



Live Wild Bird Trade and Sellers' Biosecurity Risks in Kaduna State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AA and PAA designed the study. Authors AA, HA and PAA managed the literature review, administer the questionnaires, performed the analysis of the study and wrote the first draft of the manuscript. Author AE identified the bird species. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The first highly pathogenic avian influenza (HPAI) H5N1 outbreak in Africa occurred in Kaduna State, Nigeria and despite possible introduction of H5N1 virus into Nigeria through wild birds; few studies have been undertaken on the risk of live wild bird trade and sellers' biosecurity practices on introduction, spread and maintenance of diseases in the country. This study assessed wild bird trade and sellers' biosecurity risk towards disease surveillance and control in Kaduna State, Nigeria.

Place and Duration of Study: Live wild bird markets in Kaduna State, Nigeria between March, and May 2012.

Methodology: Live wildbird markets(LWBMs) biosecurity and sellers' knowledge, attitudes and

practices on HPAI was assessed using biosecurity checklist and structured questionnaire, respectively. Wild bird trade was studied through a market survey in LWBMs.

Results: All sellers were male and their main source of income was the wild bird trade. Some sellers (22.7%) would report sick birds only when attempted treatment fails. Sellers kept poultry at home (78.9%) with 100% allowing poultry–wild birds contact. Over 31.6% sellers do not wash hands with soap after handling birds. About 86.4% sellers heard of AI with 84.2% hearing from radio. No sellers knew any HPAI clinical sign though 21.1% knew HPAI affects human beings and none believes HPAI affects human beings. Sellers would report HPAI outbreak to reduce losses (38.9%). None of the LWBMs was fenced with birds tied and allowed to move in 25% of LWBMs. Cages were wood/metal while fenced pens constructed from wood/wire mesh with un-cemented floor. No LWBM sourced birds from one reliable source neither were birds separated by species. In 50% of LWBMs, cages were stacked without paper or other materials lined within cages. No LWBM either stored feed in rodent proof containers or had a rodent control program. Other livestock were sold in 75% of LWBMs. Free flying birds interact with wild birds in 75% of LWBMs while free range poultry – wild bird interaction occurred in 25% of LWBMs. No seller wore protective clothing in any LWBM. All markets practice regular cleaning of cages and pens though none disinfects cages regularly. All LWBMs dispose dead birds properly by burning or burying though 25% dispose wild bird manure improperly. Over 75.9% of biosecurity features in LWBMs were risky with 76.2% being risky biosecurity practices and 80% (17/21) due to poor LWBM infrastructures. Food (31.8%), traditional medicine (45.5%) and pets (77.3%) were reported wild birds uses. There was high demand for birds of prey during election years. White stork (11.42%) and geese (9.94%) were the main birds on sale. Threatened and rear wild bird species were being traded in the LWBMs. Over 45% of birds were sourced from 9 foreign countries with majority coming from Chad. Bird prices range was ₦300 (\$1.9) to ₦125,000 (\$781). Mammals and reptiles were also sold in LWBMs with prices from ₦500 (\$3.1) to ₦ 1.2million (\$7500). Wild birds on sale in the four LWBMs were valued at ₦6,575,300 (\$41,100) comprising of 71.4% of total value of animals (₦9,207,300) on sale.

Conclusion: Sellers’ biosecurity practices was poor with high biosecurity risk due to low-risk perception. Biosecurity in LWBMs in Kaduna State was poor with high risk to introduction, spread and maintenance of HPAI. Wild bird trade in Kaduna State is linked to the global trade and could be a source for disease introduction into Nigeria. There is need for sellers to be trained on HPAI and other emerging infectious diseases and routine surveillance of EIDs in LWBMs. The wild bird trade should be legalized and regulated.

Keywords: Biosecurity; Kaduna State; live wild bird trade; practices; risk; wild bird sellers.

1. INTRODUCTION

The threats of wild bird trade in Nigeria to biodiversity, human and animal health is increasingly being recognized with live wild bird markets becoming important in surveillance of emerging infectious diseases [1,2,3,4].

The illegal nature and poor regulation of the wildlife trade coupled with high animal mortality and deficient inventory makes it difficult to accurately estimate the magnitude of the trade though it was estimated at \$20 billion (₦3.2 trillion) annually involving shipment of 350 million live plants and animals globally [5,6]. It has been reported that based on the financial value of illegal activities, illegal wildlife trade is second to the illegal narcotic trade [7].

Human activities ranging from increase logging for timber and clearing of forest for large scale

commercial farms that destroys wildlife habitats, bush-meat and live wildlife trade increases the threat of emerging infectious disease spread with resultant threat to species extinction [8]. The resultant loss in biodiversity has important consequence on the ecosystem and poses disease risks to livestock and humans [2].

There are reports that 61% of human diseases were potentially of zoonotic origin with 75% of emerging human infectious disease (EID) originating from wildlife [2,9]. However, prevalence wildlife-linked zoonoses in Nigeria and other developing countries are unknown due probably to misdiagnosis or under-reporting. Emerging diseases such as highly pathogenic avian influenza (HPAI) H5N1 had severe impact on human livelihoods and global economies [10].

The variability in climate and geographic features of Nigeria, endows her with one of the richest

biodiversity in the African continent with 910 species of birds [11]. Live wild bird markets can be high-risk areas for disease transmission due to high concentration and interaction of a wide variety of wild birds coming from different sources within and out of Nigeria. These birds are held in close confinement with resultant stress which might enhance shedding, mixing and dissemination of pathogens [6].

Nigeria was the first country in Africa to report HPAI H5N1 outbreak in poultry in Kaduna State in 2006 [12,13]. Though there were reports of multiple introductions of the H5N1 virus into Nigeria, including wild migratory bird routes, there have been few studies aimed at generating data on the Nigerian wild bird trade and markets [14]. Hence, there is need to develop baseline data on the live wild bird markets and trade in Nigeria.

This study assessed wild bird sellers' knowledge, attitudes and practices on biosecurity, the level of biosecurity in LWBMs; identifying and estimating the financial value of the wild bird trade.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Kaduna State, located in North Western Nigeria with an estimated population of 6 million and lies between latitude 8°45' and 11°30' North and longitude 6°11' and 9° East [15]. It shares boundary with Kastina, Kano, Plateau, Niger, Zamfara, Bauchi, Nassarawa and FCT and has 23 local government areas that are inhabited by ethnic groups including Hausa, Fulani, Kaje and Kataf amongst others [15].

Kaduna is the capital of Kaduna State and comprises four local government areas. There are five major wild bird markets in Kaduna. Each market is made up of an individual bird stands; Mutarla Mohammed Square having two bird markets; Isa Kaita road, one bird market and Traveler Mosque (Zaria road), two markets. These markets were selected for this study because they are the only fixed live wild bird markets within Kaduna State which are more easily monitored than the 'occasional' bird vendors who sell live wild birds on major roads in the State.

2.2 Assessment of Wild Bird Sellers' Biosecurity Risk

Live wild bird sellers' biosecurity risk was assessed between March to May, 2012. Questionnaires on sellers' knowledge, attitudes and practices on HPAI were designed, pretested and adjustment was made to correct limitations identified during pretesting. The questionnaires gathered Information on wild bird sellers' knowledge, attitude and practices on biosecurity and wild bird trade dynamics within the LWBMs, readiness to disclose avian influenza outbreak, method of disposal of wild bird waste, sick and dead birds, sources, and destination of birds. The questionnaires were administered to wild bird sellers and additional probe questions were also asked, when necessary, to shed more light on some issues raised during questionnaire administration.

2.3 Assessment of Live Wild Bird Market Biosecurity

The live wild bird biosecurity assessment was undertaken using a biosecurity checklist. The biosecurity checklist was designed, pretested and adjustment was made to correct limitations identified during pretesting. The checklist was used to assess the biosecurity features present in the markets that may increase the risk of introducing, maintaining or spreading AI and estimated the level of risk.

2.4 Identification and Estimation of Financial Value of Wild Bird on Sale

Live wild bird markets were surveyed in May, 2012 and birds on sale in the markets were photographed and identified. A field guide was used to assist with the identification of unfamiliar species [16]. During the actual surveys, one day was spent at the markets identifying the numbers of all species available for sale, their price and source of the birds in each stand were recorded.

2.5 Data Analysis

Data generated were analyzed by descriptive statistics using Statistical Package for Social Sciences (SPSS) version 17 program. The frequency, mean and standard error of mean were calculated. A checklist of birds within the live wild bird market was tabulated and percentage for each species within the market was calculated.

3. RESULTS

3.1 Assessment of Wild Bird Sellers' Biosecurity Risk to HPAI

Of the five LWBMs identified in Kaduna, 80% (4/5) accepted to participate in the study. The markets were the two markets in Mutarla Mohammed Square; one market in Isa Kaita road and one bird market in Travelers' Mosque (Zaria road). Of the 22 wild bird sellers interviewed, 6 (27.3%) were from the two LWBM at Mutarla Mohammed Square each; 7 (31.8%) from Travelers' Mosque LWBM and 3 (13.6%) from Isa Kaita road LWBM. All the wild bird sellers (22/22) sold birds daily and were males. However, 31.8% (7/22) were aged 20-30 years and 31-40 years with 36.4% (8/22) aged 41-50 years. All wild bird sellers reported that marketing of wild birds is their main source of income and only 4.5 % (1/22) engaged in crop farming as alternative source of income.

None of the wild bird sellers sell in other LWBMs though 13.6 % (3/22) have been seen in other LWBMs. All the wild bird sellers (22/22) had been in possession of sick birds which were reported to veterinary authorities. About 86.4% (19/22) of sellers have heard of HPAI with 84.2% (16/19) hearing from radio while 15.8% (3/19) heard from radio and television. However, 21.1% (4/19)

could only remember that HPAI killed chickens and can be prevented by provision of good food and clean water to poultry (Table 1).

All sellers (22/22) claimed they would report HPAI outbreak to veterinary authorities with 38.9% (7/18) reporting to reduce losses while 61.1% (11/18) would report because they are obligated to report (Table 2).

Seven (31.8%) wild bird sellers reported that the wild birds were purchased for food with 45.5% (10/22) and 77.3% (17/22) indicating traditional medicine and pets respectively. The demand for vultures, eagles and other birds of prey were reported to be in high demand during election years.

3.2 Assessment of Live Wild Bird Markets Biosecurity

On assessing the biosecurity of the LWBMs, none of the markets (0/4) were fenced hence no existence of entry and exit gates in the markets with no traffic control (Table 3). However, in all the markets (4/4), the cages were made of wood and metal though fenced pens were constructed with wood and wire mesh and the floor was not cemented with some birds tied on rope or allowed to roam within the LWBM (Plate I).

Table 1. Kaduna State wild bird sellers' knowledge on HPAI

Sellers' knowledge on avian influenza	% of Sellers
Wild bird sellers who heard about HPAI	86.4 (19/22 [*])
Wild bird sellers who heard about HPAI on radio	84.2 (16/19 ^β)
Wild bird sellers who heard about HPAI but could not remember any thing on HPAI	57.9 (11/19)
Wild bird sellers who heard about HPAI but knew no clinical sign	0 (0/19)
Wild bird sellers who knew HPAI affects human	21.1 (4/19)
Wild bird sellers who believe HPAI affects human	0 (0/19)
Wild bird sellers who would report HPAI outbreak	100 (19/19)
Wild bird sellers who do not know wash hands with water and soap after handling wild bird	42.1 (8/19)

HPAI= Highly Pathogenic Avian Influenza; * = Number of sellers who participated in the study; β= Number of sellers who have heard about AI

Table 2. Kaduna State wild bird sellers' attitude and practices on biosecurity

Sellers' attitude and practices on biosecurity	% of Sellers
Sellers trade in daily market	100 (22/22)
Sellers seen in other LWBMs	13.6 (3/22)
Sellers reports disease outbreak only when attempted treatment fails	22.7 (5/22)
Sellers who do not report wild bird mortality	36.4 (8/22)
Sellers kept poultry at home	78.9 (15/19)
Sellers who allow contact between poultry and wild bird	100 (15/15)
Sellers who do not wash hands with water and soap after handling wild birds	31.6 (6/22)

LWBMs= Live Wild Bird Markets

Table 3. Isolation and traffic control within live wild bird markets and biosecurity risk level

Isolation and traffic control	%Biosecurity risk	Risk level†
LWBM not fenced	100	3
No entry or exit gate	100	3
Short distance between cages	100	3
Birds not in cages	50	2
Cages not made of plastic or metal	100	3
Birds on ground	75	3
Overall	87.5	3.0

†Risk level: 0 = No risk; 3= Highest risk level. LWBMs= Live Wild Bird Markets



Plate I. Birds in live wild bird markets moving freely within the market. (a) Pelicans for sale (b) Stork tied on the legs (c) Geese(G), turkey(T) and spur-winged goose (SWG) feeding together at Isa Kiata market

None of the markets sourced birds from one reliable source though all markets (4/4) claimed new birds were quarantined. In none of the markets (0/4) were all birds sold either in one day or within one week (Table 4).

The cages in 50% (2/4) of the markets had clean feed and water troughs and food and water were provided in all the markets (4/4). However, in none of the markets (0/4) were feed stored in rodent proof containers neither did any (0/4) had a rodent control program. There were no stray dogs or cats in any of the markets (0/4) though other livestock were sold in 75% (3/4) of the

markets. Free flying birds interact with wild birds in 75% (3/4) of the markets while in 25% (1/4) of the market, there was free range poultry – wild bird interaction (Plate II).

In none of the markets (0/4) were wild bird sellers wearing protective clothing though frequent hand washing was practiced in all the markets (4/4). However, there was regular cleaning of cages and pens in all the markets (4/4) (Table 5). All the markets disposed dead birds by burying or burning though 25% (1/4) practice improper disposal of wild bird manure (Plate III).

Table 4. Kaduna State live wild bird markets management risky practices and biosecurity risk level

Management practices	Biosecurity risk (%)	Risk level [†]
No sales & mortality records kept by sellers	100	2
Birds not bought from one reliable source	100	3
Birds not separated by species in pens/cages	100	3
No separate cage for sick birds	75	3
Cages were stacked	50	2
Feed not stored in rodent proof container	100	3
Other livestock sold in LWBM	100	3
No rodent control program	100	3
Free flying birds interact with birds on sale	75	3
Interaction with free range poultry	25	3
Overall	63.24	2.18

[†]Risk level: 0 = No risk; 3= Highest risk level. LWBMs= Live Wild Bird Markets



Plate II. Wild bird (in cage) -poultry interaction at Isa Kaita road live wild bird market in Kaduna State

Table 5. Kaduna State Live Wild Bird Markets sanitation risky practices and biosecurity risk level

Sanitation	Biosecurity Risk(%)	Risk Level
Sellers do not use personal protective equipment	100	3
Sellers do not frequently wash hand	100	3
No regular cleaning & disinfection of cages/pens	100	3
No proper disposal of dead birds	0	0
No proper disposal of manure	25	3
Overall	65	2.4



Plate III. Biosecurity in live wild bird markets (a) Improper disposal of wild bird litter at Isa Kaita market (b)Local chicken scavenging from the improperly disposed wild bird litter. (c) Pied hawk and Moscovy duck in same cage (d) Mixing of Ghanaian duck and *Allen ganule* in the same cage

Table 6. Bird species observed, and their estimated cost as reported by sellers in a market survey in live wild bird markets, Kaduna State

Common Name	Family	Species	No birds on sale (%)	Unit cost (₦)	Total (₦)
Black kite	Accipitridae	<i>Milvus migrans</i>	6/543 (1.10)	10,000	60,000
Black crown crane	Gruidae	<i>Balearica pavonina</i>	14/543 (2.58)	50,000	700,000
Peafowl	Phasianidae	<i>Pavo cristatus</i>	15/543 (2.76)	45,000	675,000
Geese	Anatidae		54/543 (9.94)	10,000	540,000
African fish eagle		<i>Haliaeetus vocifer</i>	2/543 (0.37)	125,000	250,000
Accipitridae					
Pelican	Pelecanidae	<i>Pelecanus rufescens</i>	7/543 (1.29)	60,000	420,000
Allen ganulle	Rallidae	<i>Porphyrio alleni</i>	16/543 (2.95)	5,000	80,000
Mallard duck	Anatidae	<i>Anas platyrhynchos</i>	8/543 (1.47)	2,500	20,000
Common Teal	Anatidae	<i>Anas crecca</i>	14/543 (2.58)	7,500	105,000
Rock dove	Columbidae	<i>Columba guinea</i>	25/543 (4.60)	500	12,500
Quail	Phasianidae	<i>Coturnix coturnix</i>	47/543 (8.66)	300	14,100
Crowned sangrouse	Pteroclididae	<i>Pterocles coronatus</i>	32/543 (5.89)	500	16,000
Purple swamphen	Rallidae	<i>Porphyrio porphyrio</i>	20/543 (3.68)	2,500	50,000
White stork	Ciconiidae	<i>Ciconia ciconia</i>	62/543 (11.42)	17,500	1085000
Marabou Stork	Ciconiidae	<i>Leptoptilos crumeniferus</i>	2/543 (0.37)	75,000	150,000
Saudi pigeon	Columbidae	<i>Columba livia</i>	13/543 (2.39)	6,000	78,000
France pigeon	Columbidae	<i>Columba livia</i>	10/543 (1.84)	35,000	350,000
Holland pigeon	Columbidae	<i>Columba livia</i>	40/543 (7.37)	25,000	1,000,000
African gray parrot	Psittacidae	<i>Psittacus erithacus</i>	5/543 (0.92)	30,000	150,000
Red headed love bird	Psittacidae	<i>Agapornis pullarius</i>	14/543 (2.58)	10,000	140,000
Black stork	Ciconiidae	<i>Ciconia nigra</i>	1/543 (0.18)	17,500	17,500
Vinaceous dove	Columbidae	<i>Streptopelia vinacea</i>	24/543 (4.42)	500	12,000
Pied crow	Corvidae	<i>Corvus albus</i>	5/543 (0.92)	1,000	5,000
Senegal parrot		<i>Poicephalus senegalus</i>	4/543 (0.74)	2,000	8,000
Yellow – fronted canary	Frigillidae	<i>Serinus mozambicus</i>	23/543 (4.24)	500	11,500
Egyptian pigeon	Columbidae	<i>Columba livia</i>	6/543 (1.10)	5,000	30,000
Turkey	Meleagrididae	<i>Meleagris gallopavo</i>	27/543 (4.97)	2,000	54,000
Spur-winged goose	Anatidae	<i>Plectropterus gambensis</i>	1/543 (0.18)	25,000	25,000
Osprey	Accipitridae	<i>Pandion haliaetus</i>	1/543 (0.18)	50,000	50,000
Lappet-faced vulture	Accipitridae	<i>Torgos tracheliotus</i>	1/543 (0.18)	90,000	90,000
Grey heron	Ardeidae	<i>Ardea cinerea</i>	3/543 (0.55)	3,000	9,000
Long-tailed glossy starling	Sturnidae	<i>Lamprotornis caudatus</i>	4/543 (0.74)	3,500	14,000
Ring –necked	Columbidae	<i>Streptopelia</i>	16/543 (2.95)	700	11,200

Common Name	Family	Species	No birds on sale (%)	Unit cost (₦)	Total (₦)
dove		<i>capicola</i>			
Speckled pigeon	Columbidae	<i>Columba guinea</i>	17/543 (3.13)	2,500	42,500
Ostrich		<i>Struthio camelus</i>	4/543 (0.74)	75,000	300,000
Total			543/543 (100)		6,575,300

Table 7. Distribution and sources of wild birds on sale in live wild bird markets in Kaduna State

Country of origin	Common Name of bird	% of birds
Nigeria	Eagle, Parrot, Love bird, Vinaceous dove, Pied crow, quail, canaries, geese, Turkey, Osprey, Lappet-faced vulture, Grey heron, Long-tailed glossy starling, Peafowl, <i>Allen ganulle</i> , Mallard duck, Crowned sand grouse, Purple swamphen, Rock dove	55.88 (19/34)
Chad	American eagle, black stork, white stork, Ostrich,	11.76 (4/34)
Sudan	Pelican, White stork	5.88 (2/34)
Ghana	Ghanaian geese, Marabou	5.88 (2/34)
Cameroon	White stork, Green parrot	5.88 (2/34)
Saudi Arabia	Saudi Arabian pigeon	2.94 (1/34)
France	France pigeon	2.94 (1/34)
Holland	Holland pigeon	2.94 (1/34)
Egypt	Egyptian pigeon	2.94 (1/34)
Niger Republic	Spur-winged goose (Shama)	2.94 (1/34)

In assessing the risk level of the markets, of the 29 biosecurity features assessed and categorized into risky and non-risky features, all the markets had 48.27% (14/29) risky and 24.1% (7/29) non risky features. However, 60% (6/10) of the risky biosecurity features identified were related to infrastructure and 81% (17/21) were because of poor biosecurity practices of the wild bird sellers.

3.3 Identification and Estimation of Financial Value of Wild Birds on Sale

Of the 543 birds presented for sale on the day of LWBMs survey, 11.42% (62) were white stork (*Ciconia ciconia*) followed by geese which comprised 9.94% (54) of the birds on sale (Table 6). Among the birds in the LWBMs, Black crown crane (*Balearica pavonina*), Lappet-faced vulture (*Torgos tracheliotus*) and Osprey (*Pandion haliaetus*) which are threatened and rare species respectively were traded (Plate IV). The sellers claimed birds were sourced from 10 countries namely Nigeria, Chad, Sudan, Ghana, Cameroon, Niger, Egypt, Saudi Arabia, France and Holland (Table 7). The price per bird ranged from ₦300 for quail to ₦125, 000 for Osprey (American eagle). Other animals sold in the LWBMs include lion and crocodiles with prices ranging from a ₦500 for guinea pig to ₦ 1.2 million for a lion. The stock of wild birds among the four LWBMs was valued at six million five hundred and seventy-five thousand three hundred Naira (₦ 6,575,300) comprising 71.4%

of the total value of animals (₦ 9,207,300) presented for sale on the day of survey.

4. DISCUSSION

The study revealed that despite the illegality of the WB trade, these markets are in prominent areas/roads within the town. These are busy areas in the town with high human traffic thereby increasing likelihood of human exposure to wild bird infection. Live wild bird trade is a male dominated business in Kaduna, Nigeria contrary to reports in Hanoi, Vietnam where the trade is dominated by women, though most of the sellers were above 31 years similar to a Vietnamese [17]. Nonetheless, LWB trade though an illegal trade was the main source of income for all the wild bird sellers. The illegality of the trade implies the livelihood of LWB sellers are at risk because efforts to forbid the trade would result in decline in the trade and loss of income hence their livelihood [17].

The practice of LWB sellers not visiting other LWBMs would reduce the likelihood of spread of disease between LWBMs though this could be undone by the frequent visits of middlemen who supply birds to these LWBMs as they transverse other LWBMs to sell birds. Similar to reports in LPMs, the LWB sellers were willing to report sick and dead birds to veterinary authorities increasing the likelihood of swift detection of new disease outbreaks [18]. Sellers' practice to reporting disease outbreak only after their



Plate IV. Wild birds traded in live wild bird markets in Kaduna State, Nigeria. (a) Lappet-faced vulture, a vulnerable species (b) Osprey, rare and only species in Genus. (c) White stork, most abundant species presented for sale. (d) Crowned crane, a near threatened species

treatment fails would spread the pathogen and increased human exposure. Furthermore, keeping live poultry at home together with wild birds as practiced by some sellers increases human exposure and the likelihood of exchange of pathogens between the birds [19]. Hand washing undertaken by sellers as a biosecurity

measure removes unwanted materials while soap neutralizes active microbial agents [20,6].

The study also revealed that similar to previous studies involving local poultry farmers and fowl sellers in Kaduna State, radio was an appropriate source of information for wild bird sellers on

avian influenza [21,22]. However, radio was probably not an effective medium as the wild bird sellers could not recall what they heard on AI or since the AI outbreak involved poultry they could not link the AI with their trade unlike live poultry sellers [23]. In ability of WB sellers to recognize AI implies poor recognition in outbreak situations. Non recognition of HPAI clinical signs among LWB sellers though similar local poultry farmers would hamper prompt reporting of AI outbreaks and increase human exposure [24,22]. The poor recognition of clinical signs is perhaps because their primary source of AI information was the radio. Hence, visual or audio-visual educational materials may likely improve their knowledge on AI clinical signs [22].

The knowledge of wild bird sellers in Kaduna State on human infection of HPAI is poor in contrast to poultry workers and keepers in Europe and Thailand where emphasis on human aspect of HPAI was made [25,26]. The poor knowledge of sellers on human aspect of HPAI is highlighted in their belief that humans could not be infected is an indication of poor risk perception on AI which is likely to affect compliance with preventive measures [27].

The study further revealed that wild birds are used as pets, for food and traditional medicine for preparation of charm by politicians to win elections similar to reports from Asia [17]. Birds were neither released for religious merit nor for their song [28,2,17]. The use of wild birds for food, traditional medicine and as pet increases human exposure to potential pathogens they may harbored [2].

Balearica pavonina and *Torgos tracheliotus* listed as a Near Threatened and Vulnerable Species were on sale in all the LWBMs in Kaduna [29]. The continuous capture and sale of these species of birds will worsen their status to Vulnerable and Threatened species respectively. Hence, there is a need for government and non-governmental organizations to intervene through education of the sellers and hunters on the status of these birds. Also, law enforcement agents could contribute in the prohibition of the trade on threatened bird species through regular visits to the LWBMs and confiscation of the birds [29].

It was further revealed by this study that the live wild bird trade in Nigeria involves the movement of wild birds across national borders and is linked to the international wildlife trade [2]. Amongst the countries from which wild birds are sourced, Niger, Cameroon, Sudan and Holland had

reported avian influenza outbreaks with Egypt currently reporting AI outbreaks in wild birds [12,30]. Therefore, the Nigerian LWBMs poses direct disease risk to human and animals and probably have a role to play in the introduction and spread of pathogens into and within Nigeria.

Though most of the species of birds on sale were resident (Vinaeous dove), intra-African (gray heron) and Palearctic migrants (white stork) were also on sale [29]. The high concentration and mixing of these birds in LWBMs increase the likelihood of disease transmission and exchange of pathogen between resident and migrants birds [31]. This would ease the establishment of migrant wild bird diseases in resident wild birds probably resulting in an epidemic as the case of avian malaria in Hawaii Island birds [32].

There was misnaming of bird species in the LWBMs, white stork was referred to as flamingo with the assumption that it was from Australia. The misnaming is usually intended to place emphasis on the exotic origin of the birds in a bid to fetch higher prices. It is believed that this practice is derived from the average Nigerian mentality that anything foreign and expensive is better implying higher class. The high prices of foreign birds might also be due to the expenses incurred in bringing the birds into Nigeria through smuggling which might involve bribing of the quarantine and wildlife officials responsible for disease and wildlife surveillance.

The study showed that the sales of wild birds were the main source of the income to these markets compared to the mammals and reptile also on sale thereby justifying the nomenclature of the markets as LWBMs. This also highlights the acceptance of birds over other wild animals probably due to the ease of management as pets.

The sale of livestock such as sheep and turkeys in the LWBMs constitute a high risk of introduction of wild bird infection to the livestock industry with serious consequences through propagation of pathogenic organism.

The absence of fence in LWBMs though similar to reports on traditional LPMs is contrary to the situation in the upgraded live poultry markets in Nigeria [21]. However, the absence of fence and gates in LWBMs would render enforcement of traffic control impractical or impossible there by increasing direct and indirect human contact with wild birds.

The short distance between holding cages within markets increase congestion of animals of varied species in close-confinement resulting in stress with increased likelihood of shedding, mixing and spreading of potentially harmful microbes. Similarly, allowing birds to move around within the markets increases human contact and risk of disease exposure to both humans and birds contrary to situation of LWBMs in Asia where all birds are caged [28,2]. The difference observed might be due to advancement in the wild bird trade in Asia and frequent harassment by law enforcement agents which is not been experienced by Nigerian wild bird sellers [2].

The absence of cemented floor in the fenced pens poses a challenge during sanitation with a resultant build-up of potentially pathogenic microbes in the pens and subsequent transmission to new occupants as reported by previous study [31]. This feature of the market will enhance maintenance and spread of infection in the LWBMs.

Obtaining birds from different sources highlights LWBMs as potential foci for introduction and spread of pathogens with zoonotic potentials through build-up of microbes which are normal flora of some wild birds but could pathogenic to others when acquired in the LWBMs. Although all LWB sellers claimed to quarantine new birds, none could confirm the quarantine period. Not quarantining for appropriate length of time would allow introduction of birds incubating disease. Hence, there is need to highlight to sellers the need for proper quarantine which might be impractical in LWBMs. However, it might be more practical to house birds based on consignments though there is the challenged of purchase from multiple sources and limited cages within the LWBMs. Rodents, being reservoirs of *Salmonella* are likely to become infected and transmit to humans while maintaining the bacteria in the market [33].

The interaction of local poultry with wild birds and their litter at the Isa Kaita LWBM highlights the need for fencing to ensure proper traffic control of human and animals within the markets. This interaction can lead to introduction of infection from the LWBM birds to the local poultry population and vis-versa with possible human exposure.

The findings of this study is similar to reports on local poultry farmers and fowl sellers in Kaduna State who do not use PPE thereby exposing

sellers to possible infection from wild birds and carrying potential pathogen home in their clothes, hair and shoes [22,31,21]. Unlike the LPMs in Kaduna State, the LWBMs sellers do not disinfect cages and pens probably due to ignorance as they were not involved in the biosecurity trainings following the avian influenza outbreaks in Nigeria. The non-participation of the LWB sellers in these trainings were probable due to either the illegality of their trade or the authorities did not recognize the role of LWBMs in the introduction, spread and maintenance of HPAI and other trans-boundary animal diseases. There is need for government to identify and engage all stakeholders in the event of a disease outbreak and control irrespective of the legality of their trade or take necessary practical actions to regulate and monitor the trade.

The improper disposal of dead wild birds and manure poses a risk to humans and livestock and further highlights the need for educating wild bird sellers on proper biosecurity practices. The study revealed that biosecurity in Kaduna LWBMs was poor compared to the LPMs [21]. However, this difference might be due to difference in the infrastructure in the markets and the better knowledge and practices on biosecurity of poultry sellers. Despite the infrastructural failures in the LWBMs the improvement of wild bird sellers behavior and practices on biosecurity would greatly improve the biosecurity situation in the LWBMs. This further highlights the need for training of the wild bird sellers on proper biosecurity practices.

5. CONCLUSION

Wild bird sellers' knowledge and practices on biosecurity were very poor with poor biosecurity infrastructural features. Although the trade is illegal the average daily wild animal stock of a market was over a million Naira and birds were sourced from different countries. Threatened species were also sold in the LWBMs. However, there is need for government to extend biosecurity training to LWB sellers and enforcement of check in LWBMs to prohibit sales of endangered species. Similarly, there is need to discourage interaction of domestic poultry with the LWBM birds.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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