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Pattern of spread of African swine fever in south-western Nigeria, 1997-2005

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Summary

Geographic coordinates of selected pig farms with confirmed African swine fever (ASF) outbreaks in Ekiti, Lagos, Ogun, Ondo and Oyo States were used to create spatial models of pig farms and ASF outbreaks in south-western Nigeria between 1997 and 2005. The probability of ASF virus-free pigs remaining in a non-infected state when located at various distances from ASF virus infected pigs was estimated. Movement of infected stock was the most important means of spreading the virus. The estimated mean duration of clinical signs prior to death was 3.4 ± 1.1 days (mean ± standard deviation); the mean convalescent period was 16.3 ± 2.3 days and the mean period of survival after full recovery was 1 084 ± 145.1 days. The continuous presence of recovered pigs in the population enables virus spread through trade and breeding. There is an urgent need for the implementation of an ASF eradication programme in Nigeria.

Keywords

African swine fever, Disease, Geographic information system, Nigeria, Pattern, Pig, Spread.

Modello di diffusione della peste suina africana nella Nigeria sud-occidentale, 1997-2005

Riassunto

Le coordinate geografiche di selezionate aziende di suini, dove siano stati confermati focolai di peste suina africana negli stati di Ekiti, Lagos, Ogun, Ondo and Oyo, sono state usate per creare un modello spaziale sulle aziende suine ed i focolai di peste suina africana nella Nigeria sud-occidentale tra il 1997 e il 2005. È stata stimata la probabilità che suini liberi dal virus rimangano in un area non infetta quando localizzati a diverse distanze da suini infetti con il virus della peste suina africana. I movimenti di gruppi di suini è risultata la modalità principale di diffusione del virus. La durata media stimata della sintomatologia clinica prima della morte è risultata di 3.4 ±1.1 giorni (media ± deviazione standard); la media del periodo di convalescenza è stato di 16.3 ± 2.3 giorni e il periodo medio di sopravvivenza dopo la piena guarigione è stato di 1.084 ± 145.1 giorni. La continua presenza di suini guariti dal punto di vista clinico permette la diffusione del virus attraverso gli scambi per fini commerciali e per la riproduzione. Emerge una necessità urgente di implementazione di un programma di eradicazione della peste suina africana in Nigeria.

Parole chiave

Diffusione, Nigeria, Peste suina africana, Malattia, Modello, Sistema informativo geografico, Suini.

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Introduction

African swine fever (ASF) is a viral disease of domestic pigs. In the peracute form, the disease is characterised by high fever (40-42°C) and a brief period of anorexia, followed by sudden death. In the acute form, there is widespread haemorrhaging. Morbidity and mortality may approach 100% (9). Nigeria was free of ASF until 1997 (3). However, the disease now poses a considerable threat to pig production in south-western Nigeria (1, 4, 5, 6). Recent studies have combined virology and epidemiology techniques to develop more effective and efficient methods for the surveillance and control of ASF in south-western Nigeria (5, 7). It is necessary to describe the pattern of ASF spread and the distribution of pigs that have recovered from ASF, since these have been shown to serve as carriers of ASF virus (5).

The objective of this study was to describe the spatial distribution of pig farms that are free of ASF, pig farms suspected of being infected by ASF virus and pigs confirmed to be carriers of ASF virus. This analysis aims at describing baseline distributions in a geographic information system (GIS) database which may serve as a reference for the control of ASF in south-western Nigeria.

Materials and methods

This study covered the period between June 1997 and 31 August 2005, representing the period of first occurrence of ASF in Nigeria. All pigs (162) referred to the Veterinary Public Health and Preventive Medicine Clinic at the University of Ibadan, Nigeria, were observed for clinical signs of ASF and were tested for the presence of ASF by isolation or detection of viral DNA by polymerase chain reaction (PCR) and by two serological methods. The indirect enzyme-linked immunosorbent assay (i-ELISA) and immunoblotting assay were used to detect ASF virus antibodies (6, 7). As new cases were identified, they were included in the study. Pigs originated from farms within 24 out of 75 local government areas in Ekiti, Lagos, Ogun, Ondo and Oyo States of south-western Nigeria (Fig. 1). Non-spatial data were collected through interviews of farmers, using a pre-tested questionnaire on movement of recovered stock to and from farms (8). One hundred and fifty-nine questionnaires were administered. Spatial and non-spatial data gathered were managed in a GIS (ArcGIS™ Desktop, Environmental Systems Research Institute, Redlands, California).

ASF-infected pig farms included in the study were limited to 100. From 85 farms, 162 tissue samples tested positive for ASF. Pigs that showed classical clinical signs of ASF were referred to the Department of Veterinary Public Health and Preventive Medicine clinic at the University of Ibadan between 1 June 2001 and 31 August 2005. Fifteen farms were selected from respondents to the questionnaire who indicated an outbreak of ASF on their farms between 1997 and 1998 (Table I). Geographic coordinates of the 100 farms were collected using a global positioning system (GPS) (Magellan 360™). Geographic coordinates of uninfected farms within a 15-km radius of these farms were also collected. There were 59 unaffected farms within the 15-km radius of the infected farms. The probability of remaining ASF-free at 5 km, 10 km and 15 km from ASF-infected farm was determined.

Using information on the dates of first detection of clinical signs, recovery, or death, three variables (inter-farm movement of people, ASF-carrier pigs and vehicles) were estimated and assessed for their involvement in the outbreaks. Confirmed ASF spread through movement of people and ASF-carrier pigs was presented in a spatial model as lines linking one farm to another. Five clusters of infection were investigated to determine the pattern of disease spread between pig farms between 1997 and 2005.

Results

ASF outbreaks occurred in four out of the five states of south-western Nigeria studied (Lagos, Ogun, Ondo and Oyo). The mean period from clinical signs to death was 3.4 days (±1.1). The

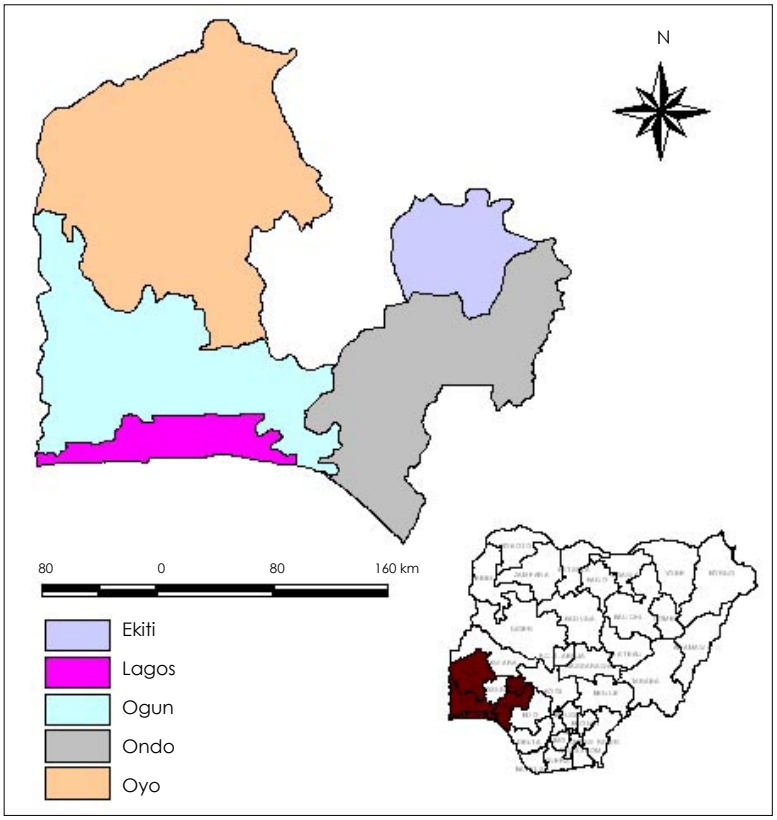

Figure 1
The five study states with an inset showing their location in south-west Nigeria

mean convalescent period was 16.3 days (±2.3). The mean period to full recovery was 1 084 days (±145.1) (Table II).

Of 159 questionnaires administered, 125 (78.6%) farmers responded. Among these, stock trading activities occurred on 112 farms (89.6%). On-farm wholesale and purchase of pigs and on-farm slaughter of stock occurred on 82 farms (65.6%). Stock inter-breeding programmes were implemented by 46 (36.8%) respondents. Forty-six (36%) respondents continued to breed from recovered pigs. The majority of movements by farmers, visitors and ASF-recovered pigs occurred within the immediate neighbourhood of the origin (Tables III, IV, V and VI). Within a 21-day period, inter-farm movement of farmers and farm workers occurred once and thee times, respectively, on average. Movement of middle men was 2-180 km, extending well beyond the immediate neighbourhood of their origin. The reason for movement was to sell purchased pigs to farms and at markets in other states (Table VII). Visitors and middle men contacted selected farms on average twice during an average period of 21 days (Tables V and VII).

Movement of farmers and farm workers to other farms was usually for the purpose of exchanging materials, such as feeds and drugs, and for stock breeding. The minimum movement distance was 0.5 km, the maximum distance being 18 km (Tables III and IV). Movement of ASF-recovered pigs via trade, middle men and breeders' activities occurred over a distance of 0.4-130 km within south-western Nigeria and occurred 1.5 times on average during a 21-day period (Table VI). Some farmers jointly hired vehicles, on average 1.4 times during a 21-day period, to convey feed to their farms to reduce the cost of transportation, while some ordered directly from feed mills an average of 2.3 times during a 21-day period (Table VIII).

Table I
Sample size and data collection on African swine fever-infected farms, south-west Nigeria, 1997-2005

Year of outbreak	Suspected cases presented for laboratory tests	Confirmed cases	Number of old cases	
			Respondents (out of 30)	Percentage
1997	–	–	8	36.7
1998	–	–	7	26.7
1999	–	–	0	18.3
2000	–	–	0	18.3
2001	37	31	–	–
2002	34	19	–	–
2003	25	14	–	–
2004	20	0	–	–
2005	29	21	–	–
Total	145	85	15	100

Table II
African swine fever survival traits among pigs in south-western Nigeria

Survival trait	Number of pigs	Mean time (days)
Clinical signs to death	1 420	3.4 (1.1)*
Convalescent period	86	16.3 (2.3)*
Post-convalescence lifespan	86	1 084 (145.1)*

Source: Field Survey, 2001-2005

* standard deviation (SD)

Table III
Average movement of farmers to and from selected pig farms

Direction of movement		Purpose	Distance (km)	Frequency in 21 days
From	To			
Home	Farm	Work	0-15	63 (27)*
Pig pen A	Pig pen B	Feeding, mating	0-0.5	97 (40)*
Farm	Neighbouring farm	Materials exchange and stock breeding	0.6-15	1 (0.6)*
Farm	Abattoir	Slaughter	0.5-3	0.6 (0.9)*

Source: Field Survey of 100 farmers, 2001-2005

* standard deviation (SD)

Table IV
Average movement of workers to and from selected pig farms

Direction of movement		Purpose	Distance (km)	Frequency in 21 days
From	To			
Home	Farm	Work	0.1-3	21 (0)*
Pig pen A	Pig pen B	Feeding, mating	0.01-0.05	31 (16.4)*
Farm	Neighbouring farm	Materials exchange and stock breeding	0.7-18	3 (7.7)*
Farm	Abattoir	Slaughter	0.5-3	0.6 (0.9)*

Source: Field Survey of 50 farm workers, 2001-2005

* standard deviation (SD)

Table V
Average movement of visitors to and from selected pig farms

Direction of movement From	To	Purpose	Distance (km)	Frequency in 21 days
Home	Farm	Personal/professional	0.2 15	1.8 (0.6)*
Farm A	Farm B	Personal/professional	0.7-25	1.8 (1.8)*

Source: Field Survey of 100 farms, 2001-2005

* standard deviation (SD)

Table VI
Average movement of pigs to and from selected pig farms

Category	Direction of movement From	To	Purpose	Distance (km)	Frequency in 21 days
Pig stock	Farm A	Farm B	Breeding	0.6-8	1 (0.8)*
	Farm	Market	Sales	0.4-130	1.5 (1)*
Stray pigs	Farm	Farm	Straying	0.4-2	2.8 (3)*

Source: Field Survey of 100 farms, 2001-2005

* standard deviation (SD)

Table VII
Average movement of trade middle-men to and from selected pig farms

Direction of movement From	To	Purpose	Distance (km)	Frequency in 21 days
Market	Farm	Purchase of pigs	2-150	0.5 (0.9*)
Farm A	Farm B	Purchase of pigs	2-180	2 (0.8)*
Farm	Market	Sales of pigs	2-150	0.7 (1)*

Source: Field Survey of 100 farms, 2001-2005

* standard deviation (SD)

Table VIII
Average movement of vehicles to and from selected pig farms

Direction of movement From	To	Purpose	Distance (km)	Frequency in 21 days
Feed mill	Farm	Feed delivery	2-17	2.3 (1.8)*
Farm A	Farm B	Feed delivery	0.2-25	1.4 (0.7)*

Source: Field Survey of 100 farms, 2001-2005

* standard deviation (SD)

The movements of ASF-carrier pigs into ASF-free pig herds, resulting in outbreaks, are shown in Figure 2. Seventy-one (71) such linkages were identified, which showed a characteristic pattern of ASF spread in the study area. The spatial distribution of ASF-free pig farms at 5, 10 and 15 km distances from ASF-infected herds in the study area is shown in Figures 3, 4, 5, 6 and 7. The probability of remaining ASF-free at a distance of 5, 10 and 15 km from ASF-infected herds in Lagos, Ogun, Ondo and Oyo States ranged from zero (Lagos and Oyo States) to 0.86 (Ondo State) (Tables IX, X and XI).

Discussion and conclusion

The continuous presence of recovered pigs in the population means there is a high probability that ASF-recovered pigs will be involved in stock trade and breeding activities. As a result of the critical role of trade, middle men and breeders' activities in the spread of ASF-virus carrier pigs, the pattern of spread of ASF outbreaks between 1997 and 2005 in

south-western Nigeria observed in this study can be described by the acronym 'TRAMMEBA' (**tra**de, **m**iddle **me**n and **b**reeders' **a**ctivities).

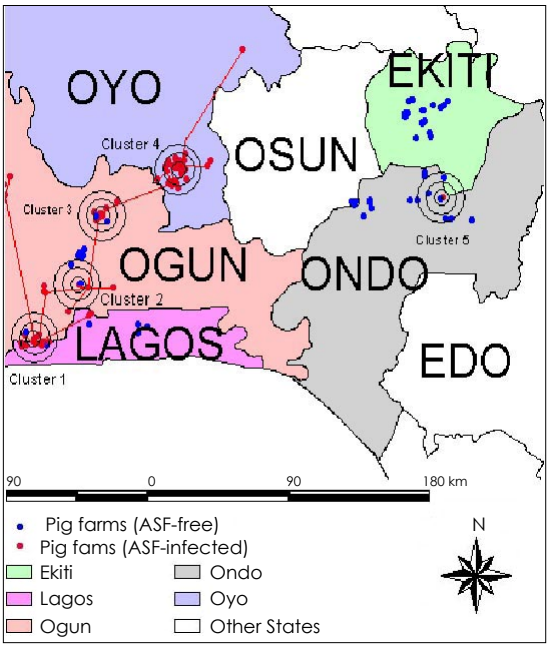

Figure 2
Pattern of spread of African swine fever in the study area, south-west Nigeria

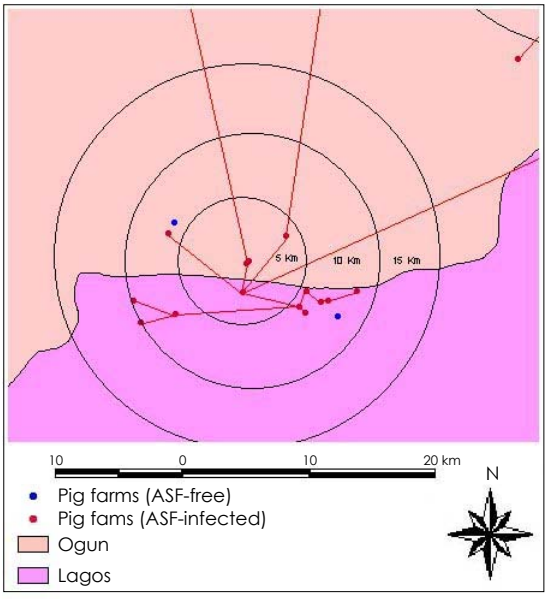

Figure 3
Pig farms free from African swine fever at distances of 5, 10 and 15 km from ASF-infected farms in Cluster 1 within Lagos and Ogun States of south-west Nigeria

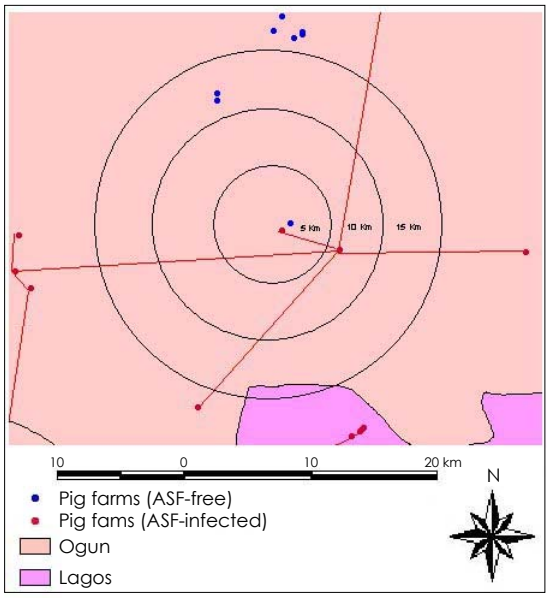

Figure 4
Pig farms free from African swine fever at distances of 5, 10 and 15 km from ASF-infected farms in Cluster 2 within Ogun State of south-west Nigeria

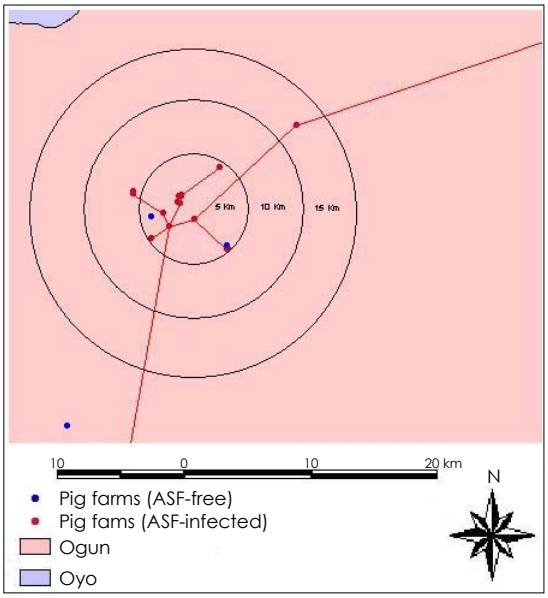

Figure 5
Pig farms free from African swine fever at distances of 5, 10 and 15 km from ASF-infected farms in Cluster 3 within Ogun State of south-west Nigeria

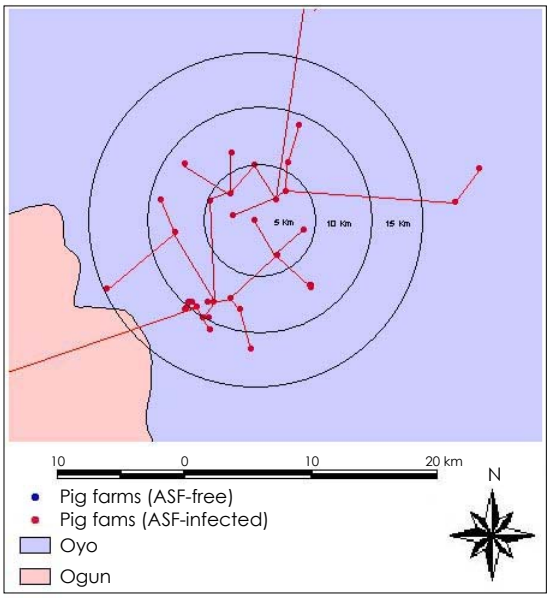

Figure 6
Pig farms free from African swine fever at distances of 5, 10 and 15 km from ASF-infected farms in Cluster 4 within Oyo State of south-west Nigeria

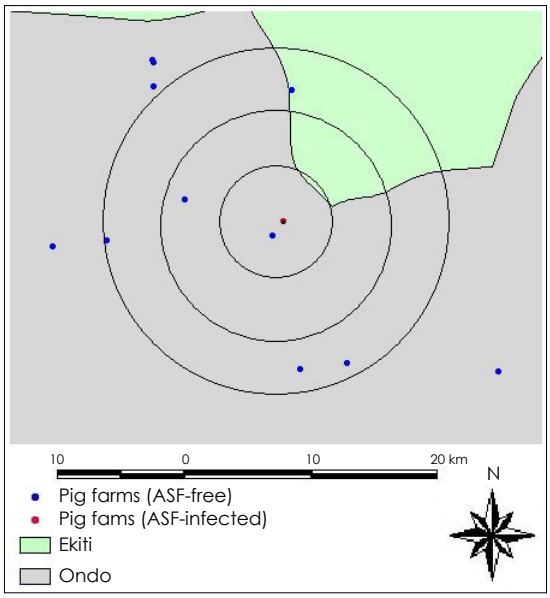

Figure 7
Pig farms free from African swine fever at distances of 5, 10 and 15 km from ASF-infected farms in Cluster 5 within Ondo State of south-west Nigeria

Table IX
Probability of remaining free from African swine fever at 5 km distance from an ASF-infected farm

Distance	Cluster 1 Lagos State	Cluster 2 Ogun State	Cluster 3 Ogun State	Cluster 4 Oyo State	Cluster 5 Ondo Stat
ASF-infected farms at 5 km	4	1	12	9	1
ASF-free farms at 5 km		1	2	0	1
Probability of being ASF-free at 5 km	0	0.5	0.14	0	0.5

ASF African swine fever

Table X
Probability of remaining free from African swine fever at 10 km distance from an ASF-infected farm

Distance	Cluster 1 Lagos State	Cluster 2 Ogun State	Cluster 3 Ogun State	Cluster 4 Oyo State	Cluster 5 Ondo State
ASF infected farms at 10 km	13	2	14	30	1
No of ASF-free farms at 10 km	2	1	2	0	2
Probability of being ASF- free at 10 km	0.13	0.33	0.13	0	0.67

ASF African swine fever

Table XI
Probability of remaining free from African swine fever at 15 km distance from an ASF-infected farm

Distance	Cluster 1 Lagos State	Cluster 2 Ogun State	Cluster 3 Ogun State	Cluster 4 Oyo State	Cluster 5 Ondo State
ASF-infected farms at 15 km	14	2	15	33	1
ASF-free farms at 15 km	2	3	2	0	6
Probability of being ASF-free at 15 km	0.13	0.6	0.12	0	0.86

ASF African swine fever

The TRAMMEBA chain identified in this study might have resulted from an existing but latent web of spread of ASF in south-western Nigeria. Previous studies (2) were unable to identify this TRAMMEBA pattern of disease spread because study scale was too local. This corroborates findings from an earlier report (10), namely that a GIS model is as good as its database accuracy. The TRAMMEBA pattern may serve as a practical basis for eradicating ASF in south-western Nigeria.

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