African swine fever in wild boar and African wild suids

1. Introduction

African swine fever (ASF) is a highly contagious* hemorrhagic* disease of suids*. Enzootic* in many African countries and in Sardinia, it has lately been introduced into the Caucasus region. From there it has spread north-west, reaching Lithuania and Poland in 2014.

This incursion into the EU has raised concerns about the potential impact on the pig sector[87] as outbreaks* can lead to high economic losses, especially for exporting countries such as the Netherlands. In addition to the direct costs, such as those incurred by eradication programs, there are also indirect costs, including the consequences of trade bans on pigs and pig products.

* Complex terms are explained in the glossary (p.13)

Contents

dwhc
dutch wildlife health centre

© dwhc

2. The virus

African swine fever virus (ASFV) is a large, enveloped DNA virus, of the genus *Asfivirus* (family *Asfarviridae)*[86, 87]. ASFV is the only member of its genus and it is the only known DNA arbovirus*. Twenty-two different genotypes have been described, and virulence* differs greatly from one isolate to another[17, 68].

3. Survival of the virus

Temperature and organic matter

ASFV is a resistant virus, and can survive for long periods in a protein environment.

ASFV remains infectious for months in blood when frozen, stored at 4°C and also when kept at room temperature[29]. In contrast, the virus is inactivated by heat treatment at 60°C for 20 minutes[50, 52].

ASFV remains viable for long periods in feces and tissues, including uncooked or undercooked pork products[50, 52, 73].

Disinfection

ASFV is inactivated by many solvents that disrupt the viral envelope and by disinfectants (1% formaldehyde in 6 days, 2% NaOH in 1 day). Paraphenylphenolic disinfectants are very effective at inactivating the virus. The pH range in which the virus can survive is wide, with some infective virus remaining at pH4 or pH13[29].

4. Geographical distribution

ASF was first described in Kenya in 1921 and the initial reports were from Eastern and Southern African countries, which is where ASFV is presumed to have evolved[87] (cf. § 5). ASF has subsequently spread to other areas of Africa, Europe and the Americas (Table 1). Currently, ASF is endemic in most of Africa[68].

During previous outbreaks in Europe and the Americas, the disease has been successfully and eradicated, except on the Italian island of Sardinia where it became endemic after its introduction in 1978[36]. However, in 2007 the disease emerged in Georgia[84] and has since spread to eight countries, including Lithuania and Poland in 2014[24, 67, 80] (cf. Table 1, Map 1).

5. Host species

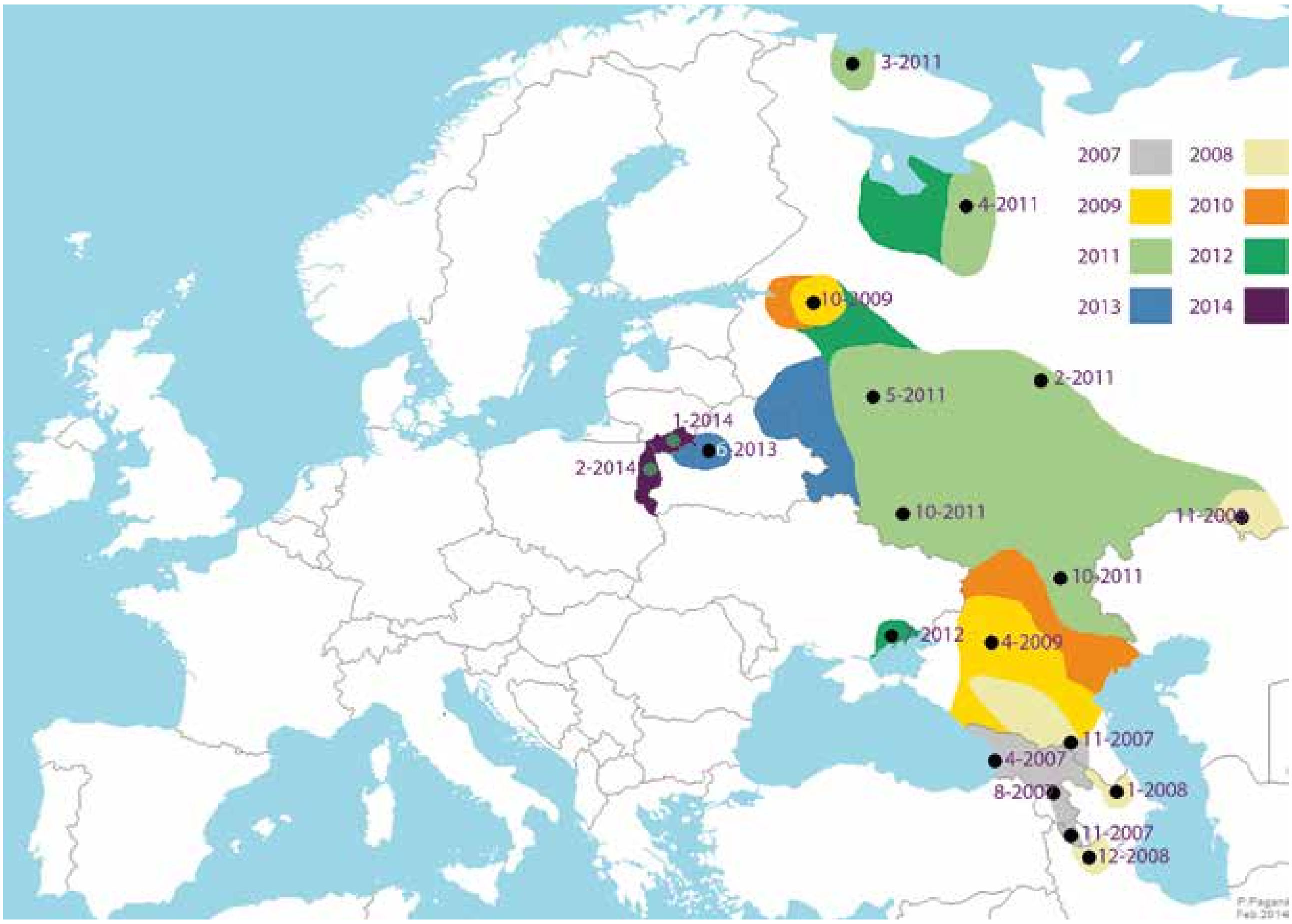
ASFV exclusively infects suids and argasid ticks of the genus *Ornithodoros*. There are no public health concerns because humans are not susceptible to ASFV[2].

Table 1 Year and country of ASF introductions. In brackets the countries where the disease was introduced but quickly eradicated.

Year of first detection	Africa	Eurasia	Americas
1957		(Portugal)[16]	
1960		(Spain)[10]	
1964		(France)[29]	
1967		(Italy mainland)[36]	
1971			(Cuba)[89]
1978	Senegal[28, 32, 74, 98]	(Malta)[96], Sardinia[36].	(Brazil)[48], (Dominican Republic)[24]
1979			(Haiti)[24]
1982	Cameroon[28, 32, 74, 98]		
1985		(Belgium)[13]	
1986		(Netherlands)[90]	
1996	Other central and western African countries [28, 32, 74, 98]		
1998	Madagascar[83]		
2007	Mauritius[47]	Georgia[84]	
2007-2014		Armenia, Azerbaijan, Russia, Iran, Ukraine, Belarus and, early 2014, Lithuania and Poland[24, 67, 80]	

dwhc dutch wildlife health centre

© dwhc



Map 1: Spread of the disease in Eurasia, 2007-2014

Suids

The natural hosts of ASFV are the African wild suids, the most important being the warthog *(Phacochoerus africanus)*[87]. The bushpig *(Potamochoerus larvatus)* and the red river hog *(Potamochoerus porcus)* are considered to be of lesser importance in the epidemiology* of ASF, because they are only sporadically infected[5, 39], and there is only a single case of ASFV being reported in the giant forest hog *(Hylochoerus meinertzhageni)*[44]. African wild suids are susceptible to infection but usually show no signs of disease.

Wild boars, domestic pigs and feral pigs* *(*all *Sus scrofa)* are also susceptible to infection by ASFV[87], regardless of their breed and age. In these animals, virulent strains of the virus cause a devastating hemorrhagic fever with up to 100 % mortality[68]. A higher level of natural resistance is observed in some domestic pig populations in Africa, where ASF is endemic, but there is no evidence of a genetic basis for resistance[76].

Ornithodoros ticks

ASFV also infects soft ticks of the genus *Ornithodoros* (family *Argasidae*). In Southern and Eastern Africa, the *O. moubata* complex is considered the natural arthropod host[43].

All *Ornithodoros* species tested to date are susceptible to ASFV infection[30]. The virus can multiply in ticks and there is some speculation that ASFV is actually a virus of arthropods, with suids being “accidental hosts”[68].

Whilst species of *Ornithodoros* ticks are present in different regions of the world, none have been reported in the Netherlands or elsewhere in Northern Europe[27, 30, 92].

dwhc dutch wildlife health centre
© dwhc


Photo 2. Free-ranging domestic pig in Sardinia

6. Transmission

Routes of infection

Four routes of infection with ASFV are recognized in suids:

(i) Contact between sick and healthy animals,
(ii) ingestion of infected meat,
(iii) tick bites or bites from other vectors,
(iv) fomites*[24, 68].

The relative importance of each route varies, depending amongst others on the host species involved. The infective doses* are quite high for ASF[75]. People contribute to the spread of ASFV by the movement of pigs and pork-products[73, 75].

Contact between sick and healthy animals

Wild boars, domestic pigs and feral pigs can infect each other by direct contact, in particular when blood is present[43]. In contrast, field and experimental data indicate that direct contact is an unlikely means of transmission both amongst African wild suid species, and between them and pigs[5, 23, 24, 41, 44].

There is no reliable evidence of the transmission of virus from sows to fetuses during pregnancy[75]. Whilst sexual transmission of this virus has not been documented in pigs, ASF virus is shed in genital secretions[73].

Ingestion of infected meat

All susceptible suids, regardless of their species or age, can be infected by ingesting infected wild boar, domestic or feral pig-containing products[23, 43, 73, 91].

In contrast, transmission by ingestion of infected African wild suid meat is unlikely under natural conditions. Under experimental conditions, tissues of African wild suids can contain sufficient virus particles to infect pigs by ingestion[91], however under natural conditions the levels of virus in warthog tissues are likely to be too low to induce infections[75, 88].

Ticks bites or bites from other vectors

Virus transmission by ticks of the genus *Ornithodoros* has been demonstrated in all suids[5, 23, 43]. In contrast, there is no evidence at all for transmission of ASFV via hard ticks (family *Ixodidae*)[29].

Some *Ornithodoros* species may have a life cycle of 15-20 years. At certain life stages they are able to survive 5-6 years without feeding, and to maintain and transmit the virus to pigs for, at least, two years[7, 15, 70]. Transmission among ticks can be transovarial*, transstadial* and/or sexual[68, 79, 81].

ASFV infection of naïve *Ornithodoros* ticks during blood meals depends on the host species involved. Naïve ticks can be readily infected when feeding on viremic domestic or feral pigs, wild boars and bushpigs[5, 71]; however, when feeding on warthogs, ticks only become infected after feeding on young warthogs during the viremic phase (cf. Map 2).

Ornithodoros species only feed for short time periods (up to 30 minutes), so they are often found only in the resting places (burrow or pig pens).
In the wild, only warthogs live in burrows, whilst wild boars, feral pigs and bushpigs rest in thick vegetation, changing place regularly. Accordingly,

dwhc dutch wildlife health centre
© dwhc

it is less likely that this latter group will come into contact with *Ornithodoros* ticks[37, 43].

In addition to ticks, stable flies (*Stomoxys* spp.) have also been shown experimentally to be potential mechanical vectors. The virus survived in these flies for at least two days without apparent loss of viral titer[8, 53]. It is not known how relevant this finding is for transmission under natural conditions. Anyhow, although these flies have a world-wide distribution, they do not fly long distances. Therefore they are more likely to contribute to transmission within herds than between herds[73].

Fomites
Indirect contact through fomites may play a role in ASFV transmission. These routes of transmission seem only to be efficient when a high virus load is involved. Infectious blood is the main matrix by which the virus is indirectly transmitted[29].

Unlikely routes
Airborne infections are unlikely. They may act only over short distances and, experimentally, the half-life of ASFV in the air was on average less than 20 min[22, 95].

Other potential-albeit to date unproven and therefore unlikely-sources of ASFV include water (the virus is rapidly diluted), and mechanical vectors such as rodents and birds[75].

Infectious period and latent infections
Experimentally, fever is a valid marker for onset of infectiousness and the duration of infectiousness was 1 to 7 weeks[20]. Depending on the virulence of the viral strain and the response of the pig to the virus, some animals may survive infection, and animals with a positive antibody titer have been detected during serological surveys[77]. Pigs that recover may shed the virus for up to a month after the disappearance of clinical signs[73].

Whilst some authors, claim that there is no evidence that recovered pigs can become long-term carriers of the virus[76, 93, 97], others suggest that these animals may be long-term carriers of the virus, and therefore represent a potential source of infection[6, 19, 68, 88]. Persistent infections of at least 70 days have been demonstrated experimentally[21].

7. Virus cycles and the role of the wild boar
Different ASF epidemiological scenarios can occur depending on the involvement of different hosts and their interactions with domestic pigs (cf. Map 2):

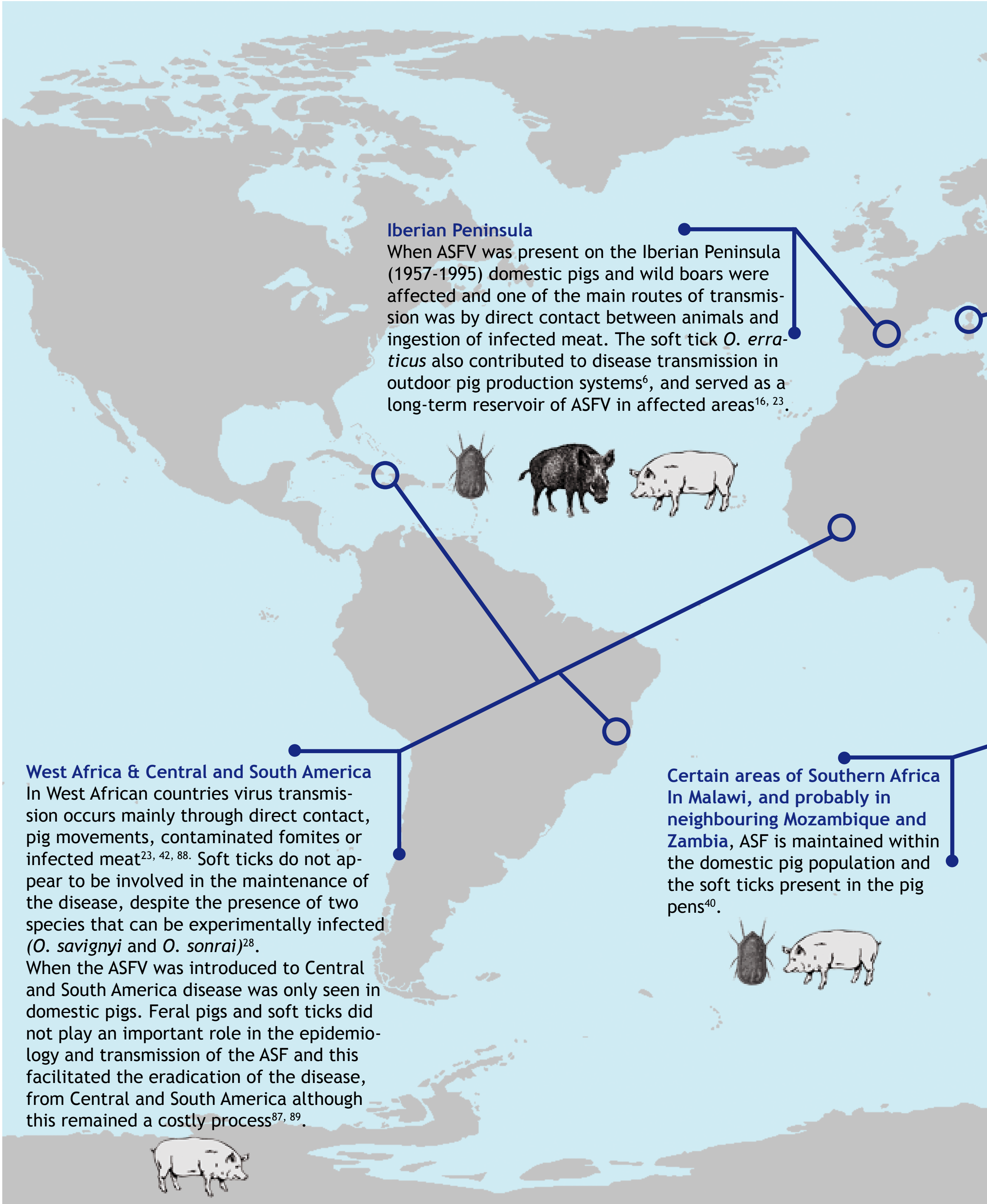
(i) African wild suids, soft ticks and domestic pigs,
(ii) domestic pigs, wild boars and soft ticks,
(iii) domestic pigs and wild boars,
(iv) domestic pigs and soft ticks, and
(v) only domestic pigs.

All these epidemiological scenarios have two characteristics in common. Except for the East African sylvatic cycle, all others are triggered by human activities and all are exacerbated by the pig rearing systems in place.

For example, in sub-Saharan Africa it is common to keep free-ranging pigs that scavenge[78], and in Sardinia, free-ranging pigs share communal lands with wild boars[54, 78]. In the Caucasus the majority of pig breeding facilities are backyard holdings, and in the affected areas of Georgia, Armenia and Azerbaijan, backyard pigs often share communal lands, and free-ranging is widely practised[12, 88].


Photo 3. Wild boar

dwhc dutch wildlife health centre
© dwhc



Map 2. ASF epidemiological scenarios

dutch wildlife health centre
© dwhc

Caucasus, Sardinia & Eastern Europe

In the Caucasus the epidemiological cycle of ASF involves domestic pigs and wild boars. Although *Ornithodoros* tick species inhabit the region, they are not known to play a role in the cycle[29, 87]. Most of the outbreaks have affected domestic pigs and have been caused by human activities, such as movements of infected animals and their products. Only a minority of the outbreaks have involved wild boars, and these have typically been caused by contact with domestic pigs[12, 29].
In Sardinia and Eastern Europe, the disease is maintained by the interaction of domestic pigs and wild boars[45, 49]. To the best of our knowledge, *Ornithodoros* ticks do not occur in these areas[31, 36].

Southern and Eastern Africa

There is a sylvatic cycle in warthogs and ticks. The ticks inhabit the burrows of warthogs and feed on their blood, transmitting the virus in the process. Adult warthogs do not develop viraemia* and do not act as a source of infection for ticks. By contrast, if young suckling warthogs are infected, although they do not develop clinical disease, they develop a short period of viraemia sufficiently high to infect naïve ticks during blood meals[43, 44, 72, 91]. Warthogs remain asymptomatically infected for life, but due to the absence of transmission between warthogs, the maintenance of infection is dependent on ticks[43, 75]. In this scenario the transmission to domestic pigs is mainly caused by the occasional bites of infected ticks and following recirculation among domestic pigs population[23, 43, 87].

© dwhc

The role of wild boars

The potential role of wild boars in the epidemiology of the disease is unclear. Evidence of infection in wild boars was reported in the Iberian Peninsula[18, 77], Sardinia[45], Russia[11], Iran[80], Belarus[67], Lithuania and Poland[67].

Some authors consider that ASFV is unlikely to persist in the wild boar population in the absence of cohabitation with infected domestic free-ranging pigs[45, 55, 77, 85]. Indeed in wild boars, the occurrence of disease is often associated with the occurrence of disease in domestic pigs[31, 77]. Similarly, it has been observed that in Sardinia and Spain, ASFV tends to disappear from wild boar populations when there is no contact with free-ranging infected pigs[45]. Therefore, wild boars are not considered to play a major role as a virus reservoir in the absence of free-ranging, infected domestic pigs or other sources of infection[26, 77, 88].

In their natural environment wild boar are unlikely to come into contact with infected soft ticks as they do not use permanent resting sites. However, contact with infected soft ticks may exceptionally occur where home ranges overlap with those of domestic pigs from infested pig pens[43].

The ASFV strain affecting the Caucasian and Eastern European region is closely related to isolates circulating in Mozambique, Madagascar, and Zambia[9, 84]. This isolate is highly virulent, with up to 100% mortality[34].

On the basis of all these data, it seems unlikely that the Caucasian isolates have the potential to become endemic in wild boar populations without a distinct change in virulence[34].

However, in areas where the disease is actively circulating and where wild boars occur at high densities and there is the possibility of interaction with free-ranging pigs - such as in the Caucasus and East Europe - wild boar could act as disseminators of the virus[23].

Photo 4 and 5. Clinical disease in wild boar experimentally infected with ASF.

dwhc
dutch wildlife health centre

© dwhc

8. Clinical findings and pathology

Susceptibility to ASFV[43, 51], quantities of viral excretion[88] and clinical signs[33, 34] are similar for wild boar, feral and domestic pigs.

Depending on the virulence of the virus strain, infection can lead to a wide range of clinical syndromes, from almost inapparent disease to peracute illness with high mortality[33, 34].

Clinical findings

Upon experimental infection with a virulent ASFV strain, clinical signs in pigs develop after an incubation period of 3 to 15 days[14, 88].

Highly virulent viruses can cause both, peracute disease with sudden death and few clinical signs, 3-4 days after infection[68] or, acute disease, characterized by high fever (41-42°C), depression, loss of appetite, hemorrhages in the skin (tips of ears, tail, distal extremities, chest and abdomen), and death in 4-10 days (up to 20 days). Mortality rates may be as high as 100%[33, 68, 69].

Moderately virulent strains typically lead to subacute disease with mild clinical signs including mild fever, reduced appetite, depression and abortion in pregnant sows. Death may occur within 15–45 days and mortality rate varies around 30–70%. This form of the disease may be confused with many other conditions in pigs, not raising suspicion of ASF[68, 69].

Low virulent strains produce subclinical infection; occasionally some animals may show weight loss, irregular peaks of temperature, respiratory signs, skin lesions, and arthritis. The disease develops over 2–15 months and the mortality rate is low[46, 68, 69]. Subacute and chronic forms of the disease may result from insufficiently attenuated vaccine, as have been used in the 1960s in the Iberian Peninsula[15].

Photos 6 to 8. Gross pathological findings in organs of pigs infected with virulent ASF virus (the strain currently circulating in the Caucaus).

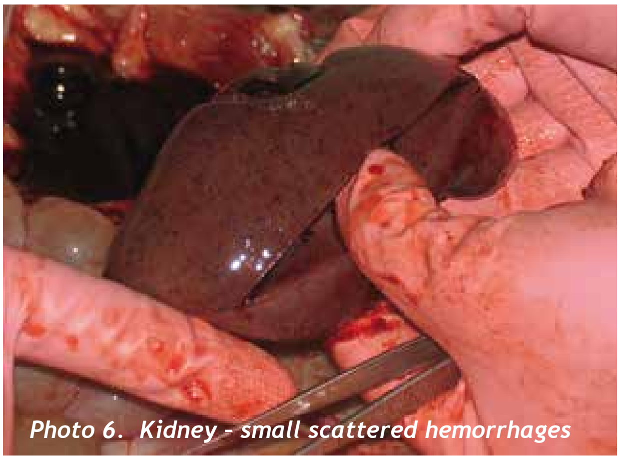


Photo 6. Kidney - small scattered hemorrhages

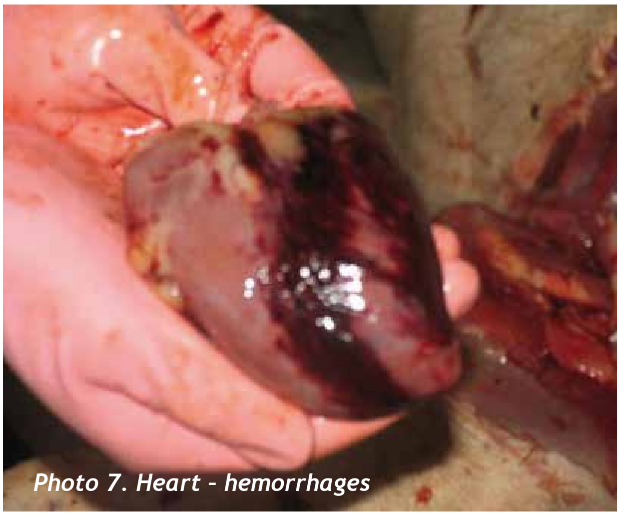


Photo 7. Heart - hemorrhages

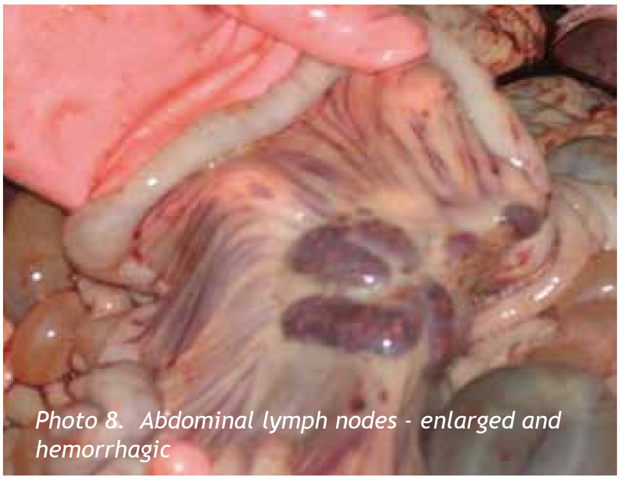


Photo 8. Abdominal lymph nodes - enlarged and hemorrhagic

dwhc dutch wildlife health centre
© dwhc

Photo 9 - 12. Gross pathological findings in organs of Florida wild boar experimentally infected with ASF virus (Haiti strain).


Photo 9. Kidney - severe multifocal cortical hemorrhage


Photo 10. Kidney - severe diffuse acute renal hemorrhage


Photo 11. Abdominal cavity - severe massive retroperintoneal hemorrhages


Photo 12. Gastro-hepatic lymph node– severe diffuse hemorrhage

Gross and microscopic pathology

Gross and microscopic findings may also vary with strain virulence[38, 94].

In cases of acute disease, carcasses are typically well-muscled with good fat reserves[33]. Some of the following lesions may be seen:

- Widespread hemorrhages in organs,
- some abdominal lymph nodes which may resemble blood clots,
- small scattered hemorrhages in the kidneys, bladder and stomach lining,
- accumulation of blood in the vessels of multiple organs (spleen, lungs, intestines, and other abdominal structures),
- accumulation of blood-containing fluids in the chest and abdominal cavities[33, 68].

Subacute forms may show the following changes:

- Fluids in body cavities (due to heart failure),
- enlarged and often hemorrhagic lymph nodes,
- signs of inflammation of the surfaces of the lungs and the heart,
- firm lungs with a mottled appearance, due to pneumonia,
- swollen and inflamed joints[33].

Chronic forms may present the following characteristics:

- Areas of severe lung damage,
- enlarged and firm lymph nodes,
- signs of inflammation of the surfaces of the lungs and the heart[3, 33, 68].

9. Diagnosis

Clinical diagnosis requires laboratory confirmation

In pigs and wild boars, the clinical signs of ASF are similar to those of other hemorrhagic diseases. At clinical or post-mortem examination, ASF can not be reliably differentiated from other bacterial and viral pig diseases such as Classical swine fever, Erysipelas, Salmonellosis, Pasteurellosis, Aujeszky's disease and other septicaemic conditions. Laboratory diagnosis is therefore required for differentiating these conditions[68, 87, 88].

Laboratory tests

Different tests are available to detect the ASFV. The most sensitive and specific methods is the

dwhc dutch wildlife health centre
© dwhc

Polymerase Chain Reaction, which is specially recommended for the identification of ASFV DNA in non-fresh or rotten tissue[68, 88].

The detection of antibodies to ASFV - i.e. serological testing - can indicate ongoing or previous infection[25]. Different versions of these serological tests are available. The most commonly used is the Enzyme-linked Immunosorbent Assay (ELISA). However, in acute disease, the death may occur before the animal has time to produce antibodies, and serological testing may fail to detect the disease in an early stage[69, 74].

Sample collection

For laboratory diagnosis of ASFV, blood samples and various tissue samples, such as spleen, kidney, lung, liver, lymph nodes and tonsils may be submitted. The spleen and visibly affected lymph nodes are the predilection samples to collect[4, 68] (for details, cf. to the OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals)[69].

Collaboration with hunting associations has been an effective means of obtaining samples for surveillance of the disease in wild boar populations[43, 77].

10. Management and control

Medical prophylaxis

To date, no vaccine or treatments are available[68, 88]. In the future, vaccines may be added to the control options. Although ASF vaccines are not yet available, a European Directive currently prohibits the use of ASF vaccines in the territory of the European Union[62].

Sanitary prophylaxis

The measures taken vary according to the epidemiological situation.

Countries or areas free of ASF

National and international policies aim at guaranteeing that neither infected live pigs nor pig meat products are introduced to areas free of ASF. At a national level, preventive measures include a Contingency Plan (cf. § 11), strict regulation of the import of animals and animal products, proper disposal of waste food from aircraft or ships, and efficient sterilization of domestic waste[68].

Individuals also have the responsibility to apply measures to prevent import and spread of disease. Though some of the measures have a legal basis, such as not feeding suid offal (swill) to pigs, others are based on common sense such as not visiting a pig farm after hunting wild boar and other biosecurity measures (cf. § 12).

Outbreak situation in previously ASF-free countries or areas

In case of outbreaks, or suspicion of disease, sanitary prophylaxis includes: Rapid diagnosis[35]; designation of the area as an infected zone, with zoning and control of pig movements; a survey of all pigs within the infected zone and the surrounding area to identify all infected animals/ populations; the rapid slaughter of all animals on infected premises, proper disposal of cadavers and litter, and thorough cleaning, disinfection and acaricide treatment; detailed epidemiological investigation, with tracing of possible sources (up-stream) and possible spread (down-stream) of infection[3, 68, 88].

Countries or areas where ASF is endemic

In infected countries or territories, disease control is primarily through the strict implementation of bio-security measures. Consequently, proposed control methods include the separation of domestic pigs and wild suids, and proper disposal of carcasses and offal from domestic and hunted animals[12]. At an individual level, a disease such as ASF that is primarily spread by direct transmission can be adequately controlled by preventing contact between domestic pigs and wild suids[43, 68]. For instance, in endemic areas of South Africa, pig producers, whose premises are surrounded by a double fencing pig-proof barrier and implement bio-security measures, have not experienced ASF since 1951[73].

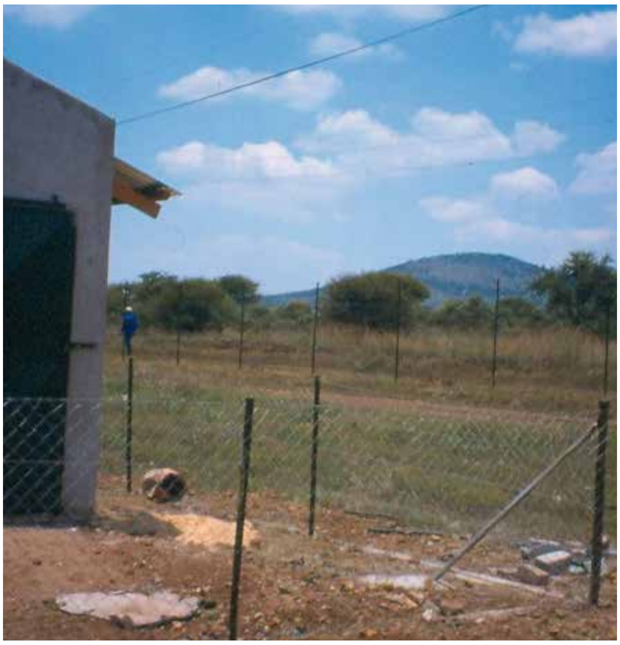
All requirements are specified by the OIE and are stated in the EU legislation (cf. § 11).

© dwhc

11. Current European Union regulations

Since the Treaty of Rome[1], in 1957, which stated the willingness to work out and put into effect a common agricultural policy and the progressive harmonization of national legislations, about 440 official documents relating to ASF have been enacted by the European Community. These represent a framework of laws, regulations and administrative provisions, principally concerning domestic pigs, that should be brought into force at national level by Member States. In the laws that also pertain to wild boars or feral pigs, the regulations do not usually differ significantly from those applying to domestic pigs.

These official documents outline different aspects with regard to ASF for the European Union. For example, the preparation and regular updating of nationals contingency plans, the sanitary requirements for intra- and extra- Community animal trade and for declaring ASF compulsorily notifiable[56, 58]; the adoption of a Community research program and the approval of a diagnostic manual[57, 63]; the rules for scientific measures concerning the control of ASF[61, 62]; and, the financial contribution from the Community for emergency measures such as the slaughter and destruction of infected animals, disinfection, and the establishment of buffer zones and other measures aimed to prevent the spread of ASF[59]. The Netherlands received such aid in 1986, which amounted to up to 50% of the expenses sustained for the eradication of ASF[60].
In the Netherlands, a National Contingency Plan based on the European directives and regulations is available[82]. This is a strategy document that defines detailed actions to be taken in the event of an ASF emergency. It takes into consideration different scenarios and phases, detailing policy instruments, measures to be taken, organizational aspects and giving legal basis to all activities. More recently, as a result of the rapid spread of the ASF on the European continent, other decisions have been enacted, to reduce the risk of introduction and spread of the disease in the EU. These include measures to prevent the transmission of the ASF virus from east European countries into the Union[64], the decision to define certain areas as 'infected'[66], and regulation of the financial contribution of the Union towards surveillance[65].



Photos 13 and 14. Double fencing pig-proof barriers in Sardinia (Photo 13) and South Africa (Photo 14). The distance between the fences in the left photo may be insufficient to protect from airborne transmission, but this route is unlikely. In South Africa, the distance between the fences takes into account the distance Ornithodoros ticks can travel.

dwhc dutch wildlife health centre
© dwhc

12. Precautionary measures

Areas where ASF has not yet been detected

Biosecurity when hunting wild boar

- Check the disease situation and the specific restrictions, rules and regulations with local authorities and/or hunter associations.
- Use gloves for evisceration and wash hands well with soap and water.
- Clean and disinfect all clothing and equipment (boots, game bag, carcass tray, knife and other materials).
- Avoid contact with livestock premises and, where this cannot be avoided, observe strict biosecurity measures (a full wash, change clothes and shoes, do not bring wild boar products onto premises where domestic pigs are kept).

Report suspect cases

- *Cases with suspect lesions* - If you see signs consistent with ASF such as bleedings in multiple organs, swollen and red lymph nodes, and enlarged spleen, or of others notifiable disease, contact the National authorities. In the Netherlands this is the **NVWA (tel: 045-5463188)**.
- *Unexplained deaths* - Please report wild boar found dead, in particular when there are several cases in a given area on one or successive days. In the Netherlands, hunted sick wild boar and wild boar found dead that are not directly suspected of notifiable diseases may be investigated free of charge for disease and/or cause of death by **DWHC (tel: 030-2537925)**.

Areas where ASF occurs

Comply with regulations

It is recommended that persons from outside defined ASF-areas do not hunt in these areas; if they do, they should comply with the measures prescribed by the national and local authorities. In ASF-infected areas in the EU, authorities will enforce the use of appropriate hygiene measures by all persons coming into contact with wild boar to reduce the risk of ASF virus spreading[62]. In addition, by law, all wild boars or feral pigs shot, found sick or dead in the infected area, including those killed by traffic, will be inspected by an official veterinarian and tested for ASF[62]. It is forbidden to take wild boar meat and products from the infected area. Derogations from this are possible and dependent on decisions by the appropriate authorities.

Additional biosecurity practices

Unless the local authorities indicate otherwise:

- Do not hunt with dogs.
- Clean vehicles inside and out, on-site or at the nearest car wash (including inner part of the mudguard). Consider covering seats in advance with plastic which can later be disposed of.
- All clothes should be washed at 60°C for a complete wash.

13. Glossary

Arbovirus	A term used to refer to viruses that are transmitted by arthropod vectors.
Bio-security	The precautions taken to protect against the spread of diseases.
Contagious	Disease spread from one organism to another.
Enzootic	Disease afflicting animals in a particular locality. The non-human equivalent of endemic.
Epidemiology	The study of the relationships of the various factors determining the frequency and distribution of diseases.
Feral pigs	A domestic pig living in the wild, either having been released or escaped from confinement.
Fomite	An inanimate object that can be contaminated with infectious organisms and serve in their transmission.
Hemorrhagic	With profuse bleeding.
Infective doses	The quantity of virus required to produce infection.
Outbreaks	The occurrence of more cases of disease than normally in a specific region.
Septicaemic	When the pathogen invades the bloodstream.
Suids	Pig species.
Transovarial transmission	Transmission of disease-causing agent from parent arthropod to offspring arthropod.
Transstadial transmission	Passage of disease-causing agent from one developmental stage of the tick to its subsequent stage.
Viraemia	Virus in the bloodstream.
Virulence	The relative capacity of a pathogen to overcome body defenses.

dutch wildlife health centre

© dwhc

14. References

1 1957. *Treaty establishing the European Economic Community. Available at: http://www.eurotreaties.com/eurotexts.html#rometreaty* Accessed 4 Feb. 2014.

2 2010. *African Swine Fever. Iowa State University. 4 pp. Available on: http://www.cfsph.iastate.edu/Factsheets/pdfs/african_swine_fever.pdf* Accessed 14 Nov 2013.

3 2013. Overview of African Swine Fever. In: The Merck Veterinary Manual. Published by Merck Sharp & Dohme Corp. a subsidiary of Merck & Co. Inc. Whitehouse Station, N.J. USA

4 Aguero M. et al. 2004. A highly sensitive and specific gel-based multiplex RT-PCR assay for the simultaneous and differential diagnosis of African swine fever and Classical swine fever in clinical samples. Vet. Res., 35: 551-563.

5 Anderson EC. et al. 1998. African swine fever virus infection of the bushpig (Potamochoerus porcus) and its significance in the epidemiology of the disease. Vet. Mic., 62: 1-15.

6 Arias M. and Sanchez-Vizcaino JM. 2002. African swine fever eradication: The Spanish model. In: Morilla A. et al. (eds), Trends in Emerging Viral Infections of Swine, 1st edn. Iowa State University Press, Iowa, USA. pp. 133-139.

7 Astigarraga A. et al. 1995. A study of the vaccinal value of various extracts of concealed antigens and salivary gland extracts against Ornithodoros erraticus and Ornithodoros moubata. Vet. Par., 60, 133-147.

8 Baldacchino et al. 2013. Transmission of pathogens by Stomoxys flies (Diptera, Muscidae): a review. Parasite, 20: 26.

9 Bastos ADS. et al. 2004. Co-circulation of two genetically distinct viruses in an outbreak of African swine fever in Mozambique: no evidence for individual co-infection. Vet. Mic., 103: 169-182.

10 Bech-Nielsen S. et al. 1995. A case study of an outbreak of African swine fever in Spain. Br. Vet. J., 151, 2: 203-214.

11 Beltrán-Alcrudo D. et al. 2009. African Swine Fever Spread in the Russian Federation and the Risk for the Region. EMPRES watch, FAO, Rome. 9 pp.

12 Beltrán-Alcrudo D. et al. 2008. African swine fever in the Caucasus. FAO EMPRES (Emergency Prevention Systems) WATCH. 1-8.

13 Biront P. et al. 1987. An epizootic of African swine fever in Belgium and its eradication. Vet. Rec., 120: 432-434.

14 Blome S. et al. 2013. Pathogenesis of African swine fever in domestic pigs and European wild boar. Vir. Res., 173, 1: 122-130.

15 Boinas FS. et al. 2004. Characterisation of pathogenic and non-pathogenic African swine fever virus isolates from Ornithodoros erraticus inhabiting pig premises in Portugal. J. Gen. Vir., 85: 2177-2187.

16 Boinas FS. et al. 2011. The persistence of African swine fever virus in field-infected Ornithodoros erraticus during the ASF endemic period in Portugal. PLoS ONE 6, e20383: 5pp.

17 Boshoff CI. et al. 2007. Genetic characterisation of African swine fever viruses from outbreaks in southern Africa (1973-1999). Vet. Mic., 121, 1-2: 45-55.

18 Caiado JM. et al. 1988. Epidemiological research of African Swine Fever (ASF) in Portugal: the role of vectors and virus reservoirs. Acta Vet. Scan., 84: 136-138.

19 Carrillo C. et al. 1994. Long-term persistent infection of swine monocytes/macrophages with African swine fever virus. J. Vir., 68: 580-583.

20 de Carvalho Ferreira HC. et al. 2013. Transmission rate of African swine fever virus under experimental conditions. Vet. Mic., 165, 3-4: 296-304.

21 de Carvalho Ferreira HC. et al. 2012. African swine fever virus excretion patterns in persistently infected animals: A quantitative approach. Vet. Mic., 160, 3-4: 327-340.

22 de Carvalho Ferreira HC. et al. 2013. Quantification of airborne African swine fever virus after experimental infection. Vet. Mic., 165, 3-4: 243-251.

23 Costard S. et al. 2013. Epidemiology of African swine fever virus. Vir. Res., 173, 1: 191-197.

24 Costard S. et al. 2009. African swine fever: how can global spread be prevented? Ph. Tran. Roy. Soc. Lon., 364: 2683-2696.

25 Cubillos C. et al. 2013. African swine fever virus serodiagnosis: A general review with a focus on the analyses of African serum samples. Vir. Res., 173, 1: 159-167.

26 Rolesu S. et al. 2007. Geographical information systems: a useful tool to approach African swine fever surveillance management of wild pig populations. Vet. Ita., 43, 3, 463-467.

27 Estrada-Pen A. and Jongejan F. 1999. Ticks feeding on humans: a review of records on human-biting Ixodoidea with special reference to pathogen transmission. Ex. Ap. Aca., 23: 685–715.

28 Etter EMC. et al. 2011. Seroprevalence of African Swine Fever in Senegal, 2006. Em. Inf. Dis., 17, 1: 49-54.

29 European Food Safety Authority. 2010. Scientific opinion on African swine fever. EFSA J., 8, 3: 1556.

30 European Food Safety Authority. 2010. Scientific opinion on the role of tick vectors in the epidemiology of Crimean-Congo hemorrhagic fever and African swine fever in Eurasia. EFSA J., 8, 8: 1703.

31 Firinu A. and Scarano C. 1988. African swine fever and classical swine fever (hog cholera) among wild boar in Sardinia. Rev. Sci. Tech. Rev. Off. Int. Epiz., 7, 4: 909-915.

32 Food and Agriculture Organization of the United Nations 1998. Peste porcine africaine en Afrique de l'Ouest Togo Sénégal - Gambie - Guinée-Bissau. Mission report from 1 to 16 June 1998.

33 Food and Agriculture Organization of the United Nations. 2000. Recognizing African swine fever. A field manual. FAO Animal Health Manual No. 9. Rome: FAO.

34 Gabriel C. et al. 2011. Characterization of African swine fever virus Caucasus isolate in European wild boars. Em. Inf. Dis., 17, 12: 2342-2345.

35 Gallardo C. et al. 2006. Antigenic properties and diagnostic potential of African swine fever virus protein pp62 expressed in insect cells. J. Cli. Mic., 44: 950-956.

36 Giammarioli M. et al. 2011. Genetic characterisation of African swine fever viruses from recent and historical outbreaks in Sardinia (1978-2009). Virus genes, 42, 3: 377-387.

37 Greig A. 1972. Pathogenesis of African swine fever in pigs naturally exposed to the disease. J. Com. Path., 82, 1: 73-79.

38 Greig A. and Plowright W. 1970. The excretion of two virulent strains of African swine fever virus by domestic pigs. J. Hyg., 68, 4: 673-682.

39 Haresnape JM. et al. 1985. A four-year survey of African swine fever in Malawi. J. Hyg., 95, 309-323.

40 Haresnape JM. et al. 1988. Isolation of African swine fever virus from ticks of the Ornithodoros moubata complex (Ixodoidea: Argasidae) collected within African swine fever enzootic area of Malawi. Epi. Inf., 101, 1: 173-185.

41 Heuschele WP. and Coggins L. 1969. Epizootiology of African swine fever virus in warthogs. Bul. Epiz. Dis. Afr., 17, 2: 179-183.

42 Jori F. et al. 2007. The role of wild hosts (wild pigs and ticks) in the epidemiology of African swine fever in West Africa and Madagascar. In: Proceedings of the 12th International Conference of the Association of Institutions of Tropical Veterinary Medicine, Montpellier, France. Camus E. et al. (ed): pp 8–22.

43 Jori F. and Bastos ADS. 2009. Role of Wild Suids in the Epidemiology of African Swine Fever. EcoHealth, 6, 296–310.

44 Jori F. et al. 2013. Review of the sylvatic cycle of African swine fever in sub-Saharan Africa and the Indian ocean. Vir. Res., 173, 1: 212-227.

45 Laddomada A. et al. 1994. Epidemiology of classical swine fever in Sardinia: a serological survey of wild boar and comparison with African swine fever. Vet. Rec., 134: 183-187.

46 Leitao A. et al. 2001. The non-haemadsorbing African swine fever virus isolate ASFV/NH/P68 provides a model for defining the protective anti-virus immune response. J. Gen. Vir., 82: 513-523.

dwhc
dutch wildlife health centre

© dwhc

47 Lubisi BA. et al. 2009. An investigation into the first outbreak of African swine fever in the Republic of Mauritius. Tran. Em. Dis., 56, 5: 178-188.
48 Lyra TM. 2006. La erradicación de la peste porcina africana en el Brasil, 1978-1984. Rev. Sci. Tech. Off. Int. Epiz., 25, 1: 93-103.
49 Mannelli A. et al. 1998. Temporal and spatial patterns of African swine fever in Sardinia. Prev. Vet. Med., 35, 4: 297-306.
50 McKercher PD. et al. 1978. Residual viruses in pork products. Ap. Envir. Mic., 35, 1: 142-145.
51 McVicar JW. et al.1981. Induced African swine fever in feral pigs. J. Am. Vet. Med. As., 179, 5: 441-446.
52 Mebus C. et al. 1997. Survival of several porcine viruses in different Spanish dry-cured meat products. Mediterranean aspects of meat quality as related to muscle biochemistry. Food Chem., 59, 4: 555-559.
53 Mellor PS. et al. 1987. Mechanical transmission of capripox virus and African swine fever virus by Stomoxys calcitrans. Res. Vet. Sci., 43: 109-112.
54 Montirano S. 2007. ASF Sardinia. Regione autonoma della Sardegna. Assessorato dell'Igiene e Sanitàe dell'Assistenza Sociale.
55 Mur L. et al. 2012. Monitoring of African Swine Fever in the wild boar population of the most recent endemic area of Spain. Tran. Em. Dis., 59, 6: 526-531.
56 Official Journal European Communities. 1964. Council Directive 64/432/EEC.
57 Official Journal European Communities. 1972. Council Decision 72/446/EEC.
58 Official Journal European Communities. 1972. Council Directive 72/462/EEC.
59 Official Journal European Communities. 1977. Council Decision 77/97/EEC.
60 Official Journal European Communities. 1986. Commission Decision 86/402/EEC.
61 Official Journal European Communities. 1991. Commission Decision 92/1/EEC.
62 Official Journal European Communities. 2002. Council Directive 2002/60/EC.
63 Official Journal European Union. 2003. Commission Decision 2003/422/EC.
64 Official Journal European Union. 2013 Commission Implementing Decision 2013/426/EU.
65 Official Journal European Union. 2013. Commission Implementing Decision 2013/498/EU.
66 Official Journal European Union. 2014. Commission Implementing Decision 2014/43/EU.
67 OIE Weekly Disease information. Available at: http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/WI/index/newlang/en Accessed on 30 January 2014.
68 OIE. 2009. African swine fever. World Animal Health Organisation, Technical Disease Cards. 1-5.
69 OIE. 2012. African swine fever. World Organisation for Animal Health. Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. 1-13.
70 Oleaga-Pérez A. et al. 1990. Distribution and biology of Ornithodoros erraticus in parts of Spain affected by African swine fever. Vet. Rec., 126, 2: 32-7.
71 Oura CAL. et al. 1998. The pathogenesis of African swine fever in the resistant bushpig. J. Gen. Vir., 79: 1439-1443.
72 Penrith ML. 2010. African swine fever. Ond. J. Vet. Res., 76, 1: 91-95.
73 Penrith ML. and Vosloo W. 2012. Review of African swine fever: transmission, spread and control. J. South Af. Vet. Ass., 80, 2: 58-62.
74 Penrith ML. et al. 2009. Preparation of African swine fever contingency plans. FAO Animal Production and Health Manual No. 8.
75 Penrith ML. et al. 2004. African swine fever. In: Infectious Diseases of Livestock, Coetzer JAW. And Tustin RC. (eds.), Vol. 2, Oxford University Press, Oxford, UK: 1088–1119.
76 Penrith ML. et al. 2004. An investigation into natural resistance to African swine fever in domestic pigs from an endemic area in southern Africa. Rev. Sci. Tech. Off. Int. Epiz., 23: 965-977.
77 Perez J. et al. 1998. Serological and immunohistochemical study of African swine fever in wild boar in Spain. Vet. Rec., 143: 136-139.
78 Personal observation.
79 Plowright W. *et al*. 1974. Sexual transmission of African swine fever virus in the tick Ornithodoros moubata porcinus Walton. Res. Vet. Sci., 17: 106-113.
80 Rahimi P. et al. 2010. Emergence of African Swine Fever Virus, Northwestern Iran. Em. Inf. Dis., 16, 12: 1946-1948.
81 Rennie L. et al. 2001. Transovarial transmission of African swine fever virus in the Argasid tick Ornithodoros moubata. Med. Vet. Ent., 15: 140-146.
82 Rijksoverheid. 2013. Beleidsdraaiboek Klassieke Varkenspest & Afrikaanse Varkenspest. Available at: http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2007/12/21/beleidsdraaiboek-klassieke-varkenspest-versie-3-0-en-afrikaanse-varkenspest-versie-1-0.html Accessed 2 Feb. 2014
83 Roger F. et al. 2001. Ornithodoros porcinus ticks, bushpigs, and African swine fever in Madagascar. Ex. Ap. Aca., 25: 263-269.
84 Rowlands RJ. et al. 2008. African swine fever virus isolate, Georgia, 2007. Em. Inf. Dis., 14, 12: 1870-1874.
85 Ruiz-Fons F. et al. 2008. A review of viral diseases of the European wild boar: effects of population dynamics and reservoir role. Vet. J., 176, 2: 158-169.
86 Salas ML. and Andrés G. 2012. African swine fever virus morphogenesis. Vir. Res., 173, 1: 29-41.
87 Sánchez-Vizcaíno JM. et al. 2012. African Swine Fever: An Epidemiological Update. Tran. Em. Dis., 59, 1: 27-35.
88 Sánchez-Vizcaínoa JM. et al. 2009. Scientific review on African Swine Fever. Submitted EFSA: 141 pp.
89 Siméon-Negrin RE. and Frias-Lepoureau MT. 2002. Eradication of African swine fever in Cuba (1971 and 1980). In: In: Morilla A. et al. (eds), Trends in Emerging Viral Infections of Swine, 1st edn. Iowa State University Press, Iowa, USA: pp. 125–131.
90 Terpstra C. and Wensvoort G. 1986. African swine fever in the Netherlands. Tij. Dier., 111: 389-392.
91 Thomson GR. et al. 1980. Experimental infection of warthogs (Phacochoerus aethiopicus) with African swine fever virus. The Ond. J. Vet. Res., 47: 19-22.
92 Vial L. 2009. Biological and ecological characteristics of soft ticks (Ixodida: Argasidae) and their impact for predicting tick and associated disease distribution. Parasite, 2009, 16, 191–202.
93 Vigário JD. et al. 1983. Experimental studies with African swinw fever virus carriers. In African swine fever. Wilkinson PJ. (ed). EUR. 8466 EN. Commission of the European Communities, Luxembourg, 63-66.
94 Wardley RC. and Wilkinson PJ. 1977. The association of African swine fever virus with blood components of infected pigs. Arch. Vir., 55, 4: 327-334.
95 Wilkinson PJ. et al. 1977. Transmission studies with African swine fever virus. Infection of pigs by airborne virus. J. Com. Path., 87: 487-495.
96 Wilkinson PJ. et al.1980. African swine fever in Malta, 1978. Vet. Rec., 106, 5: 94-97.
97 Wilkinson PJ. et al. 1983. Studies in pigs infected with African swine fever virus (Malta/78). In African swine fever. Wilkinson PJ. (ed). EUR. 8466 EN. Commission of the European Communities, Luxembourg, 74-84.
98 Yakubu B. et al. 2010. Investigation of African swine fever in slaughtered pigs, Plateau state, Nigeria, 2004-2006. Trop. An. Health Prod., 42, 8: 1605-1610.

dwhc dutch wildlife health centre

© dwhc

Photo 15. Wild boar

Text
Paolo Pagani and Jolianne Rijks

Editing
We greatly thank all the experts in the Netherlands and at the ASF workshop in Uppsala in March 2014 who reviewed the contents for their invaluable recommendations, and Rachel Thomas for editing the text.

Photos and images
Ton Heekelaar (Photos 1, 3 and 15), Paolo Pagani (Maps 1 and 2, Photos 2 and 13), Sandra Blöme (Photos 4 and 5), late Roland Geiger (Photos 6-8), Douglas Gregg (Photo 9 -12), Mary-Louise Penrith (Photo 14).

Disclaimer
The contents of this folder is informative. No claims can be made or rights derived from it.

Universiteit Utrecht

dwhc
dutch wildlife health centre

© dwhc