History of 'swine fever' in Southern Africa

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Abstract

The histories of the two swine fevers in southern Africa differ widely. Classical swine fever (hog cholera) has been known in the northern hemisphere since 1830 and it is probable that early cases of 'swine fever' in European settlers' pigs in southern Africa were accepted to be that disease. It was only in 1921 that the first description of African swine fever as an entity different from classical swine fever was published after the disease had been studied in settlers' pigs in Kenya. Shortly after that, reports of African swine fever in settlers' pigs emerged from South Africa and Angola. In South Africa, the report related to pigs in the north-eastern part of the country. Previously (in 1905 or earlier) a disease assumed to be classical swine fever caused high mortality among pigs in the Western Cape and was only eradicated in 1918. African swine fever was found over the following years to be endemic in most southern African countries. Classical swine fever, however, apart from an introduction with subsequent endemic establishment in Madagascar and a number of introductions into Mauritius, the last one in 2000, had apparently remained absent from the region until it was diagnosed in the Western and subsequently the Eastern Cape of South Africa in 2005. It was eradicated by 2007. The history of these diseases in the southern African region demonstrates their importance and their potential for spread over long distances, emphasising the need for improved management of both diseases wherever they occur.

Introduction

Classical and African swine fever (CSF, ASF) are the two most feared diseases of swine worldwide. Both are characterised by high mortality and are transboundary diseases that can have devastating effects on livelihoods that depend on pig production (Costard *et al.,* 2009; Moennig 2000). Although they are caused by completely unrelated viruses, the pathogenesis of the two diseases is similar, therefore the clinical and pathological manifestations are strikingly alike (Moennig 2000; Penrith, Thomson & Bastos 2004a). CSF is caused by a single-stranded RNA virus of the genus *Pestivirus*, family Flaviviridae, while ASF is caused by a large, double-stranded DNA virus that was only allocated to its own genus, *Asfivirus*, the only member of the family Asfarviridae, in 1998 (Dixon *et al.,* 2005). Both viruses affect only members of the pig family (Suidae) (Moennig 2000; Plowright, Thomson & Neser 1994). Both are highly contagious diseases in pigs and their ancestors, the Eurasian wild boar (*Sus scrofa ferus*), but ASF virus is the only known DNA arbovirus and also has a biological vector that can maintain and transmit the virus. In southern and East Africa, ASF virus is maintained in a sylvatic cycle between argasid ticks (tampans) of the *Ornithodoros moubata* complex and the common warthog (*Phacochoerus africanus*), which does not develop clinical signs of ASF and is believed to have co-evolved with the virus (Plowright *et al*., 1994). The other wild African suids, bushpigs (*Potamochoerus* spp.) and the giant forest hog (*Hylochoerus meinertzhageni*), can also be infected without showing clinical signs, but there is no known association between these species and *Ornithodoros* and their possible role in the epidemiology of the disease is unknown (Jori *et al.,* 2013). In some areas in Africa, *Ornithodoros* inhabits pigsties and participates in a cycle in domestic pigs (Haresnape, Lungu & Mamu 1987), but ASF virus is often introduced into pig populations by infected pigs or the meat of infected pigs fed as swill, the usual routes of introduction of CSF, and in these cases the epidemiology of the disease is similar (Penrith *et al.,* 2013). Both viruses tolerate a wide range of temperatures and pH and can survive for long periods in meat (Edwards 2000; Mebus *et al*., 1997).

The purpose of this paper is to explore the history of the two diseases known as swine fever in southern Africa. There is a particular focus on South Africa, but the account includes all of the Southern African Development Community (SADC) countries as far as it is known. (The Southern African Region, according to the United Nations [United Nations Statistics Division 2013] comprises only five countries [Botswana, Lesotho, Namibia, South Africa and Swaziland]).

Global history and current distribution of classical and African swine fever

Classical swine fever was first recognised in North America in 1830, where it is known as hog cholera, and soon after that in Europe (Terpstra 1994). Eradicated from most of the north-western hemisphere, apart from a very large outbreak that occurred in The Netherlands in 1997 (Dijkhuizen 1999) and smaller outbreaks in European countries, including the UK and Germany (data available from the World Organisation for Animal Health [OIE] Handistatus II and World Health Animal Information Database [WAHID] databases at www.oie.org), it remains widespread in Eastern Europe, Asia and South America (Moennig 2000). Apart from South Africa, CSF has not been confirmed on the African continent, although it is endemic in Madagascar (Penrith, Vosloo & Mather 2011).

The history of ASF as a disease of pigs in Africa probably dates back to whenever domestic pigs were first introduced into an area where there were infected warthogs and tampans.

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The first recorded outbreaks were reported in pigs belonging to European settlers in Kenya in 1914, which led to the studies that determined it to be a different disease from CSF (Montgomery 1921). However, it is accepted that the evolution of the sylvatic cycle between warthogs and the tampans that live in their burrows has taken place over many centuries in southern and eastern Africa (Penrith *et al*., 2004a). This lengthy evolution is supported by the genetic diversity of the virus in the region (Dixon *et al.,* 2013). Although only a single serotype of African swine fever virus (ASFV) is recognised, multiple genotypes have been reported (Boshoff *et al.,* 2007; Dixon *et al.,* 2013; Lubisi *et al.,* 2005; Nix *et al.,* 2006). There are several reports of viruses isolated from outbreaks that occurred in domestic pigs a decade or more apart showing little sequence variation, as might be expected of a DNA virus (Bastos *et al.,* 2003; Dixon *et al.,* 2013; Lubisi *et al.,* 2005; Rowlands *et al.,* 2008), also implying that evolution of ASFV has been a lengthy process.

By the late 1960s, ASF was known to occur in a large number of countries in southern and eastern Africa (Plowright *et al.,* 1994). The first report of ASF from West Africa emanated from Senegal in 1978, although it was probably established there earlier than that (Penrith *et al.,* 2013). Cameroon suffered its first incursion in 1982, by which time ASF had been reported by most countries in southern and eastern Africa (Plowright *et al*., 1994). In 1996, the diagnosis of ASF for the first time in Côte d'Ivoire signalled the beginning of a pandemic that swept through West Africa and, with the exception of Côte d'Ivoire, has not been eradicated (Penrith *et al*., 2013).

"Outbreaks of ASF were reported from 26 countries in the period 2010–2012, of which 23 are in Africa and nine are SADC members (OIE WAHIS 2013)."

African swine fever made its first appearances outside Africa in the second half of the 20th century. An introduction of a genotype I ASFV into Portugal in 1957, probably from Angola, was eradicated rapidly, but a second introduction in 1960 resulted in its subsequent spread to the Iberian Peninsula as well as to several other European countries, the Caribbean (Cuba, Dominican Republic and Haiti) and Brazil (Costard *et al*., 2009). By the 1990s, it had been eradicated from all those countries with the exception of the Italian island of Sardinia, where it has been established since 1978 (Costard *et al*., 2009; Wilkinson 1984). In 2007, a genotype II ASFV was diagnosed in the Republic of Georgia (Rowlands *et al*., 2008), followed by its spread to Armenia, Azerbaijan and Russia, where it is now well established and continues to spread (Gogin *et al*., 2013; Oganesyan *et al.,* 2013).

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History of African and classical swine fever in southern Africa

The appearance of either of the swine fevers as a lethal disease of pigs depends upon the presence of a susceptible pig population. The history of domestic pigs in southern Africa is believed to span about 500 years – it is mainly associated with European settlement in the area (Swart *et al.,* 2010), with the first pigs probably having been introduced in former Portuguese colonies. However, local populations, at least those along the coast, were evidently familiar with pigs long before that, since although archaeological evidence of pigs in the region is scarce, there are reports that pigs were bartered with local populations by Chinese and Portuguese seafarers before European settlement occurred (Swart *et al*., 2010) and a nucleus of pig-keeping of great antiquity is reported to have existed in an area extending from Angola to southern Cameroon (Amills *et al.,* 2013). On the other hand, there is no documented history of swine fever-like disease in domestic pigs in southern Africa until the dawn of the 20th century.

Outbreaks of a disease that killed large numbers of pigs were reported from the areas surrounding Cape Town as well as from the former Transvaal in 1903 (De Kock, Robinson & Keppel 1940). Investigation of the rather widespread outbreaks in the western Cape Province led to the suggestion that the disease may have been established for some time, possibly as long as two years (Hutcheon 1903, cited by De Kock *et al.,* 1940:68). The outbreaks in the former Transvaal included an outbreak in Krugersdorp that was traced to a market in Johannesburg, but the origin of the pigs could not be traced further than that (Stockman 1903, cited by De Kock *et al.,* 1940:69). The lesions were suggestive of CSF, the only known 'swine fever' at that time, and bacterial examination did not result in consistent isolation of a pathogen that could explain the disease. It was therefore concluded that it was 'European swine fever or hog cholera' and that it was probably introduced from Europe or elsewhere by means of infected pigs or their derivatives; investigations by Arnold Theiler in 1905 supported that diagnosis (De Kock *et al*., 1940). Further outbreaks of the disease were reported from the western Cape Province in 1905, 1910, 1912, 1917 and 1918, with cases also appearing in the eastern Cape Province in 1918; additional outbreaks were recorded in the former Transvaal, including the Pretoria and Krugersdorp districts, in 1904 and 1906 (Gray 1904, 1906, cited by De Kock *et al.,* 1940:69–70).

After the 1918 outbreaks were 'effectively contained' the disease was considered to have been eradicated (De Kock *et al*., 1940).

Outbreaks of a particularly virulent disease in pigs occurred near Potgietersrus (now Modimolle, in Limpopo Province) in 1926, believed to resemble the 'East African swine fever' described by Montgomery in 1921 (Steyn 1928, 1932, cited by De Kock *et al*., 1940:70). Repeated outbreaks in the same area continued into the 1930s. In 1933, an outbreak occurred in the western Cape Province that was attributed to the movement of pigs from the northern parts of the country (De

Kock *et al*., 1940). The disease spread to farms in the Western Cape Province and a stamping out policy was introduced from 1934–1936 that resulted in eradication, although outbreaks continued on one farm in the Piquetberg district until 1939 (De Kock *et al.,* 1940). When that paper was published, uncertainty prevailed about whether the South African virus was the same as the virus that caused CSF. The authors of that paper were inclined to the view that both the European and the South African diseases were caused by different strains of the same virus, or at least that the two viruses were closely related (De Kock *et al.,* 1940). However, an association between warthogs and the disease in the north-eastern part of South Africa was apparent and that area was proclaimed as a Swine Fever Control Area in 1935 (De Kock *et al.,* 1940). Subsequent studies in the area demonstrated the involvement of *Ornithodoros moubata* complex ticks in the maintenance and transmission of the virus (now accepted to be the 'East African' virus) (Plowright *et al.,* 1994; Thomson 1985), as had been demonstrated previously in East Africa (Plowright, Parker & Pierce 1969). Pig farms that are operated according to legislation requiring the facilities to be pig-proof have never experienced an outbreak of ASF in over 50 years, but sporadic outbreaks continue to occur when pigs are allowed to range freely or are not surrounded by pig-proof fencing (Penrith & Vosloo 2009).

In 1932, a disease of pigs that was later confirmed to be ASF occurred in Angola (Gago da Câmara 1933; Mendes 1994). Within the next decades, ASF was reported from most of the southern African countries (Penrith *et al.,* 2004a; Penrith & Vosloo 2009). At this time the only SADC countries from which ASF has never been reported are Lesotho and Swaziland, neither of which have significant pig populations, and the Seychelles (a group of oceanic islands) (Penrith *et al.,* 2013), as can be seen in Figure 1. The warthog and/or tampan cycle has been demonstrated in most of the countries (Jori *et al*., 2013; Penrith *et al.,* 2013) and ASF has also become endemic in domestic pigs in several countries (Penrith *et al*., 2013) (Figure 1).

Outbreaks in Botswana and Namibia have always been occasional, limited and usually warthog-related. This was also the case in Zimbabwe, where the last outbreak was reported in 1992. In the remaining SADC countries, even though the warthogs may be infected, outbreaks appear to have been related largely to the movement of domestic pigs and their products (Penrith & Vosloo 2009; Penrith *et al.,* 2013).

Studies in south-western Malawi (Mchinje district) revealed a cycle of infection involving domestic pigs and *Ornithodoros moubata* that live in pig shelters (Haresnape *et al.,* 1987). The pigs involved showed a high degree of resistance to the pathogenic effects of ASF, evidenced by the fact that up to 50% of healthy pigs had antibodies to ASFV. Subsequent studies in the adjacent area of Mozambique (Angónia district

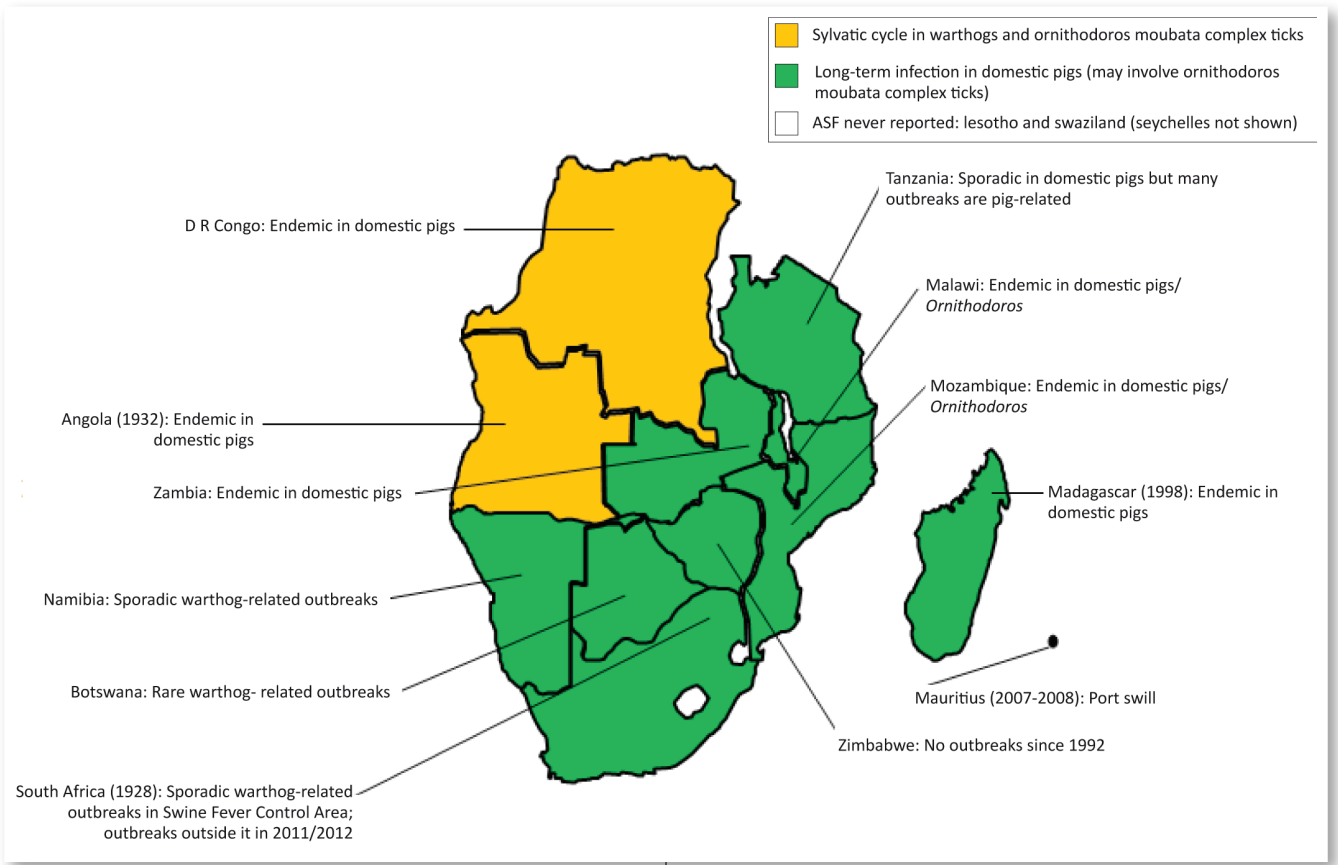

FIGURE 1: African swine fever in countries of the Southern African Development Community.

in Tete Province) revealed a similar high level of resistance (Penrith *et al*., 2004b), but the mechanism of resistance has not been elucidated. In a study carried out at the Onderstepoort Veterinary Institute from 1999 to 2001, only one out of 105 offspring of serologically-positive pigs from Angónia survived a challenge with ASF viruses homologous to the two viruses circulating in Angónia at the time that the parent herd was acquired (Penrith *et al*., 2004b). It was concluded that the resistance is not simply inherited and depends on epidemiological factors in the area. ASF was first confirmed in Mozambique in 1962 and was assumed to have been caused by contact with warthogs (Abreu *et al.*, 1962; Mendes 1971). However, warthogs are not involved in either Angónia or Mchinje and the same appears to be true of the Eastern Province of Zambia (Penrith *et al*., 2004a). Recent unpublished studies demonstrated infection in warthogs in Mozambique but outbreaks have been related overwhelmingly to movements of pigs and their products rather than warthog contact (Penrith *et al*., 2007, 2013). Until the early 1990s, ASF in Mozambique was restricted to the area north of the Save River, but in 1994 it was diagnosed in pigs at the Veterinary Faculty in Maputo, where a major outbreak occurred. It was subsequently traced to the movement of infected pigs or products into Inhambane Province, which has a large number of free-ranging pigs, whence it spread to Maputo (Penrith *et al*., 2007). ASF was absent from the area south of the Save River from 2000 until 2005, when outbreaks again occurred around the city of Maputo. Genetic analysis proved that the virus was different from the one that caused the outbreaks from 1994 to 2000 (Penrith *et al*., 2007) and sporadic outbreaks in the southern provinces have continued to occur.

Early studies in Angola indicated that outbreaks in settlers' pigs occurred after contact with free-ranging village pigs (Mendes 1994), indicating endemic circulation of the virus in domestic pigs, in which some degree of resistance was reported, but there have been no recent studies. There is little published information about the history of ASF in the Democratic Republic of Congo (DRC), but the situation there is likely to be similar to that in Angola. Warthog infection is probable in both of those countries, since it has been reported in Congo-Brazzaville (Plowright *et al*., 1994) and viruses in the eastern parts of that country were genetically most similar to viruses from Kenya and Uganda (Gallardo *et al*., 2011), which are separated from it by the DRC. In Zambia, outbreaks historically were confined to the Eastern Province. More recently, however, outbreaks have also been experienced in the southern Province, where pig keeping increased over the last decades in response to a lack of meat resulting from reduction of the cattle population by diseases (Phiri *et al*., 2002). Tanzania has increasingly reported outbreaks since the late 1990s in various parts of the country, including Dar-es-Salaam (Misinzo *et al*., 2011; Wambura, Masambu & Msami 2006). The outbreaks have been attributed to both warthog contact and the illegal movement of pigs from neighbouring countries.

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In 1998, ASF was diagnosed for the first time on the island of Madagascar, where it has since become endemic (Ravaomanana *et al*., 2011). Although bush pigs (*Potamochoerus larvatus*) and *Ornithodoros moubata* are present in parts of the island, investigation has not revealed that either plays a role in maintaining or transmitting the virus (Ravaomanana *et al*., 2011). Molecular investigation showed that the virus was one that circulated in Angónia (Bastos *et al*., 2004). In 2007, the same virus appeared in Mauritius, probably via galley waste from ships fed to pigs as swill. The outbreak was brought under control by mid-2008 (Lubisi *et al*., 2009).

In late 2011, the first outbreak distant from the control area was diagnosed at an abattoir in Gauteng in early 2012, with subsequent detection of infection in Mpumalanga and Gauteng Provinces. Fortunately, as a result of rapid action by the national and provincial veterinary authorities, supported by the South African Pork Producers Organisation and the fact that the outbreak was restricted largely to pigs belonging to speculators whose contact with pigs in either the commercial or smallholder sectors was limited, the outbreak was eradicated rapidly with a minimum of stamping out or spread. It was almost certainly due to illegal movement of infected pigs from the control area for auction.

The history of CSF in the region is brief. Madagascar (when it was still a French colony) became infected with CSF by the introduction of infected pigs from Europe in 1965 (Roger *et al*., 2000) and the disease has been endemic ever since (Penrith *et al*., 2011). A number of introductions from Madagascar into Mauritius have occurred over the last 50 years, the most recent outbreak occurring from 2000–2002 (Penrith *et al*., 2011), and each time it has been eradicated within a fairly short time. Finally, in 2004 a disease outbreak occurred in pigs in the Western Cape. Since porcine reproductive and respiratory syndrome (PRRS) had appeared there in 2004 and had been eradicated by a stamping-out campaign (Buhrmann, Koen & Oosthuizen 2008), it was the first suspect. Laboratory results, however, were negative for PRRS as well as for ASF and a variety of bacterial diseases (Sandvik *et al*., 2005). In 2005, CSF was confirmed, by which time it was rife among pigs in the Eastern Cape as well, where control was complicated by the fact that numerous households owned low numbers of free-ranging pigs that were difficult to locate and to capture. A massive stamping-out campaign resulted in its eradication, along with nearly half a million pigs, by 2007 (Akol & Lubisi 2010). Molecular genetic studies of the virus demonstrated

that it was most probably introduced from Asia (Penrith *et al*., 2011). The most likely sources would be galley waste from ships illegally fed to pigs or illegal importation of live pigs from fishing boats. The fact that many free-ranging pigs had been affected by the outbreak raised concerns that African wild pigs may have become infected and could act as a reservoir of infection. A limited experimental study demonstrated that both warthogs and bush pigs were susceptible to infection and were able to transmit the virus to members of the same species. Bush pigs were severely affected and died rapidly so would be unlikely to become a reservoir host but warthogs were less severely affected, with non-specific clinical signs and pathological lesions (Everett *et al*., 2011; Gers *et al*., 2011). Serological surveys in domestic pigs and a limited number of warthogs sampled in the Eastern Cape have yielded no positive samples since October 2007 (Akol & Lubisi 2010) and national surveillance gave no indication of spread to other provinces.

Discussion

The history of the swine fevers in the SADC countries reflects their importance for pig keeping in the region. While ASF is endemic in the region and its association with wildlife means that the infection cannot be eradicated, it is a disease that has gained importance as the number of pigs kept has increased, requiring better management strategies (Penrith *et al*., 2013). On the other hand, CSF has only affected three countries in the region, but the fact that it has been introduced from other continents demonstrates the need for continued awareness and precautions to prevent further incursions (Penrith *et al*., 2011). Both viruses have demonstrated their ability to survive for long enough periods to cover long distances and infect pigs on other continents (Costard *et al*., 2009; Sandvik *et al*., 2005).

"The outbreak of CSF in the Eastern Cape was the largest pig disease outbreak that South Africa had ever experienced. The socio-economic effects of the outbreak in the Eastern Cape are informally reported to have been devastating (C. Mather, pers. comm., 2010)."

Southern Africa has served as the source of the ASF Genotype I virus introduced into Western Europe last century (Angola) and the Genotype II virus introduced into the Caucasus in (2007) (a virus known to occur in Mozambique, Madagascar and Zambia [Rowlands *et al*., 2008]). While the sylvatic cycle means that ASF cannot be eradicated from the region, most of the outbreaks are traceable to the movement of pigs and pig products and could therefore be prevented by measures that would include improving pig husbandry and, even more importantly, improving the manner in which pigs and their products are marketed (Penrith *et al*., 2013). The presence of ASF in domestic pigs in Africa remains a threat to other regions of the world, but the risk would be greatly reduced if the disease could be managed better in Africa.

The outbreak of CSF in the Eastern Cape was the largest pig disease outbreak that South Africa had ever experienced. The socio-economic effects of the outbreak in the Eastern Cape are informally reported to have been devastating (C. Mather, pers. comm., 2010). Although the owners of the culled pigs were compensated, there were unavoidable administrative delays and the hardships for poor rural families in remote areas who depended on their pigs for income and food security have been documented in various to date unpublished reports. However, it has been stated that in spite of generous compensation the farmers in the Eastern Cape were often unwilling to cooperate and that the negative effects on producers and the local economy may outweigh the advantages of eradicating the disease by culling (Madzimure *et al*., 2012). This emphasises the need for early detection and, if possible, prevention of major foreign disease outbreaks, for which the control measures may cause even more suffering than the disease itself.

A question mark hangs over the disease that afflicted pig farms in South Africa between about 1900 and 1918. The disease was assumed to be CSF because at that stage ASF was unknown and later authors have perpetuated this assumption (Gous 2008; Penrith *et al*., 2011; Sandvik *et al*., 2005). Eight years after it was eradicated, pigs were dying of a particularly virulent swine fever in what is now the ASF Control Area in Limpopo Province and this was correctly suspected of being 'East African swine fever', or ASF (Steyn 1932, cited by De Kock *et al*., 1940:70). The fact that the earlier disease was most prevalent in the Western Cape and that the lesions described concurred with those described for CSF, in particular the button ulcers in the intestinal mucosa, favoured the diagnosis of CSF, particularly in the absence of any reports of swine-fever-like disease at that time from the Control Area, although Plowright *et al*., (1994) indicated that both diseases may have been present. However, the possibility of introduction of ASF from a source other than the Control Area cannot be excluded. Ships plied around the Cape from Angola to Mozambique and could have carried infected pigs or pork. The question of whether the incursion of CSF into South Africa in 2004 was the first or the second must unfortunately remain speculative.

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