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Review

African swine fever virus eradication in Africa

Mary-Louise Penrith[a,b,*], Wilna Vosloo[a,c], Ferran Jori[d,e], Armanda D.S. Bastos[e]

[a] Department of Veterinary Tropical Diseases, 0110 University of Pretoria, South Africa
[b] TAD Scientific, Pretoria, South Africa
[c] Australian Animal Health Laboratory, Geelong, Vic., Australia
[d] UPR AGIRs, ES Department, CIRAD, Campus International de Baillarguet, 34398 Montpellier, France
[e] Mammal Research Institute, Department of Zoology and Entomology, 0002 University of Pretoria, South Africa

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ABSTRACT

African swine fever was reported in domestic pigs in 26 African countries during the period 2009–2011. The virus exists in an ancient sylvatic cycle between warthogs (*Phacochoerus africanus*) and argasid ticks of the *Ornithodoros moubata* complex in many of the countries reporting outbreaks and in two further countries in the region. Eradication of the virus from the countries in eastern and southern Africa where the classic sylvatic cycle occurs is clearly not an option. However, the virus has become endemic in domestic pigs in 20 countries and the great majority of outbreaks in recent decades, even in some countries where the sylvatic cycle occurs, have been associated with movement of infected pigs and pig meat. Pig production and marketing and ASF control in Africa have been examined in order to identify risk factors for the maintenance and spread of ASF. These include large pig populations, traditional free-range husbandry systems, lack of biosecurity in semi-intensive and intensive husbandry systems, lack of organisation in both pig production and pig marketing that results in lack of incentives for investment in pig farming, and ineffective management of ASF. Most of these factors are linked to poverty, yet pigs are recognised as a livestock species that can be used to improve livelihoods and contribute significantly to food security. The changes needed and how they might be implemented in order to reduce the risk of ASF to pig producers in Africa and to the rest of the world are explored.

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* Corresponding author. Tel.: +27 12 342 1514; fax: +27 12 430 2192.
E-mail address: marylouise@vodamail.co.za (M.-L. Penrith).

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1. Introduction

African swine fever (ASF) is caused by a unique DNA virus (*Asfivirus*), the only member of the family *Asfarviridae*. It is endemic in most countries in sub-Saharan Africa where pigs are kept (Penrith et al., 2004a; Penrith and Vosloo, 2009). It is arguably the most important constraint for pig production in Africa, not only due to high mortality periodically causing devastating losses, but also because the fear of it discourages investment in pig production (Foueré, 2007). Because there is no vaccine and no treatment, it is most often perceived in endemic areas as a disease that cannot be prevented or cured and therefore has to be tolerated. The presence of ASF virus (ASFV) in domestic pigs on the African continent poses a continual threat to the rest of the world, as has been demonstrated by the introduction of the disease into three other continents within a period of 50 years (Costard et al., 2009b; Penrith and Vosloo, 2009). Although eradication of ASFV from its natural hosts and vectors in Africa is not an option, eradication of ASFV in domestic pigs may theoretically be achievable, provided that pigs are managed in a way that excludes contact with the sylvatic sources of infection and prevents maintenance of the virus in domestic pig populations. The question of whether eradication of ASFV from domestic pigs would constitute freedom from the disease highlights a paradox in international approaches to control of diseases involving wild hosts. While for certain epidemic diseases (e.g. classical swine fever, Newcastle diseases, notifiable avian influenza) the international standards set by the World Organisation for Animal Health (OIE) focus on eradication from livestock populations only, no clear distinction between infection in domestic and wildlife populations is made for other diseases, e.g. foot and mouth disease and ASF (OIE, 2012a). The existence of ASFV in a sylvatic cycle involving warthogs (*Phacochoerus africanus*) (Jori et al., 2013; Penrith et al., 2004a; Thomson, 1985) is not considered to pose a serious direct risk to the rest of the world but will always need to be borne in mind when designing pig management systems in Africa.

In order to assess the feasibility of eradicating ASFV from domestic pigs in Africa and if possible, to propose a strategy that could achieve this, this review examines the risk factors for its maintenance and spread among domestic pigs. These include the evolution and current status and distribution of ASF in domestic pigs in Africa and the epidemiological factors relevant to eradication, focusing on pig production and marketing in Africa as the major factors that will determine whether ASFV can be eradicated from domestic pigs. Current approaches to control of ASF are also explored, as inappropriate control measures can contribute to spread and maintenance of this and other diseases. As it is likely that eradication, if feasible, will be a long term process, approaches to managing ASF in domestic pigs in ways that are appropriate for sub-Saharan Africa, which includes some of the poorest countries in the world, are explored.

2. Historical and current distribution of ASF in Africa

ASF was first observed in settlers' pigs in Kenya in 1909 and was reported by Montgomery (1921) as an entity distinct from classical swine fever. Reports of ASF in South Africa (Steyn, 1928, 1932) and Angola (Gago da Câmara, 1933) followed. While Gago da Câmara was able to determine that the disease observed in pigs was not erysipelas, as previously thought, but was caused by a virus, its identity as the disease described by Montgomery in East Africa was only confirmed in 1943 (Mendes, 1994). In Kenya and South Africa ASF affected pigs that belonged to settlers of European origin, but in Angola pigs were also kept by the indigenous population and it was noted that those pigs showed increased resistance to ASF and that they appeared to serve as a source of infection for the pigs farmed by the Portuguese settlers (Mendes, 1994). After World War II the potential for producing pigs in the central highlands of Angola to provide meat for a burgeoning pork processing industry was recognised. ASF was proving a major constraint for pig production and a special section for research on pig diseases was established at the Central Veterinary Laboratory in Nova Lisboa (now Huambo), where attempts to develop a vaccine were undertaken from 1950 (Mendes, 1994).

Incursions of ASF into Europe focused attention on the disease. There were two separate episodes in Portugal in 1957 and again in 1960 (Wilkinson, 1989), with subsequent establishment of ASF in the Iberian Peninsula and spread to other countries in Europe as well as the Caribbean and Brazil. During the same period ASF was also reported from Malawi (Matson, 1960) and Mozambique (Abreu et al., 1962; Mendes, 1971). A link between warthogs (*P. africanus*) and ASF was recognised early in East Africa (Montgomery, 1921), but the possible involvement of an arthropod vector was only confirmed much later (Plowright et al., 1969), after Sánchez Botija (1963) reported the involvement of the argasid tick *Ornithodoros erraticus* in the epidemiology of ASF in Spain. Investigations in a number of countries in southern and eastern Africa revealed infection in *Ornithodoros moubata* complex ticks inhabiting both warthog burrows and pig shelters (Penrith et al., 2004a) but wild pigs were not investigated in Angola (Mendes, 1994) or in Mozambique, although Mendes (1971) suggested that the source of the disease, first observed in Mozambique in 1954, might be warthogs from a neighbouring country. It has recently been confirmed that infected warthogs and *O. moubata* complex ticks are present in the central parts of Mozambique (Quembo, Jori, Dwarka, Ntshali, Souto, Pereira, Heath, Vosloo, unpublished data) and most likely elsewhere in the country.

By the mid 1970s ASF had been reported either in warthogs or domestic pigs or both from most countries in southern and eastern Africa (Penrith et al., 2004a). Studies undertaken in Malawi revealed an endemic situation in domestic pigs in Mchinji District in the south-eastern part of the country bordering on Mozambique and Zambia, with large numbers of infected *Ornithodoros* ticks living in shelters in which the pigs were confined at night (Haresnape and Mamu, 1986; Haresnape and Wilkinson, 1989; Haresnape et al., 1985, 1987, 1988). No evidence for warthog involvement was found in that area.

Scott (1965) described all the countries known to have significant warthog populations as being at high risk of ASF, including Mali, which has an insignificant domestic pig population. Although the first official report to the OIE of ASF in West Africa was from Senegal in 1978 (Plowright et al., 1994), a 1959 virus isolate from Dakar (Bastos et al., 2003) indicates that the virus was introduced a good deal earlier. Two temporally unrelated outbreaks occurred in Cameroon in 1982 and 1985 (Awa et al., 1999; Ekue and Wilkinson, 1990; Nana-Nukechap and Gibbs, 1985), and genetic characterisation of the viruses from Cameroon was suggestive of a 'reverse introduction' of the virus from the Caribbean to Cameroon (Wesley and Tuthill, 1984). Investigations in both countries indicated that the sylvatic cycle was apparently not involved in either Senegal or Cameroon (Ekue and Wilkinson, 1990; Sarr and Diop, unpublished report, 1990), and recent investigations have confirmed this hypothesis in Senegal (Jori et al., 2013).

During the 1990s there appeared to be a sharp increase in ASF activity throughout sub-Saharan Africa. ASF was reported for the first time south of the Save River in Mozambique in 1993 and for the first time in more than 30 years in Kenya in 1994 (Penrith et al., 2004a). In 1996 an outbreak of ASF in Côte d'Ivoire (CIV) heralded a pandemic that affected new countries in the region (Benin, Togo, Nigeria, Ghana and Burkina Faso) from 1997 to 2003, with increased outbreaks reported in Senegal, Gambia and Cape Verde during the same period (Penrith et al., 2004a). With the exception of CIV, it has not been eradicated from any of these countries. In 1998 ASF was

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