Research Note—

Conceptual Framework for Avian Influenza
Risk Assessment in Africa: The Case of Ethiopia

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Received 2 April 2006; Accepted 23 August 2006

SUMMARY. The avian influenza (AI) epidemic is threatening Africa mainly because the flyways of migratory birds link the endemic and newly infected countries with disease-free areas in this continent and because of the risk of introduction through trade. Risk analysis provides a set of tools for supporting decision making by the veterinary services and other stakeholders, resulting in more effective surveillance and emergency preparedness. The risk assessment process could be split into three different steps: 1) risk release through the migratory birds and the official and unofficial poultry-product marketing chains; 2) risk exposure by means of studying interfaces among imported and exposed poultry and among wild and domestic birds; and 3) risk consequences for establishing the probability of AI spreading within the poultry population and the probability of it escaping detection. A conceptual framework is presented based on preliminary data and field missions carried out in Ethiopia. Field surveys and expert opinion will be necessary for the parameterization of the risk model. Spatial analysis will be used to identify high risk of exposure among wild and domestic birds. Risk communication and risk management will be based on the findings from the risk assessment model.

RESUMEN. Nota de Investigación—Marco conceptual de la evaluación de riesgo para la influenza aviar en África: el caso de Etiopía. La epidemia de influenza aviar amenaza a África fundamentalmente debido a que las rutas aéreas de las aves migratorias unen los países endémicos y recientemente infectados, con las áreas libres de la enfermedad en este continente y debido al riesgo de introducción mediante el intercambio comercial. El análisis de riesgos proporciona un conjunto de herramientas para apoyar la toma de decisiones por parte de los servicios veterinarios y otras instituciones involucradas, resultando en una vigilancia epidemiológica y una prevención más efectiva. El proceso de evaluación de riesgos puede ser dividido en tres pasos diferentes: 1) riesgo proveniente de las aves migratorias y de las cadenas oficiales y no oficiales de comercialización de productos avícolas; 2) riesgo de exposición determinado por el estudio de las interacciones entre las aves importadas y las aves expuestas y entre las aves silvestres y las aves domésticas; 3) el riesgo que surge como consecuencia de establecer la probabilidad de diseminación de la influenza aviar dentro de la población avícola y la probabilidad de detección de un escape potencial. Se presenta un marco conceptual basado en datos preliminares y misiones de campo llevadas a cabo en Etiopía. Para establecer los parámetros del modelo de riesgo serán necesarias encuestas de campo y opiniones de expertos. El análisis espacial se utilizará para identificar niveles altos de riesgo de exposición entre aves domésticas y silvestres. La comunicación del riesgo y el manejo del mismo se basarán en los hallazgos provenientes de evaluación de riesgo.

Key words: avian influenza, risk assessment, wild birds, domestic birds, Ethiopia

Abbreviations: AI = avian influenza; CIRAD = French Agricultural Research Center for International Development; EWNHS = Ethiopian Wildlife and Natural History Society; FAO = Food and Agriculture Organization of the United Nations; GIS = geographic information system; HPAI = highly pathogenic avian influenza; p = proportion of carrier; Pwd = estimation of the relative risk of exposure for the domestic population; Pww = probability of exposure; WM = number of migratory birds; WMc = number of migratory birds potentially infected/carrier; WR = number of wild resident birds; WResp = numbers of exposed among WR

Several factors may play a role in the transmission of avian influenza (AI), such as poor levels of biosecurity in poultry production systems; exchange of poultry and poultry products; trades through live birds market; presence of water (in ponds or lakes), which allows the virus to persist outside the host, and a large range of wild birds, which can carry low-pathogenicity or highly pathogenic AI (HPAI) virus strains.

Considering the risk of introduction and dissemination of the disease in this context, an integrated approach to risk assessment is proposed, combining knowledge about the migratory wild birds’ distribution in space and in time, the interfaces between wild and domestic avifauna, the persistence of the virus outside its hosts, and the market routes for at-risk products. Such a model could assess the risk of introduction and dissemination of the HPAI virus in a country or area free of disease and could identify the high-risk areas where surveillance and control measures should be strengthened. Because of the importance of the poultry sector (56 million poultry) (2), the low level of biosecurity (mainly free-range chicken), and the relatively high number of migratory water birds wintering in the Rift Valley Lakes, Ethiopia is considered at risk of introduction and spreading for HPAI. After several discussions with experts, a workshop on HPAI, and a previous prevalence study done on wild birds in February 2006, two lakes in the Rift Valley (Ziway and Awassa) were selected to be the starting points of our risk assessment study.

The following research question was considered: What is the risk of introduction of H5N1 into the poultry population around a selected area in the Rift Valley in Ethiopia during the migratory season?
MATERIALS AND METHODS

Our approach (Fig. 1) is in line with the general scheme of the risk assessment process, which can be split in our study in these three different steps: risk release through the migratory birds and the legal or illegal poultry-product marketing chains; risk exposure by means of studying interfaces among imported and exposed poultry and among wild and domestic birds; and risk consequences for establishing the probability of AI spreading within the poultry population and the probability of it escaping detection. The risk assessment of the AI infection will be dependent on spatial factors.

Release and exposure pathways via trading and migratory birds were evaluated using data collected from several sources: expert opinion (epidemiologists, ornithologists, and Ethiopian wildlife specialists), published scientific literature, a workshop, and preliminary field study in Ethiopia (2005–2006) (4).

Table 1. List of parameters and sources of information.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value distribution</th>
<th>Source</th>
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<tr>
<td>p</td>
<td>RiskPert (0.0, 0.014, 0.05)</td>
<td>Prevalence studies, (1)</td>
</tr>
<tr>
<td>WM</td>
<td>Triang (100, 300, 600)</td>
<td>(5)</td>
</tr>
<tr>
<td>WR</td>
<td>Triang (2000, 4000, 8000)</td>
<td>(5)</td>
</tr>
<tr>
<td>Surface of the 5-km buffer</td>
<td>Triang (50, 150, 300)</td>
<td>(5)</td>
</tr>
<tr>
<td>Density of chickens</td>
<td>Uniform (80, 110)</td>
<td>Geographical Information System</td>
</tr>
<tr>
<td>(number per km²)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WM</td>
<td>Triang (50, 150, 300)</td>
<td>(5)</td>
</tr>
<tr>
<td>WR</td>
<td>Triang (600, 800, 3000)</td>
<td>(5)</td>
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<tr>
<td>Surface of the 5-km buffer</td>
<td>Triang (50, 150, 300)</td>
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<tr>
<td>Density of chickens</td>
<td>Uniform (75, 105)</td>
<td>Geographical Information System</td>
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<td>(number per km²)</td>
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The first step was to assess the wild birds’ pathway using quantitative methods and spatial tools. To determine the input parameters we used, in addition to expert opinion, data from the African Waterfowl Census (6), and scientific publications (1,5).

The following quantitative risk assessment analysis was undertaken for a specific time (migratory period from December to March) and for two specific sites (Lakes Ziway and Awassa).

The method was based on quantitative risk assessment and the use of @RISK (©2006 Palissade Europe) software and included the following components:

- Release assessment: For each lake the number of migratory birds potentially infected or carrying the virus (WMc) was calculated using the estimated proportion of carrier (p; Pert distribution) times the estimation of the number of migratory birds (WM; Triangular distribution): WMc = WM × p.

Fig. 1. Conceptual framework for AI risk assessment.
However, the computed risks appear to be quite low (Figs. 2, 3; Table 2). Comparing two areas rather than providing absolute risk values, the estimated numbers of exposed among WR (WRexp) were converted into density using the buffer surfaces established using these distributions of Pww: WMc/WRexp. In order to compare the two lakes in terms of exposure assessment, WRexp were estimated as the relative risk of exposure for the domestic population (Pwd): Pwd = WRexp/density of poultry.

The density of WRexp over the density of poultry gave an estimation of the relative risk of exposure for the domestic population (Pwd): Pwd = WRexp/density of poultry.

RESULTS

To calculate the parameters (Table 1) of our analysis we had to make some choices and assumptions. We decided to focus on the potential exposure between wild and domestic birds in a buffer zone of 5 km around each lake, and we assumed that the resident Anatidae and other waterbirds (e.g., herons, storks, ibises) were susceptible and could excrete the virus and/or could be passive carriers acting as fomites; that the exposure probabilities between migratory Anatidae, resident Anatidae, other waterbirds and domestic chickens were proportional to the density of birds; and that the spatial distributions of wild and domestic birds inside the buffer zones were homogenous.

The quantitative assessment presented here has the objective of different susceptible species and should be made spatially explicit. We decided to focus on the ecology of the virus and the epidemiological roles of the different types of wild birds. A complete model should include the trade pathways and integrate the role of the environment concerning the virus survival and the routes of potential contamination among the different susceptible species and should be made spatially explicit.

EXPOSURE ASSESSMENT (Pww)

The probability of exposure fit an inverse Gauss distribution for Ziway and a beta general distribution for Awassa and could be defined as the “exposure parameter” Pww.

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DISCUSSION

Considering our assumptions, few resident birds seem to be exposed and this would result in a low probability of infectious contacts with the susceptible poultry population. The risk estimated for Awassa Lake appears to be three times greater than the risk for Ziway Lake (rate of the final mean outputs, Table 2). The area of Awassa Lake is much smaller than that of Ziway (297 km² vs. 579 km²) but Awassa Lake is known to be the richest of all of Ethiopia’s wetlands in waterfowl diversity with very high density of birds (20 wild birds/km² vs. 2 wild birds/km² for Ziway). Furthermore, the town of Awassa is one of the centers for the production and the breeding of chickens (180,000 one-day-old chicks and 100,000 adults per year). Indeed, areas with higher density such as towns and marketplaces, as well as areas without villages and inhabitants, should be considered in future spatial analysis.

In conclusion, risk assessment provides a set of tools for supporting decision making by the veterinary services and other stakeholders resulting in more effective surveillance and emergency preparedness. The results of these assessments can be used to inform resource allocation and target surveillance activities. The estimates can be refined when more complete information becomes available. This work intended to define a general framework and attempt to make use of crude data available from preliminary field investigation, given a series of assumptions. It leads to more precise identification of the necessary steps of the pathways and the input parameters that are required. Indeed, in-depth field studies are necessary in order to refine the ecology of the virus and the epidemiological roles of the different types of wild birds. A complete model should include the trade pathway and integrate the role of the environment concerning the virus survival and the routes of potential contamination among the different susceptible species and should be made spatially explicit.

REFERENCES