Carcass Disposal Methods during Major Epizootics: An Overview of African Swine Fever In Nigeria

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Abstract. Increased globalization, changes in livestock production systems, decline in animal health services and infrastructure especially in developing countries and global warming are factors that have contributed to the dynamic nature of transboundry animal diseases. In Nigeria, the management of livestock is also becoming increasingly difficult due to economic recession. Where these factors are not properly managed, a major epizootic may result. When there is a major animal disease outbreak, along with the need for immediate disease containment, a very significant question that relates to the method of handling potentially large number of dead animals will definitely arise. If stamping out method of disease control, the most common and successful approach particularly in exotic diseases such as Highly Pathogenic Avian Influenza or African Swine Fever (ASF) is chosen, the method of animal carcass disposal for slaughtered animals must also be decided. There are, also apart from disease outbreaks, many situations that may also lead to the death of animals in large numbers. These include natural disasters such as flooding or hurricanes, animal contamination by toxic chemical spills, ingestion of contaminated feed, large fires, and slaughter for animal welfare reasons such as starvation, humane culling, or deliberate bioterrorism. Although these situations could take advantage of the same planning strategy, in Nigeria, many farmers neither have any knowledge of the existence of regulatory control on carcass disposal nor has any been prosecuted for improper carcass disposal. This paper therefore examined methods of carcass disposal in Nigeria during major epizootics such as African swine fever.

Keywords. African swine Fever, mortality, carcass disposal, disease, livestock

Introduction

According to Beltrán-Alcrudo *et al.* (2017), within global livestock production, the pig sector plays a key role as a source of animal protein. Largely due to the increase in worldwide demand for meat, pigs have become a crucial food source due to their fast growth, efficient feed conversion, quick turnover, and prolificacy. Pork is the most consumed meat from terrestrial animals, accounting for over 37 percent of global meat intake, followed closely by chicken 35.2 percent and beef 21.6 percent (FAO, 2013). The pig sector has grown steadily over the past decades but the increase has been uneven around the globe. Large populations occur in China and parts of Southeast Asia such as Viet Nam, in Western Europe, Central and Eastern areas of the United States, Central America, and Southern Brazil (FAO, 2017). The sector is characterized by a deep divide between traditional, small-scale, subsistence productions and industrialized pig farming with increasing vertical integration. These two very different stakeholder groups have different priorities in adjusting production practices or investing in biosecurity to prevent and control pig diseases. Indeed, the backyard sector, characterized by low biosecurity, outdated husbandry practices and technologies, and poor awareness of, and compliance with, animal health regulations (outbreak reporting, movement control, certifications, vaccination, etc.) plays a major role in the introduction, spread, and maintenance of ASF and several other pig diseases(Robinson *et al.*, 2011; FAO, 2017).

African Swine Fever

African Swine Fever (ASF) is a highly contagious viral disease of domestic pigs; it manifests itself as a haemorrhagic fever and results in up to 100 per cent mortality (Fig: 1). The causative agent of ASF is a unique, enveloped, cytoplasmic, double-stranded DNA arbovirus, which is the sole member of the family *Asfarviridae*. Although it was generally considered that there is only one serotype of ASF virus, recent studies have reported the classification of 32 ASFV isolates in eight different serogroups based on a haemadsorption inhibition assay (Malogolovkin*et al.*, 2015).

The catastrophic effect of this disease on pig production, from household to commercial level, has serious socioeconomic consequences and implications for food security. It is a serious transboundary animal disease with the potential for rapid international spread (FAO, 2001).

Fig 1: Pig mortality during ASF incursion.

World Distribution of African Swine Fever

The disease was first described by Montgomery in 1921 in Kenya, ASF has subsequently been reported from most countries in southern and eastern Africa, where the virus is maintained either in a sylvatic cycle between warthogs (*Phacochoerusaethiopicus*) and ticks of the *Ornithodorosmoubata* complex or in a domestic cycle that involves pigs of local breeds, with or without tick involvement (FAO, 2001). Countries where endemicity is confined to the sylvatic cycle include Kenya, Namibia, Botswana, Zimbabwe and northern South Africa. A cycle in domestic pigs apparently occurs in Angola, the Democratic Republic of the Congo, Uganda, Zambia, Malawi, Northern Mozambique and probably the Congo (Brazzaville), Rwanda, Burundi and Tanzania. Madagascar experienced ASF for the first time in 1997–98; it caused serious losses and has not yet been eradicated (Plowright *et al.,* 1994).

The disease spread to Portugal in 1957, almost certainly from Angola. Although it was apparently eradicated, a second introduction in 1959 resulted in spread throughout the Iberian Peninsula and to several other countries in Europe, including France, Italy, Malta, Belgium and the Netherlands. It became well established in Spain and Portugal, where eradication was only accomplished in the early 1990s and remains endemic on the Italian Island of Sardinia. Portugal experienced an outbreak in late 1999, which was evidently rapidly contained.

In 1977, ASF spread to Cuba, where it was eradicated with the loss of some 400 000 pigs. Outbreaks occurred in Brazil and the Dominican Republic in 1978, Haiti in 1979 and Cuba in 1980.Eradication from these countries was achieved only by massive depopulation of pigs. Whether these outbreaks originated in Europe or Africa has never been established. African swine fever has been endemic in Cameroon since the first reported outbreaks in 1982.

In West Africa, it has been endemic in Southern Senegal, the Gambia and probably Guinea Bissau and the islands of Santiago and Mao in the Republic of Cape Verde. The disease has been present in this focus since at least 1958–60. An outbreak of ASF occurred in Nigeria in 1973. In 1996, Côte d'Ivoire experienced a massive outbreak that spread rapidly through the southern parts of the country. The last focus was extinguished by October 1996. In October 1997, ASF was reported in Benin, rapidly followed by Togo and two western provinces of Nigeria. Spread in these countries was rapid. In October 1999, ASF was reported in Ghana. Rapid implementation of control measures has apparently been successful, as no ASF has occurred since February 2000. Because of civil unrest in various regions and lack of disease reporting from some countries, the ASF status of a number of countries in Africa is unknown (FAOSTAT – http://www.fao.org/faostat/). All of the countries in sub-Saharan Africa that have significant pig populations must be considered to be infected, potentially infected or at risk from ASF.

In Nigeria, an outbreak of ASF occurred in 1973 in a piggery in Abeokuta, Ogun State where all the 3000 pigs in the farm died from the disease. In October 1997, ASF was reported in Benin, rapidly followed by Togo and in September 1997 the disease surfaced in free-ranging pigs in four local government areas of Ogun State, of Nigeria that have common borders with Benin Republic. The disease was first seen in villages alongside the lagoon passing into Nigeria from Benin Republic (FAO, 1998). According to Obi (2014), dead pig carcasses were seen in the lagoon and there was evidence that boats were traveling along the lagoon selling pig meat in Badagry Market and nearby villages. By December 1997 ASF was reported in Badagry in Lagos State, Nigeria and from the Lagos and Ogun State foci, the disease eventually spread to Osun, Oyo, Ondo, Ekiti, Edo, Delta, Anambra, Enugu, Abia, Rivers, Bayelsa, Akwa-Ibom, Cross-River, Benue, Kaduna and Plateau States of Nigeria. By October 1998 about 125,000 pigs had died of the disease in nine states resulting in estimated loss of N1.0 billion. In Benue State which accounts for about 21% of the national swine herd, 3,108 pig farmers in 20 out of the 23 Local Government Areas of the State were affected and 78 per cent of the 98,443 affected pigs died of ASF at an estimated financial loss of ₦ 335,954,000 ($2,777,777.78). According to Obi (2014), the national average monetary loss per pig rearing household was estimated at ₦ 55,655 ($154.60).

Apart from the immense financial losses from ASF, the outbreaks led to lack of capital for restocking, loss of confidence by pig farmers in the profitability of pig production as well as had demoralizing effects on pig marketers, loaders and pig processing enterprises and also resulted in loss of jobs. No doubt, ASF constitutes a major threat to national food security and income generation by the rural poor including women who predominantly own or tend pigs in different parts of the country. In the absence of bovine Rinderpest, ASF ranks highest among transboundary animal diseases that may have serious implication for animal protein supply and availability, for food security for the rural poor, could destabilize socio-cultural life in some areas of the country including stabilization of traditional marriages and burial rites.

Available Technology for Carcass Disposal

These technologies are presented as a hierarchy based on their reliability for pathogen inactivation (OIE, 2003).

Pyre Burning This is an open system of burning carcasses either on-farm or in collective sites fuelled by additional materials of high energy content. This is a well-established procedure that can be conducted on site with no requirement for transportation of the input material. However, this process is contrary to environmental standards for air, water, and soil. It takes an extended period of time and has no verification of pathogen inactivation. In fact, there is a possibility of particulate transmission from incomplete combustion. Further, because the process is open to view, there is a negative reaction and lack of acceptance by the public.

Composting This is a process of aerobic microbiological decomposition conducted in either open or closed systems. It preferably requires prior grinding of tissues and as well the addition of organic material for microbial maintenance. Additionally, mixing or aeration is required to assure homogeneous decomposition. This simple process, which can be conducted on site at low cost, can achieve temperatures of up to 70^{o}C. It does, however, require a significantly extended period of time. Further it is necessary to insure a constant temperature throughout the material for the total time period and it is difficult to verify the effectiveness of pathogen inactivation.

Licensed Commercial Landfill This process involves deposition of carcasses in predetermined and environmentally licensed commercial sites. Because the site has been previously licensed, all environmental impacts such as leachate management, gas management, engineered containment, flooding, and aquifers have already been considered. However, the area is open and uncovered for extended periods, there is a potential emission of aerosols, and there is resistance from the public to such an approach.

Fermentation This process is a closed system of anaerobic microbiological decomposition which requires prior mechanical and thermal treatment and which results in the production of biogas. This process does not inactivate pathogens, but typically uses non-dried rendered product as the input material.

Technologies under Development

Alkaline Hydrolysis Alkaline hydrolysis consists of treating carcasses or tissue in an aqueous alkaline solution at elevated temperatures under pressure. It converts proteins, nucleic acids, and lipids of all cells and tissues into a sterile aqueous solution of small peptides, amino acids, sugars, and soap. What remains are the mineral constituents of the bones and teeth. This process requires specialized equipment and operates at 150^{o} C for three hours. It completely inactivates pathogens with the exception of prions where infectivity is reduced, and is environmentally responsible.

Biosphere Process The biosphere process is a bio-refining technology which employs a biolytic hydrolyzer, operating under high temperature, steam pressure, and internal agitation in a sealed steel vessel. The process produces hydrolysis of protein and carbohydrate materials, fracturing long chain molecules and yielding sterile, high nutrient fertilizer as an output. It operates at 180^{o} C less than 12 atmospheres of pressure for a period of 40 minutes. It inactivates all pathogens and is environmentally sound. Inactivation of prions is still undetermined.

Special Considerations for Prion Diseases

One of the problems in demonstrating the effectiveness of the inactivation of prions (a small protein which is believed capable of infecting cells and causing self to be replicated though it does not contain nucleic acid) is the lack of a simple, rapid and inexpensive test for the presence of the infective agent, especially at low concentrations. The ultimate test is bioassay in a sensitive detector species by an efficient route, but usually this is only relevant in research. Typically this is done using panels of mice bred to be susceptible to particular types of transmissible spongiform encephalopathies (TSEs). However it must be recognized that the mouse to cattle species barrier has been demonstrated to be 500, therefore affecting sensitivity.

Although rendering at 133^{o} C and three bars of pressure for 20 minutes is a defined standard, reductions of infectivity by this technology are in the order of 1:200 - 1:1000. Commercial incinerators have an inactivation rate of one million fold, while burning on pyres has a reduction rate of 90%. (It should be noted that pyres are not suitable for sheep because of the wool and fat.) Alkaline hydrolysis produces a 3-4 log reduction in infectivity over a three hour period. Landfill and deep burial are suggested to have a reduction in infectivity of 98 - 99.8% over three years. Based on this information, rendering, incineration, and alkaline hydrolysis are the most reliable technologies at this time.

The significance of small amounts of infectivity become evident when you consider that experimentally it has been shown that exposure of sensitive species to as little as 1.0, 0.1 or even 0.01 grams of infected nervous tissue can induce infection. Given all of the above, it must be recognized that no process has been demonstrated to be 100% effective in removing TSE infectivity and there will be some residual levels of infectivity remaining after treatment.

Statutory Regulations of Dead Animal Carcass Disposal in Nigeria

Although Onyimonyi *et al.* (2013) reported that Animal Diseases Act of Nigeria provides that where any animal dies of a disease or is slaughtered in accordance with the provisions of this Act or is slaughtered otherwise than in accordance with the provisions of this Act and its carcass is in the opinion of the veterinary officer infected with disease, such carcass shall be disposed-off by burning or in such manner as the veterinary officer may direct. The Act provides for a punishment of 3 months imprisonment or a fine of ₦ 250 ($0.69) for any person who is guilty of an offence, non-compliance or contravention of this Act. The authors however noted that enforcement of the relevant provision of the statutes mentioned above is practically not in place as no prosecution of any offender of the provisions of these statues is known.

Again, statutory regulations on disposal of dead animal carcass in Nigeria appear not to discuss the disposal of dead animal carcasses where the cause of death is not disease (Onyimonyi *et al*., 2013).These practices no doubt will certainly promote the spread of ASF through movement of the infected pigs, contaminated carcasses and pork products especially during ASF outbreaks. As earlier pointed out, there are apart from disease outbreaks, many situations that could result in death of large number of animals. If we consider the massive destruction and waste of such large scale slaughter, one may thus come to the inevitable conclusion that there must be an alternative which will permit avoidance of this destruction while affecting the required disease control. Therefore the very best method of dealing with disposal of animal carcasses is to avoid the need to slaughter the animals.

Carcass Disposal Methods in Nigeria

The final report of the Avian Influenza Control and Human Pandemic Preparedness and Response Project (2007), identified the following technologies as reliable for carcass disposal/pathogen inactivation: rendering, incineration, compositing, burial, land filling and alkaline hydrolysis [www.jhuccp.org/whatwedo/projects/avian-influenza-control-and-human-pandemic-preparedness-and-response].

On the farm burial, burning and incineration of dead carcass were however observed to be the most practiced methods of disposing dead animals including pigs at major epizootics in Nigeria (Onyimonyi *et al*., 2013; Muhangi *et al*., 2015). Other reported improper disposal of pig carcasses in Nigeria included selling of dead/dying pigs for slaughter, throwing them in lagoons/rivers, bushes, slaughter and sent to market and giving pork from diseased pigs to neighbors (Onyimonyi *et al*., 2013; Obi, 2014; Muhangi *et al*., 2015). Figs 2 and 3.

Fig 2: Dead pigs disposed in garbage collection center

Burying, burning or incinerating are neither done in accordance with the recommendations of OIE (2003) nor follow any international guideline (Figs 2, 3, 4 and 5). According to animal disease emergencies carcass disposal method (www.iowaagriculture.gov), any burial action should be coordinated to ensure the selected site is away from water sources and public lands, has a steep slope greater than 15% and is in suitable soil.

Fig 3: Dead pigs disposed close to a stream

In Nigeria, no vaccine against ASF is presently approved. In the absence of vaccines, the only available option for ASF eradication is stamping out by slaughter and disposal of all infected and potentially infected pigs (FAO, 2001). Thus, all pigs on infected premises (IPs) and dangerous-contact premises (DCPs), or in a larger area if necessary, must be slaughtered immediately, whether they are obviously diseased or not (FAO, 2017). Owners should be asked to collect and confine their pigs the day before the slaughter team arrives. The animals should be slaughtered by methods that take account of animal welfare and the safety of operatives. The stamping-out approach require technology for animal carcass disposal as an integral component. According to FAO (2001), the carcasses of all pigs that die when there is an incursion of ASF should be disposed safely. This means disposal of the carcasses of animals that have been slaughtered or died naturally of the disease. It must be done in such a way that the carcasses no longer constitute a risk for further spread of the pathogen to other susceptible animals by direct or indirect means, for example by carrion eaters, scavengers or through contamination of food or water.

Fig 4: Decomposing pigs disposed in a bush

This is usually done by deep burial, depending on the nature of the terrain, level of water tables and availability of earth-moving equipment, or by burning, depending on availability of fuels and the danger of starting grass or bush fires (Fig 5).

Fig 5: Dead pigs set for disposal by burning in open air

If in situ disposal is not practical, it may be possible to transport carcasses in sealed vehicles to a disposal point. This should be done within the infected zone. It is not ideal, especially in countries such as in Nigeria where sealed vehicles for such purposes are not available and where vehicles in general are prone to breakdown due mainly to lack of maintenance culture and bad roads. If it must be done, provision should be made for an escort vehicle to disinfect any leakages and initiate salvage operations should the vehicle transporting the pigs develop technical problems or be held up. Whereas there are enabling statutory provisions that clearly stipulates the manner in which dead animal carcass shall be disposed in Nigeria, what is obtainable in practice is totally in contrast with the provisions of the statutes (Onyimonyi *et al*., 2013; Muhangi *et al.*, 2015; Jibril *et al*., 2016).Therefore, the country focuses much on prevention/control measures in the event of ASF outbreak.

Epidemiological Features influencing ASF Control/Eradication Strategies.

A number of epidemiological and other factors that favourably or unfavourably influence the strategies adopted and the ease of control/eradication of ASF in Nigeria have are as follows:

- Among factors that favourably impact on ASF control/eradication strategies include the fact that:
- It is an OIE listed viral disease
- High mortality and morbidity reaching 100 per cent
- It has no vaccine and no cure
- ASF is an emerging transboundary disease
- No domestic livestock species other than pigs is susceptible to ASF;
- Humans are not susceptible;
- *Ornithodoros* ticks that transmit ASF virus have not been described in Nigeria;
- ASF is a highly contagious and clinically apparent disease and disease recognition on the field should therefore be relatively easy.

  Those factors that are unfavourable to easy control/eradication include the facts that:
- The distribution of ASF in West Africa is not static and it is doubtful if some of the neighboring countries have adequate and effective early warning and early reaction capability to enable rapid detection and containment of the disease to the primary focus/i and eventual control or eradication. Therefore the threat of re-introduction of ASF into Nigeria from her neighbors remains high.
- In Nigeria, live pigs and pig meat are important means of spread of the disease. Scavenging and free-roaming pigs often seen feeding on village and abattoir/slaughter slab wastes and garbage play very significant role in spread of the disease among villages in Nigeria in the absence of the sylvatic cycle involving warthogs and *Ornithodorus moubata*.
- ASF virus is resistant to inactivation and may remain viable for long periods in fomites, infected pig tissues, meat and processed pig products;
- Many wild suid species and feral pigs are susceptible to ASF but may not develop overt disease;
- International, inter and intra state trade in live pigs and/or pig meat and products contribute to rapid dissemination of the virus in Nigeria;
- Although ASF is usually clinically apparent, it may be confused with other diseases by an inexperienced animal health personnel;
- Pigs that survive ASF infection may become carriers, although their role in transmitting the virus after about a month is uncertain; their tissues nevertheless remain infective for a period after active shedding has ceased;
- There is no vaccine available for ASF.

Strategies used for ASF Eradication in Nigeria

- In the absence of vaccines, the only available option for ASF eradication is stamping out by slaughter and disposal of all infected and potentially infected pigs. This is a proven method that has succeeded in eradicating ASF and other serious transboundary diseases.
- The main elements of a stamping-out policy for ASF are:
- Zoning of the country into infected zones, surveillance zones and free zones;
- Quarantine procedures to contain the disease, including pig-movement controls and prohibitions of the sale of potentially infected pig products;
- Enhanced epidemiological surveillance for ASF;
- Immediate slaughter of infected and potentially infected in-contact pigs, with prompt and fair compensation to owners;
- Safe burial or burning of carcasses and other infected materials;
- Cleansing and disinfection of infected premises;
- Keeping infected premises/villages without pigs for a safe period.

- Introduction of sentinel pigs for a period of sixty days before restocking.

Conclusion

This report examined methods of carcass disposal in Nigeria during major epizootics such as African Swine fever. Although there is no current reported case(s) of ASF in Nigeria as at the time of this report, our report show that in previous cases of ASF epizootics, the major methods of disposing carcass of dead pigs is by burying, burning or incineration. Other methods like composting, alkaline hydrolysis, licensed commercial landfill, biosphere process, etc are still under development.

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