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Understanding the poultry trade network in Kenya: Implications for regional disease prevention and control

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Abstract

Infectious diseases in poultry can spread quickly and lead to huge economic losses. In the past decade, on multiple continents, the accelerated spread of highly pathogenic avian Influenza A (H5N1) virus, often through informal trade networks, has led to the death and culling of hundreds of millions of poultry. Endemic poultry diseases like Newcastle disease and fowl typhoid can also be devastating in many parts of the world. Understanding trade networks in unregulated systems can inform policy decisions concerning disease prevention and containment.

From June to December 2008 we conducted a cross-sectional survey of backyard farmers, market traders, and middlemen in 5/8 provinces in Kenya. We administered a standardized questionnaire to each type of actor using convenience, random, snowball, and systematic sampling. Questionnaires addressed frequency, volume, and geography of trade, as well as biosecurity practices. We created a network diagram identifying the most important locations for trade.

Of 380 respondents, 51% were backyard farmers, 24% were middlemen and 25% were market traders. Half (50%) of backyard farmers said they raised poultry both for household consumption and for sale. Compared to market traders, middlemen bought their poultry from a greater number of villages (median 4.2 villages for middlemen vs. 1.9 for market traders). Traders were most likely to purchase poultry from backyard farmers. Of the backyard farmers who sold poultry, 51% [CI 40–63] reported selling poultry to market traders, and 54% [CI 44–63] sold to middlemen. Middlemen moved the largest volume of poultry on a weekly basis (median purchases: 187 birds/week [IQR 206]; median sales: 188 birds/week [IQR 412.5]). The highest numbers of birds were traded in Nairobi – Kenya's capital city. Nairobi was the most prominent trading node in the

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network (61 degrees of centrality). Many smaller sub-networks existed as a result of clustered local trade. Market traders were also integral to the network.

The informal poultry trade in Kenya is dependent on the sale of backyard poultry to middlemen and market traders. These two actors play a critical role in poultry movement in Kenya; during any type of disease outbreak middlemen should be targeted for control- and containment-related interventions.

Keywords

Poultry; Trade; Kenya; Social network analysis; Disease prevention; Disease control

1. Introduction

Infectious diseases among poultry and other food animals can have serious effects on food supply and food security and significant economic and social consequences. Trade practices can play an important role in the spread of infectious diseases among livestock and poultry populations (Fèvre et al., 2006; Fournié et al., 2013; Fournié, 2013). In Africa, the spread of Newcastle disease and fowl typhoid, which can occur through informal trade networks, has led to flock mortality of up to 90% (Musiime, 1992; Omiti, 2009). In the past decade, the spread of Highly Pathogenic Avian Influenza (HPAI) A (H5N1) has led to the deaths and culling of hundreds of millions of poultry in Asia, the Middle East, Eastern Europe, and Africa. The spread of avian viruses has been linked to the poultry trade and live bird markets (Van Kerkhove et al., 2009; Soares Magalhães et al., 2010) as well as to wild bird movements (Cecchi et al., 2008; Fusaro et al., 2010). Studies of trade networks among livestock have consistently shown links between trade and disease spread (Shirley, 2005; Ortiz-Palaez et al., 2006).

In recent years, triggered largely but not exclusively by the emergence of the H5N1 virus (Alexander, 2007), international and national animal health agencies have implemented a number of control and prevention measures (Brown, 2010). These measures have focused in part on anthropogenic factors, such as trade, in spreading the virus among poultry (Statistics, 2010).

Kenya, a developing country of 38.6 million people (Statistics, 2010) in East Africa, is a regional hub for finance and trade. Its economy is largely based on production of small-scale consumer goods and agriculture, which contributes to 25–26% of the GDP, of which poultry trade represents 30% (Nyaga, 2007; CIA, 2011). Infectious diseases circulate regularly in the poultry population; including Newcastle disease, fowl typhoid and influenza viruses (Omiti, 2009), and present the major constraint to poultry production in the country (Omiti, 2009). The Kenyan Ministry of Agriculture and Livestock Development estimates the poultry population of Kenya to be approximately 30 million birds at any given time (Nyaga, 2007; Onkundi, 2008), of which an estimated 74–80% are raised in backyard settings. Approximately 75% of households in Kenya are estimated to keep chickens (Nyaga, 2007). Most poultry are traded in informal, unregulated live bird markets (Nyaga, 2007), making containment of an infectious disease outbreak particularly challenging.

In order to improve the national capacity to control and prevent disease spread in poultry, from June to December 2008, the Kenya Ministry of Agriculture and Livestock Development (MoLD), along with the Kenya Medical Research Institute/Centers for Disease Control and Prevention-Kenya (KEMRI/CDC), conducted an analysis of the informal poultry trade network in five provinces in Kenya.

2. Materials and methods

2.1. Data collection

We conducted a cross-sectional survey of three main types of actors in the Kenyan poultry trade in five of Kenya's eight provinces. Actors included middlemen, who travel among villages and markets buying and selling poultry from other actors in the system; backyard farmers, who raise poultry both for household consumption and for sale; and market traders, who sell poultry in poultry markets or at roadside poultry stalls.

We developed three different questionnaires – one for each type of actor. The surveys included questions about volume and frequency of trade, distances covered by each actor while conducting trade and species farmed or traded. Questions were tailored to specific activities associated with each actor's role. Questions about volume, distance, and frequency of trade were included in order to better understand how birds were traded, which trade relationships were most important, and whether certain locations were more important in the movement of poultry.

Survey teams – staff of the MoLD and KEMRI/CDC – administered the questionnaires. We spent a full day training survey staff on the purpose of the study, the details of individual questions, the importance of a uniform approach to administering the questionnaire, the use of GPS units, and the importance of completeness of questionnaires. Team leads supervised and attempted to ensure the uniformity of survey administration. We administered an initial version of questionnaires in Nairobi and Central provinces. A total of 30 middlemen, 38 market traders, and 60 backyard farmers were interviewed using the first version of the questionnaire. In response to feedback from staff and interviewees in these two provinces, we made small revisions in the wording of some questions and eliminated redundant questions. Revised questionnaires were used in the three other provinces. Questions that were changed too significantly to allow for comparison were excluded from our analysis.

2.2. Site selection

From June 16 to December 4, 2008, survey teams visited each province and identified actors to interview. Within each study province surveys were conducted in selected sublocations, the smallest administrative unit in Kenya. The source of poultry was recorded by village; several villages make up a sublocation. Sublocations were selected based on poultry population density, which was determined using raster data from the UN FAO GeoNetwork (UN Food and Agriculture Organization, 2005). Each raster represents 1 km^2 on the ground, and has been assigned a poultry density by FAO, using density estimation methods (FAO, 2011). Using GIS software we selected sublocations that had ≥50% coverage by rasters with a minimum density of 200–500 poultry per km^2. In total, we selected 507 sublocations

in five provinces with high poultry density as study areas. We selected a subset of the sublocations by evaluating the proximity to population centers (villages, towns) in order to capture markets in these areas. In the selected sublocations, we identified all markets known by local Ministry of Livestock staff. At each of those sites, we administered the questionnaire to all actors except backyard farmers.

We used the probability-proportional-to-size sampling method to select a smaller subset of sublocations from which to identify backyard farmers to interview. The human population of each sublocation was obtained from the 1999 Kenyan census (Statistics, 1999) and these numbers were used to assign a probability of selection to each sublocation using SPSS 14 (Illinois, USA; 2001) statistical software. These probabilities of selection were then used to generate a random, representative sample of sublocations from those in the study areas based on human population size, ensuring that the number of interviewees was representative of the population of the sublocation. We visited backyard farmers in villages chosen randomly in the selected sublocations.

2.3. Sampling methods

In each sublocation, we visited every market identified by local MoLD staff. We used convenience sampling to identify market traders and middlemen to interview. During some interviews, traders or middlemen informed us about markets and roadside stalls that had not been identified by MoLD staff. For these sites, we used a snowball sample to identify markets and stalls to interview. In some instances market traders also worked as middlemen. In these cases, the respondent was asked which role they identified most closely with, and the corresponding questionnaire was used.

To identify households to interview for the survey of backyard farmers, we used a systematic random sample. The survey team randomly selected a starting point within the sublocation, and teams identified households to interview along transects; teams moved in opposite directions from the starting point and selected households to interview at every third homestead. If the household did not keep poultry, a household member was not present, or was unwilling to participate, the next household along the road was selected.

2.4. Network construction

Survey location was recorded using global positioning system (GPS) units, and linked to each questionnaire using a unique identification number. Completed survey data were entered into an Access 2007 (California, USA; 2006) database. GPS locations were imported into a geographic information systems (GIS) database using ArcView 9.2 software (California, USA; 2006), and mapped to their geographic location. We then used these data to construct a map of the geographic scope of the network described in our study.

We constructed relationship matrix tables using UCINet 6 social network analysis software (Massachusetts, USA; 2002) and developed layered matrix tables in order to differentiate between the types of trade relationships among the actors. For example, sales from backyard farmer to market traders were entered in a different table than that used for sales from market traders to middlemen. Separate tables describing village attribute information, such as total weekly market sales for each village were also constructed using UCINet.

NetDraw software (Massachusetts, USA; 2002) was used to illustrate the relationships in a social network image described in the UCINet matrix files. Additional analysis of network statistics was conducted using Gephi 0.8.2 (2013).

Measures of centrality, including degree centrality and alpha centrality, were calculated between nodes in the matrix tables to identify key locations (nodes) in the trading network. These nodes indicated locations where middlemen and traders bought and sold chickens. Nodes were assigned attributes based on the results of the survey. Attributes included number of middlemen and traders at each location, as well as volume of poultry bought and sold. We calculated measures for degree of centrality, a measure of importance of each node based on the number of relationships of each node to others – in this case the number of relationships originating or terminating at each node. For each node we also calculated alpha centrality, a measure of influence of each node, incorporating external sources of influence. In this case alpha centrality represents the relative importance of each node based on the volume of trade coming in and going out of each node. This importance represents the amount of influence that each node has on the rest of the network. This key player measure indicates the power of the key nodes in the network; disruption of this node would disrupt flow of trade throughout the network. Villages with higher measures of centrality are more likely to receive middlemen, traders, or poultry and may also receive visits from traders, middlemen, etc. sooner than those with lower centrality. The alpha score was calculated based on how many connections each actor had and how many connections each of their associated actors had.

In order to characterize the network in terms of the degree of clustering, distinctness between subnetworks, and cohesiveness of the entire network, we calculated a clustering coefficient, which measures the degree to which nodes cluster together within the network. A global clustering coefficient was used in order to evaluate the cohesiveness of the entire network. We also identified the number of neighborhoods, which identify and illustrate the clustering in smaller subnetworks. Clustering coefficients were calculated using the algorithm developed by Latapy (2008) as integrated in Gephi 0.8.2.

2.5. Analysis

We used SPSS 14 (Illinois, USA; 2001) to summarize and analyze data collected in the questionnaires, including demographic data, information about trading practices and hygiene practices. Poultry purchased and sold by each actor were summarized by week and aggregated by sublocation. Some participants did not answer every question in the survey. We excluded non-responders in our calculations of results for each question, and therefore the denominator varied for different questions.

3. Results

3.1. Characteristics of respondents and markets

We visited 37 markets and 134 villages. We completed 380 questionnaires, including 192 (51%) from backyard farmers, 96 (25%) from market traders, 92 (24%) from middlemen (Table 1).

Across all provinces, 76/96 (79% [CI 70–86]) traders reported that they traded only chickens. Among those who traded chickens and other species, ducks, geese, turkeys, and guinea fowl were traded in small numbers. Of 91 market traders who responded to a question about the characteristics of their bird trade, 64 (70% [CI 60–79]) said they sold only live birds, and 42/78 (54% [CI 43–65]) said they slaughtered birds on-site for consumers. Of the markets visited, only one had an isolated area used for the slaughter of live birds.

3.2. Trade relationships

Overall, 95/192 (50% [CI 43–57]) backyard farmers said that they sold their birds; 77% (CI 68–83) of respondents sold poultry to neighbors, 55% (CI 45–66) sold to friends, 54% (CI 44–62) reported selling to middlemen and 51% (CI 40–63) sold directly to market kiosks. Nearly all backyard farmers who responded to the question (143/144 (99% [CI 97–100])) said they self-hatched chicks from their own breeders; 47 (25% [CI 19–31]) also bought chicks from vendors. Of 47 farmers who bought chicks from vendors, only 2 (4.3% [CI −2 to 10]) said they acquired their birds from commercial farms.

Nearly all (99% [CI 94–100]) market traders said they sold their birds to household consumers and 90% (CI 80–95) sold to restaurants. Seventy-six percent (CI 63–87) of market traders replied that they sold their birds to middlemen. In all, 92% (CI 86–97) of traders bought birds directly from middlemen, and 78% (CI 67–87) bought from farmers who arrived at the market to sell their birds. Only 32% (CI 20–49) of market traders acquired their stock from commercial poultry distributors, selling birds raised at commercial farms.

Most middlemen (83% [CI 74–90]) purchased poultry from market traders, and most (73% [CI 63–82]) also purchased their poultry from backyard farmers. In all, 86% (CI 77–92) of middlemen reported selling their poultry to market traders, the most common purchaser of poultry. Middlemen also sold poultry directly to restaurants (39% [CI 30–49]) and at kiosks of their own (13% [CI 7–20]).

3.3. Weekly volume of trade

Overall, middlemen accounted for the largest numbers of birds moved between locations. Middlemen reported purchasing a median of 187 birds per week (interquartile range (IQR): 206), including a median of 45 birds (IQR 90) from backyard farmers and a median of 123 birds (IQR 138) from poultry markets (Table 2). Middlemen reported weekly average sales of 62.5 birds (IQR 100). Middlemen reported trading more birds in Nairobi, Kenya’s largest city, than in other parts of the country. Nairobi-based middlemen purchased a median of 337 (IQR 282) and sold a median of 188 birds (IQR 412) to market traders on a weekly basis (data not shown).

The number of birds purchased weekly was greatest in Wangige (median 1490 [IQR 1753]), a relatively small town on the outskirts of Nairobi, followed by Kombewa and Nairobi (median weekly purchases of 396 and 337, respectively). The majority of purchases (79%) were from backyard farmers. The median number of birds sold on a weekly basis by

middleman was highest in Majengo (194), followed by Nairobi (at 188 and Owimbi and Aram, each 120).

Market traders sold the greatest number of birds to middlemen (median: 50 per week, IQR 81), followed by restaurants and backyard farmers. Total weekly sales for market traders were significantly lower than for middlemen, at a median of 84 (IQR 74.25) vs. a median of 188 (IQR 412.5). Similarly, total weekly purchases were roughly one quarter (median 73 [IQR] 87.75) of those made by middlemen (337 [IQR] 281.9), making market traders a much less significant player in the movement of poultry by volume.

3.4. Travel and trade distance

Middlemen traveled a daily mean distance of 89 km (range: 2–700 km; median: 30, IQR 80). Middlemen surveyed in Nairobi reported the greatest distances traveled. Only 28% (CI 20–39) of middlemen reported collecting birds in the same area as their home; 18 of 23 middlemen surveyed in Nairobi reported that they did not trade or sell their poultry in the same village as their home, but rather traveled to other villages near Nairobi to trade. On average, middlemen in Western province traveled the shortest distance (mean: 34 km (SD 46.44)). Fifty-four percent (CI 44–64) of middlemen reported traveling most frequently by bicycle while collecting poultry, carrying birds on bicycles with them, and 46% (CI 36–56) traveled by public bus, strapping birds to the roof of buses. Private cars were rarely used (15% [CI 9–24]) (Table 1).

3.5. Network analysis

Nairobi was the most prominent node in the poultry trade network (Figs. 1 and 2). Sixty-one villages were identified as having direct ties into Nairobi through the movement of middlemen, meaning that poultry from at least 61 distinct locations were transported to and sold in Nairobi (degree of centrality: 61). This measure does not account for the multiple indirect ties to other villages where middlemen might have collected chickens before transporting them to Nairobi. Other important centers for middleman poultry sales were Ng'iya (38 degrees; 34 in-degrees and 7 out-degrees), Owimbi (25 degrees), and Rabuor (19 degrees). For market poultry purchases, however, Nairobi had only 5 degrees of centrality. Kombewa had the highest degree of centrality for market poultry purchases, with 11 degrees (Fig. 2).

While Nairobi had a high degree centrality, Ng'iya had the highest betweenness centrality. With a position on 12,261 shortest paths between nodes, including both collection and sales villages, it was a key location in the flow of poultry through Kenya, indicating that interruption of flow at Ng'iya would disrupt movement throughout much of the network. Nairobi had the next highest betweenness score – 10,761. For middleman sales, Nairobi was the key player in all trade, with an alpha score of 29.5, followed by Owimbi (10.5) and Rabuor (7.5).

Nodes in the poultry trade network in Kenya were locally clustered, resulting in smaller sub-networks (cliques), with few links between them. The average clustering coefficient for the entire undirected network was 0.237, indicating a weakly integrated network; many middlemen visited villages between which there was little trade. We identified several

complete neighborhoods (highly clustered nodes in which all neighbors were connected), including Githiga, Nakuru, and Thika, but these neighborhoods had a low number of degrees. Nairobi, although it was the most significant hub in the network, had a low clustering coefficient (0.003), suggesting that while Nairobi was highly connected to many nodes, many of those nodes were not connected to each other.

Centralization of the entire network was low (20%) but clustering of nodes resulted in 10 subnetworks, or 10 components, of the full network. The most highly connected of these components included 25% of the nodes and was centered at Nairobi. The next most highly connected of these components was Ng'iya, with connections to 16% of all nodes in the network. Nairobi and Ng'iya were the most significant hubs, with clustering coefficients of 0.1088 and 0.065.

4. Discussion

We found that in the informal poultry trade network in Kenya, middlemen played an integral role: they moved birds large distances (average 89 km); they collected birds from a number of different sources before selling them; and they caged together birds from as many as 80 markets or 20 villages overnight. In a disease outbreak, trade by middlemen could facilitate the rapid spread of disease across broad geographic areas, and middlemen could therefore be an especially important group to target when developing animal health intervention and prevention strategies in Kenya. Indeed, a recent study from Vietnam found that the presence of even one "poultry trader" (a term that is equivalent to a "middleman" in our study) at the village level was positively associated with an increased risk of the presence of H5N1 highly pathogenic avian influenza (Desvaux et al., 2011).

We identified several important villages and towns where high volumes of poultry were traded in Kenya. These key nodes acted as both collection and distribution points for middlemen and market traders who brought poultry from different areas. Nairobi, Kenya's largest city, and Ng'iya, and Owimbi, two small towns located in western Kenya relatively close to a land border with Uganda, were key sites for the sales of poultry. Nairobi, the most densely populated urban center in the country, had the highest weekly volume of trade, both into and out of the city, with an alpha score of 29.5. Interruption of trade into and out of Nairobi could therefore potentially limit the spread of a disease to most other parts of Kenya. Poultry trade network studies from Vietnam and Cambodia also found that large urban centers may act as primary hubs in the trade and mixing of birds from rural areas and locations far from the city center (Van Kerkhove, 2009).

Large markets in Owimbi and Ng'iya were important connecting sites for middlemen and market traders, the two most important players in the trade system. These and other such markets could provide an ideal place for educational interventions to reduce the spread of disease in poultry.

While some middlemen traveled long distances to sell their birds, most traded within relatively short distances (although often the trade occurred far from their homes), resulting in relatively closed-off clusters of poultry trade and movement. The nature of these closed-

off clusters would seem to make containment a more feasible possibility if an infection were identified in a timely manner in one of these clusters.

We found that backyard farmers were primarily engaged in a unilinear pattern of trade, typically selling birds to middlemen and market traders, but rarely buying birds. Our finding that backyard farmers play a passive role in the trade network, with rural farmers acting as suppliers to middlemen and big city markets, is similar to poultry trade network findings in Cambodia (Van Kerkhove, 2009).

In Kenya, backyard farmers reported hatching chicks in their farms, lessening the possibility of introduction of new birds into the flock. Because of these trade patterns, backyard farmers' poultry flocks are probably less susceptible to the introduction of new pathogens coming from other regions via trade. A study of Newcastle disease in village chickens in Ethiopia revealed that the odds of seropositivity were lower where new birds were hatched at home, as opposed to purchasing or receiving replacement birds (Chaka et al., 2013). An important threat of disease spread to backyard birds might be exposure to wild birds; most farmers in our study let their poultry roam free, and reported seeing wild birds frequently on their property. Other studies have implicated wild birds in the spread of avian influenza A viruses (Ortiz-Palaez et al., 2006; Desvaux et al., 2011). Trading by middlemen in multiple farms could also contribute to introduction of infectious pathogens into backyard farms.

Our study was subject to several limitations. First, we used a convenience sample to identify middlemen and market traders. Despite relying on local MoLD staff, we may have missed some poultry sites. In addition, we did not keep track of the response rate among people we approached to participate. However, because we visited locations on their typical market days, we were confident that our respondents were regular traders and likely quite representative of middlemen and market traders involved in the poultry trade in Kenya. Despite training and supervision, approach to questionnaire administration may have varied. While we modified the questionnaire once, the changes were mostly in wording, and we believe questions and answers to the two questionnaires were generally comparable; four questions that were not comparable were excluded from our analysis. Not all participants responded to all questions in the surveys; in our analysis, we only included questions that had complete answers, resulting in differing denominators. We did not evaluate differences between responders and non-responders for each question. Surveys were dependent on self-reported activities and behavior, which could have resulted in recall bias. We also did not ask about poultry die-offs, and how they are investigated in Kenya. In addition, we were not able to follow up with respondents to clarify discrepancies in the reported volume of sales compared to the reported volume of purchases, which sometimes differed. We did not ask backyard farmers about their replacement breeders, and therefore could not confirm that all backyard flocks were closed flocks. Finally, we conducted our surveys in a limited number of areas in the country, and thus our conclusions may not be generalizable to all of Kenya. However, we targeted the regions with the highest poultry population that may be more likely to be affected by a highly pathogenic avian influenza outbreak in poultry. Furthermore, areas not covered in this study have lower human populations than the areas we surveyed. Lastly, we conducted our study in 2008, and poultry trade practices may have changed since then. However, in Kenya, like in many other countries, changes in trading

behavior occur slowly, and the challenges of disease control – particularly avian influenza and Newcastle Disease – remain very similar today to what they were in 2008, both in Kenya in particular and in Africa in general. Nevertheless, updated evaluations of the poultry trade network in Kenya should be conducted to ensure that information is as current as possible.

Despite these limitations, this study is the first of its kind in Kenya, and presents important results that could be applied to disease control strategies in the region. Education on preventive activities, biosecurity practices, and awareness of avian influenza could be targeted in key locations in order to maximize their effectiveness in reaching important players in the poultry trade network. Education on investigation, control, containment and reporting of poultry die-offs could be targeted in those same areas. In addition, interventions to close markets or shut down poultry trade outside of markets could be more effective if they were targeted at some of the key poultry trading centers we have identified in this study.

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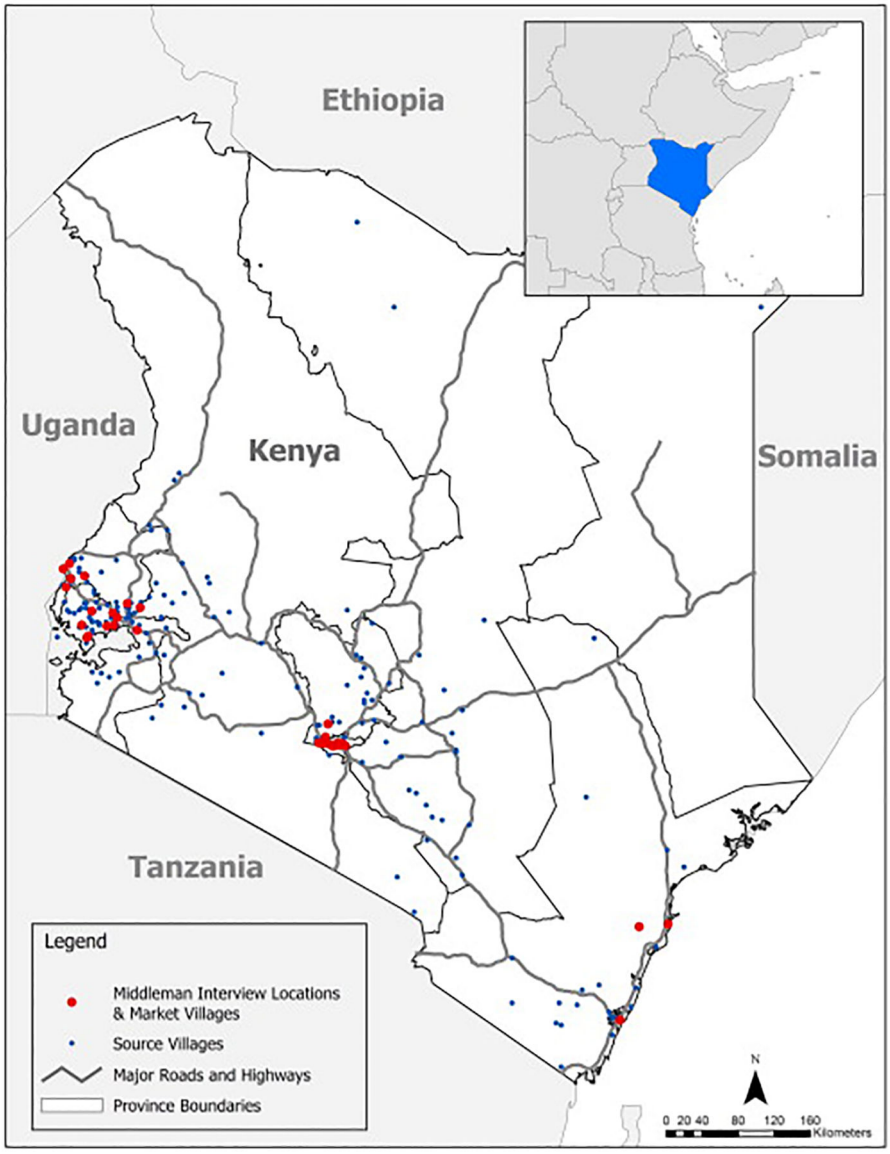

Fig. 1.

Survey locations, major markets surveyed, and common bird collection villages, Kenya, 2008. The figure is a map of Kenya with symbols for survey locations; poultry source villages, major roads and highways, and provincial boundaries. A large red circle indicates villages where markets are located. These villages and markets are locations where middlemen were interviewed. A small blue circle represents the source villages – those villages where middlemen purchased poultry from backyard farmers and other traders. A zig-zag black line depicts major roads and highways across the country. A small white rectangle portrays the color used for the body of the map, with a dark gray border which depicts the province boundaries. The country name and the names of those countries neighboring Kenya are included on the map.

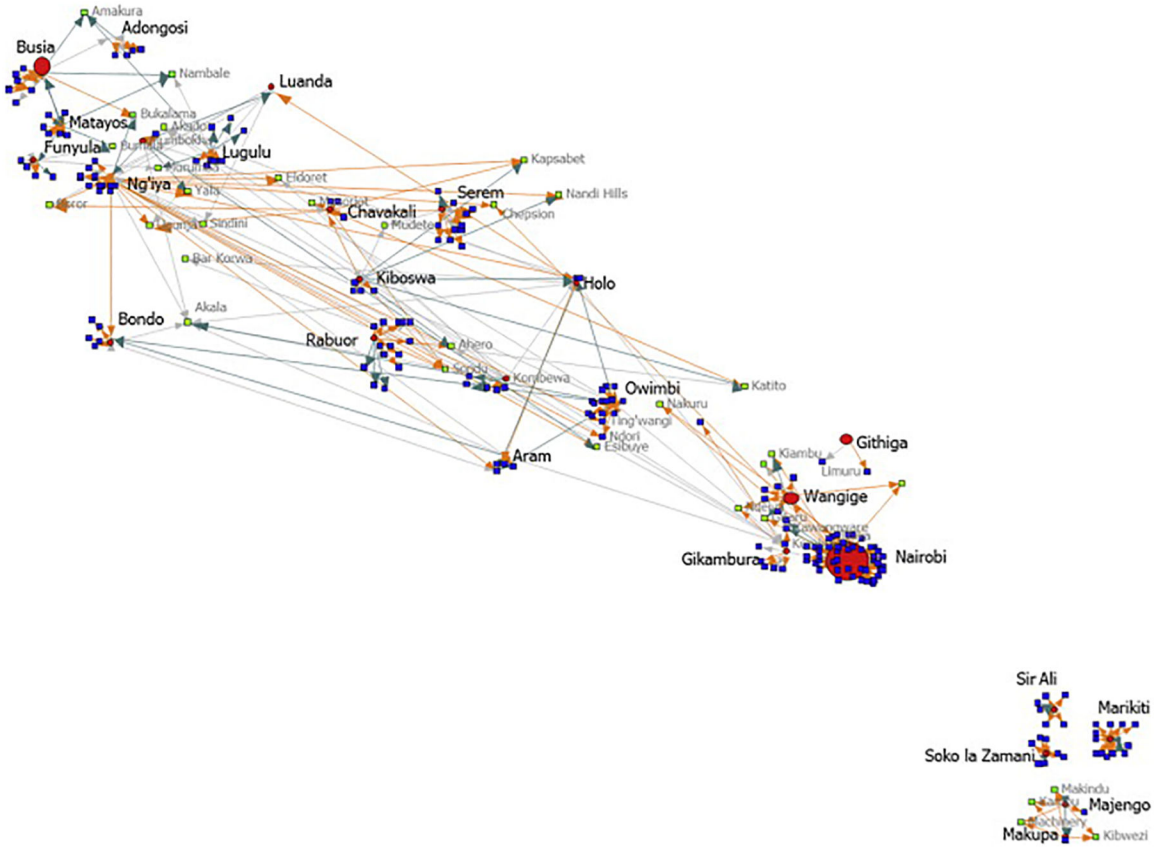

Fig. 2.

Network graphic: major middleman markets, middleman source villages for poultry collections, and trade relationships, Kenya, 2008. The figure is a graphic depicting the trade locations and relationships for middlemen in the poultry trade network. Middleman market trade villages are depicted by red circles of varying size. The size of the circle reflects the total weekly poultry purchases by all middlemen based in that village. Villages where middlemen source their poultry are depicted by blue squares. Villages that serve as connection points between source villages are represented by green squares. These villages are those at which middlemen purchase poultry, and serve as a point connecting middleman trade at two different villages that are not otherwise connected by direct trade on the middleman trade route. The direction of trade by middlemen from village to village is represented by colored arrows. An orange arrow shows middleman travel toward a source village. A turquoise arrow shows travel toward source markets, and a gray arrow shows a two way relationship in trade between a village and a middleman. This graphic is not to scale.

Table 1

Characteristics of poultry traders, Kenya, 2008.[a]

	Backyard farmers [*n*/*N* (%)]	Middlemen [*n*/*N* (%)]	Market traders [*n*/*N* (%)]
Central Province, *n* (%)	34/192 (18)	7/92 (8)	17/96(18)
Coast, *n* (%)	54/192(28)	10/92 (11)	21/96 (22)
Nairobi, *n* (%)	26/192 (14)	23/92 (25)	21/96 (22)
Nyanza, *n* (%)	39/192 (20)	33/92 (36)	15/96 (16)
Western, *n* (%)	39/192 (20)	19/92 (21)	22/96 (23)
Total, *n* (%)	192 (100)	92 (100)	96 (100)
Poultry trade/farming as primary means of income	96/158 (61)	84/92 (91)	N/A
Sell/raise only chickens	80	64/92 (70)	76/96 (79)
Mean number of birds raised at once	15.5	N/A	N/A
Raise poultry for both food and sale	111/142 (78)	N/A	N/A
Raise poultry for sale only, %	10	N/A	N/A
Mean number of source villages	N/A	4.2	1.9
Mode of transport: bicycle	15/52 (29)	50/92 (54)	N/A
Mode of transport: public transportation, *n* (%)	3/46 (7)	42/92 (46)	N/A
Daily mean distance traveled, km	N/A	89	N/A
Birds sold to market traders	35/69 (51)	75/87 (86)	N/A
Birds sold to middlemen	60/112 (54)	N/A	45/59 (76)
Birds sold to hotels/restaurants	N/A	36/92 (39)	53/59 (90)
Sell only live birds	N/A	N/A	66/94 (70)
Sell in markets, not to trader	N/A	72/80 (90)	N/A
Slaughter birds on-site for customers	N/A	N/A	41/55 (43)

[a]Denominators vary by question, in order to exclude incomplete replies; additionally, some questions were dependent on the answer to a previous question.

Table 2

Median weekly number of birds sold and bought by middlemen and market traders, Kenya, 2008.[a]

	Middlemen	Market traders
Weekly volume ofpurchases		
Median number ofbirds purchased (IQR)[b]	337 (282)	73 (88)
Median no. ofbirds purchased from backyard farmers (IQR)	45 (90)	9 (19)
Median no. ofbirds purchased from market traders (IQR)	123 (138)	N/A
Median no. ofbirds purchased from commercial farmers	N/A	30 (108)
Median weekly no. of birds purchased from middlemen (IQR)	N/A	72.5 (87)
Weekly volume ofsales		
Median no. ofbirds sold weekly (IQR)	188 (412)	84 (74)
Median no. ofbirds sold to household consumers (IQR)	N/A	15 (21)
Median no. ofbirds sold to hotels/restaurants (IQR)	39	30 (51)
Median no. birds sold to middlemen (IQR)	N/A	50 (81)

[a] Backyard farmers were not asked the questions in this table.

[b] IQR refers to interquartile range.