

REVIEW

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Current status of African swine fever

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Abstract

African swine fever is a serious viral disease of domestic pigs and Eurasian wild boars that poses a major threat to pig production. For more than thirty years after its discovery in East Africa it was limited to eastern and southern Africa, where it is believed to have originated. The ability of the causative virus to remain viable for long periods in raw or insufficiently cooked pork products has enabled it, through travel and trade, to spread widely throughout sub-Saharan Africa and to other continents. In the second half of the 20th century it had caused outbreaks in the majority of African countries where pigs are produced, as well as in a number of European countries, two of the Caribbean islands, and Brazil. By the turn of the century it had been eradicated from all non-African countries except the Italian island of Sardinia. In 2007 African swine fever arrived in the Republic of Georgia, and has subsequently spread insidiously into other Transcaucasian countries, Russia and some of its neighbours. In 2014 it reached the Baltic States and Poland through infected wild boars, and has become established in several wild boar populations from which it is difficult to eradicate. Most recently, in 2018 the first outbreaks were reported in China, home to half of the world's pig population, where it spread with unprecedented rapidity throughout China and to several other countries in the region, including the island nations of Philippines, Indonesia, Timor-Leste and Papua New Guinea. These events have posed new challenges for control, including some that parallel the situation in Africa, where poor people rely on pigs produced at subsistence level to provide for their needs and where pigs may also be socially and culturally important. The central role that humans play in the maintenance and spread of African swine fever has again been emphasised. This review describes the current status of African swine fever globally and the trends and challenges for management that face veterinarians and pig industries at all levels worldwide.

Keywords: African swine fever, Global spread, Domestic pigs, Wild boars

Background

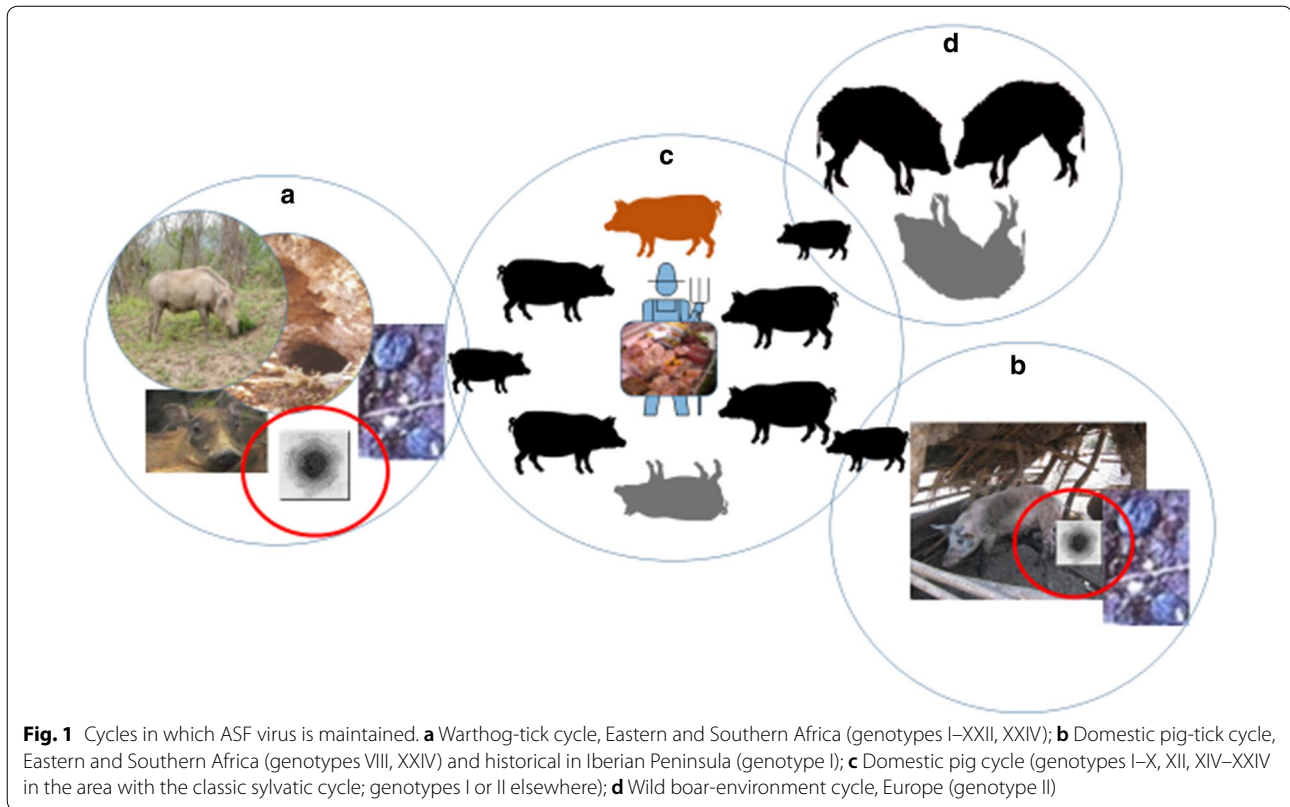
African swine fever (ASF) is a lethal disease of domestic pigs and Eurasian wild boars caused by a unique DNA virus (*Asfarviridae: Asfivirus*). It is the only member of its family and the only known DNA arbovirus. It is maintained in a sylvatic cycle between common warthogs (*Phacochoerus africanus*) and soft ticks, also known as eyeless tsetse flies, of the *Ornithodoros moubata* complex that inhabit their burrows in a large part of eastern and southern Africa (Mulumba-Mfumu et al. 2019; Sánchez-Vizcaíno et al. 2015). The existence of this cycle and the large number of p72 genotypes that are found in this area

indicate that it is the most likely area of origin of ASF from which it has subsequently spread to other parts of the African continent and the world (Michaud et al. 2013). In the absence of the classic sylvatic cycle, ASF may be maintained in a domestic pig-tick cycle involving pig-associated species of *Ornithodoros* or in domestic pig populations that may be extended by non-captive *Sus scrofa* (feral pigs or Eurasian wild boars) (Fig. 1). With an official report of confirmed ASF in Papua New Guinea submitted to the World Organisation for Animal Health (OIE) on 30 March 2020 (Table 4), the disease is now present in all of the main regions of the world exception the Americas. The situation is highly concerning for the pig industry worldwide. In spite of ongoing and promising efforts to develop a vaccine, the current status of ASF in

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terms of management tools is that there is no vaccine and no treatment.

The first description of ASF was published in 1921 (Montgomery 1921), based on outbreaks of a fatal haemorrhagic disease that had been reported mainly in Kenya since 1914 in the pigs of European settlers. Outbreaks of a similar disease had also been registered in the Eastern Province of Zambia since 1912 (Wilkinson et al. 1988). Reports of suspected ‘East African swine fever’ in the north-eastern part of South Africa were published in 1928 (Steyn 1928; 1932), followed by Angola (Gago da Câmara 1932; Mendes 1994) and Malawi (Turnbull 1931, 1932, 1934), and by the 1950s the disease was known to exist in most countries in eastern and southern Africa and the southern parts of Central Africa (Plowright et al. 1994). The disease apparently remained restricted to this region until the late 1950s, when incursions occurred into both Europe and West Africa, initiating the first international events in the history of ASF. The historical and present status of ASF worldwide is reflected in Table 1. A timeline showing the progression of ASF over time in Africa, historically in Europe and the American region, and in Europe, Asia and Oceania since 2007 is provided in Fig. 2.

In the first excursion outside Africa, an outbreak of ASF occurred close to the airport in Lisbon, Portugal, in 1957 (Vigário et al. 1983), believed to have originated

in Angola (Bastos et al. 2003). The first outbreak in West Africa was reported from Dakar, Senegal, in 1959 (Bastos et al. 2003), with anecdotal reports of outbreaks in Guinea Bissau and the island nation of Cape Verde as well (Brown et al. 2018). The outbreak in Portugal was promptly eradicated but in 1960 another incursion into Portugal occurred, with rapid spread to Spain, initiating a presence in the Iberian Peninsula that lasted for more than 30 years. During that period the virus demonstrated its potential for long-distance spread as outbreaks occurred in Belgium, France, Italy, Malta and The Netherlands in western Europe and Cuba, Dominican Republic and Haiti, and Brazil (Cwynar et al. 2019) (Table 1). The disease remains endemic in Sardinia, Italy since its introduction in 1978 (Laddomada et al. 2019). Russia experienced outbreaks in the Odessa region (now in Ukraine) in 1977 (Korennoy et al. 2017).

The next escape from Africa occurred in 2007 with the introduction of ASF into the Republic of Georgia, with rapid spread to other Transcaucasian countries (Armenia, Azerbaijan, Russia [Chechnya]) as well as further northwards into Russia (Gogin et al. 2013) and south into Iran, affecting only wild boars as there are no domestic pigs (Rahimi et al. 2010). Since 2011 ASF has infected an impressive number of countries in Europe and Asia as well as sub-Saharan Africa (Table 1).

Table 1 Historic and current status, all countries that have reported ASF

Country	ASF known presence	Species confirmed ^a	Current status	Relevant references
African region				
<i>Sub-region: Eastern, Central and Southern Africa</i>				
<i>Present</i>				
Angola	1932 to present	Domestic pigs	Endemic	(Gago da Câmara 1932)
Botswana	1979 to present	Warthogs; rarely pigs	Endemic in warthogs	(Simpson and Drager 1979)
Burundi	Isolates 1984, 1990	Domestic pigs	Endemic	(Disease information—Immediate notifications 2005–2020; Lubisi et al. 2005; Phologane et al. 2005)
Cameroon	1982 to present	Domestic pigs	Endemic	(Ekue and Wilkinson 1990; Nana-Nukechap and Gibbs 1985)
Central African Republic	2010 to present	Domestic pigs	Endemic	(Disease information—Immediate notifications 2005–2020)
Chad	2010 to present	Domestic pigs	Endemic	(Disease information—Immediate notifications 2005–2020; Bidjeh et al. 2015)
Congo (Brazzaville)	Before 1975 to present	Domestic pigs, warthogs ^b	Endemic	(Plowright et al. 1994; Badaev et al. 1992)
Congo (DRC)	1939 to present	Domestic pigs	Endemic	(Bisimwa et al. 2019; Saliki et al. 1985)
Ethiopia	2011–2014	Domestic pigs	Unknown	(Achenbach et al. 2017)
Kenya	1914 to present	Warthogs, pigs	Endemic	(Montgomery 1921; Abworio et al. 2017; Thomas et al. 2016)
Madagascar	1998 to present	Domestic pigs	Endemic	(Rousset et al. 2001; Roger et al. 2000)
Malawi	1932 to present	Domestic pigs, warthogs	Endemic	(Turnbull 1931, 1932, 1934; Haresnape et al. 1988)
Mozambique	1954	Warthogs, pigs	Endemic	(Quembo et al. 2016; de Abreu et al. 1962; Penrith et al. 2007)
Namibia	1920s	Warthogs, pigs	Endemic in warthogs	(Plowright et al. 1994)
South Africa	1926 to present	Warthogs, pigs	Endemic in warthogs	(Steyn 1928; De Kock et al. 1940)
Rwanda	482 outbreak reports	Domestic pigs	Endemic	(Disease information—Immediate notifications 2005–2020; Bisimwa et al. 2019)
Tanzania	1914 to present	Warthogs, pigs	Endemic	(Montgomery 1921; Chang'a et al. 2019; Katale et al. 2012)
Uganda	1983 to present	Warthogs, pigs	Endemic	(Plowright et al. 1994; Atuhaire et al. 2013)
Zambia	1912 to present	Warthogs, pigs	Endemic	(Wilkinson et al. 1988)
Zimbabwe	1970s to present	Warthogs, pigs	Endemic in warthogs	(Plowright et al. 1994)
<i>Historic</i>				
Mauritius	2007–2008	Domestic pigs	Free (SD 2012)	(Lubisi et al. 2009)
São Tomé e Príncipe	1979–1980; 1992	Domestic pigs	Free	(Sánchez-Botija 1982; Wesley and Tuthill 1984)
<i>West Africa</i>				
Benin	1997 to present	Domestic pigs	Endemic	(Disease information—Immediate notifications 2005–2020; Brown et al. 2018)
Burkina Faso	2002 to present	Domestic pigs	Endemic	(Disease information—Immediate notifications 2005–2020; Brown et al. 2018)
Cape Verde	ca 1959 to present	Domestic pigs	Uncertain	(Disease information—Immediate notifications 2005–2020; Brown et al. 2018)

Table 1 (continued)

Country	ASF known presence	Species confirmed ^a	Current status	Relevant references
Côte d'Ivoire	1996, 2014, 2018,2019	Domestic pigs	Free with sporadic incursions	(Disease information–Immediate notifications 2005–2020; Brown et al. 2018; Couacy-Hymann et al. 2019)
Gambia (The)	1997, 2000	Domestic pigs	Uncertain (no reports)	(Brown et al. 2018)
Ghana	1999; 2002 to present	Domestic pigs	Endemic	(Disease information–Immediate notifications 2005–2020; Brown et al. 2018)
Guinea Bissau	ca. 1959 to present	Domestic pigs	Endemic	(Disease information–Immediate notifications 2005–2020; Brown et al. 2018)
Liberia	2011 (AU-IBAR)	Domestic pigs	Unknown	(Panafrikan Animal Health Yearbook 2011)
Mali	2016	Domestic pigs	Free	(Disease information–Immediate notifications 2005–2020)
Nigeria	1973; 1997 to present	Domestic pigs	Endemic	(Disease information–Immediate notifications 2005–2020; Brown et al. 2018)
Senegal	1959 to present	Domestic pigs	Endemic	(Disease information–Immediate notifications 2005–2020; Etter et al. 2011)
Sierra Leone	2019	Domestic pigs	Uncertain	(Disease information–Immediate notifications 2005–2020; Wadoum et al. 2020)
Togo	1997 to present	Domestic pigs	Endemic	(Disease information–Immediate notifications 2005–2020; Brown et al. 2018)
Caribbean and South America-historic				
Brazil	1978–1981	Domestic pigs	Free	(Moura et al. 1978)
Cuba	1971; 1981	Domestic pigs	Free	(Negrin 1980)
Dominican Republic	1978–1980	Domestic pigs	Free	(Rivera 1983)
Haiti	1978–1984	Domestic pigs	Free	(Alexander 1992)
Europe and Transcaucasus				
<i>Present/recent</i>				
Armenia	2007–2014	Domestic pigs, wild boars	Last outbreak in pigs confirmed in 2014	(Disease information–Immediate notifications 2005–2020)
Azerbaijan	2008	Domestic pigs	Free (SD 2011)	(Disease information–Immediate notifications 2005–2020)
Belarus	2013	Domestic pigs	Uncertain	(Disease information–Immediate notifications 2005–2020)
Belgium	2018–2019	Wild boars	Not yet officially eradicated	(Disease information–Immediate notifications 2005–2020; Linden et al. 2018)
Bulgaria	2018–2020	Domestic pigs, wild boars	Not yet eradicated	(Disease information–Immediate notifications 2005–2020; Zani et al. 2019)
Czech Republic	2017–2018	Wild boars	Free (SD 2019)	(Disease information–Immediate notifications 2005–2020; Marcon et al. 2020)
Estonia	2014 to present	Wild boars, domestic pigs	Free in domestic and captive wild pigs (SD 2018); declining in wild boars	(Nurmoja et al. 2018; Schulz et al. 2019; Nurmoja et al. 2017)
Georgia	2007, 2010, 2011	Domestic pigs	Uncertain	(Vepkhvadze et al. 2017)
Greece	2019	Domestic pigs	Uncertain	(Disease information–Immediate notifications 2005–2020)
Hungary	2018–2020	Wild boars	Uncertain	(Disease information–Immediate notifications 2005–2020)

Table 1 (continued)

Country	ASF known presence	Species confirmed ^a	Current status	Relevant references
Italy (Sardinia)	1978 to present	Domestic pigs, wild boars	Endemic	(Laddomada et al. 2019; Mur et al. 2016; Contini et al. 1983)
Latvia	2014 to present	Wild boars, domestic pigs	Possibly declining in wild boars; last pig outbreak in mid-2019	(Disease information–Immediate notifications 2005–2020; Olsevskis et al. 2014)
Lithuania	2014 to present	Wild boars, domestic pigs	Endemic in wild boars	(Mačiulskis et al. 2020)
Moldova	2016 to present	Domestic pigs, wild boars	Infected	(Disease information–Immediate notifications 2005–2020)
Poland	2014 to present	Wild boars, domestic pigs	Endemic in wild boars	(Disease information–Immediate notifications 2005–2020; Cwynar et al. 2019; Pejsak et al. 2014; Pejsak et al. 2018)
Romania	2017 to present	Domestic pigs, wild boars	Infected	(Disease information–Immediate notifications 2005–2020; Cwynar et al. 2019)
Russia	2007 to present	Domestic pigs, wild boars	Endemic	(Disease information–Immediate notifications 2005–2020; Gogin et al. 2013)
Serbia	2019 to present	Domestic pigs, wild boars	Infected	(Disease information–Immediate notifications 2005–2020)
Slovakia	2019 to present	Domestic pigs, wild boars	Infected	(Disease information–Immediate notifications 2005–2020)
Ukraine	2012 to present	Domestic pigs, wild boars	Endemic	(Disease information–Immediate notifications 2005–2020)
<i>Historic</i>				
Belgium	1985	Domestic pigs	Free (SD 2008)	(Biront et al. 1987)
France	1964, 1967, 1977	Domestic pigs	Free (SD 2008)	(Costard et al. 2009)
Italy	1967, 1980	Domestic pigs	Free (SD 2008)	(Costard et al. 2009)
Malta	1978–1979	Domestic pigs	Free	(Wilkinson et al. 1980)
Netherlands (The)	1986	Domestic pigs	Free (SD 2008)	(Cwynar et al. 2019; Terpstra and Wensvoort 1986)
Portugal	1957; 1960–1993; 1999	Domestic pigs, wild boars	Free (SD 2008)	(Vigário et al. 1983; Boinas et al. 2004; Madeira et al. 2015)
Portugal (Madeira)	1965, 1974, 1976	Domestic pigs	Free	(Plowright et al. 1994)
Russia	1977 ^c	Domestic pigs	Eradicated	(Korennoy et al. 2017)
Spain	1960–1994	Domestic pigs, wild boars	Free (SD 2008)	(Sánchez-Vizcaíno et al. 2015; Sánchez-Botija 1982; Ordás et al. 1983)
<i>Asia</i>				
Cambodia	2019 to present	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)
China (People's Republic)	2018 to present	Domestic pigs, wild boars	Infected	(Disease information–Immediate notifications 2005–2020; Zhou et al. 2018; Li et al. 2019; Li and Tian 2018)
China (Hong Kong)	2019	Domestic pigs	Uncertain ^d	(Disease information–Immediate notifications 2005–2020)
India	2020	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)
Indonesia	2019	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)
Iran	2008–2009	Wild boars	Free	(Rahimi et al. 2010)
Korea (North)	2019	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)

Table 1 (continued)

Country	ASF known presence	Species confirmed ^a	Current status	Relevant references
Korea (South)	2019	Wild boars, domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020; Kim et al. 2020a; Jo and Gortázar 2020)
Lao	2019	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)
Mongolia	2019, eradicated	Domestic pigs	Free	(Disease information–Immediate notifications 2005–2020; Heilmann et al. 2020)
Myanmar	2019 to present	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)
Philippines	2019 to present	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)
Timor Leste	2019	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020; Smith et al. 2019)
Vietnam	2019	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)
<i>Oceania</i>				
Papua New Guinea	2020	Domestic pigs	Infected	(Disease information–Immediate notifications 2005–2020)

https://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Self-declarations/ENG_archive_2000_Feb_2020.pdf

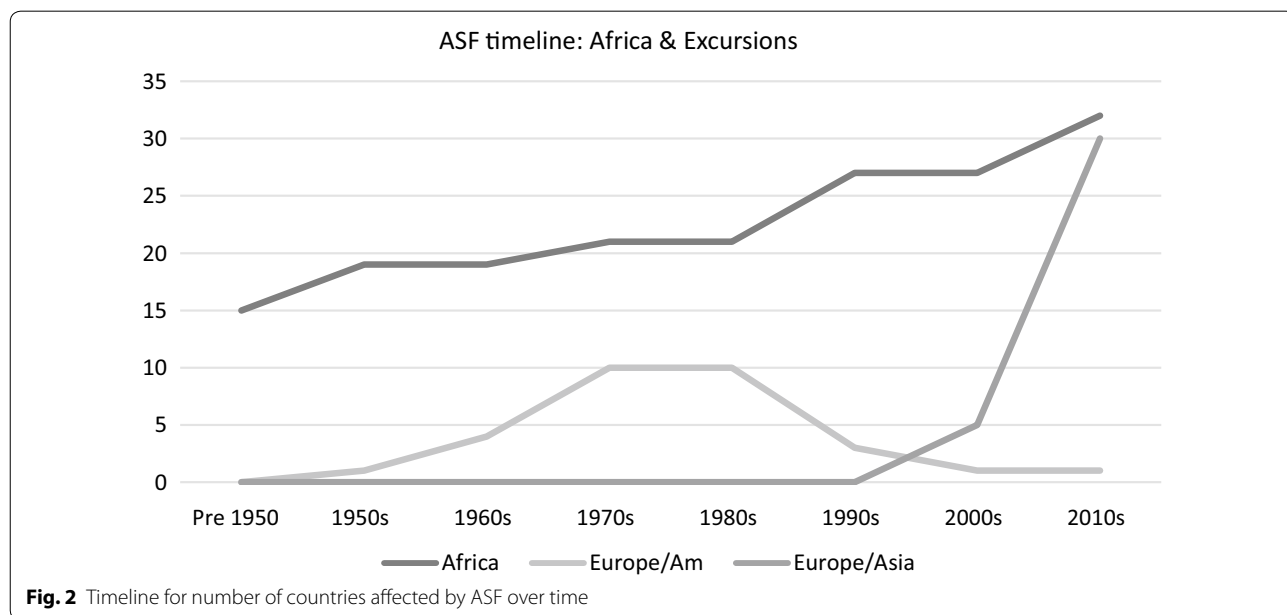
SD self-declaration to OIE

^a Note that African wild suids other than warthogs are not included, as there is relatively little information and a role in the epidemiology of ASF has not been demonstrated although, like warthogs, they are impervious to the pathogenic effects of ASF. They have no association with *Ornithodoros* ticks due to their habits and habitat, but a limited role for bushpigs may be possible

^b Warthogs are now considered to be extinct in Congo People’s Republic

^c The outbreaks occurred in Odessa, now part of Ukraine

^d The outbreaks involved infected pig carcasses from mainland China for processing; there have been no outbreaks in pigs produced in Hong Kong



This review summarises the current status of ASF in these regions as reflected in the World Organisation for Animal Health (OIE) Information System (OIE-WAHIS) database (Disease information–Immediate

notifications 2005–2020), ProMED-mail,¹ and relevant peer-reviewed publications. The links to relevant OIE

¹ The e-mail disease information system of the International Society for Infectious Diseases (<http://www.isid.org>).

Table 2 Links to Immediate notifications to the World Organisation for Animal Health (OIE), 2007–2020: Africa

Country	Report date	URL
Sierra Leone	11/02/2020	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=32924
Namibia	15/04/2009	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=8011
	10/05/2009	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=8088
Zimbabwe, Manicaland	14/02/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=29531
Zimbabwe, Mashonaland Central	23/08/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31533
	07/11/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=32134
Mali	01/01/2016	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=19778
Côte d'Ivoire, San Pedro	27/08/2014	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=15914
Côte d'Ivoire, Ferkessedougou, Korhogo	10/10/2017;	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=24989
	17/04/2018; 06/07/2018	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=26359 https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=27167
Côte d'Ivoire, Bangolo, Duekoue	01/10/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=31995
Cameroon, Extreme North	05/2010	https://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statusdetail/popup?diseaseid=12&country=CMR&y=2010&m=5&admin1=565&detail=2&sdid=430610
Chad, Mayo Kebi East	22/10/2010	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=9867
Chad, Ndjamena, Mayo Kebi East	14/09/2018; 04/02/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=27967 https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=29244
Central African Republic	11/12/2010	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=10059
	05/2012	https://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statusdetail/popup?diseaseid=12&country=CAF&y=2012&m=2&admin1=632&detail=2&sdid=533459
	07/12/2015	https://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statusdetail/popup?diseaseid=12&country=CAF&y=2015&m=7&admin1=619&detail=3&sdid=685423

reports are provided in Tables 2, 3, 4 for ease of reference. The main trends and challenges in each region for prevention and control are identified and analysed based on the information presented. Details of how these challenges may be addressed are beyond the scope of this review, but commonalities exist in small-holder pig production and human behaviour across the regions. The challenge is to identify practical, sustainable farmer-based and situation-specific solutions and develop risk mitigation strategies along pig and pork value chains that will have positive outcomes for a sector with enormous potential for poverty reduction through production of high quality protein.

Current status and trends of ASF and major challenges for management and eradication

Sub-Saharan Africa

Thirty-four countries in sub-Saharan Africa have experienced at least one confirmed ASF outbreak, the most recent one being Sierra Leone (Wadoum et al. 2020), (Table 2). In addition, the AU-IBAR yearbook for 2011 (Panafican Animal Health Yearbook 2011) reported an outbreak in Liberia that is considered credible although no details of confirmation are available. Countries are

considered to be endemically infected if outbreaks in domestic pigs have been reported to OIE on multiple occasions over a period of five or more years since 2005 and no self-declaration of freedom has been made or if the classic sylvatic cycle has been confirmed or is strongly suspected to be present.

The most important trends observed in sub-Saharan Africa in recent decades have been endemic establishment in most countries that have been recently infected; an increase in the number of countries infected or re-infected, and spread to previously free areas in countries where ASF is endemic. Poor reporting remains a challenge, as the ASF status of some countries is unknown.

Endemic area with classic sylvatic cycle in eastern and southern Africa

Infection in either warthogs or *Ornithodoros* ticks collected from their burrows or both has been demonstrated in Botswana (Simpson and Drager 1979), Kenya (Montgomery 1921), Malawi (Haresnape et al. 1988), Mozambique (Quembo et al. 2016; Quembo et al. 2018), Namibia, South Africa, Tanzania, Uganda, Zambia and Zimbabwe (Plowright et al. 1994). More than one p72 genotype has been reported from all of these countries.

Table 3 Links to Immediate notifications to the World Organisation for Animal Health (OIE), 2007–2020: Transcaucasus and Europe

Country	Report date	URL
Georgia	05/06/2007	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=5720
Armenia	29/08/2007	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=6051
	13/03/2010	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=9032
	28/09/2011	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=11075
Russia, South Ossetia Republic	07/07/2008	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=7164
Azerbaijan	29/01/2008	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=6730
Russia, Chechnya	04/12/2007	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=6546
Russia, Irkutsk	27/03/2017	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=23385
Russia, Omsk	14/07/2017	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=24296
Russia, Krasnoyarsk	06/10/2017	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=24965
Russia, Chelyabinsk	01/12/2017	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFuIIEventReport&reportid=25174
Russia, Tyumen, Yamano-Nenets	01/12/2017	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=25218
Russia, Primorskiy, Amur, Yevreyskaya	05/08/2019;	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFuIIEventReport&reportid=31280
	08/08/2019;	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31337
	12/09/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31725
Khabarovskiy	19/12/20	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=32642
Ukraine	31/07/2012	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=12168
Belarus, Grodno	21/06/2013	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=13663
Belarus, Vitebsk	07/07/2013	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=13736
Lithuania	24/01/2014	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=14690
Poland, Podlaskie	17/02/2014	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=14793
Poland, Lubuskie	15/11/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=32385
Latvia	26/06/2014	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=15485
Estonia	08/09/2014	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=16019
Moldova	04/10/2016	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=21095
Czech Republic	27/06/2017	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=24159
Romania	31/07/2017	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=24456
Hungary, Heves	23/04/2018;	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=26484
	29/08/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31594
Hungary, Szabolcs Szatmar Bereg	18/05/2018	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=26670
Hungary, Borsod Abauj Zemplen	05/10/2018	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=28174
Bulgaria, Tutrakantsi	31/08/2018	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=27760
Bulgaria, Silistra	23/10/2018	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=28379
Belgium	14/09/2018	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=27948
Slovakia	25/07/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31199
Serbia, Belgrade	11/04/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31342
Serbia, Pirotski, Borski	17/01/2020;	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=32972
	03/02/2020	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=33115
Greece	06/02/2020	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFuIIEventReport&reportid=33221

Additionally, although the presence of the classic sylvatic cycle has not been confirmed or, in most cases, adequately investigated, it is likely that it exists or historically existed in Angola, Burundi, Democratic Republic of Congo (DRC), Republic of Congo (Congo) and Rwanda

(Mulumba-Mfumu et al. 2019; Penrith et al. 2019). Ethiopia, where pig-keeping was a new activity, experienced its first outbreak in 2011, but genetic analysis of the outbreak viruses revealed subgenotypic variation that

Table 4 Links to Immediate notifications to the World Organisation for Animal Health (OIE), 2007–2020: Asia and Oceania

Country	Report date	URL
China, Zhejiang	23/08/2018	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=27636
China, Jilin	21/11/2018	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=28033
Hong Kong	12/05/2019; 05/06/2019; 04/09/19	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=30449 https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=30685 https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31644
Mongolia	15/01/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=29213
Vietnam	20/02/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=29617
Cambodia	03/04/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=30032
Korea, North	30/05/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=30664
Laos, Sarvane	20/06/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=30807
Laos, Vientane	11/07/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31056
Laos, Huaphanh	08/10/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=32036
Philippines, Luzon Island	09/09/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31677
Philippines, Mindanao Island	03/02/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=33135
Myanmar	14/08/2019; 17/02/2020; 04/03/2020	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31365 https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=33311 https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=33501
Timor-Leste	27/09/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31960
Indonesia	17/12/2019; 13/03/2020	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=32482 https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=33618
Korea, South	17/09/2019	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?reportid=31778
Papua New Guinea	30/03/2020	https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review?page_refer=MapFullEventReport&reportid=33803
India	19/05/20	

suggested a longer presence and therefore possible wart-hog involvement (Achenbach et al. 2017).

As the virus remains endemic in its sylvatic hosts, the infection cannot be eradicated from the sub-region, and outbreaks due to spill-over from the sylvatic cycle occur when proper separation between wild and domestic pigs is not in place (Penrith et al. 2013). However, in countries where relatively large numbers of pigs are kept in traditional free-ranging systems or smallholder and backyard

farms with low biosecurity, ASF virus circulates independently of the sylvatic hosts, which in many cases are only to be found in designated conservation areas where there are no domestic pigs (Haresnape et al. 1988; Penrith et al. 2019). Warthogs may be extinct in Republic of Congo (de Jong et al. 2016). The only recent report that suggested a source of outbreaks in eastern Congo close to the border of DRC attributed the infection to importation of

pigs from DRC soon after that country had reported outbreaks of ASF (Mulumba-Mfumu et al. 2019).

Trends and challenges for control

While ASF is endemic in domestic pigs in a number of countries in which the sylvatic cycle is known or believed to exist, Botswana, Namibia, South Africa and Zimbabwe until recently had only experienced sporadic outbreaks involving single farms or villages that could with reasonable confidence be attributed to spill-over from the sylvatic cycle (Mulumba-Mfumu et al. 2019). Recently, with the exception of Botswana, which has very few pigs, these countries have experienced outbreaks in domestic pigs that were either unrelated to the sylvatic cycle or may have been initiated by spill-over from the sylvatic cycle but subsequently spread markedly amongst domestic pigs.

In Namibia outbreaks of ASF occurred in 2009 in a backyard farm, a prison and villages in the Omusati and Oshana districts close to the border with Angola (Simulundu et al. 2017) (Table 2). Although according to the reports warthog involvement was suspected, the subsequent spread was more likely due to infectious pigs and pork. In South Africa, outbreaks in the ASF controlled area in domestic pigs still appear to be linked to the sylvatic cycle (Janse van Rensburg et al. 2020a). However, although occasional sylvatic cycle-related incidents occurred in the ASF free area close to the border of the ASF controlled area from its proclamation in 1935 until 2011, 2012 saw the first outbreaks in the free area that, although suspected to have originated in the controlled area, spread significantly among domestic pigs (Geertsma et al. 2012; Magadla et al. 2016). Between 2016 and 2019 outbreaks have occurred in several parts of the free area in three provinces (Janse van Rensburg et al. 2020b). These may have been initiated in the sylvatic cycle due to the introduction of infected warthogs into new areas (Swanepoel M, Leslie AJ, Hoffman LC. Farmers' perceptions of the extra-limital common warthog in the Northern Cape and Free State Provinces, South Africa. *Wildlife Society Bulletin* 2011) but in most of the outbreaks there was notable spread attributed to movement of infected pigs and feeding infected swill (Janse van Rensburg et al. 2020b). Finally, after an absence of outbreaks of ASF since 1992, Zimbabwe experienced an outbreak of ASF in 2015 in Mashonaland Central province in villages close to the border with the Tete Province of Mozambique. The pigs were free-ranging and the outbreak was attributed to movement of infected pigs and pork and careless carcass disposal (van Heerden et al. 2017). In January 2019 similar outbreaks were reported in free-ranging pigs in Manicaland Province, on the border

with Manica Province in Mozambique, and in August/September 2019 outbreaks were again experienced in Mashonaland Central (Table 2).

It is likely that the shift from isolated outbreaks related to the sylvatic cycle to notable involvement of domestic pigs in previously unaffected areas can be attributed to a marked increase in pig production, largely by smallholder pig producers. Figures available in South Africa indicated that the number of households keeping pigs almost doubled between 2011 and 2016, about 90 per cent of whom kept 10 or fewer pigs (Janse van Rensburg et al. 2020b). It was previously noted that an increase in the pig population in sub-Saharan Africa was accompanied by an increase in the number of outbreaks of ASF (Penrith et al. 2013).

Controlling ASF in a domestic pig cycle presents different challenges from preventing spill-over from the sylvatic cycle, which is usually simply a matter of ensuring adequate separation between pigs and warthogs. In Africa, the domestic cycle is largely driven by poverty amongst subsistence level pig farmers. To profit from their pigs, these farmers resort to practices that are risky for ASF, such as allowing pigs to scavenge or feeding them waste food, failing to implement even basic biosecurity measures, buying pigs as cheaply as possible from uncertain sources, not reporting disease and selling off pigs as soon as one pig shows signs of ASF (Chenais et al. 2017; Chenais et al. 2019; Dione et al. 2017; Dione et al. 2016; Lichoti et al. 2016). Providing incentives for change is the most important challenge for ASF control in this region.

Historically free (no sylvatic cycle) areas in West and Central Africa and Indian Ocean

Although warthogs are widely distributed in savannah areas in West Africa and northern Central Africa, the classic sylvatic cycle has not been demonstrated to occur there, probably due to the absence of *Ornithodoros moubata* complex ticks from the West African region south of 13° N (Etter et al. 2011; Trape et al. 2013). Absence of the ticks from the main pig-producing areas in Cameroon was also reported (Ekue and Wilkinson 1990). Limited serological examination of warthogs in Senegal and Nigeria failed to detect antibodies (Etter et al. 2011; Sarr J, Diop M. Situation épidéziologique de la peste porcine africaine au Sénégal. Institut Sénégalais de Recherche Agricole, Laboratoire de l'Élevage et de Recherches Vétérinaires, Dakar, Senegal (unpublished report) 1990; Taylor et al. 1977). Detection of ASF virus in a baby warthog and a Red River hog (*Potamochoerus porcus*) in Nigeria (Luther et al. 2007a, b) was likely due to spill-over from the outbreaks that were widespread in pigs at the time. In

Senegal, specimens of *Ornithodoros sonrai* collected from rodent burrows in earth-floored pig pens tested positive for ASF virus (Vial et al. 2007) but are considered unlikely to play an important role in the persistence of ASF virus in the country as they are not present in the endemic area, which lies south of 13° N (Etter et al. 2011).

The classic sylvatic cycle is also absent from the Indian Ocean Islands, where warthogs are not present. Although ASF became endemic in Madagascar after the first outbreaks were reported in 1998, there is no indication that the presence of a population of southern bushpigs (*Potamochoerus larvatus*) in the north of the island or of *Ornithodoros moubata* complex ticks plays any role in the epidemiology of the disease (Jori et al. 2013). In Mauritius, there are no wild African suids or *Ornithodoros moubata* complex ticks (Lubisi et al. 2009; Jori et al. 2013). The only free-ranging pigs are the descendants of domestic pigs from Europe introduced by sailors centuries ago (Oliver W, Brisbin I. Introduced and feral pigs: Problems, policies and priorities. The Eurasian Wild Pig. In: Oliver, WLB, editor. Pigs, Peccaries and Hippos Status Survey and Action Plan. Gland: IUCN/SSC 1993) that are either farmed or kept on large estates for hunting purposes. The single incursion of ASF was rapidly eradicated (Lubisi et al. 2009).

Endemic establishment of the disease in regions without the sylvatic cycle can therefore be ascribed to continuous circulation of the virus in pig populations with a high level of contact, for example in free-ranging populations that commonly occur in West Africa (Brown et al. 2018).

Trends and challenges for control

In West Africa, since 2017 two new countries reported outbreaks and Côte d'Ivoire has again experienced outbreaks after eradicating ASF by 1997. Two countries in Central Africa have become endemically infected since 2010.

An outbreak occurred in Mali in 2016, close to the border with endemically infected Burkina Faso (Table 2). After the introduction of ASF in 1996 Côte d'Ivoire succeeded in eradicating the disease with the last few outbreaks reported in October 1996 (El Hicheri et al. 1998). An outbreak occurred in the port city of San Pedro in 2014 (Table 2), probably due to scavenging pigs having access to ships' galley waste (Couacy-Hymann et al. 2019). The outbreak was eradicated after limited spread, but in 2017 and 2019 further outbreaks occurred. The first was in the north of the country in Ferkessedougou with spread to the neighbouring district of Korhogo. It was reported that prior to the outbreak there had been pig mortalities close to the border with Burkina Faso

(Table 2). The 2019 outbreaks occurred in two districts in the south eastern part of the country not sharing a border with another country. The outbreak was ascribed to the 'introduction of new live animals,' the origin of which was not given (Table 2). Sierra Leone reported ASF to OIE for the first time in 2019 (Table 2), but the disease may have been present in the country for at least 3 years (Wadoum et al. 2020).

After an outbreak in the previously unaffected Extreme North district in Cameroon in 2010, ASF spread to Chad and appears to have become established (Table 2). The introduction was traced to a city close to the border with the affected area in Cameroon and was believed to be due to infected pigs or pork brought from that country (Bidjeh et al. 2015), followed by spread to other parts of Chad. Central African Republic (CAR) also reported an outbreak in 2010 but this may not have been linked to the Cameroon and Chad outbreaks, as it occurred far from the borders of those countries and the OIE Animal Health Information Department noted that a suspicion of ASF had already been reported in 2009. Subsequently reporting has been biennial as for endemic countries (Table 2). The existence of the sylvatic cycle has not been investigated in either Chad or CAR. In CAR an association between *Ornithodoros moubata* complex ticks and warthogs apparently exists, as one nymph collected from a warthog has been reported (Uilenberg et al. 2013). Neither country had previously officially reported ASF.

With endemic infection present in several countries in West Africa, Central Africa and also in Madagascar, these regions pose a risk of ASF in spite of the absence of the sylvatic cycle. Although African exports of pork outside the continent are insignificant, intra-regional trade occurs at both formal and informal levels (Bidjeh et al. 2015; FAO. Secteur Porcin Burkina Faso. Revues nationales de l'élevage de la division de la production et de la santé animales de la FAO. No. 1. Rome: Food and Agriculture Organization of the United Nations 2012; Kouakou et al. 2017; Dutuere G. Les facteurs de compétitivité de la filière porcine dans la Bassin du Logone. 2002). Movement of people between countries due to economic imperatives or civil wars is also common and can result in movement of infected products. Traditional transhumance due to trade or climatic factors overwhelmingly involves ruminants and camels, but as borders frequently divide closely related communities, transfer of live pigs for ceremonies commonly occurs (Penrith et al. 2013; Kouakou et al. 2017). The recent introductions into Côte d'Ivoire and Mali are believed to have originated in the region, including the introduction to the former via the port of San Pedro (Couacy-Hymann et al. 2019). The virus that caused the 2007 incursion into Mauritius had

been circulating in Mozambique and Madagascar since at least 1998 (Lubisi et al. 2009).

The Mauritius and San Pedro incursions were attributed to the consumption by pigs of inadequately disposed waste food from ships containing infected pork (Lubisi et al. 2009; Couacy-Hymann et al. 2019), and this remains the greatest risk for long distance introductions of ASF.

Challenges are similar to those now being experienced in endemic areas when the sylvatic cycle spills over with continuation in domestic pigs. Risks in the way pigs are farmed and traded include free-ranging production systems that permit scavenging on potentially infected material, feeding of waste food to pigs, generally low levels of biosecurity on premises where pigs are kept and informal trading systems (Bidjeh et al. 2015; Brown et al. 2018; Wadoum et al. 2020; Dione et al. 2017; FAO. Secteur Porcin Burkina Faso. Revues nationales de l'élevage de la division de la production et de la santé animales de la FAO. No. 1. Rome: Food and Agriculture Organization of the United Nations 2012; Andriamanivo et al. 2019; Asambe et al. 2017; Costard et al. 2009; Fasina et al. 2012; Randrianantoandro et al. 2015). The challenge is how to mitigate the risks to reduce or eliminate losses due to ASF and make smallholder pig production more profitable and sustainable.

Europe and Transcaucasus

The current situation in Europe is described country by country, in chronological order of their reporting ASF, and the trends and challenges will be presented at the end of the section. The same format has been followed for Asia.

Transcaucasus

The Transcaucasus is a region at the junction of Europe and Asia, and comprises of Georgia, Armenia and Azerbaijan, as well as a part of southern Russia.

Domestic pigs in Georgia, Armenia and Azerbaijan are currently free from ASF. Since 2007, when multiple outbreaks of ASF were reported in domestic pigs in Georgia (Table 3), and 2010–2011, when ASF re-emerged (Vepkhvadze et al. 2017), no further outbreaks have been reported. A serological survey carried out in domestic pigs in 2014 in which 1231 pigs proved negative for antibodies to ASF virus suggested that the virus is not being maintained in domestic pig populations in Georgia, but the ASF situation in wild boars is unknown (Vepkhvadze et al. 2017). According to a report to EFSA, ASF spread continues in South Ossetia (Depner et al. 2017), which lies within the Republic of Georgia but since 2008 has existed as an independent republic under Russian protection, similar to Abkhazia, which was affected by ASF at the same time as Georgia (Gogin et al. 2013). South

Ossetia experienced its first ASF outbreak in June 2008 (Table 3).

The first ASF outbreak in Armenia notified to OIE was on a commercial farm in Tavush Marz in the north of the country in August 2007, followed by outbreaks in backyard and village farms in both northern districts (Tavush and Lori Marz) (Table 3) as well as Yerevan and Ararat, with an additional case in February 2008 (Rahimi et al. 2010). No outbreaks were officially reported in 2008 and 2009, but a second wave of infection is reported to have occurred on farms in Tavush Marz in 2009, infecting greater numbers of pigs than in 2007 (Sargsyan et al. 2018). In March 2010, outbreaks occurred in a small commercial farm in Tavush Marz, in feral pigs in a forest in Lori Marz, and two wild boars in Vayots Dzor, and in 2011 outbreaks were reported in village pigs in Siunik, Kotayk, Aragatsotn, Armavir and Tavush (Table 3). Further outbreaks occurred on farms in Tavush Marz in late autumn to early winter of 2011 (Sargsyan et al. 2018). Since 2011 no further outbreaks in domestic pigs have been reported, but the wild boar status is unknown. The outbreaks in village pigs in the southernmost province of Siunik not long after ASF-positive wild boars were identified in the adjacent province of Vayots Dzor just to the north of Syunik, as well as the positive wild boars identified in north-western Iran in 2008 and 2009 (Rahimi et al. 2010) suggest circulation of the virus in wild boar populations occurred, at least during that period. Since ASF was confirmed by the Armenian Veterinary Services in the disputed territory of Nagorno Karabakh in October 2013,² almost 2 years after the last reported outbreak in pigs in Armenia, it is possible that wild boars may have been source of the infection.

Azerbaijan reported a single ASF outbreak in January 2008, in one village inhabited by Christian people with about 4600 pigs (Table 3). The source of infection was most likely infected pork imported from Georgia, in the absence of evidence of infected wild boars (Beltran Alcrudo D, Lubroth J, Depner K, De la Rocque S. African swine fever in the Caucasus. EMPRES Watch, April 2008).

Challenges that remain in the Transcaucasus are the existence of disputed territories and the unknown situation in wild boars.

Europe

Sardinia (Italy)

Unlike the other affected European countries, Sardinia has experienced ASF since 1978 (Laddomada et al. 2019; Mur et al. 2016; Cappai et al. 2018; Iglesias et al. 2017). There is no evidence of involvement of *Ornithodoros*

² <https://armenpress.am/eng/amp/519844>.

ticks in ASF in Sardinia (Mur et al. 2017). The only species of the genus known to occur on the island is associated with sea birds and is found in habitats where pigs are unlikely (Fois et al. 2016). Both domestic pigs and wild boars were infected, and persistence of the virus has depended largely upon circulation in free-ranging pig populations (Laddomada et al. 2019; Mannelli et al. 1997; Mur et al. 2018). It has generally been accepted that wild boars play a secondary role to infected domestic pigs (Mur et al. 2016; Laddomada et al. 1994), but under some circumstances they may play a more important role (Mur et al. 2016; Mur et al. 2018). There is no evidence that Sardinia has ever been a source of infection for other countries.

Russia

The first ASF outbreak on Russian Federal territory was recorded in December 2007 in dead wild boars along the Argoun and Argoun-Shatoy rivers in Chechnya Republic on the border with Georgia (Table 3). Its subsequent spread in Russian territories between 2007 and 2012 has been well documented (Gogin et al. 2013). It can now be considered endemic in most of European Russia with new outbreaks reported in domestic pigs and/or wild boars in 26 administrative regions between 2018 and 2020, including a number of large commercial pig farms (Disease information—Immediate notifications 2005–2020).

Since 2017 there has been concerning expansion of ASF eastwards (Disease information—Immediate notifications 2005–2020). Outbreaks have occurred in the eastern federal districts of Urals (Chelyabinsk, Omsk, Tyumen, Yamalo-Nenetsky), Siberia (Irkutsk and Krasnoyarsk) and most recently (2019–2020) in the Far East (Amurskaya, Khabarovsk, Primorskiy and Yevreyskaya Avtonomnaya Oblast) (Table 3). These last outbreaks have been concentrated along the border with China. The virus that was isolated from the outbreak in Irkutsk, Siberia in 2017 proved to be identical to the original virus introduced into Russia in 2007 and is now comparatively rare among recent Russian isolates (Kolbasov et al. 2018).

The first outbreak in the Far East occurred on a small farm with 70 pigs in Primorskiy Kray in July 2019, followed a few days later on 5 August 2019 by an outbreak in village pigs in Amurskaya Oblast (Table 3). At about the same time, two outbreaks involving 7 wild boars were identified in forest in the same general area as the first outbreak in Primorskiy Kray. Outbreaks have occurred among domestic pigs and wild boars in Yevreyskaya Avtonomnaya Oblast and in wild boars in Khabarovskaya Krai in 2019 (Table 3). Outbreaks in wild boars in Amurskaya Oblast were registered in 2019 and 2020, and also in wild boars in 2020 (Table 3).

All the outbreaks in the Urals region and Siberia occurred in domestic pigs, with no evidence for a link to wild boars. On the other hand, cases in wild boars have occurred in the Far East. However, considering the distance between the Far East and the nearest known infections in wild boars in European Russia, it is extremely unlikely that Russian wild boars could be implicated in an ASF introduction to the Far East. Infection in wild boars has been reported only in three localities in China, none of them particularly close to the Russian Far East. However, there were outbreaks of ASF in the adjacent Chinese province of Heilongjiang in domestic pigs in early September 2018, and since the first outbreaks of ASF in August 2018 in Liaoning Province in China (Zhou et al. 2018) the situation in China has remained dynamic, with ASF having spread throughout the country within months of the initial outbreaks.

Ukraine

Apart from an outbreak in Odessa in 1977 when it was still part of the USSR (Korennoy et al. 2017), Ukraine experienced its first outbreak of ASF in domestic pigs in July 2012, in the Zaporozh'Ye district in village pigs (Table 3). No further outbreaks were reported in 2012 or 2013, but in January 2014 ASF was detected in a wild boar, a backyard pig farm and some village pigs in Lugansk, which shares a border with Russia (Disease information—Immediate notifications 2005–2020). From that time to the present, Ukraine has reported numerous outbreaks in both wild boars and domestic pigs (Disease information—Immediate notifications 2005–2020). In 2016 outbreaks occurred in Odessa and Chernovtsy districts that share borders with Moldova and the latter district also with Romania. By the end of 2017 ASF had been reported in all of the administrative districts of Ukraine, mostly in both wild boars and backyard pigs as well as in mainly small farms. Large numbers of immediate notifications submitted between 2018 and April 2020 indicate that active circulation of the virus continues in Ukraine (Disease information—Immediate notifications 2005–2020).

Belarus

Belarus has only reported two ASF outbreaks, both in 2013. The first occurred in June 2016 in village pigs in the Grodno district in the west that shares a border with Lithuania (Table 3). The second, at the beginning of July, was on a commercial cooperative farm with 20,611 pigs close to the eastern side of the Vitebsk district that shares borders with Latvia to the west and Russia to the east. The Grodno outbreak was attributed to contaminated feed and the origin of the Vitebsk outbreak was not determined (Table 3). Both outbreaks were rapidly resolved.

Lithuania

The first outbreak was reported in wild boars found close to the border with Belarus in January 2014 and ASF continues to the present in wild boars (Table 3). The last outbreak in domestic pigs was reported to OIE in 2018. Up to the end of 2017 two out of 52 outbreaks were recorded in commercial pig farms, the majority of cases having occurred in backyard holdings (Pautenius et al. 2018). Outbreaks in both wild boars and domestic pigs increased markedly in 2017 and 2018 (Mačiulskis et al. 2020; Pautenius et al. 2018). A study on buried wild boar carcasses in Lithuania failed to demonstrate the presence of infectious virus in samples from the carcasses or the adjacent soil (Zani et al. 2020), suggesting that environmental persistence may not present a long-term threat of ASF.

Poland

In Poland, the first identification of the ASF virus was in February 2014 in a sample from a dead wild boar found 900 m from the border with Belarus in the Hajnowski region of the Podlaskie district (Pejsak et al. 2014) (Table 3). By 31 August several more cases in wild boars and two outbreaks in backyard pig farms, all close to the border with Belarus, had been diagnosed (Pejsak et al. 2014). The first 18 months of the virus presence in Poland were characterised by repeated introductions of the virus via wild boars close to the Belarus border, followed by the disease spreading slowly in areas heavily populated with wild boars, which had a dominant role in maintaining the virus (Smietanka et al. 2016). Reports to OIE reflected spread of the disease over the next years to neighbouring districts on the eastern border of Poland. The first outbreaks in wild boars and domestic pigs in Lubelskie to the south and Mazowieckie to the west were reported in 2016, followed by Warminsko-Mazurski to the north in wild boars in 2017 and domestic pigs in 2018. A few outbreaks were reported in domestic pigs from Podkarpackie, to the south of Lubelskie, in 2018 (Disease information–Immediate notifications 2005–2020). The genotype II viruses isolated from samples taken from two wild boars in Lithuania and two in Poland indicated a variant that was identical to isolates from Belarus and Ukraine (Gallardo et al. 2014), but this was not able to confirm the origin of the viruses, as the same variant was reported to have been circulating rather widely in southern and central Russia since 2012 (Goller et al. 2015).

Until 2018, ASF remained confined to the infected districts in the east of Poland. The need to prevent transfer of the infection in wild boars to new areas through human activities was foreseen in an epidemiological study of ASF in wild boars in Poland over a four-year period (Pejsak et al. 2018). However, in 2019 infected

wild boars were found in Lubuskie district in the west of Poland close to the border with Germany, more than 500 km from the infected eastern districts (Table 3) and subsequently in the neighbouring district of Wielopolskie (Disease information–Immediate notifications 2005–2020). Most recently two outbreaks of ASF on commercial pig farms in western Poland have been reported by ProMED-mail. The first occurred in Lubuskie district, affecting more than 23,700 pigs³ on a commercial farm 66 km from the German border; it was reported that wild boar carcasses had been seen near the pig houses. On 4 April 2020 ProMED-mail posted the news that an outbreak of ASF had been confirmed on a commercial farm in Wielkopolskie⁴ near Poznan, less than 150 km from the border with Germany. It is evident that these outbreaks could not have been caused by natural migrations of wild boars, and that anthropogenic activities offer the only plausible explanation.

Latvia

Three dead wild boars found close to the border with Belarus in June 2014 tested positive for ASF (Table 3). Following this event, 32 cases occurred on pig farms and 217 in wild boars during the remainder of 2014 (Olsevskis et al. 2014). The outbreaks in domestic pigs were in backyard holdings, the majority (20) with fewer than 10 pigs and the largest with 196 pigs, and all were attributed to breaches of biosecurity. The last outbreak in a pig farm was reported in July 2019, with 10 reports of ASF in pig farms in 2018 (Disease information–Immediate notifications 2005–2020), but reports of infected wild boars continued into 2020. An evaluation of the current epidemiological situation in wild boars indicated a decrease in active circulation of the virus and suggested that managing the wild boar population to keep numbers as low as possible, continuing surveillance and removal of wild boar carcasses could result in elimination of the infection (Olsevskis et al. 2020). An experimental oral vaccine developed from a field strain of reduced virulence recovered from a wild boar in Latvia was reported to show promise (Barasona et al. 2019).

Estonia

A dead wild boar was discovered in Valga County 6 km from the border with Latvia in September 2014 (Table 3). The first pig farm was affected in July 2015. From 2015 to 2017 there were 26 outbreaks in pig farms, involving both backyard and large commercial farms, with lower

³ Based on media report: <https://www.pigprogress.net/Health/Articles/2020/3/ASF-Poland-First-outbreak-on-farm-in-Western-Poland-559288E/>.

⁴ Based on media report: <https://www.theguardian.com/environment/2020/apr/08/african-swine-fever-outbreak-reported-in-western-poland>.

mortality observed on the commercial farms (Nurmoja et al. 2018). There were 17 outbreaks in domestic pigs in 2015, 6 in 2016 and 3 in 2017, while in wild boars there were 1095 outbreaks in wild boar in 2015, 1570 in 2016 and 867 in 2017. An 18th outbreak in pigs reported and investigated in 2015 could not be confirmed, as samples from dead pigs were not available and the remaining pigs on the farm were negative for virus and antibodies (Nurmoja et al. 2018). Eighty-eight per cent of the outbreaks in domestic pigs occurred in areas where there were also outbreaks in wild boars within a 15 km radius of the farm. The reduced risk of outbreaks in pig farms may have been due to a marked reduction in the number of backyard holdings over the three-year period. The number fell from 696 in 2014 to 25 in 2017 owing to the imposition of strict biosecurity requirements for all pig farms (Nurmoja et al. 2018).

All the outbreaks in domestic pigs were detected in summer. Summer high incidence was ascribed to more wild boar activity closer to farms. Blood-sucking arthropods could also be involved and requires investigation but one would expect more outbreaks if they were important, as well as more cases within herds (Nurmoja et al. 2018). A survey has been conducted to determine the species of Diptera associated with Estonian pig farms (Tummeleht et al. 2020). A preliminary investigation of trapped Diptera detected traces of ASF virus in two flies and two mosquitoes, but further investigations to determine whether these insects could maintain and transmit infectious ASF virus are required (Herm et al. 2020).

An ASF virus strain with a consistent deletion of 14,560 base pairs at the 5' end and consequent reorganisation of the genome was identified from field samples in north-eastern Estonia and under experimental conditions showed reduced virulence in trials with domestic and miniature pigs (Zani et al. 2018). High virulence was observed for a virus that caused outbreaks in another part of the country at the same time, so a general decline in virulence in Estonia is unlikely. Both in Estonia and Latvia the virus appeared to be of low contagiousness and spread slowly (Nurmoja et al. 2018; Olsevskis et al. 2014), but the case fatality rate was high.

Analysis of surveillance data in wild boars in Estonia provided some cause for optimism that incidence in wild boars was declining, suggesting that control measures might be achieving some success and achieving eradication of the infection in the wild boar population (Schulz et al. 2019; Schulz et al. 2020).

Moldova

The first two outbreaks were reported in September 2016 in backyard farms not far from the Ukrainian border (Table 3) and were attributed to swill feeding, using meat

brought from Ukraine on a public holiday some 6 weeks previous to the primary outbreak.⁵ Since that time the country has suffered repeated outbreaks in both domestic pigs and wild boars. Until 2018 the majority of outbreaks involved mostly backyard pig farms, but in 2019 outbreaks in wild boars considerably outnumbered those in pig farms, and this trend continues into 2020 (Disease information—Immediate notifications 2005–2020).

Czech Republic

The first outbreak occurred in wild boars in Zlin district in late June 2017 (Table 3). In the immediate notification it was suggested that two wild boars found dead had crossed the Czech border with Slovakia, which had never reported ASF in spite of the usual EU surveillance. The nearest known infected wild boar population was 400 km away in Poland. It was later concluded the source of the infection was likely raw bacon discarded by a laundry worker from Ukraine in the hospital behind which the wild boars were found.⁶ Some local spread had occurred among wild boars. Using the approaches of careful definition of infected area, a complete ban on hunting within that area, intensive surveillance for dead boars and subsequent testing, and finally depopulation of the remaining wild boars resulted in eradication of ASF, the first time that ASF has been eradicated in a free-living wild population (Marcon et al. 2020). Eradication was confirmed in a self-declaration of freedom from ASF accepted by the OIE in 2019 (Table 1).

Romania

The first report was in July 2017 in a backyard farm in the Satu-Mare district and the source of infection was not determined at the time of reporting (Table 3). Further outbreaks in backyard farms and wild boars were reported in 2017 and 2018 in the same district, which shares borders with Hungary and Ukraine (Disease information—Immediate notifications 2005–2020). In 2018 outbreaks in backyard farms and to a lesser extent wild boars occurred in a number of districts from the north east of the country to the Black Sea coast (Disease information—Immediate notifications 2005–2020). Until July 2018 outbreaks involved backyard farms and sometimes wild boars, but after numerous outbreaks in backyard farms and a few in wild boars in the Tulcea district, an outbreak occurred on a large breeding farm with more than 40,000 pigs.⁷ Over time there was a shift from

⁵ Information from a ProMED-mail posting available at <https://promedmail.org/promed-post/?id=20160929.4525246>.

⁶ https://ec.europa.eu/food/sites/food/files/animals/docs/reg-com_ahw_20170918_african_swine_fever_wild_boars_cze.pdf.

⁷ Based on media report, <http://promedmail.org/post/20180704.5887708>.

backyard farms to wild boars as the main victims of ASF. OIE immediate notifications reflect 1310 outbreaks in domestic pigs and 549 in wild boars, with 21 in domestic pigs and 34 in wild boars in 2019 and 79 in domestic pigs and 250 in wild boars so far registered in 2020 (Disease information–Immediate notifications 2005–2020).

Hungary

So far only wild boars have been affected by ASF in Hungary. The first of 893 cases was registered in Heves district in April 2018 (Table 3). The area is heavily industrialised, with employment of foreign workers, and the source was believed to be waste food. In May 2018 a dead boar in Szabolcs-Szatmar-Bereg district about 1 km from the border with Ukraine was positive for ASF, and considering the level of infection in wild boars in Ukraine it seemed likely that the outbreak was the result of the normal wild boar spring migration (Table 3). This outbreak involved 211 events in 2018 (Disease information–Immediate notifications 2005–2020). A third outbreak, of undetermined origin and involving 1938 cases, started in Borsod-Abaj-Zemplen district in September 2018 (Table 3). Outbreaks continued through 2019 to the present at localities widely spread over the eastern half of the country, including at one locality close to the border of Romania (Disease information–Immediate notifications 2005–2020). A series of 239 outbreaks in Heves in August 2019 were considered to represent a new epidemiological unit along the Tisza River, south of the M3 motorway (Disease information–Immediate notifications 2005–2020).

Bulgaria

The first outbreak occurred in the Varna district in a backyard pig farm in Tutrakantsi in August 2018 (Table 3). A study of this outbreak could not determine the source of infection but identified anthropogenic factors linked to the potential for unrestricted human access to the pigs in spite of their secure confinement as the highest probability for introduction of the virus (Zani et al. 2019). This was followed by the diagnosis of ASF in a dead wild boar found entangled in a fence on the border with Romania in the district of Silistra (Table 3). The following months saw reports of further outbreaks in wild boars and in domestic pigs in backyard holdings as well as a large industrial farm and a breeding farm; subsequently deaths of wild boars due to ASF were reported from the same area (Disease information–Immediate notifications 2005–2020). Further ASF cases were confirmed in wild boars at localities in the north-eastern area where the previous outbreaks had occurred but also at two localities in the south, near to the border with Greece (Disease information–Immediate notifications 2005–2020).

Belgium

The first case was reported in September 2018 in the Luxembourg province of Belgium in wild boars (Linden et al. 2018) (Table 3). The source of the infection was not determined, but the distance from the nearest infected wild boar population, namely Czech Republic 1000 km away, pointed to anthropogenic factors (Gilliaux et al. 2019). The virus isolated proved to be a variant of the genotype II virus originally introduced into Georgia from Africa in 2007 that was most similar to viruses that were identified in Ukraine, Belarus, Estonia, European Russia and China between 2012 and 2018 (Garigliany et al. 2019). Sequencing of the complete genome revealed that of the ASF viruses for which information on complete sequencing of the genome is available, the Belgian isolate most closely resembled a 2014 isolate from Estonia (Gilliaux et al. 2019). Experimental infection of young wild boars with the Belgian 2018/1 isolate confirmed its high virulence in wild boars (Pikalo et al. 2020). In spite of the outbreaks in wild boars, Belgium reaffirmed their self-declaration of freedom in domestic pigs and captive feral pigs in May 2019.⁸ Outbreaks in free-living wild boars continued into 2019, with relatively large numbers of cases reported up to March, with marked tapering off from April to July and the last fresh case reported on 11 August 2019. The last reports from 21 October 2019 to 14 April 2020 concerned the bones of wild boars estimated to be from 3 to 6 months old, suggesting that the last cases may have occurred in September 2019 (Disease information–Immediate notifications 2005–2020).

Slovakia

Outbreaks of ASF were reported in backyard farms in July and August 2019 in the Kosice district close to the border with Hungary (Table 3), with reported cases in wild boars in the same area from August 2019 to April 2020 (Disease information–Immediate notifications 2005–2020).

Serbia

The first outbreak in Serbia was reported in domestic pigs in a village in the Belgrade district in August 2019.⁹ Altogether 18 outbreaks occurred between July and November 2019 (Table 3), mainly in the same area in Belgrade district but also in the adjacent Podunavski district and the Srednji Banatski district on the border with Romania.

The first outbreaks in Serbia reported in wild boars occurred in January 2020 in the Pirot and Bor districts,

⁸ https://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Self-declarations/2019_04_Belgium_ASF_ANG.pdf.

⁹ Based on a media report in Bosnian, <http://promedmail.org/post/20190803.6603847>.

the former sharing a border with Bulgaria and the latter with Romania. The outbreaks occurred close to the respective borders (Table 3).

Greece

ASF was confirmed in a backyard farm in the province of Kentriki Makedonika, distant from any international border. The source of the infection was reported to be undetermined (Table 3).

Trends and challenges

The two most important trends that can be identified for ASF in Europe are (1) endemic establishment in domestic pig and wild boar populations and (2) unpredictable long distance ‘leaps’ of the infection into new areas. The former trend in domestic pigs is linked to low biosecurity pig farming with practices that include allowing pigs to roam and feeding unsafe catering waste. This trend has played a relatively minor role in most of the affected EU states but appears to be important in the Danube Delta, judging from the number of outbreaks in backyard farms in Ukraine, Moldova, Romania and Bulgaria (Disease information–Immediate notifications 2005–2020). Stringent requirements for increased biosecurity as well as losses due to ASF resulted in a marked reduction of both smallholder pig farms and ASF in domestic pigs in Estonia (Nurmoja et al. 2018), but in less developed countries this is unlikely to happen. In 2005, large numbers of free-ranging pigs belonging to poor communities in the Eastern Cape province of South Africa were culled to eradicate an incursion of classical swine fever and a ban was placed on pig keeping unless good quality housing was available for the pigs. As this was unaffordable for the majority of pig keepers even after compensation for pigs culled, and they were heavily dependent upon their pigs to sustain their families, free-ranging pig husbandry was simply resumed (Madzimore et al. 2012).

The wild boar problem is unique. During the lengthy presence of ASF in the Iberian Peninsula wild boars played a minor role if any in the epidemic, although there was evidence of infection in wild boars in areas where domestic pigs were infected (Mur et al. 2012). The current situation is probably related to the high numbers of boars present in the affected states. The number of suspected instances of transboundary transmission amongst wild boars indicates meta-populations that move freely across borders.

The phenomenon of long-distance leaps of the virus is not unique to Europe by any means, but some spectacular examples have emerged in Europe in recent years. The first events occurred in Russia after ASF had been confined to the endemic southern area with gradual spread into the central area of European Russia until 2011, with

the most distant affected locality being Arkhangelsk in the far north (Gogin et al. 2013). The eastward spread since 2017 that has affected localities in the Urals, Siberia and Far Eastern regions of Russia all suggest apparent long-distance transmission of the virus, but the Far East outbreaks could have had a more local origin in China. The other remarkable leaps that could only have been due to anthropogenic activity were the outbreaks in wild boars in Czech Republic and Belgium and the sudden appearance of ASF in western Poland. Given the amount of publicity that ASF in Europe has enjoyed, these actions can be considered surprising.

Asia and Oceania

Apart from ASF in the Transcaucasus at the junction of Europe and Asia, a report of ASF in wild boars in Iran close to the Armenian border (Rahimi et al. 2010) and the recent eastward extensions of ASF into Asian Russia, the Asian continent remained free of ASF until August 2018, when it was first reported in China. With half of the world’s pig population, the threat of ASF in China had been a topic of concern in several publications previously (Costard et al. 2009; Anon. Preparing for the worst: African swine fever in China. *Vet Rec* 2017; Oura 2013; Vergne et al. 2017). When the first outbreak was announced on 3 August 2018 in north-eastern China it was accepted to be a major disaster for pig production in China (Wang et al. 2018) and a serious threat to other countries in Asia (Wang et al. 2019).

China

The first cases of ASF in China appeared in mid-June 2018 in a farm in Shenyang City, Liaoning Province, on the north-eastern coast of China. The pigs were reported to have been fed waste food, and 400 pigs died within a month after the first pigs began to show clinical signs usually observed in acute ASF (Zhou et al. 2018). Several other farms were affected and samples from dead pigs at one of the farms proved positive for a genotype II ASF virus highly related to those circulating in Eastern Europe (Zhou et al. 2018). The first available immediate notification to OIE reported outbreaks in Zhejiang Province (Table 4). By mid-August 2018 ASF outbreaks had been registered in four more eastern provinces (Disease information–Immediate notifications 2005–2020), all situated on or near the south-eastern coast of China. A commercial farm in Zhejiang Province and village pigs in Anhui and Jiangsu Provinces were affected and ASF-positive pigs were diagnosed at an abattoir in Henan Province (Disease information–Immediate notifications 2005–2020). By January 2019 ASF had spread across 25 of China’s provinces (Zhou et al. 2019). Subsequently all of the mainland provinces as well as Hainan, an island

province off the south coast, have reported ASF (Disease information–Immediate notifications 2005–2020).

In Hong Kong, ASF virus was detected in a condemned carcass of an imported pig in May 2019 and in three and one imported pigs that died after being brought to the same slaughterhouse in June and September 2019 respectively (Table 4). The autonomous enclave of Macao has not reported ASF.

Taiwan has reported detection of ASF virus in pork products brought into the country by travellers from China (Wang et al. 2019).

In spite of the rapid spread of ASF throughout China, it has only been reported a few times in free-living wild boars. One dead wild boar in Jilin Province (Table 4) tested positive for ASF virus in November 2018. Sequencing of the virus isolated from the boar indicated that it was identical to the Georgia 2007 virus that was also isolated from the outbreak in Irkutsk in 2017 (Kolbasov et al. 2018), while the viruses isolated from outbreaks in China had belonged to the more recently discovered variant that was circulating in eastern Europe including Russia (Li et al. 2019). The next cases in free-living wild boars involved nine dead boars found near a village in Shaanxi Province in 2019 and, in March 2020, two and five dead boars found at two locations in the same forestry district in Hubei Province (Disease information–Immediate notifications 2005–2020). An outbreak occurred in 77 out of 375 farmed wild boars in Heilongjiang Province in November 2018, the rest of which were destroyed, and another outbreak in captive wild boars occurred on a farm in Inner Mongolia in February 2019, in which all 222 wild boars were infected and 210 died; the remaining 12 were destroyed (Disease information–Immediate notifications 2005–2020).

In all of the outbreaks, quarantine and blockades were instituted and remaining pigs in the epidemiological unit were destroyed, resulting in the loss of an estimated half of the pig population and major disruption of pork production. The number of outbreaks apparently declined over time, but a disturbing number of the recent detections of infected pigs have occurred at checkpoints and abattoirs (Disease information–Immediate notifications 2005–2020), indicating that infected pigs are being moved in spite of restrictions.

Outbreaks of ASF in neighbouring countries were reported from early 2019 and are described in chronological order below.

Mongolia

With a total pig population of fewer than 30,000, Mongolia seemed an unlikely target for ASF. Nevertheless, it was the first of China's neighbours to report the disease. Outbreaks in domestic pigs occurred from 9 January to

6 February 2019 and were reported to be resolved on 27 March 2019 (Table 4). The outbreaks and control measures have been described (Heilmann et al. 2020). The pig farms involved were semi-intensive backyard farms and the source of the outbreaks was considered to be waste food fed to the pigs that contained imported infected pork products, supported by limited testing that discovered such products at food premises (Heilmann et al. 2020). No further outbreaks have occurred.

Vietnam

The event is reported to have started on 1 February 2019 (Table 4). Between that time and 18 August 2019 8501 outbreaks occurred, mainly in smallholder pigs, throughout the country (Disease information–Immediate notifications 2005–2020). No further outbreaks have been reported. The official estimate is that 21 per cent of the pig population was lost, but according to a report in *Pig Progress* the figure could be as high as 40 per cent and outbreaks continue to occur.¹⁰ The most likely source of infection was considered to be infected pork products from China, as the first outbreaks occurred in northern Vietnam close to China (Le et al. 2019).

Cambodia

After the first outbreak was reported (Table 4), six further outbreaks were reported in March and April 2019 in village pigs in the Rattanakiri district in the far north-east of Cambodia on the border with Vietnam, with spread to several villages (Disease information–Immediate notifications 2005–2020). The outbreaks were declared resolved in May 2019 (Disease information–Immediate notifications 2005–2020). However, in June 2019 six outbreaks were registered in village pigs in rather widely separated locations in the central southern region of the country (Disease information–Immediate notifications 2005–2020).

Korea, North

An outbreak on a cooperative farm with 99 pigs was reported on 23 May 2019; 77 pigs died and the rest were killed (Table 4). No further outbreaks have been reported. The farm was close to the north-western border with the Liaoning Province of China.

Laos

The first outbreaks were reported in village pigs in Sarvane province from 2 to 8 June 2019 (Table 4). Spread occurred to further provinces (Savannakhet, Sekong,

¹⁰ <https://www.pigprogress.net/Health/Articles/2020/4/ASF-accelerated-a-lot-in-Vietnam-pig-industry-575108E/>.

Khammuane, Attapeu, Champasak) from late June to September 2019 with 21 outbreaks in village pigs (Disease information–Immediate notifications 2005–2020). An outbreak occurred on a small commercial farm (110 pigs) in Vientiane Capital on 23 June 2019 (Table 4), followed by considerable spread around Vientiane and across the central north-eastern parts of the country in July to September (Disease information–Immediate notifications 2005–2020). The disease had become widespread, affecting mainly village pigs. In July and August 2019 the epidemic spread north-eastwards, with 15 outbreaks in village pigs in Huaphanh Province at localities throughout the province (Disease information–Immediate notifications 2005–2020). In August and September two and four each of an ‘unidentified suid’, most probably wild boar, were found in the forest in Huaphanh Province and were positive for ASF (Table 4). The last outbreak reported in village pigs in 2019 was at the beginning of October, and there have been no further reports since that time.

Philippines

The first outbreak cluster in village pigs was on 25 July 2019 in Rizal Province. In the cluster of 7 outbreaks 525 out of 536 pigs affected died of ASF and 7416 pigs were culled (Table 4). In September/October there were further outbreaks on Luzon Island in village pigs near the capital city and further to the north-east with culling of 5131 pigs (there were 59 deaths due to ASF). Further outbreaks occurred, mainly in Bulacan, Pampanga and Manila, in August to October, with 40,303 pigs culled (177 deaths due to ASF). Forty outbreaks from August to September resulted in culling of 74,967 pigs with 0 deaths reported. Outbreaks in September and October resulted in 17,763 pigs being culled, no deaths reported. The outbreaks continued until March 2020, with large numbers of pigs being culled and the infection apparently disseminated throughout Luzon Island (Disease information–Immediate notifications 2005–2020).

In January 2020 an outbreak occurred on Mindanao Island on the southern coast in backyard farms, with the deaths of 1000 pigs recorded (Table 4). Six more outbreaks occurred in backyard farms in February, with northward spread and 2261 deaths and 18,369 pigs destroyed. In another outbreak in February separately notified, the entire susceptible population of 2529 pigs was reported to have been destroyed (Disease information–Immediate notifications 2005–2020).

The first outbreak was suspected to have been caused by swill feeding, followed by illegal movement of pigs that were already sick being sold for a lower price. Subsequent spread was attributed to illegal movement of pigs, swill feeding and fomites (Disease information–Immediate

notifications 2005–2020). The suspected source of the outbreaks was infected pork products brought into the Philippines by airline passengers as ASF viral genome was detected in several confiscated pork products.¹¹

Myanmar

The first outbreak was in village pigs in Shan State on 1 August 2019, followed by another outbreak in village pigs in August, an outbreak in backyard pigs in August and another in backyard pigs in September (Table 4). All the outbreaks occurred in Shan State. No further outbreaks were reported in 2019. However, 2 outbreaks were reported in domestic pigs, again in Shan State, in February 2020 (Table 4).

Indonesia

After high mortality in pigs had occurred in September 2019, ASF was confirmed in November 2019 and 521 outbreaks of ASF were reported in backyard farms in 21 out of 33 districts in Sumatera Utara Province with a start date of 4 September 2019 (Table 4). Out of an estimated 1,228,951 pigs based on a 2018 census, 38,123 pigs died, with a case fatality rate of 100 per cent. The origin of the infection was not established but spread was attributed to movement of pigs, vehicles and fomites (Disease information–Immediate notifications 2005–2020).

Timor-Leste

The first outbreak cluster was reported on 9 September 2019 in backyard pigs (Table 4). One hundred outbreaks were reported on smallholder farms in the Dili Municipality, with the loss of 405 pigs that died of ASF. Based on a 2015 census, the number of smallholder pigs in the municipality is estimated to be 44,000. In the follow-up report (13 March 2020) there were 26 outbreaks reported in 12 clusters between September and December 2019 that were scattered (Table 4); outbreak statistics were not provided in the summary. The devastating impact that ASF can have on the smallholder pig farmers who produce 100 per cent of the country’s pigs, which are culturally as well as economically important, has been described (Smith et al. 2019). To date no further outbreaks have been reported.

Korea, Republic (South)

The introduction of infected pork products into South Korea by airline travellers from China was confirmed in August 2018 after surveillance of products entering the country was enhanced when China reported its

¹¹ <https://www.rappler.com/nation/233015-canned-goods-tainted-african-swine-fever-virus-clark-airport>.

first outbreaks of ASF (Kim et al. 2019). The first outbreak of ASF occurred more than a year later, on a commercial farm with 2450 pigs on 16 September 2019 in Gyeonggi-Do on the north-eastern border with North Korea (Kim et al. 2020a) (Table 4). Further outbreaks in pigs in the same area (including Incheon Metropolitan City) occurred in September and October 2019, after which no more domestic outbreaks were reported (Disease information–Immediate notifications 2005–2020; Kim et al. 2020a). However, from October 2019 to date, outbreaks in wild boars have been reported in Gyeonggi-Do and Gangwon-Do provinces, mostly in the Demilitarized Zone along the border with North Korea (Kim et al. 2020b). The highest number of outbreaks occurred in January 2020 (Jo and Gortázar 2020).

Papua New Guinea

ASF was confirmed in free-ranging village pigs four villages in Southern Highlands province in March 2020 in a population of 700 pigs, with the deaths of 396 out of 500 pigs affected (Table 4).

India

Unusual deaths among village pigs in north-eastern India commenced in the Arunachal Pradesh district in late January 2020, with outbreaks occurring in 11 villages in Arunachal Pradesh and Assam between January and April, with the deaths of 3701 pigs. The cause of the deaths was confirmed to be a genotype II ASF virus on 18 May 2020 (Table 4).

Trends and challenges

The great majority of outbreaks have occurred in backyard farms and village pigs, where implementation of biosecurity measures is usually inadequate or absent. An additional challenge for control in Timor-Leste and most recently Papua New Guinea is that pigs have important traditional and cultural roles, for example as ceremonial animals (Smith et al. 2019; Ayalew et al. 2011). This social and cultural importance of pigs is paralleled in some African countries but is usually not a consideration in modern animal disease control approaches.

The spread of ASF in Asia has been much more rapid in Asia than it has been in Europe. This is apparently due to movement of live pigs as well as pork. In China ASF detections at road barriers and abattoirs are considerably more frequently reported than elsewhere (Disease information–Immediate notifications 2005–2020). An additional phenomenon since ASF was detected in China were reports emanating from several countries, namely Australia, Japan, Northern Ireland, Philippines, South Korea, Taiwan and Thailand of infected pork products being introduced by airline passengers (Wang et al. 2019;

Kim et al. 2019; Ito et al. 2020; Jurado et al. 2019). In most cases the origin of the meat was specified to be travellers from China. Most of the reports either indicated that traces of the ASF virus genome were detected or did not specify the testing procedure, but attempts to culture the viruses detected in South Korea were not successful (Kim et al. 2019). The level of risk of introduction of ASF by the genomic material detected has yet to be determined.

Perspectives on managing the current ASF situation

The scale of the ASF situation that currently prevails is unprecedented. Given the diverse contexts in which the disease is present, a ‘one size fits all’ top-down approach can no longer be recommended. Eradication of ASF from areas outside Africa in the previous excursion was largely managed by massive eradication programmes carried out by countries that were either at least relatively well-resourced or by large-scale international funding. The countries currently affected include lower income countries and the major crises currently demanding international funding, most of which have direct public health impacts, suggest that unlimited funds will not be available to manage ASF. This may not be a bad thing, as in settings where numerous owners keep a few pigs to keep abject poverty at bay, drastic control measures may have far worse effects than the disease itself, and a more measured approach can provide sufficient mitigation and even result in ultimate eradication.

The key to avoiding major and costly ASF epidemics is preventing pigs from becoming infected, and in the absence of a vaccine this depends on the implementation of biosecurity measures based on knowing the epidemiological risks. It also involves risk-based surveillance to avoid introduction of the virus into new countries and to ensure rapid detection of outbreaks to enable a timely response.

Managing ASF to protect commercial pig production

Although some large commercial farms in several countries have suffered serious losses to ASF, the relatively low incidence of outbreaks in the commercial sector in many of the countries affected indicates that good biosecurity does prevent the disease. However, especially in areas where the risk of ASF is very high, for example where the virus is circulating in wild boars or poorly controlled populations of domestic pigs, compartmentalisation of commercial pig farming enterprises can be strongly recommended.¹² As the ASF virus is not airborne over distances greater than a few metres in a closed housing system (Wilkinson et al. 1977; de Carvalho Ferreira et al.

¹² OIE Terrestrial Animal Health Code Chapters 4.4 and 4.5.

2013) and to date no important role for flying arthropods as mechanical vectors has been demonstrated (Plowright et al. 1994; Forth et al. 2018; Tummeleht et al. 2020), the introduction of ASF into farms invariably involves human activity that can be prevented if biosecurity is strictly implemented.

Managing ASF in semi- and non-commercial pig production

The challenges posed for implementation of biosecurity in smallholder, backyard and traditionally kept village pigs are well known, while finding the answers to the problems is a work in progress. Awareness creation and moving towards modernisation of production are usually recommended but the latter is not achievable without adequate support and the former may have the opposite effect to that intended (Chenais et al. 2017; Chenais et al. 2019). The main incentive for improving pig husbandry would be profit, which is only likely if easily accessible markets are available. A thorough understanding of the social networks and pig value chains in which pigs and pork are traded will help to involve producers, traders and other value chain actors to work with animal health practitioners to find situation-specific, socially acceptable and affordable ways to mitigate the risk of ASF.

Managing ASF in free-living wild boar or feral pig populations

Before the incursion of ASF into the Baltic States and Poland, it was generally accepted that ASF in wild boar populations was self-limiting (Mur et al. 2016; Gogin et al. 2013; Mur et al. 2012), but it was also considered likely to be maintained in sufficiently large populations of wild boars (Gogin et al. 2013). In Belgium and Czech Republic it was possible to eradicate the infection (Macon et al. 2020), which in both cases could be restricted to a limited area. However, Estonia and Latvia, where the whole countries were infected, the combination of surveillance for and burial of wild boar carcasses and population reduction due both to ASF and to increased hunting pressure has resulted in a demonstrable decline in virus circulation (Schulz et al. 2019; Olsevskis et al. 2020).

Managing ASF at the interface with the classic sylvatic cycle

The only way to prevent ASF at the interface with the classic sylvatic cycle is to ensure good separation of the domestic pigs. For commercial farms this has been successfully achieved over many decades, but where small-scale pig farming occurs at the interface the challenge will be similar to those experienced in managing the risks that are present in that farming sector.

Managing outbreaks of ASF

How outbreaks of ASF are managed will depend on the resources available to the national veterinary services, the legislation governing outbreak management, and the contribution of the pig sector to national income. Countries with a large export trade in pigs and pork would be motivated to get rid of ASF as rapidly as possible, whereas countries that do not export pork will be more likely to take a less drastic approach. Whatever approach is taken, the cooperation of the pig producers and other pig value chain actors is paramount and the approach should be acceptable not only to them but to the public at large. It must also be feasible in terms of logistics including appropriate disposal of dead pigs, available financial, human and other resources, and animal welfare. It is increasingly recognised that various options are available for managing an animal disease emergency, and it is important that the measures should not cause more damage than the disease itself (Rubira 2007).

Managing ASF with a vaccine

A safe and effective vaccine would have immense advantages for the management of ASF, but the operative words are *safe* and *effective*, and for many countries one would need to add *affordable*. Many of the affected countries are tropical, so not having rigorous cold chain requirements would be an additional prerequisite.

Although efforts to find a vaccine are ongoing and progress is reported to be promising, a word of caution has been sounded about potentially unsafe vaccines based on previous unfortunate experiences with insufficiently attenuated viruses (Gavier-Widén et al. 2020). It should furthermore be remembered that a good vaccine is an important tool in the toolbox of disease management, but will never replace the need to implement good biosecurity in pig farming operations.

Conclusion

Two main trends have been identified that characterise the current ASF situation globally: endemic establishment in free-living wild pig populations and in domestic pigs reared under hazardous husbandry conditions, and persistent high-risk activities on the part of humans.

The tendency for ASF to become endemic in areas where small-scale pig production under conditions of inadequate or no biosecurity predominates is common to Africa, Asia and Eastern Europe. In these settings conventional approaches to ASF control are likely to fail due to lack of producer cooperation and the realities that create this reluctance. The challenge is to provide the incentives and support required to enable subsistence pig farmers to invest in improving biosecurity, because prohibiting non-commercial pig production can only work

if is not essential for survival. In a number of African countries, particularly in West Africa in areas that are not suitable for cattle production, as well as in Timor-Leste, Papua New Guinea and possibly other countries in the Asian-Pacific region pigs have cultural and social as well as economic importance, and this further complicates control, which in order to be acceptable must respect the customs and beliefs of the pig keepers.

While maintenance of ASF virus by African wild suids that are tolerant to the infection is not a major problem as they are not efficient at spreading the virus, the predominant involvement of wild boars in Europe has created a highly challenging situation. There is no easy recipe for managing ASF in free-living susceptible pig populations, particularly when they include meta-populations that extend across international borders. However, there is evidence that the combination of surveillance based largely on finding and safely disposing of dead wild boars and wild boar population reduction have had positive results in two of the affected countries. Fortunately, with the exception of South Korea the involvement of wild boars in Asia so far has been insignificant.

Risky practices that lead to the spread of ASF are not confined to the informal pig sector, where they are largely responsible for local spread within the sector. Rapid spread over large areas as occurred in China as well as long-distance 'leaps' that have infected pigs or wild boars as happened in Russia, Poland, Czech Republic and Belgium can only be ascribed to human activities that are likely financially motivated. Persuading humans to change their behaviour, whether it results from ignorance, carelessness or the drive for profit is the greatest challenge of all.

Delimitation of infected areas and stamping out all the pigs within a defined radius is the traditional approach to controlling and eradicating outbreaks of ASF. Compliance is usually obtained by paying reasonable compensation to farmers for healthy pigs culled. The success of the approach depends on the resources available to carry out the measures as quickly as possible and to enforce quarantine and movement control, with the latter expected to involve checkpoints on major roads. It also depends on knowing the number and location of all the pigs involved. This information is seldom reliable in the informal pig sector. If a quick and efficient culling operation cannot be guaranteed, a more measured approach such as modified culling in agreement with the owners is more likely to be successful.

Abbreviations

ASF: African swine fever; AU-IBAR: African Union-Interafrican Bureau for Animal Resources; CAR: Central African Republic; DRC: Democratic Republic of Congo;

FAO: Food and Agriculture Organization of the United Nations; OIE: World Organisation for Animal Health.

Acknowledgements

Not applicable.

Authors' contributions

MLP conceived and wrote the manuscript. The author read and approved the final manuscript.

Authors' information

MLP is a veterinarian attached to the Department of Veterinary Tropical Diseases at the University of Pretoria, South Africa. She has a strong interest in the epidemiology and control of diseases of pigs with a strong focus on African and classical swine fever and on how to manage them in resource-poor settings through practical and affordable risk management in small-scale production systems and the value chains available to them.

Funding

Not applicable.

Availability of data and materials

The datasets analysed during the current study are available in the OIE WAHIS repository at https://www.oie.int/wahis_2/public/wahid.php/Wahidhome/Home.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

There are no competing interests.

Received: 7 May 2020 Accepted: 23 July 2020

Published online: 05 August 2020

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