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Retrospective survey of spatio-temporal spread of avian influenza in and around Maiduguri, Borno state northeastern Nigeria

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ABSTRACT

Highly Pathogenic Avian Influenza (HPAI) is a viral disease affecting the digestive, nervous and respiratory systems of all domestic and wild birds that is characterized by respiratory, reproductive, digestive and/or nervous signs with high morbidity and mortality. Following the first report of Avian Influenza (AI) in Nigeria in January 2006 and its subsequent confirmation in February 2006, this study was designed to Retrospectively Review the Spatio-Temporal spread of HPAI in and around Maiduguri, Borno State, Nigeria. Out breaks were recorded from six (6) farms within Maiduguri and its environs, the index case of AI in Maiduguri was noticed on the 11th November, 2006 and was reported on the 13th November, 2006. Subsequent transmission from the index case could have been through aerosol or contaminated dust in the direction of wind flow as occasioned by the prevailing harmattan period which coincides with the outbreak period between November 2006 and January 2007. An age-specific mortality rate of 33.7% was recorded among birds of age group 0- 30 weeks, while 53.1% among the age group 31-60 weeks and 44.1% was recorded among adult birds of unknown age group. It is recommended that there should be

improved management practices, which include strict enforcement of biosecurity measures to reduce human and fomite contacts risks that could occur without observing or breach of biosecurity protocols. Improve litter and other poultry waste management, exclusion of other animal species on poultry farms, and institution biosecurity against risks from neighbourhood farms' activities.

1. Introduction

Highly Pathogenic Avian Influenza (HPAI) is a viral disease affecting the digestive, nervous and respiratory systems of all domestic and wild birds that is characterized by respiratory, reproductive, digestive and/or nervous signs with high morbidity and mortality with an incubation period of few hours to few days (Alexander, 2007a; Swayne and Suarez, 2000). It is highly contagious and infectious and may be fatal in humans (de Jong and Hien, 2006; O.I.E., 2012). Influenza viruses belong to the Family Orthomyxoviridae which contains four Genera: Influenza A, B, and C viruses, and Thogoto virus(de Jong and Hien, 2006; Ducatez et al., 2007). The three types (A, B, and C) of Influenza viruses are classified on the basis of antigenic differences among their nucleopcapsid (NP) and matrix (M) proteins(Cattoli et al., 2009; Ducatez et al., 2007). Influenza A viruses are further divided into subtypes based on the antigenic relationships of their hemagglutinin (HA) and neuraminidase (NA) surface glycoproteins (Claas et al., 1998; de Jong and Hien, 2006). The HA and NA genes are extremely variable in sequence, and less than 30% of the amino acids are conserved among all the subtypes (Tsukamoto, 2006). A total of 16 different HA subtype (H1-H16) and 9 different NA subtypes (N1-N9) have been identified (Fouchier et al., 2005). To date, all outbreaks of the highly pathogenic form have been caused by influenza A viruses of the subtypes H5 and H7 (Alexander, 2007a, b; Poland et al., 2007). The AI viruses are present in the secretions from the eyes, mouth and nostrils and faeces from infected birds (Abdu et al., 2005; Thomas and Noppenberger, 2007). Contaminated faeces from infected bird can contain enough of HPAI viruses to infect other birds (Swayne, 2009). The infection cycle among birds depends on faecal-oral transmission chains, by inhalation of aerosol and contaminated dust (Abdu et al., 2005; Koopmans et al., 2004), broken contaminated eggs may infect chicks in the incubator (Swayne, 2009). Boender et al. has demonstrated that the probability of between-flock virus transmission decreases with increasing distance between an infected and an uninfected flock (Boender et al., 2007). Several routes are considered to be important during AI epidemics, such as movements of visitors, materials, and fomites, but, as shown for some other viral diseases (Li et al., 2004; Otake et al., 2010) also airborne transmission has been hypothesized (Chen et al., 2006; Chen et al., 2005; Tsukamoto, 2006).The so-called wet markets, where live birds are sold under crowded conditions, are multiplicators of spread (Bulaga et al., 2003; Shortridge et al., 1998). The disease affects all ages, but is more serious in the young (Cox and Subbarao, 2000). In Nigeria, the disease was first reported in January, 2006 and subsequently confirmed in February, 2006 (Adene et al., 2007). Within months the spread became very noticeable and by September 2008, 3,337 cases have been reported in 97 Local Governments from 25 States and the FCT in the Country (Baba, 2006; Cecchi et al., 2008). With the introduction of the disease into the country, the potentials for its spread and continued presence are high especially among the family poultry populations (Baba, 2006). All African strains clustered within three sublineages denominated A (South-West Nigeria, Niger), B (South-West Nigeria, Egypt, Djibouti) and C (Northern Nigeria, Burkina Faso, Sudan, Côte d'Ivoire), with distinct nucleotide and amino acid signatures and distinct geographical distributions within Africa(Fusaro et al., 2009; Monne et al., 2008).As H5N1 emerged essentially at the same time in the north and south-west of Nigeria, the substitution rates confirmed that the virus probably did not spread from the north to the south, given the observed sequence diversity, but that it entered the country via three independent introductions (Ducatez et al., 2007; Fusaro et al., 2009).The strains from Burkina Faso seemed to originate from northern Nigeria. Atleast two of the sublineages also circulated in Europe in 2006 as seen in Germany, further suggesting that the sublineages had already emerged outside of Africa and seemed to have followed the East African/West Asian and Black Sea/Mediterranean flyways of migratory birds (Ducatez et al., 2007). In Russia and Kazakhstan, outbreaks have been associated with contact between domestic poultry and wild waterfowl at open water reservoirs (especially wetlands and lakes) (Morris et

al., 2005). In Nigeria, such wetlands exist, with free flying wild birds and domestic ducks visiting and resting, and these have been speculated as one of the sources of the recent introduction of the disease into the country (Baba, 2006). It is still unclear, however, whether wild migrating birds now provide a reservoir for HPAI H5N1 virus (F.A.O., 2011; Peiris et al., 2007).

2. Materials and methods

This study was conducted in Maiduguri, Borno state. Borno state has an area of about 69,436 km2. It lies within latitude 10-14°N and longitude 10-18°E. The state is located within the north-eastern corner of Nigeria. It shares border with the Republic of Niger to the North, Chad to the North-East and Cameroon to the East (BSBLS, 2011). Its neighbouring states include Adamawa to the south-east, Yobe to the west and Gombe State to the southwest. It has a population of 2.6 million; about 90% of the population are farmers (BSBLS, 2011).

Cases are those birds presenting the signs of sudden disease appearance in a flock and many birds die either without premonitory signs or with minimal signs of depression, inappetence, ruffled feathers and fever. Others showing weakness, staggering gait, soft-shelled eggs, or stop lying. Combs and wattles are cyanotic and oedematous, and may have petechial or ecchymotic haemorrhages at their tips. Profuse watery diarrhoea is frequently present and birds are excessively thirsty. Respiration may be laboured, haemorrhages may occur on unfeathered areas of skin, oedema of the face and neck and neurological signs such as torticollis and ataxia may also be seen. Birds often sit or stand in a semi-comatose state with their heads touching the ground. The mortality rate varies from 50 to 100%; and/or post-mortem lesions of yellow or grey necrotic foci in the spleen, liver, kidneys and lungs. The air sacs may contain exudates; the spleen may be enlarged and haemorrhagic. Histological lesions characterised by vascular oedema, haemorrhages especially in the myocardium, spleen, lungs, brain and wattles; and perivascular cuffing, gliosis, vascular proliferation and neuronal degeneration in the brain. Records of outbreak including the location, numbers and species of birds affected, dates and other epidemiological data supporting the outbreak were collected and verified using data from the Avian Influenza Control Project(AICP) Desk Officer in Maiduguri, Borno state.

The information obtained from the committee is as follows:

1. The name of the farm or farmers that had an outbreak of AI.
2. The location of the farm giving the co-ordinates of the farm.
3. The date the disease was observed and reported, the date when depopulation took place.
4. The number of birds that died and the number depopulated.
5. The sample that was sent to the National Veterinary Research Institute (NVRI) Vom, Plateau state for laboratory analysis (fresh whole carcass packed on ice).
6. The result of the laboratory diagnosis from NVRI Vom.
7. The results of serological survey of the years, 2008 and 2009.

Structured questionnaires were administered on five of the six farmers that had confirmed cases of an AI outbreak on their farms and the responses to the questions were analyzed. The data were analyzed based on the spread of the disease from the primary infection point and the subsequent infection and the possible contributory factor such as source of day old chicks, source of feed, a clinician that attends to individual farms, presence or visits to farms by wild birds, species of birds kept, nearness to the water body and wind direction.

3. Results

The index case of avian influenza in Maiduguri was noticed on the 11th November, 2006 and was reported on the 13th November, 2006, located at latitude 13º 9' 18 and longitude11º 50'. A total of 494 layers of 52 weeks of age and 6 adult turkeys was affected. Fifty three percent (53%) mortality was recorded in the layers within 48 hours; no mortality was recorded in turkeys. On the 1st December, 2006, the second case was reported, but it was first noticed on 27th November, 2006. This was located on latitude13º 10'12 and longitude11º 49'12 about 2.64 km South East in the direction of the index case, having 35 geese hens, one geese cock, 5 swan hens and two swan cocks all adults in age were on the farm. There was a mortality of 85.7% of the geese hen only in four days; however none was recorded in the geese cock, swan hens and cocks respectively (Table I; Fig. I). The third case was first noticed on the 16th of December, 2006. The farm had sixty 52 weeks old layers, forty two 6 weeks old cockerels and 3 adult local chickens. 60% mortality was recorded in the layers, while no mortality was recorded in

the other birds on the farm. The farm is located on latitude13º 7' 30 and longitude11º 48'12 with a distance of about 5.4kms on the South West direction in the second case (Table 1; Fig. 1).

Table 1
Spatial and temporal spread of avian influenza in Maiduguri, Borno State, Nigeria.

	Co-ordinates		Dates						
S/No.	Latitude	Longitude	Reported	Noticed	Flock size	Flock type	Age(Wks)	Mortality rate (%)	No. depopulated
					494	Layers	52	260 (52.6)	234
1	13°9'18	11°50'	11/11/2006	13/11/06	6	Turkey	Adult	0 (0)	6
					35	Geese hen	Adult	30 (85.7)	5
					1	Geese cock	Adult	0 (0)	1
					8	Swan hen	Adult	0 (0)	8
2	13°10'12	11°49'12	27/11/06	12/01/2006	2	Swan cock	Adult	0 (0)	2
					60	Layers	52	36 (60.0)	24
					42	Cockerels	6	0 (0)	42
3	13°7'30	11°48'12	16/12/2006	30/12/2006	3	Local Cocks	Adult	0 (0)	3
					57	Layers	28	39 (68.4)	18
					44	Pullet	6	0 (0)	44
					9	Broilers	6	0 (0)	9
4	13°12'	11°48'36	26/12/2006	01/04/2007	13	Ducks	Adult	0 (0)	13
5	13°6'54	11°51'12	01/04/2007	01/11/2007	50	Pullets	11	29 (58.0)	21
6	13°9'54	11°48'48	26/1/2007	28/1/2007	250	Layers	36	131 (52.4)	119

On the 26th December, 2006, the fourth case was noticed on the farm and was reported on 4th January, 2007. There were 57 to 28 weeks of age; pullets of 6 weeks of age were 44 in number, 9 broilers also of 6weeks of age and 13 adult ducks. 68% mortality was recorded in the population of the layers, but none was recorded in the pullets, broilers and the ducks. The farm was located 8.16 km in the eastern direction from the third case and is on latitude13º 12' and longitude11º 48'36.The case that was reported on the 11th January, 2007 was the fifth case, it was first observed on the 4th of January, 2007. It had 50 pullets of 11 weeks old. The mortality rate was 58% during the period. The farm was located onlatitude13º 6'54 and longitude11º 51'12 with a distance of 10.24 kms in the North West direction to the forth case. The sixth case was noticed on 26th January, 2007 and was reported on 28th January, 2007. There were 250 layers of 36 weeks of age. 52.4% case mortality was recorded in three days. The farm was located on latitude13º 9'54 and longitude11º 48'48, with a distance of 6.88 kms from the fifth case in the South Eastern direction (Table 1; Fig. 1).

Serological survey for the antibody of AI was carried out in 2008 and 2009 but the results were negative. Samples of whole fresh carcass on ice or ice pack that were sent to the NVRI Vom, Plateau state for laboratory diagnosis recorded ten cases. The highest Specie-specific mortality rate of 83.3 % was recorded in geese, while the disease is most severe among layers where 955 were with 51.8% mortality. The other species infected had no mortality as shown in (Table 2). An age-specific mortality rate of 68 (33.7%) was recorded among birds of age group 0- 30 weeks, while the age group 31-60 weeks accounted for a mortality rate of 427(53.1%); however, mortality rates of 30 (44.1%) was recorded among adult birds of unspecified or unknown age group (Table 3). The response to the questionnaires were analyzed and presented in Table 4 ,On source of birds, Sapic Farm was the source of 40% of the day old chicks in Maiduguri, Borno state, being the most patronized farm. Vital Feeds provided 80% of the feed used on these farms during the period of study with only 20% by Livestock feeds. Some farms had multiple Clinicians providing veterinary medical services and different species were kept. Layers were kept by all the farmers, followed by 60% keeping broilers. While cockerels and other species were 40% each. Wild birds were seen around 80% of the farms infected with AI as shown in Table 4. On 11/11/2006 a farmer noticed the disease in flock of about 500 layers, turkeys, swan, cocks and geese in which 290 (52.63%) mortality was recorded out of 544 birds and following reports to the authority on 13/11/06 about 254 birds were depopulated. On 12/01/2006 a farmer reported an outbreak which was noticed a month earlier on 27/11/06 among 104 birds comprising of layers, cockerels and local chickens, 36 (34.6%) mortality was recorded while 69 birds were depopulated (Table 5).

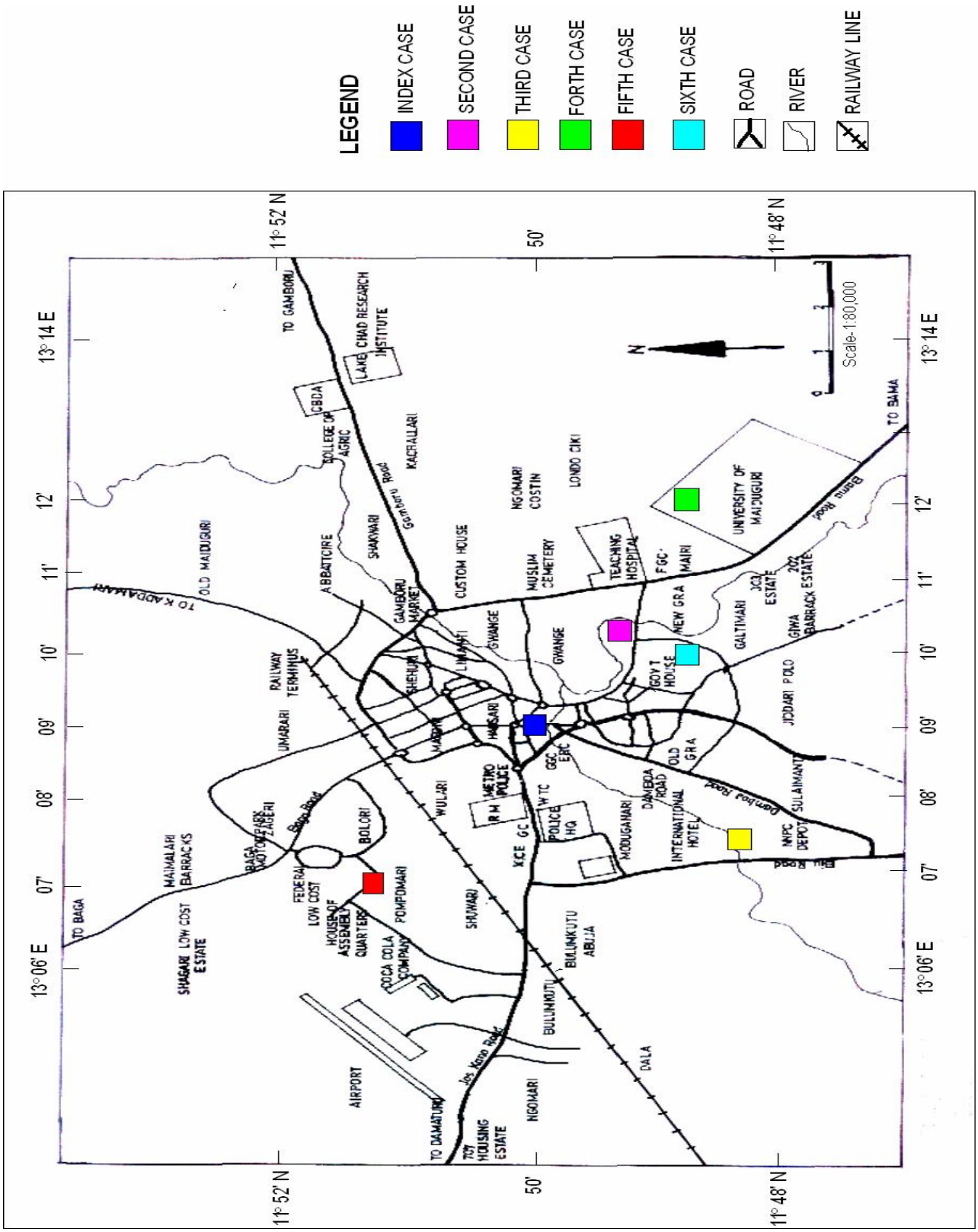

Fig. 1. The map of Maiduguri, Borno state of Nigeria showing spatial spread of outbreaks of Avian Influenza (AI).

A mortality of 39 (34.5%) was recorded in a farm from an outbreak noticed on 16/12/2006 and reported on 30/12/2006 among birds of flock size 113 comprising of cock, layers, pullets and broilers from which 74 birds were depopulated. On 26/12/2006 the disease was noticed among 13 ducks following reporting on 01/04/2007 all the 13 birds were depopulated. An outbreak noticed on 01/04/2007 was reported on 01/11/2007 among 50 pullets from which 29 (58%) mortality was recorded, while 21 birds were depopulated. A mortality rate of 131 (52.4%) was recorded among 250 layers from an outbreak noticed on 26/1/2007 and reported on 28/1/2007 with subsequent depopulation of 119 birds (Table 5).

Table 2
Specie-specific Mortality Rate of AI outbreak in Maiduguri, Borno state, Nigeria.

	Species	No. affected	Mortality rate (%)	No. depopulated
1	Layers	955	495 (51.8)	460
2	Broilers	9	0	9
3	Cockerels	42	0	42
4	Local chickens	3	0	3
5	Geese	36	30 (83.3)	6
6	Swan	10	0	10
7	Turkey	6	0	6

Table 3
Age specific mortality rate of AI outbreak in Maiduguri, Borno state, Nigeria.

S/no.	Age (Wks)	No. affected	Mortality rate (%)	No. depopulated
1	0-30	202	68(33.7)	134
2	31-60	804	427(53.1)	377
3	Adult(un-specified)	68	30(44.1)	38

4. Discussion

The introduction of the Avian Influenza virus into Maiduguri town and its environs could have been through infected birds, movements of visitors, materials and fomites. This is in consonant with the assertions of Li *et al*. and Oteke *et al*. (Li *et al*., 2004; Otake *et al.*, 2010). Subsequent transmission from the index case could have been through aerosol or contaminated dust as occasioned by the prevailing harmattan period which coincides with the outbreak period between November 2006 and January 2007. This also concur with (Chen *et al*., 2006; Chen *et al.*, 2005; Otake *et al.*, 2010; Tsukamoto, 2006) who hypothesised airborne transmission on AI virus. The other possible route of transmission between farms is the source of feeds, where most of the farms involved in the outbreak buy their feed mainly from one source, although there are many selling points of poultry feeds in Maiduguri, three of the four farms involved got their feed from the same source, and this Livestock feed selling point is just about one hundred meters from the local live bird market and poultry slaughter and processing point. Any conceivable contact between possibly contaminated poultry/poultry products, areas around poultry houses contaminated with faecal material from wild/free ranging birds and contaminated biotic vectors on the one hand and domestic poultry on the other hand are all risk factors for transmission (Busani *et al*., 2009; Koch and Elbers, 2006; Ssematimba *et al.*, 2012). The presence of mixed poultry species in most of the farms involved in the outbreak is another management flaw that could contribute to the occurrence and spread of AI. Other workers have also reported that risky management practices, which include human and fomite contacts that occurred without observing or breach of biosecurity protocols, poor waste management practices, presence of other animal species on poultry farms, and poor biosecurity against risks from farm neighbourhood activities (Ssematimba *et al*., 2012). Therefore, transmission could have occurred either through the feed, day-old chicks or other fomites during transportation of the feeds as the feed is manufactured in Plateau State that already had an outbreak. Both feeds and live birds can be considered a potential source of infection because they are also transported through Yobe State which was an infected State before Borno State.

Table 4
Descriptive questionnaire analysis of factors that may contribute to the spread of AI in Maiduguri, Borno state, Nigeria.

S.No.	Factors	Respondents	Response	Percentage (%)
1	Source of bird	5	Sapic (2)	40
			ECWA (1)	20
			Obasanjo Farms	20
			Gujba Farms	20
2	Source of feeds	5	Vital Feeds (4)	80
			Livestock Feeds (1)	20
3	Source of Vet. services	5	State Vet. Clinic (3)	60
			Sunday Gwari (2)	20
			VTH Unimaid (1)	20
			ECWA (1)	20
4	Presence of wild bird	5	Present (4)	80
			Absent (1)	20
5	Species of birds reared	5	Layers (5)	100
			Broilers (3)	60
			Cockerels (2)	40
			Others (2)	40

Table 5
Temporal spread of AI outbreak in Maiduguri, Borno state.

S.No	Dates		Flock size	Flock type	Age (Wks)	Mortality rate (%)	No. depopulated
	Noticed	Reported					
			494	Layers	52	260 (53.3)	234
1	11/11/2006	13/11/06	6	Turkey	Adult	0	6
			35	Geese hen	Adult	30	5
			1	Geese cock	Adult	0	1
			8	Swan hen	Adult	0	8
2	27/11/06	12/01/2006	2	Swan cock	Adult	0	2
			60	Layers	52	36 (34.6%)	24
			42	Cockerels	6	0	42
3	16/12/2006	30/12/2006	3	Local Cocks	Adult	0	3
			57	Layers	28	39 (34.5%)	18
			44	Pullet	6	0	44
			9	Broilers	6	0	9
4	26/12/2006	01/04/2007	13	Ducks	Adult	0	13
5	01/04/2007	01/11/2007	50	Pullets	11	29 (58%)	21
6	26/1/2007	28/1/2007	250	Layers	36	131 (52.4%)	119

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