Risk Analysis of Wild Birds in Spread of Highly Pathogenic Avian Influenza

YANG Shuo, and Ian Robertson*

Murdoch University, Western Australia, WA6163, Australia

Abstract. Outbreaks of highly pathogenic avian influenza (HPAI) H5N1 have taken place in 15 countries in Asia, Europe and Africa since 2003, and have caused great economic losses. Much likelihood has been considered as risk factors, of which wild birds are attributed as one of the main factors. This is related to the environmental deterioration in the wetland and expanse of human's activities in production. The risk analysis in this paper only focused on the effect of wild birds to HPAI, and confirmed the high risk of wild birds in the spread of AIVs.

Key words: avian influenza, HPAI, H5N1, wild bird, risk analysis

CLC number: S85 Document code: A Article ID: 1006-8104(2010)-01-0077-07

Introduction

Avian influenza is one of the most serious poultry diseases, causing enormous threats to the poultry production, and the virulence of AIV has been continually growing. Highly pathogenic avian influenza (HPAI) caused by HPAI H5N1 has resulted in deaths of human.

The first report that human died of H5N1 occurred in Hong Kong in 1997, a three years old boy died from the respiratory failure. Three months later, he was diagnosed to be the first human case of H5N1, and the first case in the mainland of China happened in November 2003, reported by Ministry of Health of China. In China, 31 people have been diagnosed to be infected with HPAI, including 21 died case since October 2003, and the rate of case fatality is about 70%.

In China, only 20 days after the first occurrence, HPAI spread swiftly in North and South parts of China. According to situations of infected places, associated with birds' habits in seasonal migration, people began to hesitate that wild birds were spreading HPAIV. Up to now, more than 100 types of birds have been identified which can carry HPAIV and many wild birds died of HPAI.

China has abundant bird resources. It is reported China owns 1 331 types of birds, constituting 10% of all bird species in the world. On the other hand, surveillance and monitoring of wild birds were quite uncompleted before the occurrence of human death of HPAI. From then on, the disadvantage gradually got attention of governments and the public.

Although HPAI is the result of many risk factors, the aim of this paper is only to study the risk analyses of wild birds in the spread of HPAI.

Hazard Identification

Distribution of AIV is in every corner of the world.
Every outbreak of HPAI severely struck the industry of chicken production, and caused enormous losses; furthermore, human infected with HPAI has occurred and caused a great public panic since 2003, and human have to begin to recognize the virus again and to indentify its pathogenic factors.

In general, wild birds are natural reservoirs of HPAI, and carriers of many germs and diseases. More and more proofs have shown that migratory birds have certain relationship with HPAI of poultry. The first HPAI H5N1 outbreak in wild birds occurred in May 2005, 6 345 heads of wild birds died of H5N1 in Qinghai Lake. Qinghai Lake national nature reserve is the largest inland salt lake in China and it is an important inhabiting and breeding site for waterfowl and shore birds. There will inhibit more than 100 000 water birds every year. After H5N1 outbreak in Qinghai Lake, 35 cases of HPAI H5N1 occurred in eight provinces successively in China, and the space and time of these outbreaks just coincided with migratory routes of wild birds.

After the outbreak in Qinghai Lake, HPAI H5N1 took place in Kazakhstan, Mongolia, Russia, and Indonesia, followed by Turkey, Romania, Greece, Germany and other European countries. Following the Europe, HPAI took place in Africa. Most of these countries are located on the flyways of migrants, and there were correspondence between the time of outbreaks and that of migration.

In addition, it was identified that viruses found in Europe have the same origins with those found in Qinghai Lake. Therefore, a hypothesis was raised that migrants can carry H5N1 and spread it on the flyway.

Proving the hypothesis, however, is very difficult, because various bird species can carry AIV, but their susceptibility to virus strains might not be the same and is nearly unknown. In addition, different habitats and migratory routes bring tremendous difficulties to the investigation. Therefore, it is necessary to carry out a great number of field investigations and molecular epidemiology.

Risk Assessment

Release assessment

Migratory factors which are related to HPAI transmission consist of the amount and breed of migrants, travelling routes of migrants, means of transmission and smuggling wild birds.

Firstly, the amount and species of passing migrants can affect the transmission of the HPAI virus. Wild birds are natural and enormous pathogen reservoir and agency. The amount and breed of migrants directly affect their distribution and activities, and thus impact the spread of HPAI. Up to now, H5N1 has been isolated from more than 100 bird species, but the majority of them are migratory waterfowl, especially mallard duck. Other wild birds producing AIVs include various species of shorebirds, gulls and terns, quail, pheasants, marine birds, upland gamebirds and ratites.

Secondly, migrating routes for birds of passage influence transmission of HPAI. Many countries where have outbreaks of HPAI are on travelling routes of migrants, and times of outbreak also comply with that of migration. AIV is usually found in the main pathways of waterfowl, but many water birds follow migratory pathways from their breeding grounds to wintering grounds and return to breeding grounds, major flyways of migratory birds are shown in Fig. 1. Subtypes of the virus found in pathways are different, especially if wild birds only follow their flyways and do not fly into other species' routes. Subtypes of virus found in birds are always different from that in neighboring ways, and proportion of birds with virus always vary by flyway, it always changes even in the same pathway in consecutive years.

Direct and indirect contacts between wild birds and domestic birds cause the prevalence of HPAI. The main hosts of AI are poultry, waterfowl and shorebirds. Majority parts of South China and Central China are located in global migratory routes of migrants, where are studded with water networks. Because of the suitable weather, there are a great number of free-
range and mixed culture chickens, ducks and geese the whole year. The particular environment creates conditions that various birds can contact closely, and thus the virus can transmit from wild birds to domestic birds. The modes of transmission consist of excreta-water-mouth and mouth-water-mouth, especially excreta-water-mouth, which proved that wild birds, especially water birds are original hosts of AIV, all the subtypes can survive in mallards except H13 that has only found in seabirds and gulls; however, mallards always act as latent infection, and spread the virus to the environment through excreta.

The spread of AIV mainly relies on the horizontal transmission, and little proof has been shown vertical transmission, though AIV survived in eggs laid by experimentally infected chickens[6].

Smuggled wild birds could be another agent of HPAI. For example, a smuggled eagle from Thailand was tested out with H5N1 at an international airport in Belgium in 2004[21]. In addition, not only wild birds, but smuggling race birds, ornamental birds, pet birds and rare birds have the potential risk of transmitting HPAIV.

Exposure assessment

Although the influence of migrants is less than international avian trades or living poultry trade in markets, wild birds have positive impacts on the worldwide avian influenza outbreak, prevalence and transmission[2].

AIV shows different virulence on distinct species of birds. In general, ducks are less prone to be infected. AI viruses were isolated from healthy ducks in Guangzhou Province in 1980 and 1989, respectively, and ether of them did not cause avian influenza of ducks. Then, duck origin AIV has highly pathogenicity to other species. Zhao et al. isolated six duck origin type A influenza viruses from healthy ducks in Nanjing and artificially infected various birds. The results showed that morbidity and mortality of 27 days old quails were 50% and 0, respectively; morbidity and mortality of 22 commercial leghorn chickens were 100% and 62.5%, respectively; morbidity and mortality of 25 days old SPF leghorn chickens were 100% and 88.9%, respectively. Meanwhile, the low virulent geese origin AIV showed high virulence to chickens[7]. In 1995, some flocks of geese showed symptoms are similar with AI in South China; from these geese, the high virulent virus to chicken (H5N1) was isolated by Tang et al[8].
Distribution of water also influences the spread of HPAI. Distribution of migrants depends on water system. Virus carriers continuously contaminate water with their excreta, and the virus is brought to another place drifting with the current, so the affected areas are increased continuously.

The amount and scope of wetlands and nature reserves also affect the transmission of virus. According to FAO, between 2005 and 2006, the statistics of epidemic areas of HPAI in Europe, Asia and Africa correlate closely to distribution of lakes, rivers and wetlands. Affected areas are always close to waters and wetlands, so epidemic areas are well connected in waters and wetlands. On the other hand, that human destruct the nature is another reason for the prevalence of HPAI. Over-reclamation of wetlands and decrease in area of lakes and wetlands reduce the living space of wild birds but increase the opportunity that they contact poultry. Because a multitude of animal farms are built around wetlands and lakes, poultry and wild bird activity interweave with each other more and more frequently, wild birds infect the virus to poultry, and poultry infect wild birds again. For example, free-range ducks and wild water birds always find food in the paddy field together in Thailand. Studies have shown that the spread of HPAI was connected with distribution of paddy field in Thailand (Fig. 2).

On the other hand, that human destruct the nature is another reason for the prevalence of HPAI. Over-reclamation of wetlands and decrease in area of lakes and wetlands reduce the living space of wild birds but increase the opportunity that they contact poultry. Because a multitude of animal farms are built around wetlands and lakes, poultry and wild bird activity interweave with each other more and more frequently, wild birds infect the virus to poultry, and poultry infect wild birds again. For example, free-range ducks and wild water birds always find food in the paddy field together in Thailand. Studies have shown that the spread of HPAI was connected with distribution of paddy field in Thailand (Fig. 2).

Consequence assessment

Direct consequences

Wild waterfowl and shore birds are carriers of HPAI, but they also are victims of the disease. Up to now, thousands of wild birds have died of HPAI, including many exotic and rare species. In recent years, because of the decrease in habitats and hunting, the amount of wild birds has been continuously reducing, but the disease aggravates the status quo. On the other hand, some countries or regions are prone to slaughter wild birds to protect poultry from HPAI. This unreasonable and irresponsible measures also have negative effects on the existence of wild birds.
Then, HPAI H5N1 causes a multitude of deaths of chicken and seriously affects poultry industries on a global scale. According to Ministry of Agriculture of China, 50 outbreaks of H5N1 occurred in 16 provinces in 2004. 144 900, 129 100 and 9 045 000 chickens were infected, died and were stamped out, respectively. In 2005, the total of 32 cases of H5N1 took place in 13 provinces, sick, died and slaughtered chickens were 163 100, 154 600 and 22 571 200, respectively\(^{(11)}\).

In addition, infected host species for H5N1 has expanded to wild birds, canines, felines, swine and mustelidae\(^{(1)}\). Canines have been proved as other potential hosts of HPAI H5N1\(^{(12)}\). In Thailand, tigers fed by AI infected chickens died\(^{(13)}\), and feline-to-feline transmission has been experimentally recognized\(^{(14)}\).

Foremost, HPAI has not only adversely affected poultry and poultry production, but human public health. Until January 7, 2009, 393 cases of H5N1 infected including 248 dead have identified in 15 countries and regions, and the mortality rate is more than 60%.

**Indirect consequences**

Chicken production is the traditional industry in China; Meanwhile, it is an industry that has been developed very fast in recent years. Up to now, the total of production of commercial chickens and frozen chicken production in China has been 2.5 billion heads and more than 600 tons respectively per year, according to 15% of the whole amount in the world\(^{(16)}\). HPAI is a catastrophic illness to chickens, and causes widespread public alarm, and thus leads to a series of problems: if it spreads to the whole country, governments have to spend enormous budget on culling, eradication, cleaning, and disinfection. Then, chicken producers will incur terrible losses: their incomes will decrease dramatically; some of them will go bankrupt; a great number of workers will lose their jobs. Meanwhile, that people do not want to eat chickens give rise to greater damage to domestic market that has been already sluggish; however, chicken products in short supply will cause rising prices. On the other hand, international chicken trades will be restricted, chicken export will be all suspended, and China will lose all her shares of the overseas market.

**Risk estimation**

According to studies which analyze the role of wild bird in the spread of AIVs, wild birds are the major carriers of AIVs infection, and are the high risk factor in the spread of AIVs.

Poultry exposed in the environment where have wild birds and high risk to be infected AIVs. Although human infection is rare, the reported case-fatality is high\(^{(15)}\). A study reported that approximately 10% of poultry workers in Hong Kong were found with antibodies to H5N1, though the birds did not show any clinical signs of avian influenza\(^{(16)}\). HPAI has enormous threats to animal and human health, and has caused great losses.

**Risk Management**

HPAI has not been effectively controlled since 2003, but it has been still spreading continuously, and human has known more about HPAI than before, especially the function or position of wild birds in the epidemiology of HPAI. Killing wild birds is not an effective way to avert the risk of HPAI and to contain the spread of HPAI. Therefore, people should not lay the blame on wild birds for the spread of HPAI and should not wash out wild birds mercilessly. Accurate modes consist of enhancement of surveillance of activities of wild birds, the entry and exit animal quarantine and crackdown on smuggling.

For surveillance of activities of wild birds, satellite remote-sensing is an effective tool. Using satellite images, migratory routes can be monitored at the time, associated with observation of climate and landscapes that are connected with bird migration and agriculture, early alarms can be sounded to potential susceptible countries on time.

On the other hand, the decrease of contact between wild birds and poultry can effectively reduce the risk of HPAI. Because wetlands can isolate wild birds from
poultry, so the restoring of wetlands can help curb the spread of AIV, but other preventive measures including isolation, quarantine and treatment are only temporary emergency measures. In addition, the removal of all the poultry farms in the path of migratory path is also conducive to reduce the risk of the spread of AIV between wild birds and poultry.

Meanwhile, international poultry movement, especially illegal bird trade should be restricted. Poultry and poultry products should not be imported from countries with AI. High punishment and fine may not hinder all the smugglings, but the enhancement of customs is significant to hit the illegal bird movement.

Vaccination is another method to prevent HPAI, but vaccination is not the sole resolution, because the rate of vaccine prevention hardly achieves 100% and the population of poultry always is very large. Vaccination should be recognized as a short-term control measure and works as supplementary means.

Risk Communication

Confronting the spread of HPAI, it has not been the problem for individuals, a government or an organization, but is an international issue for all the society, and governments at all levels, especially in the process of investigation of wild birds. Surveillance and monitoring system for wild birds cannot be constituted completely by single country because the migration of wild birds is a worldwide activity, so risk communication is particularly important for monitoring activities of wild birds.

Then, the concrete aims of global communication strategies involve that it can monitor wild birds' population dynamics and law of migration; it can help farmers, veterinarians and governments to master the latest disease information; it can help decision-making for governments to protect both biodiversity and public health; it can decrease the risk of food safety; it can ensure the normal operation of domestic and international trades; it can increase scientists' ability to investigate epidemiology of wild birds, and thus grow human's cognition to AI.

Some other factors should be considered in the process of risk communication: some countries or regions might conceal the truth to protect their own economic benefits; because confined by the level of technology, ability of diagnosis and different communicable ways, some producers, companies or governments might not provide the exact and effective information on time. In order to ensure successful progress of communication, governments should appoint certain organizations or departments to collect, reshape and deliver information. On the other hand, nations need to enact laws to protect the risk communication from the restriction.

Conclusion

Risk analysis of AI is paid close attention in recent years and is also an important step in the prevention of HPAI. Many factors cause the spread of HPAI, destruction of ecosystems of wild birds and smuggling wild birds accelerate the spread of AIV and increase the variability of strains which have threatened human health. Therefore, it is necessary to develop universal surveillance system to eliminate the disease. Effective control and prevention include the restoration of ecological system, isolation of natural habitats of wild birds, establishment of a sound satellite monitoring system, and one-factor analysis of wild strains. In addition, it could be considered that sprays biological medicine to reduce the virulence of AIV on the habitats.

References

1 Yee K S, Carpenter T E, Cardona C J. Epidemiology of H5N1 avian influenza [J]. Comparative Immunology, Microbiology and Infectious Diseases, 2009, 32: 325-340.
4 Friend M, Franson J C. Field manual of wildlife diseases general


