultry flocks. It is important, therefore, to detect the presence of the virus in this country at the earliest possible stage, whether in the wild bird population or in domestic or commercial poultry. Equally important is having effective biosecurity measures in place to protect individual poultry units from the introduction of the virus. We have concerns about the scope of the wild bird surveillance programme, and recommend that more research is undertaken to quantify the risk of infection from wild birds.

We recognise the potential role of vaccines in the prevention and control of avian influenza. To produce more effective and easily administered vaccines will require further research. This should not be inhibited by the constraints on the current use of vaccines.

I should like to thank all the members of the Working Party and those who gave oral or written evidence; also our Secretary, Ian Melville who provided extensive assistance in the preparation of the report. The Working Party stands ready to provide further advice, should circumstances require this.

The views expressed in this report do not necessarily represent the views of the RSE Fellowship.

Introduction

1.1 Avian influenze is a disease of birds resulting from infection with a type A strain of the influenza virus. Wild birds, especially waterfowl, are host to a large number of influenza viruses that are typed primarily by differences in two glycoproteins that project from the surface of the virus. Sixteen haemagglutinin subtypes (H1 – H16) and nine neuraminidase subtypes (N1 – N9) have been identified, and viruses with different combinations of these subtypes have been found in birds and in humans. However, viruses infecting humans are usually specific to humans and, similarly, avian viruses seldom infect humans.

1.2 Most wild birds infected with an influenza virus show no obvious effects. Low Pathogenic Avian Influenza (LPAI) has been found in wild bird populations throughout the world, and occasionally spreads to domestic poultry. The absence of clinical signs can make the presence of infection difficult to detect, although flocks may show signs of respiratory distress, diarrhoea or loss of appetite. Some viruses of the H5 and H7 subtypes have been found to mutate to become highly pathogenic, giving rise to systemic infections, rather than ones restricted to the respiratory and enteric tracts, that can result in the deaths of whole flocks within a matter of hours of infection. Highly Pathogenic Avian Influenza (HPAI) is highly contagious and is a notifiable disease in the UK and most other countries.

1.3 Outbreaks of avian influenza have occurred in a number of countries, the first reported in Italy ("fowl plague") in the late 19th century. In 2003, an outbreak of HPAI in the Netherlands spread to Belgium and Germany affecting some 250 farms and resulting in the slaughter of more than 28 million poultry. The strain of virus was identified as H7N7. Prior to 2007, the last outbreak of HPAI in the UK was in a turkey flock in Norfolk in 1991.

1.4 One strain of the avian influenza virus, H5N1, is of particular concern at present. The first outbreak caused by H5N1 was detected in Hong Kong in 1997. Prompt action by the Hong Kong authorities in destroying the entire population of 1.5 million birds in 3 days contained the disease. H5N1 re-emerged in late 2003 in an unprecedented epidemic sweeping through poultry in most Asian countries. In many of these countries H5N1 is now endemic.

1.5 By July 2005 the disease had spread to Kazakhstan and Russia, and more recently into Turkey, Romania and Croatia. The first case in the European Union occurred in Greece and the disease has now been confirmed in Austria, Denmark, France, Germany, Italy, Spain, Hungary, Poland, the Czech Republic, Slovakia, Slovenia, Sweden and the UK.

Wild Birds in Scotland

2.1 Scotland is home, for at least part of the year, to a considerable number of wild birds that are capable of carrying the influenza virus. The higher risk species are water birds, including all species of swans and geese, and some species of ducks, waders and gulls. The species that are classified as near higher risk are the remainder of the ducks, waders and gulls as well as terns.

2.2 The majority of these species are, at least to some extent, migratory. East to west migrations imply that birds reaching the shores of Scotland might have passed through areas that are infected with the AI virus. Although east-west movements can occur for many reasons, the firths and lochs of Scotland are particularly important as feeding and resting areas when the winter temperatures over the continent of Europe are abnormally low. At such times increased monitoring would be advisable. North to south (and vice versa) migrations generally occur in the autumn and spring. For example, many geese breed in Arctic areas, such as Greenland and Svalbard, but winter in Scotland (and elsewhere in GB and Ireland). It is considerably less likely that those birds coming from Arctic areas will have passed through infected areas. However, the high-risk species that overwinter in northern Africa might have passed through infected areas before they reach Scotland.

2.3 Scotland holds substantial populations of the higher risk and near higher risk species. For this reason more than half of the extent notified to the European Commission as Specially Protected Areas (Birds Directive of 1979) is located in Scotland. Whilst it remains unknown how far a bird could travel once it has become infected with HPAI, any outbreak in Scotland has the potential to have nature conservation consequences as well as significant economic effects.

The Scottish Poultry Industry

3.1 According to the Scottish Executive[1], in June 2006 there were 1,023 people employed on specialist poultry farms in Scotland. Although almost 5,000 holdings were recorded as keeping laying hens, 97% of the laying flock was kept on the 89 holdings having flocks of more than 1,000 birds. It is clear, therefore, that there are many people throughout Scotland who keep poultry primarily for domestic egg production or as a hobby.

3.2 Similarly, over 99% of broiler production was recorded as taking place on the 75 holdings having flocks of more than 10,000 birds, although 1,331 holdings were recorded as keeping broilers and other table birds.

3.3 Chickens are by far the most numerous type of poultry kept in Scotland. Although ducks, geese and turkeys have also been recorded, there is little commercial production of these birds.

3.4 The value of egg production for food in Scotland in 2005 was £31 million, approximately 2% of the total gross output of Scottish farming. The value of table poultry was higher with corresponding figures of £88 million and 5%.

3.5 We understand that in the case of commercial laying flocks, no birds are hatched in Scotland and most are brought in from English hatcheries. The situation with broilers is very different with one of the world's major companies, which supplies approximately 50% of the global poultry meat industry, having a large pedigree unit in Scotland.

3.6 Although shooting is an important element in the rural economy of Scotland, we are not aware of any information on game bird numbers specific to Scotland. In the UK some 40 million pheasants and 15 million partridges are bred each year, of which 15 million pheasant and 2.6 million partridge are shot. In addition, approximately one million ducks, mainly mallard, are released each year.

H5N1 Disease of Poultry

4.1 The H5N1 virus has the capacity to wipe out whole flocks of poultry within a short space of time. It is very contagious, as demonstrated by its rapid spread through many countries. If it were to become established in Scotland, the implications for our egg and poultry meat producers would be significant. Although the Scottish poultry industry is small compared with the cattle and sheep industries, it would still impact adversely on the rural economy.

4.2 Little information exists on the viability of the H5N1 virus in different environments but it is known that, in addition to being carried by birds, it can be carried on human hands and feet, and possibly by vehicles. However, the rapid spread of the virus, at least in Asia, has been shown to be due primarily to the movement of infected poultry. There exists the possibility of H5N1 being introduced into the UK by the import of infected birds. Poultry chicks, game bird chicks (especially pheasants) and mallard ducklings are imported, but mainly from elsewhere in the EU where the incidence of the disease is low and the level of monitoring for the disease is high. Moreover, all imported birds are subject to veterinary inspection and monitoring at an early stage following their arrival in the country.

4.3 H5N1, unlike other HPAI viruses, is known to have spread to wild bird populations. This raises the possibility that the virus could be introduced into the UK by migratory birds. Indeed, the Chief Veterinary Officer (Scotland) considers this to be the most likely route by which the disease would be introduced into Scotland and the rest of the UK.

4.4 It appears unlikely, however, that the outbreak of HPAI at a turkey-finishing unit in Suffolk in February 2007 was caused by the disease being introduced by wild birds. The virus was confirmed as the H5N1 strain and molecular genetic studies found it to be virtually identical to the virus isolated from two outbreaks in geese in Hungary in January 2007. These results suggest a common source for the outbreaks in Suffolk and in Hungary, or a direct link between the Hungarian incidents in January 2007 and the Suffolk incident the following month. Investigation of the Suffolk outbreak concluded that there was little evidence to implicate wild birds and that circumstantial epidemiological evidence suggested the most likely route for introduction of the virus was in, or associated with, the transport of turkey meat from Hungary to the UK.

4.5 The Suffolk outbreak was contained and we understand that modelling studies suggest that this will be typical of most outbreaks with the disease not spreading beyond the index case. Professor Woolhouse's research group at Edinburgh University was one of six groups from throughout the UK brought together under the DEFRA Modelling Consortium for a 6-month project looking at the modelling of HPAI. A common feature of the models examined was

[1] The Scottish Executive is now known as the Scottish Government.

that they drew demographic data on the location of flocks from the Poultry Register. However, not only does the Register exclude flocks of less than 50 birds but it has been suggested to us that it is incomplete and sometimes inaccurate, at least for Scotland, particularly at the level of data required for modelling.

4.6 Another difficulty is the absence in the literature of information on disease parameters for H5N1 infection. Professor Woolhouse's group has, therefore, employed H7 virus data in its HPAI modelling studies.

4.7 In spite of these limitations, the models had looked at a number of disease control options, but it was emphasised to us that only tentative conclusions could be drawn at this stage, and that these did not provide a sound basis for policy development.

4.8 It appears to us that the Consortium was a useful exercise, not least in identifying the requirements for improved demographic data on flocks and more information on the parameters of H5N1 disease. Although we recognise that modelling studies are only one source of information relative to HPAI planning, we consider that further funding should be provided to develop and refine HPAI models.

Surveillance Programmes

5.1 Surveillance is being conducted across Europe to detect avian influenza in poultry and wild birds. In the UK, all reports of disease in poultry are investigated. In addition, blood samples are taken for testing from randomly selected poultry farms.

5.2 Because the greatest risk of introduction of the H5N1 virus into Scotland is thought to be through wild bird movements, a programme of surveillance is underway, with samples being taken from birds shot by wildfowlers, and from live birds caught for ringing. Of 381 shot birds tested in GB in 2006 only two tested positive, in both cases for a low pathogenic H5 virus subtype. There were no positive results from the testing of live birds.

5.3 For the purposes of wild bird monitoring in GB, the country has been divided into 100 kilometre squares, each of which has been assessed in terms of its importance for the risk species of wild bird. Within Scotland 16 squares have been identified as high risk, mainly down the east of the country from Angus to the Borders. Within this area all reported deaths of wild birds on the list are investigated, whereas elsewhere only reports of ten or more deaths are followed up. In addition, Scottish Natural Heritage and the Royal Society for the Protection of Birds are monitoring their Reserves for the incidence of high mortality rates.

5.4 Monitoring in GB reflects current EU thinking and concentrates on wetland birds (section 2.1) as being the highest risk. The EU list of high risk species is an informed judgement based on factors such as the east-west movements of birds. The Scottish Government has drawn up its own list that includes seven species not found on the EU list. However, we are concerned that the Government's list might not include all high risk species and that others, including some of the gulls, might also be relevant.

5.5 We have concerns about the wild bird surveillance programme as it has been described to us. We recognise that in theory, testing of wild birds, both live and dead, could be helpful in detecting the introduction of the H5N1 virus into Scotland; detecting propagation of the virus within the Scottish wild bird population; or in providing early warning of a threat to human health, bird conservation or the poultry industry. The concentration on testing of wetland birds suggests the aim is to detect the introduction of the virus at an early stage, but the limited blind sampling would appear inadequate for this purpose.

5.6 Similarly, we doubt the ability of the current surveillance to pick up the propagation of the virus in the wild bird population, or to provide early warning of a threat to poultry or humans. There is no testing of those gull species that tend to have contact with wetland birds and that are also frequently found in the vicinity of poultry houses, and we consider this a major omission.

5.7 Evidence from around the world suggests that H5N1 does not pose a significant threat to wild bird conservation. Even if it did, there is little that could be done to mitigate the effects of the disease in wild birds. Related to this, it appears to us that wild bird mortality rates vary significantly from year to year and this means there is a lack of baseline data to assist in the recognition of particularly high mortality rates that merit further investigation.

5.8 We agree that there is a theoretical risk that wild birds could play a role in introducing the H5N1 virus into Scotland and in infecting poultry, particularly free range birds. However, it is not clear how significant this risk is in practice, and more work is required to quantify the risk both to inform any wild bird surveillance and to provide guidance to the poultry industry on biosecurity priorities. If wild bird surveillance is to continue, there is a requirement for greater clarity as to its

purpose. Once the purpose is decided, a robust sampling and testing programme should be designed on scientific principles that will meet this purpose.

5.9 We also recommend that further consideration be given to who should conduct the monitoring. Currently data on wild birds are collected mainly by NGOs, in particular RSPB. As we understand it, RSPB has received no offer of financial assistance, or recompense from, its agencies or the poultry industry. We recognise that RSPB is well-qualified to carry out this work but take the view that it should be adequately recompensed for the monitoring it undertakes relevant to avian influenza. Consideration should be given to whether the poultry industry, being potentially the principal beneficiary, should be asked to contribute to the costs of a more effective wild bird monitoring programme.

5.10 In the case of an outbreak of H5N1 in a free-range flock, increased monitoring of wild birds in the vicinity is recommended in order to detect the possible spread of the virus from the infected poultry to the wild bird population.

The Diagnosis of HPAI

6.1 An outbreak of HPAI in any group of susceptible birds will cause noticeable illness and an increase in the number of dead birds. In the case of an outbreak in poultry, where the local veterinary surgeon suspects HPAI the regional State Veterinary Service (SVS) will be alerted and will visit the farm. If the SVS also suspects HPAI, samples of dead birds will be sent to the Veterinary Laboratories Agency (VLA) at Weybridge for laboratory confirmation.

6.2 Illness and die-offs in those species of wild birds considered most at risk from AI must also be investigated. Sick or freshly dead birds are collected and transported, taking precautions to avoid any risk of spreading infection, to the nearest regional veterinary laboratory for post-mortem examination. There are eight such laboratories in Scotland (Thurso, Inverness, Aberdeen, Perth, Edinburgh, St. Boswell's, Ayr and Dumfries) run by the Veterinary Services of the Scottish Agricultural College (SAC). If the post-mortem findings suggest HPAI, a pool of tissues and a sample of intestine are sent to VLA Weybridge for laboratory confirmation.

6.3 At VLA Weybridge, virus detection in the first instance is by real-time reverse transcriptase PCR (RT-PCR). If negative, both the sender of the samples and the regional SVS office are informed, and no further testing is carried out. If there is evidence of the presence of AI virus, attempts are made to isolate it and to type it by haemagglutination inhibition testing and nucleotide sequencing before notifying a positive result. Pathogenicity testing is carried out by injecting day-old chicks with the recovered virus.

6.4 Rapid diagnosis is very important and we both welcome the development and encourage the introduction of on–site diagnosis based on PCR technology. This will allow action to be taken expeditiously, although confirmation will still be required by the World Reference Laboratory (Weybridge).

6.5 In the case of an HPAI outbreak in poultry, culled birds are tested for the presence of virus, but follow-up investigations mainly consist of testing sera from live birds for the presence of antibody to the virus. Serological testing can be carried out in the dedicated facility in Dumfries (which, we understand, can be activated within weeks).

Prevention and Control of Avian Influenza in Poultry

Biosecurity

7.1 Everyone to whom we spoke recognised the importance of biosecurity measures to protect poultry flocks from the introduction of avian influenza, as well as from other diseases. The poultry industry in Scotland is aware of the importance of biosecurity and has adopted good practice, with all companies having prepared detailed biosecurity plans. Companies are responsible for their own biosecurity policies, and the measures employed vary with the level of biosecurity attaching to breeding flocks being considerably higher than for laying birds. Clearly, there are limits to what can be achieved by way of protection for free-range flocks.

7.2 There is no legislation governing biosecurity measures and the Scottish Government Rural Directorate has no powers to inspect or regulate biosecurity standards. Although it is clearly in the interests of the industry itself to be vigilant with regard to biosecurity, it was acknowledged to us that in practice the implementation of biosecurity plans can fall short of the ideal, particularly at times when the risk is perceived as low. For example, casual visitors to poultry units should be actively discouraged.

7.3 Imports of infected poultry meat are a potential source of disease. It is an important aspect of biosecurity to ensure that live poultry are separated from meat plants, that measures are in place to avoid any possible transfer of virus from meat to

poultry and that waste from meat plants is disposed of in ways that ensure it cannot infect wild birds.

Protection and surveillance zones

7.4 In the case of an outbreak of avian influenza in poultry in Scotland, strict biosecurity will be important in controlling the spread of disease. However, legislative measures will also come into force. The European Commission reacted quickly to the H5N1 threat with legislation intended to demonstrate to other areas of the world a robust approach to disease control with the aim of safeguarding exports, whilst at the same time allowing for derogations based on risk assessment in order not to constrain unnecessarily the industry within the EU. An EU Directive requires the establishment of protection and surveillance zones where HPAI and LPAI of virus subtype H5 or H7 is found or suspected in kept birds, or when H5N1 is detected in wild birds. These requirements of the EU Directive have been transposed into Scottish legislation that also defines the size of zones and the measures that apply within them, including restrictions on the movements of poultry and eggs.

Culling of infected flocks

7.5 The legislation also makes provision for the culling of flocks in which HPAI has been confirmed. The limited modelling studies of avian influenza indicate that most outbreaks will not spread beyond the index case if prompt action is taken to destroy the infected birds and to trace at-risk contacts. Current practical experience supports this.

Vaccination

7.6 Vaccines offering protection from H5N1 infection are available commercially. Those licensed for use in Europe contain inactivated virus; these vaccines require to be administered by intramuscular injection with two doses, 2-3 weeks apart, required for maximum protection. Such vaccines have been used in some countries, e.g. Mexico, for more than ten years without other control methods. However, while they prevent disease, they do not eliminate the virus, and it may remain undetected in flocks with the risk of spread to other birds.

7.7 Although stocks of H5N1 vaccines are held by DEFRA for use in an emergency, our understanding is that current contingency plans for the control of AI do not include vaccination of domestic poultry in advance of an outbreak of infection. While the vaccination of broiler birds is not an option because of their short life-spans, vaccination of laying and breeding flocks could be considered if the culling of infected birds, movement controls and surveillance methods failed to halt spread of the virus and the disease became established here. Vaccination of domestic poultry might also be considered if virus prevalence were to become so high in the wild bird population that repeated 'spillovers' of infection to poultry were to occur.

7.8 Vaccination of collections of rare birds such as those held for genetic conservation purposes, whether held privately or in zoos, should be allowed if they are at high risk of infection. However, the efficacy of the vaccines in birds other than domestic poultry is largely unknown and would benefit from further research.

7.9 Vaccination as a protective measure could be attractive if more effective, cheap vaccines can be developed, particularly if their method of delivery were to allow easy administration to large flocks without the requirement to handle each individual bird. We recommend that financial support be provided for research into, and development of, more effective and "user-friendly" vaccines.

Risks to Human Health

8.1 It is important to stress that there is no risk of human infection with an avian influenza virus from the ingestion of properly cooked poultry meat or eggs. Direct infection of humans results from close contact with infected birds, as has happened in a relatively small number of cases in the Far East. The major concern is that a virus causing influenza in poultry may evolve to infect humans and result in human-to-human transmission of the disease.

8.2 There were three human influenza pandemics in the twentieth century beginning in 1918 (Spanish influenza, H1N1), in 1957 (Asian influenza, H2N2) and in 1968 (Hong Kong influenza, H3N2), each caused by a virus related to an avian influenza virus. In 1997, H1N1 (Russian influenza) strains re-emerged and continue to co-circulate with H3N2 strains today. The World Health Organisation considers that we are closer to another human influenza pandemic than at any time since 1968. A recent joint study by the Royal Society and the Academy of Medical Sciences, chaired by Professor Sir John Skehel, examined the extent to which scientific evidence is being incorporated into preparedness for a pandemic. We endorse the findings of that study and have not sought to cover the same ground but to examine only aspects particular to Scotland.

8.3 Skehel noted "there is general agreement in the scientific community that the risk of a human pandemic is elevated because of the wide distri-

bution of H5N1 viruses, but there is a range of opinions about the likelihood of a pandemic primarily because the H5N1 viruses have been widely distributed for over a decade without the occurrence of a pandemic".

8.4 We have also noted that research suggests that currently circulating strains of H5N1 viruses are becoming more capable of causing disease in animals than were earlier strains of the virus. One study has found that ducks infected with H5N1 are now shedding more virus for longer periods without showing symptoms of illness. This finding has implications for the role of ducks in transmitting disease to other birds, and possibly also to mammals including humans. Other studies have documented H5N1 virus infection in pigs, in cats and in dogs. H5N1 has been isolated from tigers and leopards in zoos in Thailand, and H5N1 virus infection has been reported in a wild stone marten in Germany and in a wild civet cat in Vietnam. The H5N1 virus strains that emerged in Asia in 2003 are continuing to evolve and may adapt in such ways that other mammals also become susceptible to infection.

8.5 In our view, although the H5N1 virus poses a threat to the poultry industry here, as evidenced by the outbreaks in Suffolk and Norfolk, the risk of a new human pandemic strain of virus evolving in Scotland or elsewhere in the United Kingdom is remote. However, it will be important to detect an incipient pandemic originating elsewhere if we are to be prepared for it striking the UK. It will only be feasible to produce a meaningful projection of a pandemic if good data are available at an early stage, and this means identification of changes in the virus in the first 100 or so cases. The increasing availability of high through put, rapid nucleic acid sequencing equipment will facilitate this and improve surveillance. The analysis of surveillance data with a view to early detection of disease events such as pandemic influenza and estimation of rates of spread requires that the data are shared immediately with modellers. We recommend that this is afforded a high priority in Scotland by the relevant authorities, in particular by Health Protection Scotland.

8.6 Very significant planning is being undertaken in Scotland in preparation for a possible human influenza pandemic. For the purposes of planning, it is considered not unreasonable to assume similar attack and mortality rates to those of the last two influenza pandemics affecting the UK. However, societal circumstances today are now very different with, for example, greater mobility and smaller household sizes. In addition, scientific advances mean that the start of a pandemic can be identified, the causative agent characterised and effective interventions developed more quickly than in the past. Although mortality has been high in the small number of H5N1 cases in humans to date, a pandemic would only develop if a strain of virus were to evolve with a level of virulence such that it could multiply and spread before the death of the host. Moreover if, as reported, a "cytokine storm" is the main cause of death in H5N1 infections in humans, a good range of anti-inflammatory drugs is now available to treat patients.

8.7 Within Scotland the measures being taken in preparation for a pandemic include stockpiling of antiviral drugs and masks. The adequacy of these measures is kept under constant review but, until a pandemic occurs, there is no way of knowing exactly what will be required. The intention is to use antiviral drugs for the treatment of patients, but limited prophylactic use might be considered early in a pandemic.

8.8 We have explored the potential value of movement restrictions as a means of restricting the spread of the disease. It is expected that local schools in the area of an outbreak would close, and most public events would be cancelled. The evidence from modelling studies suggests that movement restrictions would have little impact on the spread of disease and there is no intention to introduce restrictions on travel here in the case of a pandemic. It is difficult to predict how people will react to a pandemic, for example by staying at home. There is little doubt that businesses would be affected significantly, but this is recognised and considerable efforts are being devoted to contingency planning in both the private and public sectors.

8.9 We recognise that it is unlikely that a vaccine effective against a new strain of pandemic influenza virus could be produced before the disease affects the UK. Even if a vaccine were to be available, there would be significant costs in making this available to the whole population. In addition, consideration would have to be given to the possible risks of neurological complications associated with the widespread use of a new vaccine. Small stocks of an H5N1 vaccine are available and could be used, if appropriate, to protect key health workers. The hope is that, should there be a pandemic, a vaccine might be developed to protect certain priority groups from the second wave of infection.

8.10 Although we recognise the reasons for the current emphasis being placed on preparations for a human pandemic caused by the H5N1 virus, H7 and H9 viruses are also known to have infected humans. It is quite possible that the next human influenza pandemic will be caused not by H5N1 but by some other strain of virus, and we recommend that those responsible for planning for dealing with a pandemic take account of this possibility.

Conclusions and recommendations

9.1 Avian influenza viruses, not least the H5N1 strain that is currently of concern, pose a significant threat to the poultry industry worldwide, including that in Scotland.

9.2 The only effective means of protection available to the Scottish poultry industry is to prevent the virus infecting its poultry flocks. It is important, therefore, to have the means of detecting the presence of the virus in this country at an early stage, whether in the wild bird population or in domestic or commercial poultry, and to implement biosecurity measures as quickly as possible to protect individual poultry units from the introduction of the virus.

We recommend that Scotland should adopt, as soon as it becomes available, the use of on-site diagnosis based on PCR technology.

9.3 In Scotland, poultry and wild birds are monitored to detect the presence of avian influenza viruses. This monitoring needs to be done more rigorously.

We therefore recommend that:

Research is undertaken to quantify the risk of infection of poultry in Scotland with the H5N1 virus by wild birds.

A review is undertaken of the risk species of wild bird to be monitored, in particular with a view to including those species of gull that have contact with wetland birds and are also found in the vicinity of poultry houses.

A robust surveillance programme for the wild bird population should be developed on scientific principles.

The surveillance programme should be sufficiently flexible to respond to severe changes in weather, that can affect wild bird migration patterns.

Adequate funding is provided for the scientific monitoring of wild birds, and further consideration is given to who should carry out this work, including the collection of carcasses.

9.4 We recognise that mathematical modelling studies provide useful input to the planning for an avian influenza outbreak (paragraphs 4.5–4.8) but that the modellers require more robust data on which to build their models.

There are seven major epidemiological aspects (or risks) that require addressing:

- the risk of disease introduction to the wild bird population of the UK
- the risk that the infection is propagated in this population
- the risk that the infection is subsequently introduced to domestic and farmed birds
- the risk that the infection is propagated and maintained in the domestic and farmed bird population
- the risk that the infection spreads from infected farm birds to the wild bird population
- the risk that transmission to humans occurs from wild bird populations
- the risk that transmission to humans occurs from domestic and farmed bird populations

We recommend that appropriate and rigorous risk assessments are applied to these scenarios, where necessary providing the funding to collect robust data to parameterise these models.

9.5 We have stressed the importance of biosecurity in protecting commercial poultry flocks from infection. In drawing up biosecurity plans for the prevention of avian influenza, the poultry industry requires to be clear as to how the virus is most likely to be introduced into one of its units (paragraphs 7.1–7.3).

We recommend that guidance is provided to the poultry industry on the relative importance of different potential disease vectors for avian influenza to inform its biosecurity planning.

9.6 We recognise the potential role of vaccines in the prevention and control of avian influenza, particularly if more effective vaccines that could be more easily administered were to become available (paragraphs 7.6–7.9).

We recommend:

That funding is made available for the development of improved avian influenza vaccines.

The vaccination of collections of rare birds, especially those held for genetic conservation purposes.

Given the problems of implementing biosecurity for free range birds, we also recommend that vaccination of such flocks should be permitted in a high risk scenario.

Annex 1: Membership of the RSE Avian Influenza Working Party

Chair:

Professor John Coggins FRSE
Vice-Principal for the Life Sciences, Medicine & Veterinary Medicine, and Professor of Molecular Enzymology, University of Glasgow

Members:

Professor Richard Elliott FRSE
Professor of Virology, Centre for Biomolecular Sciences, University of St Andrews

Professor Peter Kennedy FRSE
Burton Professor of Neurology and Head of Division of Clinical Neurosciences, University of Glasgow, and Consultant Neurologist, Institute of Neurological Sciences, Southern General Hospital, Glasgow

Professor Karl Linklater FRSE
Former Principal and Chief Executive, Scottish Agricultural College and Past President of the British Veterinary Association

Professor Pat Monaghan FRSE
Professor of Animal Ecology and Joint Research Director of the Institute of Biomedical and Life Sciences, University of Glasgow

Dr Peter Nettleton
Former Head of the Virus Surveillance Unit, Moredun Research Institute, Edinburgh

Professor Hugh Pennington FRSE
Emeritus Professor of Bacteriology, Institute of Medical Sciences, University of Aberdeen

Professor Stuart Reid FRSE
Dean of the Faculty of Veterinary Medicine and Professor of Veterinary Informatics and Epidemiology, University of Glasgow; Professor, Department of Statistics and Modelling Science, University of Strathclyde

Professor Michael Usher FRSE
Former Chief Scientist, Scottish Natural Heritage

Secretary:

Ian Melville
Research Officer, Royal Society of Edinburgh

Annex 2: List of those who gave evidence

Ms Laura Bates	Kilduncan Eggs
Dr John Burlison	Scottish Natural Heritage
Dr Harry Burns	Chief Medical Officer, Scottish Executive Health Department
Ms Jacqueline Campbell	Head of Pandemic Flu Co-ordination Team, Scottish Executive Health Department
Mr Michael Darrah	Deans Foods
Dr Colin Galbraith	Scottish Natural Heritage
Professor Charles Milne	Chief Veterinary Officer, Scottish Executive Environment and Rural Affairs Department; Honorary Professor, Royal Veterinary College
Mr Donald Peddie	Kilduncan Eggs
Mr Neil Ritchie	Animal Health Division, Scottish Executive Environment and Rural Affairs Department
Mr Colin Shedden	Director (Scotland), British Association for Shooting and Conservation
Mr Kevin Smith	Grampian Foods
Dr Bill Stanley	Aviagen Ltd
Dr Bradley Turner	Aviagen Ltd
Mr Paul Walton	Royal Society for the Protection of Birds
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