Category: REVIEW

THE AFRICAN SWINE FEVER EPIDEMIC IN WEST AFRICA, 1996 - 2002

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ABSTRACT

African swine fever (ASF) is a contagious, highly fatal, haemorrhagic viral disease that only affects members of the *Suidae* family. Currently no vaccine or treatment exists, so the disease has potentially devastating consequences for the pig industries, availability of affordable protein livelihoods and trade.

This study aimed to consolidate historical information generated by working towards the control and eradication of ASF in previously unaffected countries in West Africa during 1996-2002. This descriptive analysis entailed the evaluation and review of archived records and reports of outbreaks, data from veterinary services, veterinary consultants and peer-reviewed publications. Specifically, the analysis focused on establishing the sequence of events in the spread of the disease throughout the region, as well as the possible sources and pathways (mostly human-driven, i.e. movement of pigs and swill feeding). The socioeconomic aspects of the epidemic were also assessed. Finally, the prevention and control measures applied were described and evaluated.

Major challenges for control that were identified involved lack of capacity to respond to an outbreak of animal disease and the nature of the pig sector in the affected countries. Most of the pigs were produced in low biosecurity subsistence husbandry systems. Actions taken by producers to limit economic losses due to the epidemic (e.g. illegal selling of pigs and infected pork, hiding of outbreaks) increased the risk of spread and frustrated control efforts. The disease has persisted in an

endemic state ever since and has negatively affected pig production and marketing in most of these countries.

The analysis of this information will allow a better understanding of the disease dynamics in a region infected for the first time, and learning how the prevention and control interventions that were implemented worked or failed. This will help the development of better tailored, sustainable and locally sound interventions. The authors provide a set of recommendations for ASF prevention and control.

Keywords: African swine fever; emerging diseases; historical; West Africa

1. INTRODUCTION

African swine fever (ASF) is a contagious, highly fatal, haemorrhagic disease of pigs caused by African swine fever virus (ASFV), the only member of the *Asfarviridae* family. Historically, it was confined to East and southern Africa, where the virus evolved and is maintained in an ancient sylvatic cycle between the common warthog (*Phacochoerus africanus*) and argasid (soft) ticks of the *Ornithodoros moubata* complex that live in their burrows (Plowright *et al.*, 1969; Thomson *et al*., 1983; Thomson, 1985; Jori *et al*., 2013). Since the middle of the last century, it has become widespread in domestic pigs throughout sub-Saharan Africa (Penrith *et al*., 2013). The most striking event was the epidemic in West Africa, which started in Côte d'Ivoire in 1996, followed by outbreaks in Benin, Nigeria and Togo in 1997, Ghana in 1999, and eventually Burkina Faso in 2003 (Bastos *et al*., 2003; Penrith *et al*., 2013). These newly infected countries, which had significant and fast-growing pig populations, became ASF endemic. Only Côte d'Ivoire and Ghana managed to eradicate ASF. Côte d'Ivoire remained ASF-free until August 2014, when an outbreak was reported in the port city of San Pedro (OIE, 2014). The source of the outbreak was probably ship galley waste that was deposited at an open landfill, as pigs that scavenged on the landfill were reported to have been the first to die. Ghana eradicated ASF by early 2000, but only briefly until it was re-introduced and became endemic.

In West Africa, ASF had first been recorded in Senegal in 1959 (Etter *et al*., 2011). It was later found to also be established in Guinea-Bissau, The Gambia and Cabo Verde (Penrith *et al*., 2013). During the 1990s epidemic, ASF outbreaks continued to be reported in already affected Cabo Verde (1996-1999), The Gambia (1997 and 2000) and Senegal (1996-1999, 2001 and 2002) (OIE Handistatus II, 2015a). Guinea-Bissau only began to report ASF to the World Organisation for Animal Health (OIE) in 2002. All of these countries had relatively small pig populations in the 1996-2002 period (FAOSTAT,

2015), i.e. Cabo Verde (between 100,000 and 200,000 heads), Gambia (14,000-16,000), Guinea-Bissau (310,000-353,000) and Senegal (171,000-291,000).

Although the infection of new countries appeared to be arrested after the introduction of ASF into Burkina Faso in 2003, ASF remains active in the region, with regular reports of outbreaks in Benin, Burkina Faso, Ghana, Nigeria and Togo. Reports of ASF from the western endemic focus of Cabo Verde, The Gambia, Guinea-Bissau and Senegal are sporadic, but in April 2015, the island of Boa Vista, Cabo Verde, never previously infected, experienced a devastating outbreak of ASF (OIE, 2015b), followed by a report of an outbreak on Santiago Island (OIE, 2015c). Most recently, the first outbreak of ASF was reported from Ségou, in southern Mali on the border with Burkina Faso, attributed to the illegal movement of pigs (OIE, 2016).

This study focuses on the outbreaks that occurred in the newly infected countries during the period 1996 to 2002 and for which assistance was received from the Food and Agriculture Organization (FAO) (Côte d'Ivoire, Benin, Nigeria, Togo and Ghana) (Table 1). Assistance was also provided by FAO to Cabo Verde and The Gambia, and all affected and at-risk countries in West Africa were included in a regional project. The assistance was provided in the framework of Technical Cooperation Programme (TCP) projects, which arise from agreements between the Government of a country and FAO, whereby the latter provides its knowledge and technical expertise upon request, drawing from its own resources and those of its network of Reference Centres. ASF-focused activities included enhancing local capacity for rapid response to outbreaks, recovery efforts, disease prevention and control, and improvement of standards and practices in support of livestock industries.

Table 1. FAO-funded projects on African swine fever (ASF) in West Africa (1996–2001)

Country	Duration
Côte d'Ivoire	01 July 1996–01 March 1997
Benin	01 October 1997–01 July 1999
Togo	01 March 1998–01 January 2000
Cabo Verde	01 April 1998–01 September 1999
Nigeria	01 April 1998–01 January 2000
Burkina Faso, Cameroon	01 April 1998–01 September 1999
Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia and Senegal	
Ghana	01 November 1999–01 August 2001
The Gambia	01 June 2000–31 May 2001

Despite the generation of a large amount of information as a result of the various activities carried out by veterinary services and international organizations, such as FAO, throughout the region, much

of these data have remained archived and unpublished or only partially published. As a result, the dynamics and underlying factors driving this epidemic have not been fully elucidated or exploited.

The frequent outbreaks in the sub-region are indicative of the weaknesses in the prevention and control strategies in use. This may correspond with a general lack of resources, as well as the gaps in understanding the underlying factors that facilitate ASF spread. Better understanding would allow for the development of more effective prevention and control strategies. These would be of great value to the veterinary services and the rapidly expanding pig industry, as the issue affects participants at all levels, from the smallholder subsistence pig farmer to the large-scale commercial operator. The aim of this study was to consolidate information amassed from various sources on the 1996-2002 ASF epidemic in West Africa. This will contribute to a better understanding of the ASF dynamics in the region. Data gathered include disease events, ASF prevention and control measures implemented, the socio-economic aspects of pig production, and the structure of the pig sector in different countries and how it was affected by the epidemic. With this in mind, the main objectives of this study include the following: (1) Map the outbreaks in the affected countries and establish the sequence of events in the spread of the disease throughout the region; (2) Establish possible sources and pathways of introduction and spread of infection; (3) Identify risk factors implicated during and after the epidemic; (4) Describe existing socioeconomic structures and pig farming systems; (5) Describe how these were affected and determine the magnitude of direct and indirect losses due to ASF; (6) Describe and evaluate the prevention and control measures applied.

2. SOURCES OF INFORMATION

This descriptive analysis entailed the compilation and review of existing, archived data collected by veterinary services, FAO and others. These included records of outbreaks, project reports, scientific papers, personal communications and other official records. Journals and other publications were obtained by searching online databases, as well as being provided directly by the authors themselves, liaisons and other persons cooperating with this project.

Some outbreak data were retrieved using EMPRES-i, which is the global animal health information system of FAO's Emergency Prevention System in animal health (EMPRES). Outbreak data were also sourced from the OIE in the form of the FAO-OIE Animal Health Yearbook (hardcopy), OIE Handistatus II and the World Animal Health Information Database (WAHID).

Statistical data on pig production were obtained through FAOSTAT, the corporate statistical database maintained by the FAO through its working directly with countries (FAO, 2015). These data

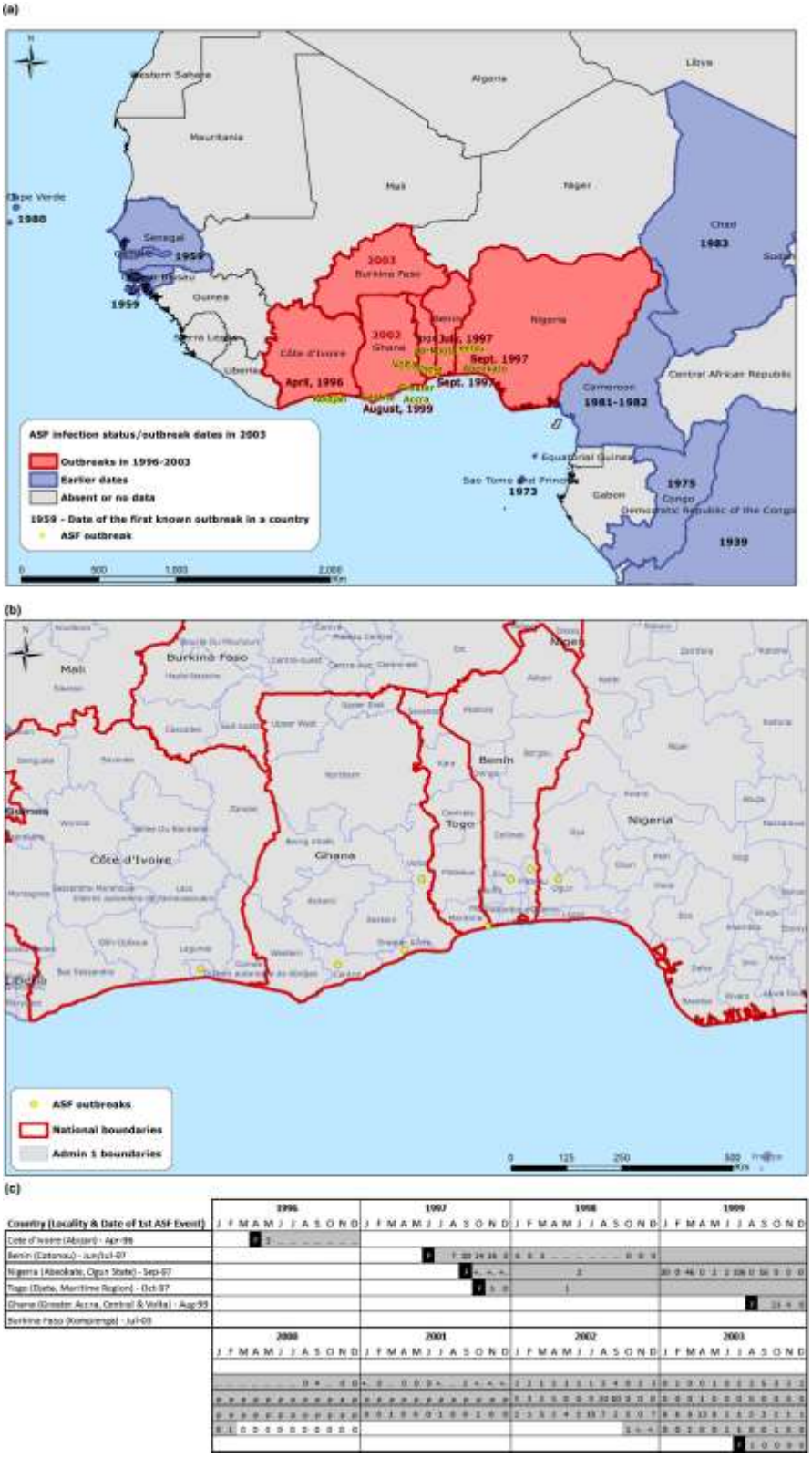

Figure 1. African swine fever between 1996 and 2003 in West Africa: the whole region (a), zoomed (b) and the timeline in newly infected countries (c). (F = observation date of 1st outbreak; +.. = disease present, number of outbreaks unknown; … = no information available; p = ASF presence, but outbreaks not disclosed by month) (Source: OIE, 2016). Dates from outbreaks reported to OIE refer to the reporting, rather than the observed date); the disease remained endemic in all countries (up to today, with outbreaks reported yearly), so the zeros in the OIE reports for some countries in 2003 are just circumstantial for those particular months

were used in Microsoft Excel to generate graphical representations of pig production in West African countries. ESRI ArcGIS 10.1 software was used to map ASF outbreaks in the region (Figure 1).

3. POSSIBLE ORIGIN AND INTRODUCTION OF OUTBREAKS

The available molecular genetics and historical evidence support domestic pigs and/or their products (e.g. pork) as the source of introduction of ASF into West Africa. Based on genotyping using the p72 gene, to date only one genotype (genotype I) has been recovered in West Africa (Bastos *et al*., 2003; Phologane *et al*. 2005; Luka *et al*., 2016). The virus isolated from the Dakar outbreak in 1959 was not distinguishable from the virus in Europe at that time or a virus from Angola that was believed to have been the source of the introduction into Europe (Bastos *et al*., 2003). Within Eastern and southern Africa where sylvatic cycle occurs in addition to the domestic pig cycle, 23 p72 genotypes (I to XXIII) have been identified (Bastos *et al*., 2003; Boshoff *et al*., 2007; Achenbach *et al*., 2016). A sylvatic cycle involving wild suids has never been demonstrated in West Africa (Penrith *et al*., 2004; Jori *et al*., 2013).

The geographic origin of the infected material that was believed to be the source of the first reported outbreak in Côte d'Ivoire was not established. Molecular genetic characterization of viruses from the ASF outbreaks in Côte d'Ivoire, Benin, Togo, Nigeria and Ghana during the period 1996 – 2000 using the p72 gene for genotyping and the central variable region (CVR) of the *9RL* open reading frame to establish subtypes (Phologane *et al*., 2005) revealed that the viruses all clustered within a single subtype but the CVR product differed from that of all the viruses used for comparison (Phologane *et al*., 2005).

The introduction of ASF into Côte d'Ivoire (Figure 1), is believed to have occurred on 16 April 1996 in Abidjan, affecting pigs fed exclusively on food waste collected from a skip in a suburb inhabited by many diplomats and other expatriates (El Hicheri *et al*., 1998). Subsequent outbreaks in Côte d'Ivoire were invariably traceable to the movement of infected pigs or pork (El Hicheri *et al*., 1998). ASF had never been reported from Côte d'Ivoire or any of its immediate neighbours (Liberia, Guinea, Mali, Burkina Faso and Ghana) (M.-L. Penrith, 1996, unpublished data; Etter *et al*., 2011). Around the time of the outbreak in Côte d'Ivoire, none of the neighbouring countries reported infection and the disease did not appear to have spread beyond national borders (M.-L. Penrith, 1996, unpublished data).

The primary source of the outbreaks that occurred in Benin in June/July 1997 was never established. The index case was in a neighbourhood of Cotonou (Hende) located near the "international market" in Dantokpa, Akpakpa District, where merchants of the entire sub-region gathered. It is therefore

possible that infected pigs or pork were introduced by this route (K. El-Hicheri, 1998, unpublished data). From Benin, ASF spread rapidly, with cases subsequently reported in neighbouring Nigeria and Togo (Figure 1).

The considerable interval between eradication of ASF in Côte d'Ivoire (the last case occurring in October 1996) and the reporting of the disease in Benin in mid to late 1997 suggests separate sources of virus in these two outbreaks. However, it is possible that the virus remained undetected in infected products during that time, or outbreaks may have occurred without official reports at this time.

In Nigeria, Babalobi *et al*. (2007) reported that an unconfirmed but probable ASF outbreak occurred on a commercial piggery in Ogun State in 1973, in which all of the pigs died. No further reports of ASF occurred until September 1997, when outbreaks of high mortality in pigs were reported in four local government areas of Ogun State bordering Benin and around the city of Lagos. Confirmation was obtained only in 1998 when an affected cooperative farm in Agege, Lagos, was tested (Odemuyiwa *et al*., 2000; Otesile *et al*., 2005; Babalobi *et al*., 2007).

In Togo, the first ASF outbreak was reported in October 1997 in Djéta, a quiet fishing village with pig farmers located in the Prefecture of Lac, Maritime Region, on the border with Benin (K. El Hicheri, 1998, unpublished data; OIE, 1998). The source of infection was reported to be infected pigs bought cheaply in Benin and disposed of in Djéta (I. Makedonski, 1998, unpublished data). New foci subsequently appeared and it was not established whether these all originated from Djéta or were the result of independent introductions.

Incursion of ASF into Ghana in 1999 was probably related to the widespread occurrence of the disease in neighbouring countries (Figure 1). The initial introduction is believed to have been the result of swill feeding. Epidemiological investigations revealed circumstantial evidence that pork originating from Togo had been mislabelled as originating from France in order to circumvent movement bans (F.G. Davies, 1999, unpublished data). Introduction into Ghana would have been facilitated by the impossibility of curtailing the movement of people, pigs and pork products across the porous border and by the closely related communities living on either side of the border, which traditionally reared free-ranging pigs penned only at night. Subsequent spread in Ghana likely resulted from the illegal movement of pigs and/or pork (M.-L. Penrith, 2000, unpublished data). After successful eradication in 2000, outbreaks were reported again in 2002, reportedly due to introduction of pigs from Togo (M.-L. Penrith, 2002, unpublished data), which led to the endemic establishment of the disease, with outbreaks being reported every year since (Penrith *et al*., 2013).

Burkina Faso's first outbreak was reported on 1 July 2003 in Kompienga, in the south of the country, bordering Benin, and involving 400 swine (OIE Handistatus II, 2016; OIE WAHID). Burkina Faso was self-sufficient in pork production. Therefore, the most likely source of infection was illegal cross-border movement of pigs or meat. Both Benin and Togo had ongoing outbreaks in the first half of 2003.

4. RISK FACTORS IMPLICATED IN MAINTENANCE AND SPREAD OF ASF

Understanding the dynamics of ASF introduction and spread in West Africa is important for the development of risk-based approaches to designing strategies for its prevention, surveillance, control and eradication. The endemic establishment of ASF in most of the affected countries has led to various projects and studies to evaluate risk factors and biosecurity practices in ASF epidemics. Most of these studies were carried out or published after the 1996-2003 period of initial spread. Therefore, control measures implemented during the initial epidemics were based on the risks perceived or identified at that time, while more recent efforts have had the benefit of the broader base of information.

During the epidemic, risk factors for the maintenance and spread of ASF that were identified and evaluated included free-ranging pigs, inexperienced farmers, swill feeding and informal marketing systems. A questionnaire survey carried out in Ghana revealed that 37% of herds were not permanently housed, 51% of the farmers interviewed had been farming pigs for less than five years, and 78% of the producers did not sell their pigs through formal outlets. Only 9% of the farmers fed swill in the form of catering waste to their pigs (M.-L Penrith, 2000, unpublished data). An even higher percentage of the pigs were kept in free-ranging systems in the other countries (ML Penrith, 1996-2000, personal observation). An additional high risk linked to informal marketing was proximity to an infected country (ML Penrith, 2000, unpublished data). This applied to the Volta Province that shares a long border with Togo, believed to be the source of the re-introduction of ASF in 2002. Similarly, the outbreak in Mali in 2016 occurred close to the border with Burkina Faso (OIE WAHID, 2016). Based on a survey of pig farming from 2008 to 2013, Kouakou *et al*. (2016) identified proximity to villages near the Burkina Faso border as the greatest risk for re-introduction of ASF into Côte d'Ivoire, but the 2014 re-introduction highlighted another major risk, namely careless disposal of galley waste from ships at sea ports.

Recent studies have identified a number of risk factors that contribute to in-country maintenance and spread of ASF. These include presence of slaughter facilities/home slaughter in pig farming communities, indiscriminate disposal of pig viscera and waste materials after slaughter, presence of an infected pig farm in the neighbourhood, uncontrolled access to pigs by farm-gate buyers

collecting pigs and pig products from within farms and veterinarian/paraveterinarians during outbreaks without observance of strict biosecurity, i.e. poor implementation of biosecurity measures, salvage sale of survivor and apparently healthy pigs without testing, continuous maintenance of sick and survivor pigs in the herd, and delayed response by the veterinary authorities to respond to outbreaks (Fasina *et al.,* 2012; Kabuuka *et al*., 2014; Dione *et al*., 2015; Muhangi *et al*., 2015; Nantima *et al*., 2015). Permanent confinement of pigs and exercise of reasonable levels of biosecurity protected farmers from ASF, according to a study on pig production in south-eastern Nigeria (Nwanta *et al*., 2011). The application of simple biosecurity measures to prevent ASF was shown to be cost-effective in two studies in Nigeria (Babalobi *et al*., 2007; Fasina *et al*., 2012).

5. SOCIO-ECONOMIC IMPACT OF ASF OUTBREAKS

The pig production systems observed in the region can generally be classified as extensive (i.e. pigs are free-ranging and scavenge for food), intensive (i.e. animals are permanently confined and feed is provided), and semi-intensive (i.e. intermediate systems in which animals are confined at night or seasonally or only certain groups are permanently confined, but in all cases feed is supplied). Compared with developed countries, commercial farms are generally small, with herds not exceeding 500 – 1000 pigs (M.-L. Penrith, unpublished data).

The main purpose of keeping pigs is to generate income (Penrith *et al*., 2013). In the event of an ASF outbreak, extensive and semi-intensive systems with low or no biosecurity are more likely to be affected (Costard *et al*., 2013), but, if affected, intensive and commercial operations would be expected to experience greater financial losses owing to the higher value of and greater investment in the system. In addition because of the establishment of zones for stamping out, commercial operations may incur heavy losses even if herds are not infected. In addition, when zones in which all the pigs are culled are established, unaffected commercial operations may nevertheless incur heavy losses.

The gravity of the ASF epidemic in West Africa is generally considered high in terms of its impact on livelihoods and local and regional trade, but it is difficult to provide precise figures due to a lack of data. There is also the matter of “value”, a subjective consideration that is greater than a monetary measurement. Before the incursion of ASF, pork was the most affordable meat (excluding poultry), and the resulting shortage due to mortality and bans on sales therefore deprived many people of an inexpensive source of high quality protein. In addition, cultural practices require pigs for use in ceremonies (M.-L. Penrith, 1998, unpublished data), and these would also have been negatively affected. The fact that the epidemic was regarded as important in the region is illustrated by the

undertaking of a regional project by FAO to support all the countries in the region and the organisation at the request of the West African countries of a regional workshop on ASF Lomé, Togo, in 2001 by the Pan African Programme for the Control of Epizootics (PACE). Today, the disease remains of the highest importance in the region, and is repeatedly mentioned among the most serious infectious diseases in official reports by international organizations (FAO, 2012; FAO, AU-IBAR, ILRI, 2017; Grace *et al*., 2015; OIE, 2012; World Bank, 2016).

Table 2. Available figures relating to the impact of African swine fever (ASF) in newly infected countries in West Africa between 1996 and 2002

Country	Total pigs pre-ASF	Total pigs post-ASF (% reduction)	Commercial (% of losses)	Smallholder (% of losses)	Total no lost (ASF+culling)	Estimated cost at the time (USD)	CPI and inflation adjusted 2016 cost (USD)[a]
Côte d'Ivoire	400,000 (DVS)	264,000 (16,000 commercial)	75% –	25% –	29% (>80% of commercial pigs)	7,120,223 D 28,919.919 T	10,806,583.45
	464,000 (EI)	(−34% to 43%)	72%	28%			
Benin	470,300 (FST)	263,723 (−44%) (FST)	<10%	>90%	54%	>6,000,000 ns	43,892,645.00
Nigeria	4,487,326[b] (FST)	4,666,817[b] (+4%) (FST)	<10%	>90%	125,000[c]	10,000,000 D	8,902,130.84
Togo	312,000 (FST)	354,000 (+13%) (FST)	28%	72%	17,500	8,175 C 82,700 D	12,129.15
Ghana	332,000 (FST)	324,000 (−2%) (FST)	40%	60%	14,950	13,316,558 D 85,040 C	122,701.04

C, compensation costs; D, direct costs; DVS, Department of Veterinary Services; EI, Epidemiological Inquiry; FST, FAOSTAT; T, total costs; USD, United States Dollar; CPI, consumer price index.

[a] Source for calculation: Department of Labour, Bureau of Labour Statistics. Databases, Tables & Calculators by Subject (CPI Inflation Calculator). Available at: http://www.bls.gov/data/inflation_calculator.htm. Accessed 06 May 2016).

[b] Figures for the Nigerian pig population were reported locally to be close to 7 million.

[c] Up to October 1998 in nine states; a figure of 247,000 lost at Oke Aro on a single cooperative reported by FAO (2002, unpublished data) may have referred to a later date.

Table 2 summarises the available figures for the pig population before and after the outbreak, based on FAOSTAT (2015) and other sources; the proportions of pigs in commercial and non-commercial farming systems before the ASF outbreaks; the number of pigs lost through death and culling during the outbreaks, and estimated costs. Depending on whether the commencement of the outbreak was reported early in the year (e.g. Côte d'Ivoire) or late in the year (the remaining four countries), the pig population figures are given for the year before or for the same year of the outbreak, respectively. However, these figures were unlikely to be accurate, but were mere approximations from multiple sources.

Because the animal population estimates are doubtful, the estimated figures relating to actual costs based on estimates from various sources may also be inaccurate and incomplete but can serve as bases for future estimations. They refer to the value of the pigs lost, the value of compensation paid, or, in the case of Benin, an undefined amount (Babalobi *et al*., 2007). The costs for Togo are certainly an underestimation, as they are based on a very low value for pigs used for compensation (K. El Hicheri, 1998, unpublished data).

Commercial pig production was well developed in larger urban areas of Côte d'Ivoire, especially Abidjan, where 80% of the country's commercial pigs were located (El Hicheri *et al*., 1998). The larger farms used European breeds housed in modern piggeries and fed commercial ration. Smaller farms generally used mixed breed pigs fed a variety of agricultural by-products, with catering swill being used mostly in larger cities, and household swill in smaller operations (M.-L. Penrith, 1996, unpublished data).

In Côte d'Ivoire, the main impact of ASF was on the commercial sector. Many commercial farms in the Greater Abidjan area were well isolated and never experienced ASF, but compulsory slaughter of all residual pigs in the Abidjan area essentially destroyed the nucleus of commercial pig production. About 50% of the country was affected geographically and 29% of the pig population eliminated, including the greater portion of the commercial herd, which was reduced to 16,000 pigs (El Hicheri *et al*., 1998). Figure 2 demonstrates the severe impact of the ASF outbreak on pig production. Although the results of the sentinel programme and serological surveys were encouraging (El-Hicheri *et al*., 1998), restocking was delayed for up to three years, mainly due to fear that the disease would recur (Georges Edoukou, 2000, personal communication).

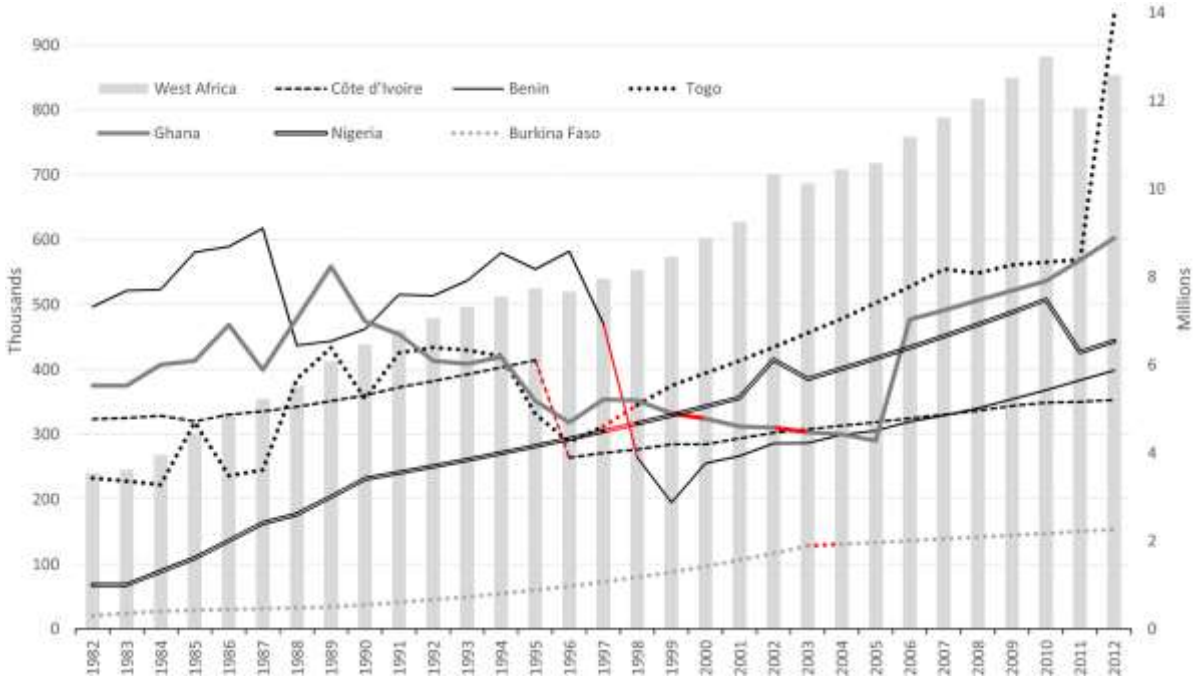

Figure 2. Pig production in 1982–2012 (FAOSTAT) in West Africa. Years of the first ASF outbreak indicated in red; the right scale (in millions) corresponds to West Africa, Nigeria and Burkina Faso

At the time of the outbreak in Benin, commercial pig keeping was of increasing importance and made use of pigs of all types, from pure local breeds, through cross-breeds, to European breeds, but the commercial sector was small, with just 40,000 animals per year slaughtered in controlled abattoirs (El Hicheri *et al*., 1998). The graph showing pig production from 1982 to 2012 (Figure 2) depicts a dramatic decrease between 1996 and 1999, which is likely attributable mainly to the presence and spread of ASF. Commercial farmers and other actors in the pig sector, especially butchers, suffered severe economic losses as a result of the ASF epidemic due to prohibition of pork sales., during which pork sales were prohibited as a control measure (M.-L. Penrith, 1998, unpublished data).

In Nigeria, over 90% of the pig population was raised on smallholder farms under extensive, traditional management systems, concentrated mainly in the middle belt and southern parts of the country due to religion, cultural bias and taboo (F.G. Davies, 1999, unpublished data). The pig population in Nigeria had increased steadily each year to reach about 4.5 million heads at the time of the outbreak (FAOSTAT, 2015), but according to local figures, the population was more than 7 million heads, the largest national pig herd in Africa. At the time of the outbreak, pig production had, in fact, been the fastest growing livestock sub-sector in Nigeria (Babalobi *et al*., 2007). As a result of the ASF outbreak in 1997, affected producers in all sectors lost virtually their entire stock, with less than 1-2% surviving. To date, the losses at the level of the smallholder, who played a significant role

in assuring food security, have not been properly assessed. The socio-economic implications were especially significant, given the fact that pigs were often kept by women for generating income to sustain the household, children and school fees. However, owing to the large size of the pig population, no effect on overall growth in the pig sector was observed in 1997 or afterwards (Figure 2).

In Togo, losses in the very small commercial sector appear to have been lower than those in the traditional sector. The total mortality was 15,000 pigs, with about 10,000 pigs dying of ASF in 39 rural locations and an additional 5,000 deaths in the two major centres of Kara and Lomé (largely in the commercial sector) (K. El Hicheri, 1998, unpublished data). Figure 2 shows no effect on the steady growth of the pig population at the time of the outbreak, probably due to the low number of pigs involved.

In Ghana, approximately one third of the pig population was raised commercially in intensive or semi-intensive production systems. Free-range farming took place almost exclusively in rural communities and on the outskirts of some urban areas, and was the most common system used despite strict legal restrictions. Meat produced in this manner tended to be shunned by consumers as “unclean”. Intensive rearing operations, most common in urban areas, had become increasingly prevalent and were favoured by the overall development and urbanization of the country, coupled with its increasing demand for pork. However, there was a 23% decrease in pork consumption from 1,658,920 kg in 1999 to 1,270,760 kg in 2000 due to ASF. Between August and December of 1999, 8,775 pigs died of ASF and 6,175 pigs were culled, with USD 85,040 paid in compensation to farmers. Overall, the outcome of the outbreak was not too negative, since 98% of the pig population remained uninfected. This is reflected in Figure 2, which shows a mild decline in pig production possibly linked to the outbreaks in 1999 and the re-introduction in 2002, but in 2005 a sharp rise was recorded followed by steady growth (FAOSTAT, 2015), in spite of the fact that the disease became endemic.

The last country to succumb to the epidemic in the sub-region, Burkina Faso, was not the recipient of a TCP. Therefore, a comparable amount of information was not available. Burkina Faso was the country with the second largest pig population in West Africa (1,715,105 head in 2002 [FAOSTAT, 2012]), which had been growing exponentially during the period of the outbreaks and consisted mostly of free-ranging pigs (FAO, 2012). Figure 2 indicates a slowing of growth in the pig numbers from 2002. The effects at household level as well as on the small commercial sector that exported pork to its southern neighbours was grave (FAO, 2012).

In summary, the epidemic caused losses in both the informal and commercial sectors, but the actual magnitude of the financial losses was difficult to compute, particularly in the informal sector, where data were scarce and negative impacts of a non-economic nature were also reported.

Table 3. Control measures implemented in newly infected West African countries during ASF outbreaks (1996–2002)

Control measures	Côte d'Ivoire	Benin	Nigeria	Togo	Ghana
Definition of infected areas	X	X	X	X	
Compulsory slaughter, burial, disinfection	X	X	X	X	X
Compensation payments to owners	X	X		X	X
Movement restriction of pigs, products	X	X	X	X	X
Cessation of all pig slaughtering activities	X	X		X (r)	Temp
Closure of pig abattoirs	X	N/A		N/A	Temp
Declaration of National Emergency	X				
Surveillance (active, passive)	X	X	X	X	X
Public awareness campaign	X		X	X	X
Ministerial declaration orders issued	X				
Sensitization of farmers	X	X	X	X	X
Confinement of uninfected animals		X[a]			X
Sentinels used	X	X[b]		X[b]	X
Training of technicians and other personnel	X	X	X	X	X

N/A, not applicable; (r), recommended; temp, temporarily.

[a] Regulation was passed but compliance in informal sector was poor to non-existent.

[b] A programme was proposed and recommended to be carried out after cessation of outbreaks.

6. EVALUATION OF THE PREVENTION AND CONTROL MEASURES APPLIED DURING THE EPIDEMIC

The conventional measures employed to control and eradicate ASF outbreaks are quarantine of infected premises; bans on the sale and movement of pigs and pork in the infected area, and stamping out of pigs on infected premises and those considered 'dangerous contacts', with

destruction of the carcasses by deep burial or burning (Plowright, 1986; Arias and Sánchez-Vizcaíno, 2008). These measures were applied to a greater or lesser degree during the period from 1996 to 2000 in the affected countries, together with public awareness campaigns, sensitization of farmers, training of veterinary and other personnel (e.g. extension officers), and establishment or improvement of laboratory diagnostic capacity for ASF (Table 3). Surveillance systems were also designed and established.

In evaluating the implementation and outcomes of control measures applied throughout the region during the epidemic, it was found that each country presented its own context as created by its prevailing circumstances regarding infrastructure, legislation, structures of the pig sector and production chains, financial and human resources, veterinary services and economic climate, among other factors.

Only two of the five countries, Côte d'Ivoire and Ghana, succeeded in eradicating the disease within months of its detection, using different approaches. In Côte d'Ivoire, the entire Greater Abidjan area was declared infected and all the pigs in the area were culled, with compensation paid at one third of market value. Eradication was therefore achieved at the expense of the pig industry.

In Ghana, only infected herds were culled (modified stamping out), minimising the number of pigs for which compensation needed to be paid. Owners were paid for healthy pigs slaughtered at the market rate per kilogram, with pigs weighed in front of them and receipts issued for the total number of kg; payments were made within days of culling. Initially, there was a total ban on movement and sale of pigs, but to avoid unnecessary hardship as well as illegal transactions - particularly during the period of high demand before Christmas - the ban was lifted to permit movement by veterinary permit from certified healthy farms to the designated pig abattoir for slaughter. Sale of the meat was permitted only from two designated commercial outlets. Eradication in Ghana was therefore effected with relatively little damage to the industry as it supported the economic survival of the farmers whose herds remained uninfected, allowing the industry to continue functioning.

The absence of circulation of ASF virus was confirmed in Côte d'Ivoire and Ghana by the wide distribution of sentinel pigs throughout previously infected areas (El Hicheri *et al*., 1998; M.-L. Penrith, personal communication, 2015). It is, however, difficult to attribute the termination of the outbreaks in the two countries entirely to the control measures. The most probable determining factor may have been that the level of contact in the overall pig population was low. Villages or village clusters were scattered and the distance between them was sufficient to reduce contact and would not permit free-ranging pigs from different epidemiological populations to mingle (M.-L.

Penrith, 1996, 2000, unpublished data). Ghana also had the advantage of awareness created by the previous outbreaks in neighbouring countries.

In order to keep Ghana ASF-free after its successful eradication, recommendations included the maintenance of active surveillance, public awareness, restriction of importation of live pigs or pork from West Africa and border controls to prevent the smuggling of pork and pork products (M.-L. Penrith, 2000, unpublished data). However, in 2002, the re-introduction of ASF into Ghana resulted in disease becoming endemic.

Eradication was not achieved in the remaining countries. The formal sector was small in Benin and Togo, and ASF occurred mainly in populations of free-ranging village pigs. There was, therefore, great difficulty in applying the necessary ASF control measures. In Benin, resistance occurred partly owing to an initial lack of funds for compensation and partly due to unwillingness to confine healthy pigs, as one function of pigs was to 'clean up' the surrounds of the villages (M.-L. Penrith, 1998, unpublished data). Non-compliance with control efforts (Table 3) resulted in a marked northward extension of the epidemic in December 1997 – January 1998. The inclusion of butchers was identified as a useful addition to the strategy, as they were reported to be more successful in confiscating pigs at roadblocks than the official teams. Raising awareness among commercial farmers about on-farm biosecurity through the formation of a national pig farmers' association protected commercial farms from ASF (M.-L. Penrith, 1998, unpublished data).

In Nigeria, federal and state animal health services at the time of the outbreak were faced with limitations in operational funds as well as institutional and logistic capacities. While it was determined that control would only be achieved through the slaughter of all infected and in-contact pigs, the lack of compensation for culled animals induced many farmers to move their animals away, thus spreading ASF even farther. Extensive movement of pigs through the country's network of markets played an important role in the spread of ASF. Many semi-commercial and commercial production units in Kaduna and Plateau States established their own form of quarantine as a result of FAO's support, prohibiting the entry of pigs from outside and taking steps to prevent the contamination of their premises by personnel and vehicles. These production units remained ASF-free for an extended period and thus became the reservoir of stock from which restocking was attempted. Nevertheless, spread of infection was linked in part to attempts at restocking (F.G. Davies, 1999, unpublished data).

Attempts to coordinate control programmes in Nigeria were hindered by the varying degrees of autonomy of administrative structures at Federal, State and District levels. For example, the unpopular State-level mandate of closure of markets could be rescinded at the District level,

thwarting attempts to create a consistent, unified effort to mitigate risk. The initiation of active surveillance became a main goal. Another aim was to pursue ASF control at the level of the farmers, so that some safeguards would be in place in the absence of coordinated state or country-wide mechanisms (F.G. Davies, 1999, unpublished data).

The application of control measures in Togo (Table 3) was constrained by inadequate mobilization of resources, the lack of emergency management structures, the absence of strong and active professional structures, and the reluctance, lack of compliance and often hostility from farmers due to dissatisfaction with the level or lack of compensation. All pigs in the first focus where the disease was reported were culled and the owners compensated. Nevertheless, the spread of ASF continued, and the depletion of funds meant that culling had to be abandoned. Many of the problems were rectified with the establishment of checkpoints (supported by police and traditional leaders) at strategic points on major roads and at international borders, bus and railway stations and markets. Also, veterinary personnel were trained and organized into a national unit and regional cells to respond to outbreaks. Information and awareness campaigns were organised for policy makers, traditional leaders and operators of the pig industry, and localities affected by ASF, as well as on a national scale through the media (radio, TV, press) and meetings at the prefectural and village level. In spite of improved capacity to respond to outbreaks, the disease became endemic.

Major constraints for control of the ASF epidemic were common to all the countries, although there may have been differences in details. Managing an epidemic in livestock requires a collaborative effort on the part of the government animal health authorities and the relevant livestock sector.

In the affected countries, the government veterinary services lacked capacity to deal with a major outbreak of a new and serious transboundary disease. Lack of capacity was largely linked to financial limitations. These exist in most developing countries, necessitating prioritization of government expenditure. In spite of its importance in generating food and income, agriculture is often not prioritized, and the livestock sector often receives the least funding (Kamuanga *et al.*, 2008). Lack of political will to commit funds to controlling an animal disease was a major contributor to the failure of eradication. Under-resourced veterinary services that were inadequately staffed and funded resulted in poor motivation, while a lack of funding for adequate compensation to owners thwarted control measures due to lack of owner compliance. This was compounded by lack of logistic support (e.g. police or military personnel).

The nature of the pig sector made compliance with control measures problematic. An overarching problem at all levels was a lack of understanding of the dynamics of ASF. Unfamiliarity of

veterinarians and producers with the disease contributed to late diagnosis and therefore spread of the disease.

The dynamics of ASF in the West African epidemic were determined exclusively by the dynamics of the pig sector itself, which were not well understood because the pig sector was not regarded as being of primary importance and was highly fragmented, unprofessional and disorganized. The majority of pigs were produced in traditional free-ranging or smallholder subsistence husbandry systems with low or no biosecurity that required little or no investment and were sold in response to often urgent financial demands on the producers. The imperative to limit economic losses by selling pigs regardless of prohibitions on movement and sales militated against producer compliance with control measures. Informal and clandestine marketing were rife in spite of restrictions. Porous borders ensured that such clandestine trade thrived, with cross-border transactions encouraged by price differentials.

Lack of knowledge of the sector contributed to inadequate sensitization of and communication with stakeholders, leading to sub-optimal cooperation. It also meant that insufficient economic data on the sector were available to convince governments to invest in control and eradication.

At the onset of the outbreak, none of the countries had laboratory diagnostic capacity for ASF. Diagnostic capacity for ASF was established at various levels in all of the affected countries during the TCPs, including the upgrading of the laboratory in Côte d'Ivoire to act as a regional reference laboratory for ASF. However, service delivery by the veterinary laboratories, particularly in terms of communicating results, was generally very weak, which resulted in a poor culture of sample submission by producers and animal health officers. Sustaining and improving capacity has remained problematic, as it requires resources that are often only available through donor projects (M.-L. Penrith, personal observation, 1995-2014).

The existence of such shortcomings at key points in the strategy highlights the need for alternative approaches to gaining and maintaining control of the impact of ASF. Practicability and cost-effectiveness are the foundation upon which further efforts at control and eradication must be based, bearing in mind that options that may be viable in developed countries may not be feasible in Africa, largely owing to lack of infrastructure and resources and the imperatives of poverty. The challenge has been identified as examining current options and developing alternatives as necessary, with the goal of minimizing losses due to ASF, preserving the status of areas and countries that are uninfected, and promoting the continued and improved production of pigs, which play a key role in household food security and other socio-economic aspects of daily life in the region (Penrith *et al.* 2013).

7. DISCUSSION

The early to mid-1990s saw an emergence of ASF in previously uninfected countries (and regions within countries). While the cause of the epidemic in West Africa has not been definitively identified, the period immediately preceding the epidemic of the 1990s was characterized by notable expansion of the pig industry - particularly in peri-urban areas - to meet the needs of rapidly growing cities throughout the sub-region. Such expansion was evident in several affected countries, including Côte d'Ivoire, Benin, Nigeria, Togo and Burkina Faso. This involved the concentration of large numbers of highly susceptible pigs of improved breeds, the increased use of local labour in the operation of farms, and weak biosecurity and risky practices, all of which may have played a role in setting the stage for the events that unfolded (Penrith *et al.*, 2013).

While ASF has remained endemic in many West African countries, it has had devastating effects not only on the economics but also on health and food security initiatives. Pig production and its associated industry provides enormous economic opportunity to many families to get out of the poverty trap. The production system is also suitable in peri-urban areas where a large population of urban poor live. In most West African communities, pork remains the cheapest source of meat and it serves many important traditional roles. With the advent of ASF and its devastating effects, those opportunities were lost, poverty increased, food security threatened and psycho-social health was negatively impacted especially among the pig farming communities and others for whom pigs are important.

The epidemic that began in 1996 created the foundation for the current situation in West Africa was created. With outbreaks occurring annually and endemicity widely established since the initial epidemic, improved control of ASF should be prioritized with the aim of mitigating periodic heavy losses and enabling the development of commercial pig farming where conditions are suitable (Penrith *et al.* 2013). That said, as shown in Figure 2, the pig production in all affected West African countries has continued to increase despite the presence of ASF.

While the information gathered and explored here is by no means exhaustive, useful insights were gained that should influence future approaches to ASF control:

- There is a need for improved biosecurity, husbandry practices and production systems, moving to a more commercialized, professional and vertically integrated pig sector. This can be achieved through training, encouraging pig associations to improve marketing, soft loans and microcredit to improve farms, identification of locally available and affordable housing materials and feedstuffs to improve feasibility of permanent confinement of pigs, etc.

- There is a need to encourage and promote the formation of farmers' associations to improve access to information on good husbandry practices, biosecurity and health management, markets, value addition, feed, veterinary and financial services, and to lobby government for support.
- Farm and animal identification and censuses are essential to enable the location of animals in the event of outbreaks and animal health interventions. Tracking facilitates culling, movement control, and back- and forward tracing during outbreaks.
- Preparedness (e.g. contingency planning, standard operating procedures - SOPs, financial support, etc.) based on the principles of early warning, detection and notification, early reaction, coordination and enabling research is essential and implies effective surveillance to detect and account for any changes in the epidemiological situation.
- There is a need to understand pig and pork value chains throughout the region in order to identify and mitigate risks throughout the chain, as recommended by FAO (FAO, 2011).
- Awareness and training of all stakeholders, from veterinarians to farmers, middlemen and other value chain actors is needed to improve reporting (passive surveillance) and biosecurity. Incentives may be needed to encourage reporting, but good outbreak communication will also improve farmers' cooperation.
- Sustainable outbreak control strategies that are adapted to the West African reality must be developed. It is necessary to move away from the traditional approach, which cannot be applied to countries that lack the necessary resources. For example, if there are no funds for compensation, stamping out should not be applied, but rather modified stamping out and controlled marketing of animals, as practiced in the initial epidemic in Ghana. Cooking of carcasses of healthy slaughtered animals may also be explored. The strategies need to be developed in consultation with the pig farmers, who should be actively involved in the control.
- There is a need for better coordination of control at national and regional levels through strengthening intraregional networks to find solutions to technical and financial problems in support of individual country control efforts.
- Animal disease management and control in its broadest sense should be prioritized within the highest levels of governments to ensure that veterinary services throughout the region are equipped to effectively play a key role in surveillance, reporting and response, improving people's lives, livelihoods, and economic growth, and public health.

Continued exploration of the subject is recommended, as over time, new technologies and insights may emerge that may inform new approaches to ASF control, or reinforce pre-existing concepts.

Future research should focus on detailed mapping of the pig and pork value chains and value chain risk analysis in order to apply mitigation (FAO, 2011). Identification of risks would be supported by obtaining pork production data specific to affected areas and periods and analysis of outbreak trends in relation to market locations, pork price, proximity to international borders, social networks and mechanisms of dissemination of infected animals and material. To ensure that ASF management interventions are cost-effective, the costs related to ASF outbreaks, including costs of surveillance, diagnosis and prevention and control efforts should be analysed.

In conclusion, although the present study describes events that took place twenty years ago, the spread pathways, risk factors, socio-economic impact and critical review of prevention and control actions of that ASF epidemic are still highly relevant today, thus providing valuable lessons learnt that could and should be applied in the current pig health management in the region and elsewhere.

8. LIMITATIONS OF THE STUDY

In attempting to quantify the extent and impact of the ASF epidemic in West Africa, the main limitation was that the data available are not complete, in spite of efforts made through epidemiological enquiries to gather as much data as possible. In particular, information relating to the index cases in outbreaks could not be considered definitive, and epidemiological enquiries suggested that outbreaks may have been in progress prior to the identified 'index' cases. Unrest in parts of the sub-region had led to considerable transhumance and the situation with regard to ASF was unknown in some countries due to a complete lack of surveillance and reporting. There was also little information on the traditional and smallholder sectors of the pig industry that in most countries comprised 70 to more than 90 percent of the pig sector. FAOSTAT (2015) figures are of use in reflecting overall production trends, but need to be used with caution because in the absence of hard data provided by the countries, these are based on estimates. Furthermore, FAOSTAT does not have the level of resolution to elucidate the fluctuations that may occur at a community or provincial level affected by epidemics or other losses.

Finally, the lengthy period of time that had passed since the period being investigated negatively affected the data recovery process. Much of the information collected was no longer available through archival material and had to be sought from persons who were directly involved with the investigations. However, not all of these persons could be traced and contacted. Therefore, some data or reports were simply not retrievable.

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