INTRODUCTION

Following the rapid spread of highly pathogenic avian influenza (HPAI) H5N1 viruses in 2005–2006 from Asia to Europe and North and West Africa, concerns arose that H5N1 viruses could become established in these regions and spread across the entire African continent. Newcastle disease (NCD) is already a recurring and widely distributed problem in African poultry. Based on experience gained from previous Food and Agriculture Organization of the United Nations (FAO) projects in Africa, the Gripavi research project (Box 1) Ecology and Epidemiology of Avian Influenza and Newcastle Disease in Tropical Countries was designed to improve understanding of the ecological and epidemiological factors involved in the maintenance and spread of avian influenza and NCD viruses. Aiming also to assess prevention and control measures, it was coordinated by the International Cooperation Centre and control measures, it was coordinated by the International Cooperation Centre for Agricultural Research for Development (CIRAD), France, and implemented from 2007 to 2011 with financial support from the French Ministry of Foreign Affairs. In collaboration with national and international research groups, studies were conducted in five African countries and Viet Nam, and included field studies on wild and domestic avian host populations, and poultry market chains. (Circulation of influenza viruses in domestic pigs was also studied but the results are not included in this article.)

H5N1 HIGHLY PATHOGENIC AVIAN INFLUENZA IN NORTH VIET NAM: CLEAR IDENTIFICATION OF RISK FACTORS AT THE REGIONAL AND LOCAL LEVELS

Studies on the spatial determinants of major epidemics in Viet Nam showed that China was a source of HPAI H5N1 for north Viet Nam, through illegal imports of poultry. Communes or villages located along the roads that connect the two countries illegally imported to meet the demand for good genetic material or because of high consumer demand for poultry meat during the New Year (Tet) celebration (Desvaux, 2012).

At the local level, the existence of natural or artificial water bodies appears to be strongly correlated with outbreak probabilities (Desvaux et al., 2011; Desvaux, 2012). Several risk factors related to poultry trade movements – such as the presence of at least one poultry trader in the village – were also identified as drivers of the local dissemination of the virus from one village to another (Trevennec et al., 2011; Desvaux et al., 2011).

Serological and virological prevalence studies conducted on domestic poultry populations in the Red River Delta area provided indirect evidence that vaccinated populations with low levels of immunity can contribute to persistence of the virus within the poultry population (Box 2). More precisely, it is hypothesized that the virus is maintained in ducks on long production cycles (and, to a lesser extent, in non-vaccinated Muscovy ducks on long production cycles) and that non-vaccinated broilers or ducks on shorter production cycles probably contribute to virus dissemination through the farming management system used to raise them (Desvaux et al., 2012a). Under these conditions, broiler chicken flocks, which are generally not as well vaccinated as layers and breeders, act as effective sentinels of HPAI virus in a village by showing clinical signs after infection.

AVIAN INFLUENZA IN AFRICA: VIGILANCE IS STILL REQUIRED

In 2012, six years after the first cases in Africa, most of the African continent remains free of HPAI H5N1 virus, although HPAI H5N1 is endemic in Egypt.

Large-scale surveillance studies of more than 15 000 wild birds conducted in 20 countries across Africa found no healthy wild birds infected with HPAI H5N1 viruses (Gaidet et al., 2012a; 2012b). This result is consistent with the findings of all the global-level monitoring programmes conducted since 2006. However, these intensive surveys present a higher risk of infection and often report outbreaks during the early stages of an epidemic (Desvaux 2012; Trevennec et al., 2011). Low levels of H5N1 circulation have also been observed in remote villages of ethnic minorities living close to the border with China (Trevennec et al, 2011). Field surveys indicate that large numbers of spent hens, day-old chicks and ducklings are
Box 2: Avian influenza and NCD vaccination issues

In Viet Nam, cross-sectional serological and virological surveys carried out from the end of 2008 to June 2010 improved understanding of the epidemiology of the H5N1 disease in a vaccination context and enabled evaluation of the vaccination programme implemented in Viet Nam. The results of using an inactivated H5N1 vaccine in northern Viet Nam highlighted the difficulties in maintaining good flock immunity throughout the year in poultry populations (Desvaux et al., 2012b; 2012a). This finding was confirmed by follow-up on the H5 antibody kinetics in birds vaccinated with the Re-1 vaccine under field conditions. Sero-protection did not last more than three to four months (and even less for ducks) (Desvaux, 2012). Studies also demonstrated that vaccination coverage could be improved by simple actions to prevent vaccination failure and to optimize and harmonize the different protocols used for chickens and ducks.

Phylogenetic analyses of NCD viruses revealed some original velogenic strains never before described in Africa (Servan de Almeida et al., 2009; Maminiana et al., 2010; Hammoumi et al., in press). For example, the new genotype XI, presumably derived from an ancestor close to genotype IV, which was introduced into Madagascar probably more than 50 years ago, is specific to the island (Maminiana et al., 2010). A new genotype and sub-genotype (XIV and VII) were also detected in West Africa and Ethiopia respectively, and seem to be specific to these regions (Hammoumi et al., in press). Under experimental conditions, different levels of protection after vaccination have been observed in poultry vaccinated with current vaccines based on genotype II strains and challenged with genotype XI. Under these conditions, clinical protection is normally acquired, but virus excretion – and hence “silent” circulation – can occur. This might explain why sporadic outbreaks with “new” genotypes in chickens vaccinated with “old” genotypes are observed in Madagascar and elsewhere in Africa.

revealed widespread circulation of low pathogenic avian influenza (LPAI) viruses – the precursors of most HPAl viruses found in poultry – in a large number of wild bird species and in all regions of Africa (Gaidet et al., 2012a; 2012b; Guerrini et al., in press). Globally and locally, the prevalence of LPAI viruses was relatively low (1 to 15 percent) and, despite wide geographical and taxonomic coverage, no clear hot-spot for avian influenza infection was found (Gaidet et al., 2012a). Seasonal and geographical variations in the prevalence of LPAI viruses across Africa were positively related to the local density of the wildfowl community and to the wintering period of Eurasian migratory birds (Gaidet et al., 2012b). Higher prevalences were systematically found in wild ducks of the Anas genus than in other duck species, whatever their foraging behaviour (dabbling or diving) or geographical origin (Eurasian or Afro-tropical), suggesting the existence of intrinsic differences in receptivity to infection among duck taxonomic groups. Repeated sampling in Mali and Zimbabwe showed, for the first time, the continuous circulation of LPAI viruses throughout the year in wild bird communities in Africa (Cappelle et al., 2012; Caron et al., 2011).

Studies aimed at characterizing and evaluating contact and pathogen transmission probabilities between wild and domestic birds are key elements in estimating the sanitary risks for domestic poultry. In the inner Niger Delta, in Mali, the spatial distribution of wild ducks was modelled using environmental data to evaluate the contact rate and the probability of avian influenza virus circulation among wild birds (Cappelle et al., 2010). The results indicated that transmission is likely to be greater during the period of flood recession at the end of the dry season, or in years of low rainfall and low flooding, when high densities of aquatic wild birds congregate on the few remaining water bodies. Also in Mali, satellite tracking of African wild ducks showed that the end of the dry season is a propitious period for contacts between domestic poultry and wild ducks (Cappelle et al., 2011), because the two populations share the same remaining flooded habitat close to villages. LPAI virus was also found in domestic birds in villages bordering wetlands (Molia et al., 2010a). In Zimbabwe, a detailed analysis of the bird communities living at the interface between villages/poultry farms and natural wetlands identified the wild bird species with potential to act as “bridge species” – species with ecological characteristics (abundance, habitat requirement, mobility, feeding behaviour) that foster contacts with both wild ducks and poultry – which may therefore transmit the virus between wild and domestic bird populations (Caron et al., 2010).

Identifying risk situations suggests ways of making surveillance more effective. Rather than systematic monitoring of wild birds, which is expensive and difficult to implement, surveillance should focus on specific seasons and sites, such as wetlands with high concentrations of wild birds that are close to farms. In the inner Niger Delta, for instance, analyses indicate that surveillance should target migratory ducks at the end of their wintering period in Africa – when they are at their highest density (February to March) – particularly in years of low rainfall. Such monitoring could also include domestic birds, targeting areas of contact with wild birds, such as in Mopti and Bamako market, where large quantities of wild birds are sold alongside domestic poultry during periods when a sharp decline in the Niger River level creates good conditions for hunting.

NEWCASTLE DISEASE IN AFRICA: A WIDESPREAD DISEASE RELATED TO BREEDING AND TRADING PRACTICES

While the prevalence of influenza viruses is fairly limited in African domestic bird populations, NCD is a recurring and widely distributed problem, especially in backyard farms. In more than 22 000 samples from domestic and wild birds collected and analysed in the Gripavi project, NCD virus prevalences of between 3.5 and 6 percent were found in domestic birds (using polymerase chain reaction [PCR]), against less than 1 percent for avian influenza viruses. Figures for wild birds were about 1 to 3 percent for NCD and less than 1 percent for avian influenza.

Studies in Mali, Ethiopia and Madagascar all emphasize the importance of trade in virus spreading (Rasamoelina Andraiamanivo et al., 2012; Chaka et al., 2012b; Molia et al., 2010a). Investigations showed that attendance at a market and the vicinity of traders are correlated to a higher prevalence of NCD virus on farms. In Madagascar, the risk of infection at the district (Fokontany) level is statistically related to the density of trade flows (Rasamoelina Andraiamanivo et al., 2012). Similarly, the risk of virus circulation increases in markets because of the high density of domestic birds coming from different areas.

Farming practices also affect virus circulation. In Mali, the risk of infection is lower on commercial farms applying health protection measures (biosecurity) than on small and traditional farms with little protection (Molia et al., 2011). In Ethiopia, NCD virus prevalence and exposure levels decrease when backyards are cleaned more regularly and drinking places are protected. In Madagascar, two types of farming are more susceptible to infection by the NCD virus: small backyard farms that do not apply biosecurity measures, and factory...
farms, which have more frequent contacts with the outside (visits by veterinarians, purchases of food and chicks) (Rasamoelina Andraiamanivo et al., 2012). Contact with the outside also plays an important role in traditional farms in Ethiopia, where the infection rate is higher if breeders renew their poultry through outsourcing, and the exposure level decreases when eggs and chicks come from the farm’s own stock (Chaka et al., 2012a).

Although common and widespread, NCD is poorly monitored in Africa. Its control relies mainly on vaccination, which is often unavailable to small farmers, or individual prevention strategies such as seasonal destocking. The Gripavi project has tested other approaches to monitoring or controlling avian infections such as NCD. A network system analysis approach applied to the poultry sector in Ethiopia, Mali and Madagascar identifies major exchange nodes and paths for domestic bird circulation. This approach enables the visualization of potential paths of bird and virus movements and evaluation of the degree to which farmers, markets or villages are connected. When virus is introduced or emerges at a point in the network, it is therefore easier to identify key paths or network nodes for epidemic monitoring and control (Rasamoelina Andraiamanivo et al., 2012).

Most bird species are considered susceptible to NCD virus, and NCD cases have been previously reported in some wildlife species, especially cormorants and pigeons. The Gripavi project’s testing of more than 9 000 wild birds for NCD found three main new results: an average of about 3 percent PCR-positive birds for NCD, compared with about 1 percent for avian influenza virus, associated with virus circulation in all the tested families; higher NCD prevalence in wild than domestic birds in Mali in the dry season (Miguel et al., 2012); and the circulation of strains that are closely related phylogenetically in several species of wild and domestic birds. All major NCD control programmes in Africa should therefore take into account the poorly understood wild bird component.

FARMERS – AT THE HEART OF SURVEILLANCE AND CONTROL SYSTEMS

For endemic NCD, as for the now endemic H5N1 HPAI in Viet Nam, poultry farmers occupy a central position in surveillance and control processes. Surveillance networks for avian pests can be well organized, as in Mali (Molia et al., 2010b), but they always rely on farmers for the notification of suspected cases. The reporting rate is very low (about 17 percent in Mali), because of several factors such as fatalism and poor perception of the value of reporting suspected cases (Molia et al., 2012). Experience in Madagascar showed that it is extremely difficult to mobilize actors for long-term and effective surveillance over large territories. Network analysis, which identifies the most central nodes, could partially solve the problem by improving the targeting of surveillance sites without reducing the sensitivity of the system (Rasamoelina Andraiamanivo et al., in preparation).

In endemic areas such as Viet Nam, farmers are observed to be more involved in managing sanitary problems. They implement their own disease management and surveillance practices, and their collaboration with the authorities’ surveillance network is limited. In these “informal” surveillance networks, information on health is transmitted rapidly over a radius of no more than a few kilometres. These networks define cases according to local knowledge of diseases, encouraging farmers to adopt measures that minimize the predicted effects of disease – such as by selling sick or exposed animals – rather than tackling the causes. As a result, farmers’ perception of diseases is different from that of veterinary agents: farmers do not operate in the same “epidemiological territory”, do not define diseases in the same way, and do not target the same objectives for control.

At the village or commune level, it appears that communities seek a compromise between economic interests and virus containment at a tolerable or acceptable level (Desvaux and Figuié, 2011).

CONCLUSIONS

Although no major health crisis linked to the H5N1 virus has occurred at the continental level in Africa, the work outlined in this document shows that vigilance must continue. Highly pathogenic strains of avian influenza are present in some countries where control measures cannot always keep them under control, and conditions in several parts of the continent are conducive to the persistence or emergence of potentially dangerous pathogens in both wild and domestic birds. More attention should also be paid to NCD surveillance, as this widespread virus is poorly controlled by veterinary services, which give it little consideration. In both Africa and Asia, risk factors were found mainly in poultry breeding and trading practices, and breeders are at the heart of monitoring and control systems. In addition, wild birds can carry some of the virus strains they share with domestic birds, and their role is likely to be mostly in virus introduction, under specific conditions.

By bringing together a multidisciplinary team (from ecology, epidemiology, virology and sociology) on common research issues, the Gripavi project helped to improve understanding of the risk of avian influenza and NCD introduction and spread. The scientifically based outputs of the project can contribute to improving the efficiency of HPAI and NCD surveillance and control strategies. The next step would be to implement the recommendations on an operational scale, through close cooperation among farmers, technical services and research teams.
REFERENCES


