Social network analysis: an information tool for effecting targeted disease surveillance amongst rural poultry farms in eastern Zambia

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Abstract
Rural poultry production is important for its nutrition and economic value in the tropics and subtropics of the world. Unfortunately, disease is among the greatest challenges to this sector. Lack of a sustainable poultry disease surveillance system and possible existence of communities and occasions where interaction between birds may be high presents an opportunity for targeted surveillance of poultry diseases in these regions. Zambia is an example of a developing country located within the tropics that faces the challenge of frequent poultry disease outbreaks. Consequently, an interview based survey that studied the rural poultry movement in eastern Zambia as a tool to derive information required for setting up targeted surveillance was conducted. This is the first study that formally describes poultry movement networks within Zambia and the surrounding region. Its findings provide a foundation for more targeted surveillance and a deeper understanding of the cultural and practical constraints that influence trade in developing countries.

KeyWords: *Rural poultry, social network analysis, targeted surveillance, Zambia*

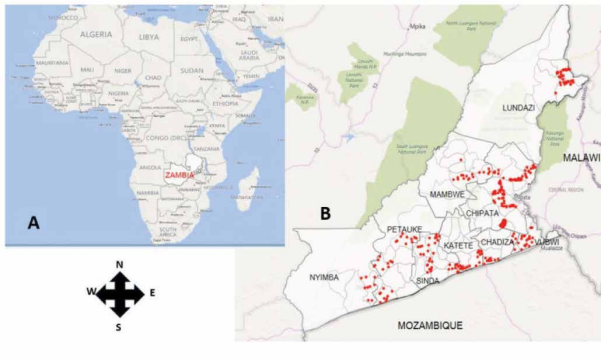
Introduction
Disease is among the greatest challenges to rural poultry production. Newcastle disease (ND) caused by Newcastle Disease Virus (NDV) is among the most common diseases that affect rural poultry and its active surveillance has been a challenge. The nutritional and socioeconomic importance of rural poultry subjects them to extensive movement within and between communities. Unfortunately, such movements are known to be accompanied by the spread of highly infectious poultry diseases. Because of this, communities that receive a lot of poultry are at higher risk of introducing infectious poultry diseases like ND.

Lack of a sustainable active poultry disease surveillance system and possible existence of communities and occasions where poultry interaction may be high presents an opportunity for targeted surveillance in resource poor tropical and subtropical countries (1). Targeted surveillance involves placing surveillance systems in areas that are considered as high interaction areas or hotspots for livestock movement especially if those areas are associated with high disease prevalence. A continuous assessment of the poultry disease situation in these areas would serve to monitor disease status for the region. Timing this targeted surveillance with occasions associated with increased poultry movement would further increase its effectiveness (1) at early detection of diseases.

Poultry movement networks have been studied in some tropical regions like the south Asian pacific islands (1) and Asia. Unfortunately, despite serious problems with poultry diseases like ND, very few studies that study the rural poultry sector and its movement networks have been conducted in sub-Saharan Africa and Zambia. This study analysed rural trading practices in eastern Zambia and evaluated the practicability of social network analysis as a tool for informing targeted poultry disease surveillance within a rural African environment.

Materials and methods
The study was an interview-based questionnaire survey (conducted from September to December in 2014) that targeted a cross section of poultry farmers, traders and service providers in the eastern province of Zambia (Figure 1). Three questionnaires were developed that targeted each respective stakeholder group (poultry farmers, traders and service providers). Interviews were conducted by local veterinary assistants that were trained in administering the questionnaires prior to commencement of the study. Questionnaires were based on those used by Brioudes and Gummow (1) in the Pacific Island countries.

Figure 1. Location of Zambia and its Eastern province within Africa (A) including districts, veterinary camp zones and farmers sampled (dots) within the province (B)



To obtain a representative sample of villages and farmers, a two-stage cluster sampling strategy (2) was used to sample camps and villages (sampling units) from each of the nine districts of the Eastern province of Zambia.

Data analysis

Descriptive statistical analysis was used to examine quantitative and qualitative data.

Spatial analysis

Dot density maps were created by adding data layers to reference layers (Shape files) using Epi Map version 7.2.

Social network analysis

Tables with network data for live poultry and its products obtained through farmer and trader (combined) interviews were exported from Epi Info to Excel where they were merged and edited. They were then imported into Ucinet® where a Ucinet file was created and saved.

Within the Ucinet software, 1-mode poultry network socio graphs were drawn using Net draw (3). Networks were assessed by calculating for the power and centrality of the network (3).

Results

A total of 459 poultry farmers, 118 poultry traders and 82 service providers were interviewed across the eastern province of Zambia.

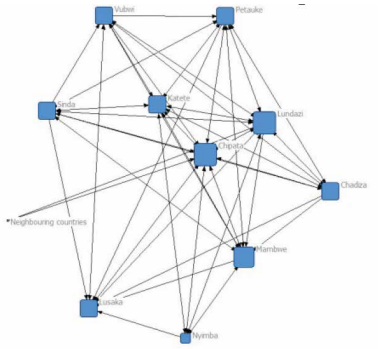
Only 29.4% of farmers indicated having received live poultry in the last 12 months. Among these farmers, 48.5% said they received day old chicks from commercial hatcheries while 19.9%, 7.1%, 7.7% and 2.6% had responses for receiving indigenous chicks, indigenous chickens, commercial layers and mature broilers respectively. Furthermore, 44% of them said they sourced the poultry from fellow rural farmers while 23%, 15.8%, 13.8% and 3.1% had responses for hatchery agents, medium to large scale poultry farms and village markets respectively. Overall, each farmer received an average of 37 live birds in the last twelve months (responses=47, standard deviation= 98.59, range 1-530).

The type of live poultry that left farming households, were 87% indigenous chickens, while broilers, commercial layers, pigeons and ducks were recorded at 3.8%, 1.4%, 2.1% and 0.7% respectively. Fifty seven percent of farmers sold poultry to fellow rural poultry farming households. Village markets, medium to large scale poultry farms, consumers and shops received 28.4%, 8.2%, 1% and 0.3% of poultry sold respectively. Overall, an average of 32 live birds left each farming household in the last 12 months (responses=104, standard deviation=168.15, range 1-1675).

Poultry networks

Bigger and more developed towns were generally good senders and receivers of rural poultry. The network had 71 ties and 11 nodes (districts). Chipata (mean=11.8, standard deviation=11, sum=118) had most out ties followed by Katete (mean=7.9, standard deviation=7.38, sum=79) and Lundazi (mean=7.6, standard deviation=9.35, sum=76). For districts receiving poultry, Chipata had the highest ties (mean=16.5, standard deviation=10.75, sum=165) followed by Lundazi (mean=6.5, standard deviation=9.08, sum=65). The overall density for this network had an average matrix value of 4.5 (standard deviation=7.12 and average weighted degree=45). The overall average matrix value for the district poultry products networks was 2.7 (standard deviation=2.7, average weighted degree=14) (Figure 2).

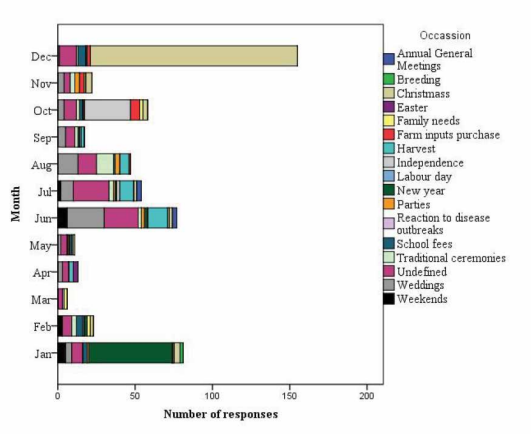
Figure 2. Movement of live poultry between districts of eastern Zambia per the data from rural poultry farmers and traders (Size of Nodes corresponds to in and out degrees).



Seasonality of trade

Only 48.4% of farmers were aware of months with increased trade in poultry and its products. Among these, most responses were for December (26%) followed by January (13.6%) and June (12.9%). March received the least responses at 1%. Christmas was the most common occasion associated with increased trade (25% of responses) followed by weddings (11.1%), New Year celebrations (10.2%) and crop harvests (5.9%) (Figure 3).

Figure 3. Farmers responses to months with increased trade in poultry and its products and corresponding occasions associated with the trade.



Discussion

Camps and districts with most in degrees and out degrees were both good senders and receivers of poultry and its products. Such nodes would be good targets for placing disease surveillance platforms since they had links to most other nodes in their respective networks thus making them potential hot spots for capturing early warning signs of disease outbreaks (1). Results for this study revealed that the provincial capital (Chipata) was the most influential sender and receiver of poultry followed by its larger neighbouring districts (Katete and Lundazi). This is consistent with other findings of research performed elsewhere where capitals and larger towns tend to be most influential hubs for poultry trade (1,4). Results further revealed that the risk of poultry disease transmission through movement of infected poultry from other provinces within Zambia, and neighbouring countries into eastern Zambia, through its provincial and international boundaries respectively exists. Such a scenario necessitates the need for regional collaboration when conducting poultry disease surveillance.

Socio network analysis results of this study partially agrees with a retrospective study earlier conducted because most districts identified as High to medium ND incidence districts (5) have been also identified as most influential senders and receivers of poultry and its products in this study. This finding reveals an important correlation between poultry movement and poultry disease outbreaks in this region. Taking advantage of this correlation by placing rapid disease surveillance systems in these hubs would reduce reporting time of poultry disease outbreaks thus enhancing response to poultry disease outbreaks.

Assessing seasonality of poultry and its products trade enables efficient timing of disease surveillance (1) as, for example, surveillance can be carried out during or just before the anticipated increase in trade of poultry and its products. Interestingly, reaction to disease outbreaks was also mentioned as one of the occasions that triggers high sales of poultry and its products, which may worsen disease dissemination.

Even though only part of the Zambian network was studied, results of this study demonstrate that hubs of high poultry interaction through trade and other movements exist within Zambia. This is likely within the Southern African region and hence the need to expand the study to other countries within this region. These hotspots may be associated with high poultry disease transmission and therefore could serve as targets for their early detection. Bearing in mind that developing countries are challenged with resources, targeted surveillance may provide a cost-effective option for enhancing poultry disease surveillance (1,4). Additionally, prior knowledge on hotspots and influential nodes could assist in poultry disease control by isolating them promptly through livestock movement bans in the event of disease outbreaks.

References

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Acknowledgements

We are grateful to Zambian Veterinary Services, Australian Aid (AUSAid), James Cook University and the National Research Foundation (South Africa) for funding this work.