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REGULAR ARTICLES

Variations in clinical presentation and anatomical distribution of gross lesions of African swine fever in domestic pigs in the southern highlands of Tanzania: a field experience

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Abstract African swine fever is a contagious viral disease responsible for up to 100% mortality among domestic pigs. A longitudinal study was carried out to determine the clinical presentation and anatomical distribution of gross lesions in affected pigs in Mbeya region, Tanzania during the 2010 to 2014 outbreaks. Data were collected during clinical and postmortem examination by field veterinarians and using a structured questionnaire. A total of 118 respondents (100%) showed awareness about African swine fever. During previous outbreaks, the mortality rate was almost 100%, while in 2014 it was estimated to be less than 50%.The clinical picture of the 2010–2012 outbreaks was characterized by high fever, depression, inappetance, mucosal congestion, hemorrhages, erythematous lesions in different body parts, and abortion. Several internal organs including the kidneys, spleen, and liver were congested and edematous. During the 2014 outbreak, a number of pigs (49.7%) were asymptomatic when brought to slaughter slabs but were found to have African swine fever gross lesions at postmortem examination as compared to 12.3% in 2010–2012. Bluish discoloration, which is normally distributed on the non-hairy parts of the body, was not apparent in some pigs except at postmortem examination. Some pigs (36.1%) presented nasal and/or oral bloody discharges which were uncommon (9.1%) during previous outbreaks. Moreover, other gross features included enlarged dark red renal lymph nodes and spleen. Clinical signs such as anorexia, diarrhea, and pyrexia were mainly observed when affected pigs reached moribund stage. The majority of pregnant sows died without presenting abortions. In some litters, suckling piglets (3–6 weeks) survived from the disease. These findings indicated that in 2014, African swine fever outbreak in Mbeya region was characterized by a different clinical picture.

Keywords Mbeya · Pig · African swine fever virus · Gross lesions

Introduction

African swine fever (ASF) is a highly contagious, deadly, hemorrhagic viral disease of domestic pigs. The disease is caused by a double-stranded DNA virus of the *Asfarviridae* family and genus *Asfivirus*. To date, there are about 22 identified African swine fever virus (ASFV) genotypes (I–XXII), characterized on the basis of nucleotide sequencing of the variable 3′-end of the B646L gene, encoding the major capsid protein p72 (Leblanc et al. 2012; Atuhaire et al. 2013; Misinzo et al. 2013; Dixon et al. 2013). The virus replicates in the cytoplasm of infected cells. African swine fever infection occurs through a complex transmission cycle involving domestic pigs, soft ticks, and wild African pigs and warthogs, which do not develop signs of the disease (Guinat et al. 2016). The ability of the virus to survive within a particular ecosystem primarily depends on the ecology of its wild host populations and their interaction with domestic pigs, which subsequently influences the host and vector species densities and interrelationships (Costard et al. 2013). The disease has high morbidity, especially in naive pig populations, and can lead to high

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mortalities. The mortality rate in domestic pigs is almost 100%, leading to serious socioeconomic impact on people's livelihoods (Atuhaire et al. 2013).

For many years, ASFV was confined primarily in the African continent. In East Africa, the disease was reported for the first time in Kenya in 1921 (Lubisi et al. 2005). During the mid-last century, it was also reported in Europe and later on also spread to South America and the Caribbean. In Europe, South America, and Caribbean except Sardinia, the disease was stopped through strict eradication programs (Guinat et al. 2016). Recent reports have indicated further spread of ASF, beyond traditional geographic boundaries, with introduction of p72 genotype II into the Republic of Caucasus, Georgia and its subsequent spread to Eastern Europe (Armenia, Azerbaijan, and Russia), where it has become endemic (FAO 2014). In Tanzania, ASF has been reported in the following regions: Mbeya, Arusha, Dar es Salaam, Iringa, Njombe, Katavi, Rukwa, Morogoro, and Kilimanjaro (Misinzo et al. 2013). Episodes of ASF outbreaks are common. For example, in Mbeya region, several episodes of outbreak were recorded at varying time intervals in 1987, 2001, 2003, 2010, 2011, 2012, and 2013/2014. The socioeconomic implication of ASF is enormous especially in families depending entirely on pig farming as a mean for subsistence. The endemic status of ASF has seriously affected the international trade involving pigs and their products. Currently, most of the African countries do not have a well-defined surveillance system in place to monitor ASF outbreaks.

The clinical manifestation of the disease in pigs depends on the strains of ASFV involved, the ecological zone, dose of the virus, and immune status of the host and an enzootic status of the disease. Pigs infected with less virulent isolates seroconvert without symptoms and may abort or develop chronic ASF (Atuhaire et al. 2013). Since there is no vaccine or treatment for the disease, control measures are mainly geared at timely detection of outbreaks and reporting to relevant authorities, compulsory slaughter or stamp-out, limited movement of potentially infected pigs, disinfection, and controlled visits to pig houses during the outbreak (Penrith et al. 2013). The socioeconomic implication caused by ASF is enormous due to death of pigs, feeding, and cost of disposal of dead pigs and other indirect losses (Chenais et al. 2015). The aim of this work was to study the clinical presentation and anatomical distribution of gross lesions in affected pigs in Mbeya region, Tanzania during the 2010 to 2014 ASF outbreaks in different smallholder pig farms in Mbeya region, west southern highlands, Tanzania (Fig. 1).

Materials and methods

Study area

This study collected data from Chunya district council, Mbarali district council, Mbeya district council, Mbeya city council, Mbozi district council, Ileje district council, and Rungwe district council in Mbeya region. Mbeya is one of

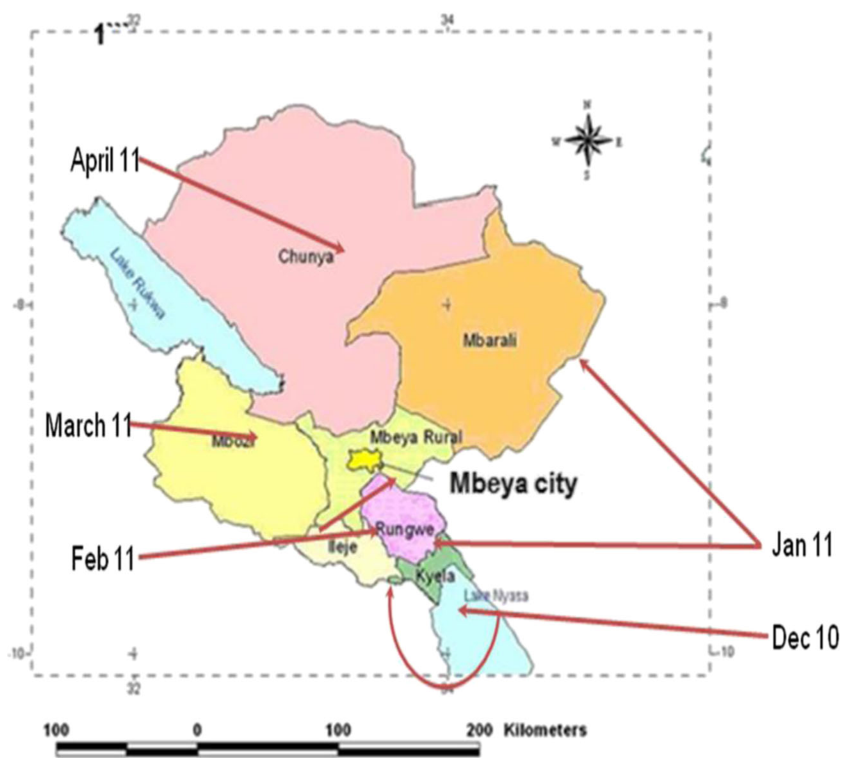

Fig. 1 A map of Mbeya region showing administrative districts/councils and dates outbreaks

the 30 regions of Tanzania and is located in the west southern highlands of Tanzania. Administratively, the region is divided into ten district councils, namely, Chunya, Mbarali, Mbozi, Ileje, Momba, Busokelo, Kyela, Rungwe, Mbeya district council, and Mbeya city council. Mbeya shares borders with countries of Zambia and Malawi to the immediate South, Rukwa region to the West, and Tabora and Singida regions to the North, while Iringa region lies to its East, with Tunduma and Kasumulu in Mbozi and Kyela districts, respectively, being the main entries and/or exist into neighboring countries of Zambia and Malawi. Its coordinates are 8°30′0″ S and 33°0′0″ E. Mbeya region lies at an altitude of 475 m above sea level, with high peaks of 2981 m above sea level. The general range of temperature is between −6 °C in the highlands and 29 °C on the lowlands. The weather from June until October is dry and cold. The heaviest rainfall occurs during the months of December to March. The area around Rungwe district and Mbeya town enjoys abundant and reliable rainfall which stimulates abundant agriculture on the rich volcanic soils. The average rainfall per year is around 900 mm. The rainy season is from November to May. According to the 2012 national census, the region had a population of 2,707,410 (USD 1269.18) (URT 2012).

Study design and data collection

This was a longitudinal study whereby seven out of ten districts of Mbeya region were purposively selected based on the pig population and previous history of ASF outbreaks. The total pig population in the study area was 155,957, and distribution among the study locations is summarized in Table 1. The study was carried out by considering all ASF outbreaks encountered from November 2010 to 2014. A semi-structured questionnaire was used as a tool for data collection and was administered to selected pig keepers and middlemen. Selection of pig farmers was purposively done based on the criterion that they kept pigs at the time of the study and had case(s) of ASF reported in their farm. Middlemen were also purposively selected based on the fact that they were persons involved in buying pigs from farmers and selling them to retailers or consumers. This was a farm-based study that involved face-to-face interviews with heads of pig farm (≥18 years old). Specifically, semi-structured questionnaires were administered to purposively selected pig keepers and middlemen to gather data on the number of pigs before and after the disease, control measures of ASF, sources of infection, knowledge on ASF, and socioeconomic losses caused by ASF. Clinical signs of ASF during outbreaks and the anatomical distribution of gross lesions were also recorded at farm level and from the slaughter slabs by veterinarians.

Table 1 Number of pigs in Mbeya region and deaths during the 2014 ASF outbreak

District	Number of pigs	Deaths due to ASF
Busokelo	21,982	0
Mbarali	11,889	0
Mbeya city	5,096	1592
Mbeya DC	22,412	366
Mbozi	6,914	0
Ileje	6,118	0
Momba	23,343	149
Kyela	32,877	0
Rungwe	19,815	36
Chunya	5,511	132
Total	155,957	2,275

Key informants

Key informants consisted of field veterinarians in the study area who also filled special forms for secondary data on the number of pigs in the districts and mortalities during various outbreaks. Veterinarians also filled special forms for secondary data on the number of pigs in the councils and number of pigs that died of ASF in the area under their jurisdiction. As part of animal diseases surveillance by the Ministry of Agriculture, Livestock and Fisheries, all veterinarians, by virtue of their position, are responsible to attend and report all cases by filling special animal diseases surveillance forms, which are normally collected daily from slaughter slabs and farms.

Clinical sign variations

Clinical sign variations and anatomical distribution of gross lesions were observed and recorded during clinical examination of sick animals and postmortem examination of dead animals. Furthermore, data on clinical signs were also collected by field veterinarians during routine field activities which involved pig farm visits, provision advisory services on animal production, and animal health management (e.g., routine deworming, iron injection, and treatment) and passive surveillances in the study area. Passive surveillance involved collection of animal diseases surveillance forms from slaughter slabs on a daily basis. In the context of this study, special emphasis was put on the most presenting clinical signs and anatomical distribution of classical gross lesions of ASF in affected animals. Furthermore, samples (sera, spleens, lymph nodes, and kidneys) were collected from clinical cases and were shipped to the Department of Microbiology and Parasitology, Faculty of Veterinary Medicine, Sokoine University of Agriculture for laboratory confirmation.

Data analysis and interpretation

Data were entered and summarized in Microsoft Excel spreadsheet and subsequently imported to Epi Info^{TM} software version 7 for further analyses. Descriptive statistics such as percentages, averages, and frequency were computed.

Results

Pig farmers' characteristic and livelihood sources

At total of 118 pig farmers were interviewed comprising (number of respondents in brackets) Chunya district council (15), Mbeya city council (15), Mbeya district council (17), Mbarali district council (16), Ileje district council (20), Rungwe district council (16), and Mbozi district council (19). The main economic activities for livelihood in the study area were reported to be crop farming, livestock keeping, and petty trading. Although pig farmers in the study area kept other animal species such as cattle, goats, and sheep, small-scale pig farming was an important source of livelihood and income as indicated by 100% of respondents. Mbeya region has a total of about 155,957 pigs (Table 1).

Knowledge on ASF and its control measures

All respondents (100%) showed awareness on ASF. Respondents knew ASF from massive death of pigs and clinical signs (80%), which included loss of appetite, bluish discoloration, change of movement, lying down, abortion, and huddling together. When respondents were asked on control measures for ASF, the following were some of the control measures applied in the study area: slaughtering or selling of affected animals to middlemen and butcher men at lower prices in Mbarali (83%) and Mbeya city (32%). It was also observed that following ASF outbreaks, 50 and 47% of respondents in Ileje and Chunya district councils respectively stopped keeping pigs. On the other hand, about 63 and 33% of respondents in Mbarali district council and Mbeya city council respectively moved their pigs from the affected to non-affected areas in an attempt to reduce losses due to mortalities. In Mbarali district councils, 93% of the respondents isolated sick animals from healthy ones and improved biosecurity measures by limiting access to pig houses. Disinfection of pig houses and premises was indicated as one of the reliable control measures of the disease, and this was indicated in Mbarali district council (100%), Mbeya city, and Rungwe district council (73%) while other districts ranged from 40 to 63%. In an attempt to fight against the disease, it was observed that Kyela, Rungwe, Mbarali district councils, and Mbeya city councils received reasonable support from the Ministry of Livestock and Fisheries in terms of finances (Tsh. 2,000,000.00), disinfectants (100 L), and motorized machines (Mbarali 1, Mbeya city 2, Kyela 2, and Rungwe 1) for disinfection of pig houses.

Sources of ASF infection during outbreaks in Mbeya region

The 2010 ASF outbreaks in Mbeya region started in Kyela district in southwestern Tanzania, after warnings from the neighboring district of Karonga in northern Malawi. Then the disease spread to the bordering region of Iringa in February 2011 through feeding pigs with contaminated feeds and live pigs which were transported illegally to Mbeya region. About 26% of ASF cases in Mbeya city resulted from introduction of live pigs in the area. In Ileje, Mbarali, and Mbeya district councils, 100% of ASF cases resulted from introduction of new pigs in the area. Feeds (not swills) were the source of infection in Mbarali (69%), Chunya, and Ileje (52%), and pig meat was observed to be the source of infection in Mbarali (50%) and Mbeya district councils (37%). Unauthorized animal health providers who could not abide by the biosafety and biosecurity measures were also reported to serve as source of infection from one farm to another in Ileje district council and Mbeya city council (26%).

Variations of clinical presentation and anatomical distribution of gross lesions

During the 2014 ASF outbreak, there were variations in the clinical picture as compared to previous (2010–2012) outbreaks. The variations were based on the extent of spread of the disease in the region where only five out of ten district councils were affected, mortality rates, anatomical distribution of gross lesions associated with the disease, number of pigs affected, and the clinical signs. The clinical picture of the 2010–2012 outbreaks was characterized by high fever (up to 42 °C); depression; loss of appetite; erythema on the lateral and medial part of the right and left ears, medial and lateral aspects of the hind limbs, and distal extremities; and abortion. Mucosal congestion and hemorrhages were also observed. Several internal organs including the kidneys, spleen, and liver were congested and edematous. On the contrary, during the 2014 outbreak, the classical clinical signs of ASF (EFSA 2014) were not apparent to some of the affected pigs. A number of pigs (49.7%) were asymptomatic when brought to slaughter slabs but were found to have ASF gross lesions during the postmortem examination as compared to 12.3% during 2010–2012 outbreaks. Bluish discoloration, which is normally distributed on the non-hairy parts of the body, was not apparent in some pigs except during postmortem examination. Some pigs (36.1%) presented nasal and oral bloody discharges which were uncommon (9.7%) during previous outbreaks. Moreover, other gross features included enlarged dark red renal lymph nodes and spleen. Clinical signs such as diarrhea and pyrexia were mainly observed when affected pigs reached moribund stage. The majority of pregnant pigs died of ASF without abortion. In some litters, suckling piglets (3–6 weeks) survived from the disease. Other pigs died from the disease without showing diarrhea and pyrexia, which are common clinical signs of ASF. Subnormal temperature was recorded from a small proportion of diseased pigs. Furthermore, laboratory tests using polymerase chain reaction (PCR) specific for ASF virus (ASFV), performed by partial amplification of the major structural protein (VP72) gene of ASFV using p72U and p72D primers delimiting an amplicon of 472 base pairs (bp), confirmed the outbreaks.

Mortalities due to ASF

All the ten districts of Mbeya region were affected by the ASF 2010–2012 outbreaks. In 2014, the disease was reported in only five districts. This outbreak was reported for the first time in Mbeya city and then spread to Rungwe, Mbeya, Chunya, and Momba council districts whereas Mbarali, Kyela, Mbozi, Ileje, and Busokelo districts were not affected. Mortality rate during the previous outbreak was almost 100%, while during the 2014 outbreak, it was estimated to be less than 50% ($n = 25$). During the 2010/2012 outbreak, more than 15,017 pigs died of ASF within a period of 2 years. During the 2014 outbreak, a total of 2275 pigs died of ASF for a period of 1 year (Table 1). Pigs reported to die of ASF during sampling (passive surveillance) in Chunya, Mbeya, Rungwe, and Momba district councils and Mbeya city council were 314 out of 471 (66%) equivalent to 34% survival rate (Table 2).

Socioeconomic losses associated with ASF outbreaks

All respondents interviewed ($n = 118$) kept pigs as source of pig farmer's income. The average price of pigs before the disease was about Tsh. 84,113.00 and sharply dropped to an average of about Tsh. 44,400.00 during and immediately after ASF outbreak. Pig keepers sold their animals to middlemen as a coping mechanism to avoid losses from the disease. Many pig keepers therefore decided to dispose of their pigs to middlemen at lower prices as it was revealed in Mbarali district council (83%) and Mbeya city council (32%). In Mbarali district council, 83% of respondents tried to isolate sick pigs from healthy ones in order to control the spread of the disease in the pig houses. Some pig keepers especially in Mbarali (63%) and Mbeya (33%) tried to shift their pigs from the affected to non-affected areas in order to rescue their pigs from the disease. Other pig keepers decided to stop keeping pigs in Ileje (50%) and Chunya (47%) including some pig projects proposed to be financed by District Agricultural Development Plans (DADPs) that were also terminated. Farmers in Mbeya city council were the most affected by ASF with an overall loss of Tsh. 31,249,667.00 (USD 14,631.72), and Mbarali district council was the least affected with an average of Tsh. 2,220,000.00 (USD 1,039.45) total loss. Other direct losses were from purchases of drugs for treatment of the ASF-infected animals (Tsh. 25,288.00; USD 11.84), disinfections (Tsh. 16,898.00; USD 7.91), and feeds (Tsh. 149,867.00; USD 70.17); indirect costs were in the form of education and were significantly high in Mbeya city council (Tsh. 820,000.00; USD 383.94), followed by Mbeya district council (Tsh. 478,250.00; USD 223.93) and Mbarali district council (Tsh. 176,500.00; USD 82.64); in the form of health aspect, Mbarali was ranked high to Tsh.127,500.00 (USD 59.7) followed by Mbeya district council (Tsh. 114,167.00; USD 53.46) and Mbeya city council (Tsh. 104,894.00; USD 49.11) as summarized in Table 3.

The losses due to ASF in agriculture were high in Mbarali. In terms of business, the losses were high in Mbeya city and Mbeya district councils. Other losses were high in Mbarali district council. The losses due to abortions in infected sows were high in Mbeya district council where about nine (9) abortions were reported. Losses due to deaths of animals were high in Mbeya city. Sales of pigs as a coping mechanism was mostly reported in Mbeya city and Mbarali district councils.

Table 2 Pigs reported to die of ASF during sampling (passive surveillance) in Chunya, Mbeya city, Mbeya, Momba, and Rungwe district councils

Council	Number of farmers	Number of pigs before outbreak	Number of deaths due to ASF	Death (%)
Chunya	8	63	41	65.08
Mbeya DC	6	104	44	42.31
Mbeya city	5	177	141	79.66
Rungwe	3	42	22	52.38
Momba	3	85	66	77.65
Total	25	471	314	66.67

Table 3 Summary of indirect losses as indicators of socioeconomic impact of ASF

Council	Costs (Tsh./hh)					
	Indirect	Education	Health	Agriculture	Business	Others
Chunya	0.00	231,333.00	118,000.00	180,000.00	254,666.00	5,000.00
Ileje	895.00	27,631.00	37,631.00	47,000.00	20,000.00	28,684.00
Mbarali	8,125.00	176,500.00	127,500.00	970,100.00	56,625.00	25,000.00
Mbeya DC	83,333.00	478,250.00	114,167.00	318,333.00	197,500.00	66,667.00
Mbeya city	75,789.00	820,000.00	104,894.00	97,105.00	74,210.00	10,526.00
Rungwe	6,250.00	131,250.00	73,750.00	141,250.00	0.00	0.00

Discussion

African swine fever is an important, highly contagious hemorrhagic viral disease affecting swine. Notification of outbreaks is mandatory due to its high mortality rates and the great sanitary and socioeconomic impact it has on international trade in animal and swine products. Thus, the current endemic situation of ASF in sub-Saharan Africa and Europe is a major threat to the pig industry worldwide. This study was carried out to elucidate the clinical picture of ASF outbreaks in Mbeya region in Tanzania based on the spatial and temporal retrospective data retrieved from daily and monthly reports from District Veterinary Officers (DVOs). The study also aimed at describing and comparing clinical signs and anatomical distribution of gross lesions of ASF in pigs during different outbreaks which occurred between 2010 and 2014. Pig keepers, DVOs, and middlemen were interviewed on the characteristics of ASF outbreaks in their areas of jurisdiction by use of a structured questionnaire and interviews. African swine fever outbreaks occurred during the entire period of study (2010–2014). Consistent with previous studies in Tanzania and other East African countries like Uganda (Atuhaire et al. 2013; Misinzo et al. 2013), our research findings have proved that ASF is endemic in districts of Mbeya region since throughout the study period, the disease was reported through passive surveillance tools.

Pig keepers in the sub-Saharan Africa region continue to experience waves of outbreaks of ASF on an annual basis. Difficulties in eradicating ASF result from its complex epidemiology and complex virus, and is further complicated by the booming pig meat business especially in cities, which has increased the movement of pigs and their products from one location to another (Lubisi et al. 2005; Misinzo et al. 2013; Guinat et al. 2016). Pig keepers in Mbeya region were aware of ASF as evidenced by a high proportion of respondents who knew ASF from its clinical picture, as a disease characterized by massive death of pigs, loss of appetite, bluish discoloration, change of gait, abortion, and huddling together. Similar findings indicating a high level of awareness have been reported by studies carried out elsewhere (Muhangi et al. 2014). Although most pig farmers interviewed in the study area indicated awareness on ASF, they could not identify some of the pigs with ASF until when such cases were depicted by field veterinarians at the slaughter slabs during meat inspection. This was due to the fact that not all cases presented the classical clinical signs of ASF.

Previous studies have also shown that the clinical signs and lesions suggestive of ASF may vary with virulence of the virus and endemic status of the disease and other factors including the environment and the host immune status (Penrith and Vosloo 2009; Guinat et al. 2016). Such variations may have contributed to the observed differences in severity and clinical picture of ASF during various outbreaks. This phenomenon was apparent when features of ASF outbreaks that occurred in different districts of Mbeya region, between 2010 and 2014, were compared. During 2010–2012 outbreaks, animals suspected to have ASF presented almost all classical signs of ASF. However, the 2014 ASF outbreaks presented a different clinical picture where the disease was characterized by relatively lower morbidity and mortality rates. Some animals were asymptomatic when brought to slaughter slabs, but were found to have ASF gross lesions during postmortem examination. Differences in gross lesions were in terms of reduced erythematous lesions on the lateral and medial part of the right and left ears, medial and lateral aspects of the hind limbs, and distal extremities. Other classical lesions like mucosal congestion and hemorrhages were also not apparent. Several internal organs including the kidneys, spleen, and liver, apart from being congested and edematous, were also enlarged. These findings were at odds with previous studies, where non-classical clinical signs were observed in places and the disease was reported for the first time (Gallardo et al. 2015; Sánchez-Vizcaíno et al. 2015).

Most field veterinarians use classical clinical signs and anatomical distribution of gross lesions to tentatively diagnose ASF, especially in rural settings where laboratories and diagnostic facilities are in serious shortage. It is worth noting that presentation of non-classical signs of ASF might have contributed to a substantial number of cases to escape undetected at farm level and therefore underreported. Indeed, in this report, we provide data indicating that some of the pigs were only suspected of having ASF, during postmortem examination, since the diagnosis of such cases under field conditions and in the absence of confirmatory tests was complicated by the lack of specificity of classical clinical signs and pathological lesions.

Furthermore, during the 2014 ASF outbreak, only half of the district councils of Mbeya region were affected, and the disease was characterized by low mortality rates and non-classical clinical signs. Previous studies elsewhere have suggested that in areas where ASF is endemic, mortality rates tend to decrease and sub-clinical or chronic ASFV infections may become more frequent (Atuhaire et al. 2013; Gallardo et al. 2015). In line with previous studies, findings from this report highlight the potential role of survivor pigs in the disease maintenance and dissemination in areas where moderate to low virulent viruses may be circulating and the disease may have attained endemic status (Gallardo et al. 2015). Another plausible explanation for the observed differences in the clinical picture and anatomical distribution of gross lesions could be due to differences in the viral strains, responsible for the various outbreaks during the study period. Although AFS cases in the present study were not confirmed and viral strains not genotyped by diagnostic laboratory tools, this scenario is not likely to apply because previous studies reported that all outbreaks in Mbeya region and other parts of Tanzania were mainly due to infection by the virulent p72 genotype II ASFV identical to the Georgia 2007/1 (Misinzo et al. 2013, 2014).

The socioeconomic implication of ASF in the small-scale piggery industry is higher for the reason that pork meat in developing countries like Tanzania provides an affordable source of high-quality protein and serves as a reliable source of income to pig farmers. Eradication of ASF is likely to have a direct impact on poverty alleviation and by minimizing losses associated with disease. The socioeconomic implication of the disease was in the form of substantial reduction of household income generated from pig keeping. Unless strict control measures are designed and implemented, frequent ASFV outbreaks imply that pig keepers will continue to suffer from economic losses in affected communities because of live pig market and pig meat business bans. Furthermore, in the absence of strict zoo-sanitary measures, porosity of borders and unregulated movement of live pigs and/or their products are the major issues of concern when considering control and prevention of future ASF outbreaks. In the context of the 2014 ASF outbreak in Mbeya region, the disease was imported from the neighboring regions, and its spread was attributed to lack of knowledge on how to control the disease and porosity of the borders especially between Tanzania and Malawi. Certainly, most of the outbreaks especially in 2010 started from Kyela district. This was driven by stringent ASF control measures in Karonga district in Malawi where almost all pigs in the affected area were killed, thus propagated illegal transfer of live pigs and contaminated maize bran to Tanzania via Kyela district. Ritual dances which included pork meat consumption also contributed to the spread of the disease especially at the border between the two countries.

Furthermore, middlemen played a big role in spreading ASF by moving diseased pigs from the affected areas, where they were sold at a throwaway price or sometimes in terms of loan agreement then transported them to unaffected area to sell them at high prices to maximize profit. Extremely poor biosafety and biosecurity measures at farm level also contributed to spread the disease from one location to another. In some cases, introduction of infected live pigs from other places was a common practice that also contributed to the fast spread of ASF infections. Furthermore, smuggling of infected pigs had a substantial contribution in the spread of the disease. Feed for pigs was another source of infection especially in Mbarali (69%), Chunya, and Ileje (52%), and pig meat was observed to be a source of infection in Mbarali (50%) and Mbeya (37%). Even when quarantine was reinforced in Rungwe district, still businessmen and other people devised alternative means including transporting pig meat by mixing with other food material like banana or even maize to unaffected areas. This behavior was a cause of outbreak of ASF crossing from Tukuyu in Rungwe district council to Igurusi in Mbarali district council due to the close relationship of communities in the area.

In conclusion, African swine fever continues to cause a serious threat to pig keepers in Mbeya region. The 2014 ASF outbreak presented a different clinical picture. Differences were noticed particularly with respect to the number of districts affected in Mbeya region, morbidity and mortality rates, and anatomical distribution of gross lesions. Generally, a small number of pigs were affected as compared to previous outbreaks. Clinically, the disease was characterized by non-classical clinical signs of ASF. Some pigs were asymptomatic when brought to slaughter slabs but were found to have ASF gross lesions during the postmortem examination. These findings highlight the potential role of survivor pigs in the disease maintenance and dissemination and that the disease in Mbeya region may have attained endemic status. Unless strict control and preventive measures are instituted, the region will continue to experience waves of ASF outbreaks characterized by non-classical clinical signs.

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Compliance with Ethical Standards

Competing interests The authors declare that they have no financial or personal relationships which may have inappropriately influenced the writing of this article.

Ethics statements The ethical clearance for conducting this study was granted by the Institutional Review Board of Sokoine University of Agriculture (SUA/FVM/R.1/9). Permission to conduct the study in Chunya district council, Mbarali district council, Mbeya district council, Mbeya city council, Mbozi district council, Ileje district council, and Rungwe district council in Mbeya region was sought and granted by regional and district livestock officers. Additionally, a verbal consent was sought from each participant after the authors had explained the aim of the study to them. This study adhered to the Tanzania Animal Welfare Act (Anonymous 2008).

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