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## ecology and biosecurity

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## ecology and biosecurity

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# Contents

# Foreword

African swine fever (ASF) is a devastating hemorrhagic viral disease of pigs, affecting domestic and wild pigs of all ages and sexes. The disease is the cause of major economic losses, threatens food security and safe trade, and challenges sustained swine production in affected countries. Since ASF emergence in Georgia in 2007, the disease has spread to many countries in Europe and in 2018 was detected in East Asia, where over 60 percent of global domestic pig inventories are found.

The spread of the African swine virus genotype II into the Eurasiatic wild pig population was unprecedented; the increased densities in wild pig that had taken place in eastern and central Europe over the past few decades was a prime environment for the ASF virus to expand its geographical distributional range. Climate change and extensive cereal production enhanced local wild pig densities and expanded their geographical distribution. Besides these general tendencies, hunting management boosted wildlife abundance by curbing the hunting of wild sows thereby maintaining or increasing the local reproductive stock. They created winter feeding areas aimed at preventing the once-typical demographic crashes of the wild pig populations due to scarce food availability determined by the forest tree seed (mast) cycles. These areas promoted higher fecundity and fertility parameters. As a result, in most of Eurasia, wild pig management practices have artificially increased both abundance and geographical distribution of wild boars by bypassing the natural carrying capacity of the environment.

ASF spread progressively within China in the second part of 2018 with transboundary spread in early 2019 to Mongolia, Viet Nam and Cambodia. Similar to the epidemiological situation in wild swine in Europe there is a heightened risk for ASF endemicity in East and Southeast Asia and further progressive global spread with unpredictable consequences.The control of ASF when wild pig populations are involved in the transmission and maintenance cycle represents an additional challenge for the veterinary and wildlife authorities, given the added complexity in disease epidemiology, lack of previous experience, the unprecedented geographical scope of the problem, and its transboundary and multi-sectoral nature.

The idea of this publication was proposed by the European Commission as a follow-up to the recommendations of the Standing Group of Experts on African swine fever (hereafter referred to as SGE ASF) in the Baltic and eastern Europe region under the umbrella of the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE) Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) for Europe.

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This publication is an example of truly multidisciplinary and multi-institutional collaborative efforts. We are grateful for the contributions of a number of technical reviewers in the early stages of the production of this publication: Klaus Depner, Friedrich-Loeffler-Institut (FLI), Silvia Bellini, Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna (IZLER), Andrey Gogin, European Food Safety Authority (EFSA), Edvīns Oļševskis, Food and Veterinary Service of Latvia (FVS), Sandra Blome (FLI), Francesco Berlingieri (EC DG SANTE), Francisco Reviriego (EC DG SANTE), Ago Partel (Independent Expert), Andriy Rozstalnyy, Food and Agriculture Organization of the United Nations (FAO), Kazimieras Lukauskas (OIE), Gregorio Torres (OIE), Aleksey Igolkin, All-Union Foot-and-Mouth Research Institute (ARRIAH), Daniel Beltran-Alcrudo (FAO), Frank Verdonck (EFSA), Konstantine Gruzdev (ARRIAH), Sofie Dhollander (EFSA), Morner Torsten, Norwegian Veterinary Institute (NVI), Sophie Rossi, Office National de la Chasse et de la Faune Sauvage (ONCFS), Christian Gortazar, Institute of Game and Wildlife (IREC), and Kurt Vercauteren, United States Department of Agriculture, Animal and Plant Health Inspection Services (USDA/APHIS), Wildlife Services, National Wildlife Research Center. FAO provided technical review, editing, layout and printing of this publication and dissemination.

# Acronyms

| | |
|---|---|
| **ASF** | African swine fever |
| **ASFV** | African swine fever virus |
| **BDD** | bait delivery device |
| **BOS** | boar operated system feeder |
| **CCS** | critical community size |
| **CSF** | Classical swine fever |
| **CVO** | Chief Veterinary Office |
| **DIM** | disease independent mortality |
| **EFSA** | European Food Safety Authority |
| **EU** | European Union |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **GF-TADS** | Global Framework for the Progressive Control of Transboundary Animal Diseases |
| **IC** | immune-contraceptives |
| **ISPRA** | Istituto Superiore per la Protezione e la Ricerca Ambientale |
| **Nt** | host threshold density |
| **OIE** | World Organisation for Animal Health |
| **SGE ASF** | Standing Group of Experts on African swine fever |
| **SFVS** | State Food and Veterinary Service |
| **SOCO** | Single Overarching Communications Outcome |

# Introduction

In 2007, African swine fever (ASF) was introduced in the Caucasus and has now spread to several countries in eastern and northern Europe. In 2018 the ASF crisis expanded to Asia. The large-scale epidemic travelled thousands of kilometres away from its original incursion point in Georgia and, in addition to endemic establishment in domestic pigs, the disease eventually invaded populations of wild boar. In Europe, from 2014 to 2015 the circulation of this virus in the natural ecosystems developed into a self-sustained epidemiological cycle. Currently, the disease is endemic in wild boar populations in several countries and continues to expand its range in Europe, causing very serious concern. Controlling this sylvatic epidemic of ASF is a very challenging task for the veterinary authorities, given the complexity of the disease epidemiology, the lack of previous experience, the unprecedented geographical scope of the problem, and its transboundary and multi-sectorial nature.

This document was prepared following recommendations of the Standing Group of Experts on African swine fever (hereafter referred to as SGE ASF) in the Baltic and eastern Europe region. The group was set up under the umbrella of the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) to build closer cooperation between countries affected by ASF fostering a more collaborative and harmonized approach to the disease across the Baltic and eastern Europe subregion. At the eighth meeting of SGE ASF (SGE ASF8) in Chisinau, Moldova, on 20–21 September 2017, the World Organisation for Animal Health (OIE), the Food and Agriculture Organization of the United Nations (FAO) and the European Union (EU) decided to cooperate in the preparation of a technical, but at the same time, practically usable, document containing a compendium of essential information about hunting management, biosecurity and wild boar carcass disposal.

The purpose of this document is to provide an evidence-based overview of ASF ecology in the northern and eastern European populations of wild boar. It should briefly describe a range of practical management and biosecurity measures or interventions, which can help stockholders in the countries experiencing large-scale epidemics of this exotic disease to address the problem in a more coherent, collaborative and comprehensive way. The publication should not be viewed as an authoritative manual providing ready-made solutions on how to eradicate ASF from wild boars. The facts, observations and approaches described in the document are presented with the intention to broadly inform veterinary authorities, wildlife conservation bodies, hunting communities, farmers and the general public about the complexity of this novel disease and the need to plan wisely and coordinate carefully any efforts aimed at its prevention and control.

In order to reduce risks and prevent the negative implications of the now widespread presence of ASF in the ecosystems of northern and eastern Europe, close and continuous cross-sectorial collaboration is essential. Veterinary authorities, forestry and wildlife management agencies, nature conservation and hunting bodies, organizations, communities and clubs should be mutually informed on different aspects of the problem, which sometimes go well beyond their immediate competencies and conventional responsibilities. Therefore, the focal target audience of the publication includes a rather broad range of potential readers, whose decisions or actions on national or local scales are concerned with controlling ASF in wild boars and mitigating the negative implications of this devastating disease for agriculture, as well as for the forestry and game management sectors.

The geographical scope and most of the information or examples provided are intentionally limited to the countries of northern and eastern Europe. These countries share similar environments, agroecological and wildlife management systems, and experience the same sylvatic transmission cycle of ASF, which emerged a few years ago. As the epidemiological situation in Europe remains dynamic and the knowledge about ASF epidemiology in wild boars is far from complete, the document will require future revision and updates in order to reflect new findings, experiences and lessons to learn.

The publication consists of seven chapters. The first chapter describes the epidemiological cycle of ASF in wild boars as it is currently perceived by expert and research communities. It details the main risk factors related to the circulation of the virus in the ecosystems of northern and eastern Europe. Chapters 2 and 3 briefly reflect on some questions and issues (some of which are controversial) that are typically raised and debated in relation to wild boar biology and population management in the context of ASF control. Chapters 4 and 5 are dedicated to a detailed description of the practical implementation of the key elements of biosecurity strategy recommended at the level of hunting grounds. Those elements are based on the experiences of countries in northern and eastern Europe affected by the ongoing sylvatic epidemic of ASF. There is a chapter on data collection, stressing the need for continuous systematic efforts to better document field observations in order to improve our understanding of disease epidemiology as it evolves and expands its geographical range. Finally, the document addresses risk communication strategies and approaches, which are crucial for effective cross-sectorial collaboration among stakeholders dealing with such a complex problem as the spread of ASF in wild boars. Each chapter opens with a short paragraph briefly introducing its contents and concludes with a summary of the take-away points of each discussion. A list of references is provided for those who want to familiarize themselves with more in-depth information and peer-reviewed publications on the matters reviewed.

## Chapter 1

# Epidemiology of African swine fever in wild boar populations

**Vittorio Guberti and Sergei Khomenko**

*This chapter describes the epidemiology of African swine fever (ASF) in the wild boar populations living in northern Europe. The aim is to focus on the most successful determinants of the virus – wild boar ecological systems. The chapter briefly describes the evolution of the disease transmission cycles in its journey from Africa to northern Europe.*

### EPIDEMIOLOGICAL CYCLES AND GEOGRAPHICAL DISTRIBUTION OF ASF IN EUROPE

ASF is a disease of pigs, which was originally associated with the ecological niche of the ticks of the genus *Ornithodorus* and Common Warthog (*Phacochoerus africanus*) in sub-Saharan Africa. Warthogs and ticks, which naturally co-inhabit burrows, can sustain the transmission cycle of this virus for unlimited time. It is a well-established natural host–vector–pathogen system, the so-called "sylvatic transmission cycle of ASF" (Penrith and Vosloo, 2009), whose distribution is restricted to parts of the African continent. Warthogs are naturally resistant to the African swine fever virus (ASFV) and usually do not develop clinical disease. Animals are infected when piglets and develop life-long immunity.

FIGURE 1
**From warthogs to wild boars: adaptive modification of ASFV transmission cycles on the way from Africa to Europe**


*Note:* cycle 1: the natural African sylvatic cycle; cycle 2: the anthropogenic cycle involving ticks (Africa and Iberian Peninsula); cycle 3: the pure anthropogenic cycle (western Africa, eastern Europe and Sardinia); cycle 4: wild boar-habitat cycle (northeastern Europe, 2014 to present).
*Source:* Chenais *et al.*, 2018

In Africa, the virus has shown a trend to shift towards a more anthropogenic cycle (Figure 1, cycle 2) in which domestic pigs instead of warthogs assumed the role of an epidemiological reservoir with the occasional involvement of *Ornithodoros* ticks. In the past, this kind of transmission cycle was also reported from the Iberian Peninsula. Again, in Africa, driven by the growing human population and increasing numbers of domestic pigs, ASF spread to the areas where it never occurred naturally before. In the new areas, its transmission cycle no longer involves ticks or warthogs (Figure 1, cycle 3). The virus spread in domestic pigs is facilitated by human activity. Movements of animals due to trade, sale of infected meat, and free-range pig-raising are the main risk factors in this system. A similar, purely domestic, pig cycle, has also evolved in the Caucasus starting from 2007 (EFSA, 2010a; 2015) when the genotype II virus was first introduced in Georgia. Thereafter, it spread northwards, primarily from the domestic pig population, moving from the Caucasian countries to the Russian Federation, Belarus, Ukraine and then to other European countries (Gogin *et al.*, 2013; Figures 2 and 3).

Finally, the most recent step in the evolution of the biological cycle of ASFV and its geographical spread is related to the formation of the so-called "wild boar–habitat cycle" (Figure 1, cycle 4) which developed in northern and eastern Europe. For example, since 2014, spread occurred in the Baltic states, Poland, Czechia (Khomenko *et al.*, 2013; EFSA, 2017), followed by Hungary, Romania and Belgium. This novel host–pathogen–environment system emerged and now steadily expands its range in Europe (EFSA, 2017) facilitated by the exceptional stability and resilience of ASFV in the environment and carcasses of animals. This cycle is characterized by the continuous presence of the virus in the affected wild boar populations, which represents a serious challenge for the pig production sector and wildlife management authorities, as well as hunters. In the last four years, ASF has become endemic in wild boars over remarkably large areas (Figure 3) and the scale of the problem now poses a major threat to the European pig production sector (Figure 2).

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**Photo 1**
*Free-ranging domestic pigs in Georgia feeding next to a waste bin, illustrating one of the main mechanisms of disease spread in domestic pigs*

FIGURE 2

**Complex of epidemiological factors and transmission pathways involved in sustaining endemicity and facilitating geographical expansion of ASFV in eastern Europe (cycles 3 and 4, Figure 1)**

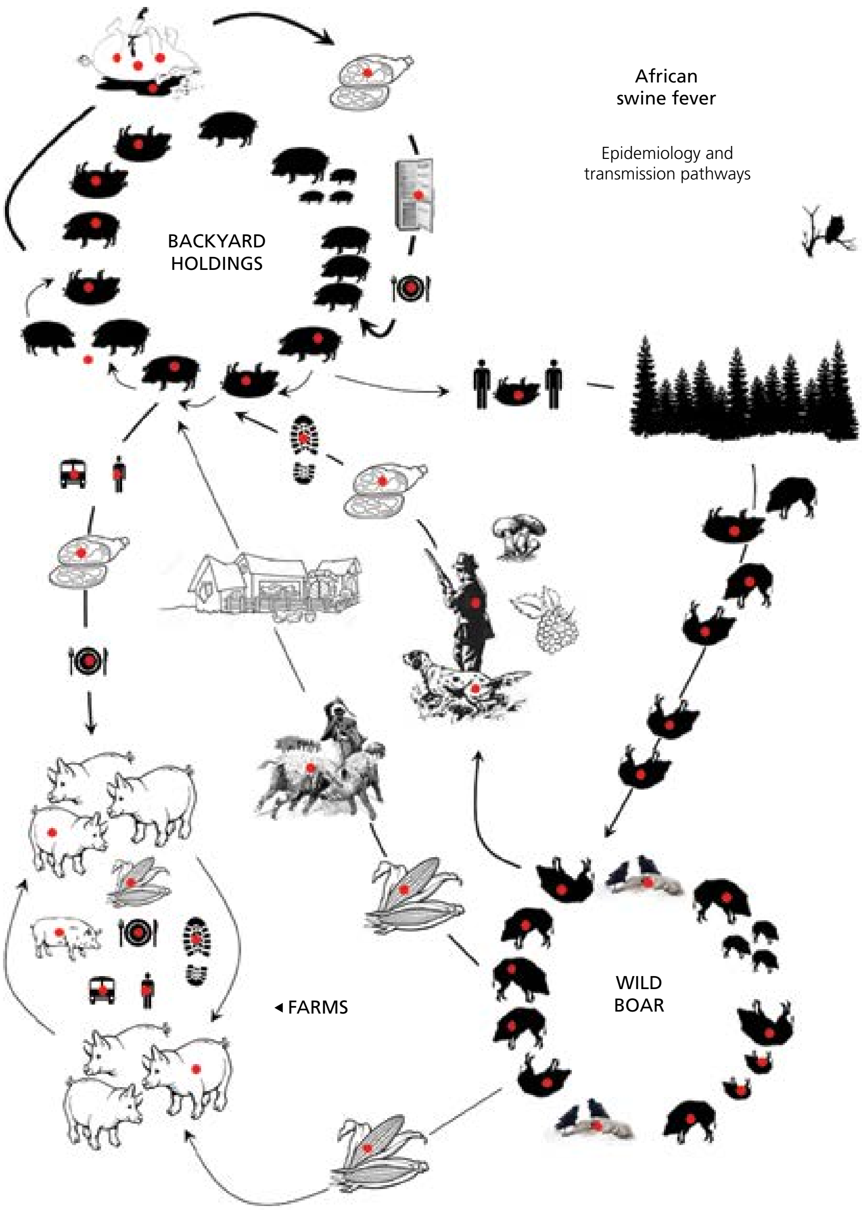
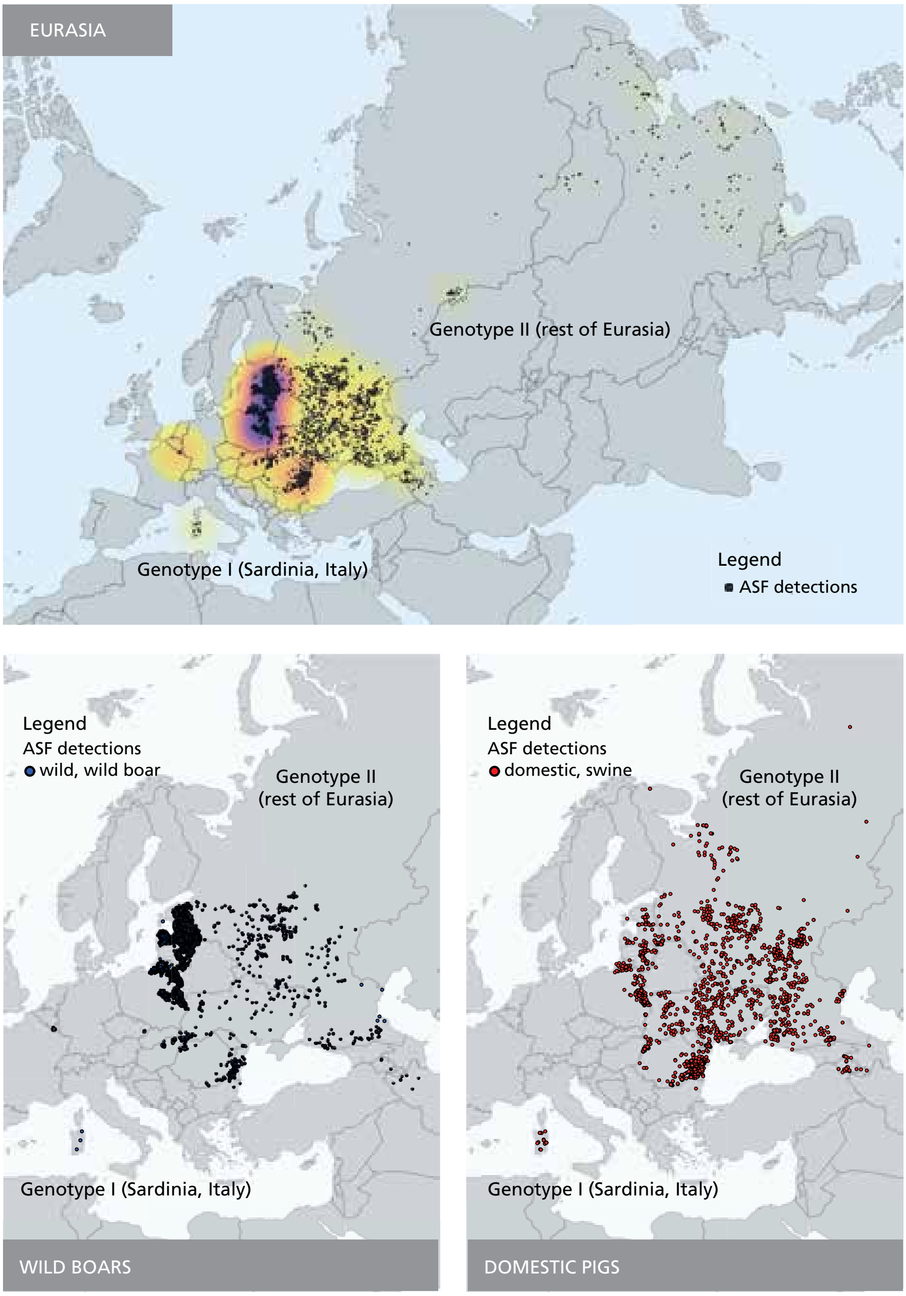


FIGURE 3
**Geographical occurrence of ASF**




*Source:* Based on official notifications to OIE in 2008–2018 (as of March 2018)

## CHARACTERISTICS OF THE ASFV CIRCULATING IN EURASIA

ASF is caused by a DNA virus belonging to the *Asfarviridae* family. It affects only those species belonging to the *Suidae* family. In Europe, the sole susceptible species are domestic pigs and wild boars. They show similar clinical signs and have similar case fatality rates. Although a total of 23 genotypes of the virus are known to circulate in Africa, only 2 of them currently occur in Europe. Genotype II spread extensively in eastern Europe from 2007, while Genotype I has been reported in Sardinia, Italy, only (Gabriel *et al.*, 2011). Most recently, genotype II ASFV was introduced and spread over most of China, and from 2018 to 2019 its occurrence range expanded to Mongolia, Viet Nam, Cambodia and, likely, other countries of the region. The Genotype II virus now circulating in Europe and Asia has a very high case fatality rate in almost any infected pig, irrespective of whether they are wild or domestic. The genetic structure of ASFV is rather stable and thus the use of molecular epidemiology for tracing back the origin of the virus is of limited use.

## ENVIRONMENTAL RESISTANCE

The extreme environmental resistance of the pathogen is the key to understanding the epidemiology of ASF and developing adequate measures and interventions for its control, both in the pig production sector and under natural conditions, when it circulates in wild boar populations. Currently available information on the potential of different matrices to facilitate spread of the virus is provided in Box 1.

In any ASF-infected wild boar population, hunters can encounter and interact with five categories of animals whose epidemiological role in spreading the disease is different. These categories are:

**Susceptible:** any healthy individual that has never been infected by ASFV and, thus, is susceptible to it. Such animals normally comprise the largest part of the population. The number of susceptible animals changes seasonally because of reproduction and mortality largely due to hunting, but predation, starvation and disease may also contribute.

**Incubating:** any individual that is infected but does not yet show visible clinical signs of the disease. Incubating animals could spread the virus for a few days (usually one) before showing evident signs of the disease. The number of incubating animals is usually very small (usually less than two percent) and is dependent on the phase of virus invasion, season and other factors. The only way to find out if a hunted wild boar is in the incubation phase is to collect samples and test them in the laboratory; positive animals should be safely destroyed.

**Diseased:** a wild boar showing clinical signs or one apparently healthy when shot, but which tested virus positive. In experimental conditions, wild boars show clinical signs for four to nine days before death (Nurmoja *et al.*, 2017a); 90 to 95 percent of diseased animals die (Pietschmann *et al.*, 2015; Nurmoja *et al.*, 2017a). Clinical signs are not pathognomonic, being represented by any of the possible abnormal behaviours (lack of escaping, trembling of hind legs, prostration etc.) that simply indicate that the wild boar is sick. In the hunting bag, the average virus prevalence ranges from 0.5 percent to 2.5 percent; however, according to local sampling strategies or specific epidemiological situations it could be higher (for example, 13.7 percent in south Estonia; Nurmoja *et al.*, 2017b). The true proportion of virus-positive animals in the population can be under-represented in the hunting bag. This happens because sick animals deviate from their predictable behaviour, changing their

BOX 1

**Role of different matrices for the secondary spread of ASF**

**Oral-nasal excretions/secretions**

The virus is present in both nasal and oral secretions of infected animals and can be detected even before its appearance in blood and clinical signs.The quantity of shed virus is relatively low, though sufficient to trigger new infections. In the oral-nasal fluids, the virus is shed for a few days (two to four) while its half-life is not known. Oral and nasal fluids are likely to be involved in the direct contact spread of the infection.

**Blood**

The virus is detected in the blood of infected wild boars at two to five days (average is three days) post exposure. The detection of the virus in the blood is concomitant with the onset of clinical signs. The virus is massively shed in the blood where it can survive for 15 weeks at room temperature, months at 4 °C and indefinitely when frozen. The blood contamination of soil, hunting premises and tools, including knives, clothes and cars used for transport of infected hunted animals are important sources for the local persistence and further spread of the virus.

**Raw meat**

The virus is present in the meat of sick animals, too. Since the virus is resistant to putrefaction, it can survive for more than three months in meat and offal. It remains infective for almost one year in dry meat and fat, and it survives indefinitely in frozen meat.

Also, the meat represents an important source for both the local maintenance and possible further spread of the virus. Frozen meat of infected wild boars can ensure survival of the virus for years and thus represents a possible source for new epidemics.

**Carcasses**

As in meat, the virus can survive in whole carcasses for a very long time depending on ambient temperatures. A frozen carcass can maintain infectious virus for months, which means that the pathogen can overwinter even in the temporary absence of any live host and initiate a new transmission cycle when the defrosted carcasses are visited the following spring by susceptible wild boars. In the natural history of ASF in the wild boar cycle, the virus survival in carcasses plays a crucial role. It outlives its host. Once an infected wild boar dies, the virus remains infectious in the carcass for an extended period of time. In such an epidemiological framework, safe removal of carcasses from the environment and their disposal is one of the most important disease control measures, without which ASF eradication from wild boar populations is not possible.

**Offal**

The virus survival rates in offal are similar to those in carcasses. Whenever an infected animal is dressed in the field, the offal (including viscera, skin, head and other parts of the body) becomes an important potential source of the virus. Particularly in winter, when hunting activities take place, offal that has not been properly disposed of has the potential to increase the risk of secondary infections and the spread of the disease.

**Faeces and urine**

Both are infectious and the half-life of the virus is determined by the environmental temperature. ASFV survives longer in urine than in faeces. Its half-life in urine ranges from 15 days at 4 °C to 3 days at 21 °C. In faeces, virus half-life ranges from eight days at 4 °C to five days at 21 °C and the virus DNA is detectable from two to four years (de Carvalho Ferreira *et al.*, 2014). The half-life of the virus is strongly affected by enzymes (proteases and lipases) produced by bacteria colonizing faeces and urine; thus, the exact survival time in the forest where ASF is actively circulating is not fully comparable to the estimates obtained in laboratory conditions. However, in areas highly contaminated by infected faeces and urine the risk of secondary spread of the virus will be more likely through such sources as contaminated boots, tyres or hunting tools. At feeding stations attended by many animals, contamination by infected faeces or urine could increase the rate of secondary infections.

**Soil**

Viral DNA has been detected in the soil after the removal of the body of an infected wild boar. Even when the carcass has been removed, the soil where it rested can remain contaminated. More research is needed to understand the role of contaminated soil as a risk factor for disease transmission, addressing the survival of the virus (persistence of viable virus) in different matrices and ecological conditions.

**Scavenging insects**

It has been hypothesized that ASFV can potentially survive in insects (adult or larval stages) scavenging on infectious carcasses. However, despite the fact that maggots of the Green bottle fly (*Lucilla sericata*) and Blue bottle fly (*Calliphora vicina*) have been detected as contaminated with ASF DNA, the presence of viable ASFV could not be proven (EFSA, 2010a; Forth *et al.*, 2018). It is not known if the virus maintains its infectivity in other scavenging invertebrates. In any case, scavenging insects are attracted to wild boars thus increasing the contact rates between infectious carcasses and susceptible wild boars.

**Hematophagous insects and ticks**

The stable fly (*Stomoxys calcitrans*) is considered a mechanical vector of the virus capable of carrying the virus for 48 hours (Mellor *et al.*, 1987), but their role in the transmission cycle in Europe has not yet been fully investigated. The role played by other blood-feeding arthropods is unclear especially in the wild. *Ornithodoros* ticks strongly involved in the natural ASF transmission cycle in Africa do not occur in the currently affected parts of the European continent.

**Fomites**

High environmental resistance of the virus implies that its transmission is possible via any fomite (including contaminated, non-living objects capable of carrying infectious organisms, such as shoes, clothes, vehicles, knives or equipment).

**Food/kitchen waste**

The high resistance of the virus means that thermally untreated food such as sausages, salami or ham, as well as food leftovers originating from infected animals (both domestic pigs and wild boars) and accidentally released into a wild boar habitat, can initiate an ASF epidemic. Food waste is considered the main source of the virus in the long distance spread of ASF.

**Grass and other fresh vegetables**

Infected wild boars could contaminate fresh vegetables (as in the case of green corn plants damaged by wild boars); adding grass or vegetables to the feed of domestic pig should be forbidden everywhere ASF is present in wild boar populations.

daily routines, losing appetite, and shifting to inaccessible parts of their territory, all of which prevent them from being easily hunted. Only laboratory tests can verify if a wild boar is infected with ASF, or any other pathogen, and is to be destroyed. Sick animals also have a higher probability of collision with cars and are more prone to predation. Any wild boar killed in a road accident in ASF-affected or at-risk areas should, therefore, be ASF tested.

**Seropositive:** animals that survived the disease and developed antibodies against ASFV. Antibodies are detectable from the tenth day after the infection (Nurmoja *et al.*, 2017a). In infected areas, the proportion of seropositive wild boars in the hunting bag ranges from 0.5 percent to 2 percent; however, the number of seropositive animals is correlated with the length of time of ASFV persistence in the area. Thus, increased seroprevalence reveals an endemic stability rather than a decreased lethality of the virus. ASF antibodies do not neutralize the virus; thus seropositive animals are still susceptible to the infection even if the phenology of the virus in these animals is not known, such as the amount of shed virus or duration of the infectious period. There is no evidence that seropositive animals that survived infection with genotype I and II ASFV became long-term spreaders of the virus (Nurmoja *et al.*, 2017a; Petrov *et al.*, 2018). There is also no evidence that these animals can spread the virus to susceptible animals from 50 to 96 days post infection (Nurmoja *et al.*, 2017a). However, the virus was found to be viable in the lymph nodes of seropositive animals (EFSA, 2010a); hence, they have to be considered as virus positive individuals and safely destroyed when hunted and found to test positive for ASFV.

**Dead:** The majority of wild boars infected with AFSV die (90 to 95 percent) and remain in the environment for some time providing an important source of infection for other pigs. Discovery of carcasses by hunters or other people visiting wild boar habitats is the most frequent way of detecting disease in ASF-free areas. Any dead wild boars should be removed from the forest and safely destroyed, as well as tested for the presence of ASFV or other pathogens. Although in any wild boar population there is always a proportion of animals that die naturally (Keuling *et al.*, 2013). In cases of ASF, the number of carcasses increases substantially, thus signalling the virus incursion or, more often, an ongoing epidemic. In Europe, detection of ASF-infected carcasses increases in winter and late spring or early summer, while the proportion of infected dead animals (and carcasses) peaks from July through August. These observations reflect some patterns of the disease transmission cycle and population dynamics, as well as the cumulative effect of climatic and seasonal factors on carcass decomposition and the probability of their detection by people.

## INFECTION ROUTES AND MECHANISMS INVOLVED

### Direct horizontal transmission

The usual physical contact among wild boars in the same group and, sometimes, with individuals from other groups, provides sufficient means to transmit the virus between an infected and a susceptible individual as happens with many other infectious diseases of animals. Direct horizontal transmission plays a very important role at relatively high wild boar density as, for example, happens when the virus is newly introduced into a disease-free population.

### Local indirect transmission through contaminated environment

The habitats of the infected wild boar population can be heavily contaminated through remnants of animals that have died from infection (that is, whole carcasses or their parts disseminated by scavengers); infected materials originating from hunting ASF-positive animals (blood, meat, offal) that spill over or are disposed of directly into the habitats and excretions of sick animals (urine, faeces). The mechanism of environmental transmission can be more or less effective depending on the time of year, the weather and other factors.

a) **Infected carcasses:** The indirect transmission via infected carcasses of wild boars (or domestic pigs) is considered to play a pivotal role in the epidemiology of ASF (see the results of a first study into the topic in Box 2). Infectious carcasses have the capacity to maintain live virus in the habitat for a much longer period of time (months) compared to its persistence in excretions, especially during winter, thus making wild boar population density and contact rates irrelevant for long-term maintenance of the ASF transmission cycle. Carcasses can also be attractive to other animals, particularly in summer, after they pass through the first stages of decomposition. These carcasses provide good conditions for the development of rich communities of invertebrate insects.
b) **Remnants of infected animals:** Offal abandoned by hunters when dressing infected animals on the hunting spot also plays a relevant role by increasing virus loads in the environment. A susceptible wild boar living in a contaminated habitat has a high probability to become infected with the virus.
c) **Excretions:** The virus excreted with urine and faeces contaminates wild boar habitats and, during favourable periods like winter when temperatures are low, can be transmitted to susceptible animals. In the proximity of wild boar feeding points, environmental contamination could be of higher importance. In winter, provided with regular supplementary feeding, wild boars tend to reduce their home ranges and move to within just 200 to 300 metres of the feeding point. This tendency, along with the increasing probability of encountering other individuals that can infect through direct contact (see **Direct horizontal transmission**), also increases probability of infection.

## LONG-DISTANCE INDIRECT TRANSMISSION INVOLVING HUMANS

People can transport the virus over large distances through contaminated meat and other sub-products such as skins, skulls, tusks or other hunting trophies. Irrespective of whether the virus originates from domestic pigs or wild boars this mechanism provides the means, even if unintended or accidental, of spreading the disease over distances greatly exceeding those involved with the transmission mechanisms described above. Release of the virus with contaminated materials by humans is particularly dangerous because the disease may flare up in the least expected area very far away from known outbreaks in domestic pigs or cases in wild boars. There were many occasions, including those in Europe, when indirect long-distance spread of the virus initiated new isolated clusters of infection in wild boars (as well as in domestic pigs), some of which have developed now into long-lasting outbreaks (see Figure 3). The most recent examples of the role indirect long-distance transmission can play in the geographical expansion of the disease are the localized epidemics of ASF in Czechia (Zlin district), in Poland (Warsaw), in Hungary (Heves County) and the most recent virus incursion in Étalle, Belgium.

## TRANSMISSION CHAIN IN WILD BOAR POPULATIONS

Once the virus is introduced into an ASF-free wild boar population, an epidemic is likely to occur. The more effective the spread of the virus, the sooner it leads to a relatively rapid decline of the wild boar population. If the affected population is, at the same time, hunted for sanitary or recreational purposes, the reduction of wild boar numbers might become evident even more quickly. As a result of decreasing populations, the number of interspecific contacts also declines and the epidemic moves into an endemic phase (Figure 5).

Often, at hunting ground level, a fade out of the virus is apparent but its reappearance within months is a common occurrence. Reappearance is likely to be determined by wild boars that moved in the infected area and contacted the "dormant" virus in the infectious wild boar carcasses. While the virus tends to remain endemic in previously infected areas (mainly because of infected carcasses), it also spreads by direct contact into the yet unaffected, neighbouring wild boar groups. Therefore, the epidemiological cycle of ASF in wild boars is characterized by a combination of local, endemic persistence with a

BOX 2

**Role of wild boar carcasses in ASF epidemiology**

African swine fever virus (ASFV) is extremely stable in the environment and is efficiently transmitted via blood and meat of infected animals. It can persist at 4 °C for over a year in blood, for several months in boned meat and for years in frozen carcasses (Sanchez-Vizcaino *et al.*, 2009; CFSPH, 2015). ASF-infected wild boars usually die from the infection. Their carcasses become exposed to scavengers, including ASF-susceptible wild boars. The decomposition process may vary substantially depending on a variety of factors including the weight of the dead animal, the season and the weather conditions. Especially in winter, it may take several months before the carcass, including large bones, is skeletonized and fully decomposed.

However, little was known about the behaviour of wild boars towards their dead fellows, particularly regarding the question of whether or not wild boars feed on wild boar carcasses. To date no published studies done in the wild have explicitly focused on interaction patterns, the frequency and intensity of contacts, potential cannibalism and the conditions that may trigger these phenomena among wild boars and wild boar carcasses. However, these data were of particular interest for understanding the persistence and spread of ASF. Therefore, an extensive study was conducted with the aim to provide field data on the interfaces between live wild boars and wild boar carcasses to better understand the dynamics of ASF perpetuation in a wild boar population. In the study, 32 wild boar carcasses on 9 study sites in northeast Germany were monitored under field conditions by photo-trapping for 13 months (from October 2015 until October 2016). Depending on the temperature and the size of the carcass, it took between four days (young female in summer) and three months (adult male in winter) before skeletonization was complete.

During the study period, 520 wild boar visits were recorded at all study sites. About one-third of the visits (189) led to direct contact with dead conspecifics; including 20 visits in winter and 169 visits in summer. Most contacts were observed in August (33), September (52) and October (54).

The closest type of contact consisted of sniffing and poking on the carcass (without leaving any signs of cannibalism, e.g. bite simultaneous steady geographical spread (epidemic wave) to the neighbouring disease-free areas. Calculations show that natural geographical spread of ASF in the wild boar populations with density typical for northern and eastern Europe occurs at the speed of about 1 to 3 kilometres per month resulting in a 12 to 36 kilometre expansion of the endemic zone in a year (EFSA, 2017 and Belgium data). There are observable differences between infected areas, which are probably determined by different local wild boar densities, the timing of incursions, as well as the types of interventions and management activities put in place.

In such a framework, direct animal-to-animal transmission of the virus is prevalent at the onset of the infection (during the epidemic), whereas following the decline in wild boar population, the indirect mode of transmission through infectious carcasses and/or contaminated habitat becomes more important for the local maintenance of infection (endemic phase). Intensification of direct transmission might also occur episodically following the reproductive season when the host population size almost doubles and new-born

marks), chewing on bare ribs and rooting on the soft soil that had formed after decomposition of several carcasses on the same spot. In general, wild boars, regardless of their age, were more interested in this particular soil surrounding and underneath the carcasses than in the carcasses themselves. Young animals in particular displayed obvious signs of excitement (that is, bristling neck hairs). In winter, wild boars were exclusively observed in the dark and were not seen returning to the carcass within the same night. In summer, they were seen day and night. However, with few exceptions, they only stayed at the carcass site for a short time (less than three minutes). The animals seemed to avoid direct contact with fresh carcasses; on average, 15 days passed until they had direct contact with a dead conspecific.

Under the given ecological and climatic conditions, there was no evidence of intra-species scavenging or cannibalism. However, it must be assumed that all previously mentioned types of contact may represent a risk of ASFV transmission.

The high resistance of ASFV and the relatively long time remnants of dead wild boars may remain in the environment, are likely to contribute substantially to the contamination of the habitat and to the presence of infectious ASFV which can last for a long time – perhaps months or even years – in a region. Hence, the spread of ASFV through carcasses might be more important than direct contact with live infectious animals.

It was concluded that the rapid detection and removal (or safe destruction and decontamination on the spot) of carcasses is an effective control measure against ASFV transmission in the wild boar population. Even if a carcass is detected and removed several days after the death of the animal, late removal might still be an effective control measure. Therefore, safe methods of removal and decontamination of the environment need to be developed. Hunters should be appropriately trained and involved in ASF contingency measures.

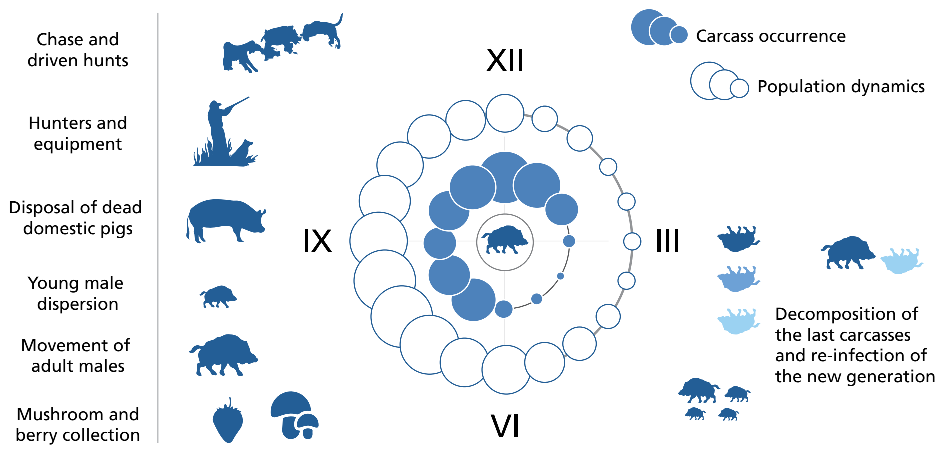
*Source:* Extract from Probst *et al.*, 2017 individuals (from two to six months of age) explore the habitat. This behaviour increases interspecific contact, as does regrouping or aggregation of herds when it occurs in the maize fields and the like.

ASF dynamics in wild boars have also been characterized by occasional episodes of long-distance spread of the virus beyond normal movement range of wild boars (see **Transmission routes and mechanisms**). Despite some very occasional long-distance movements (for example, approximately 100 kilometres in 6 months; Jerina *et al.*, 2014), wild boars are generally a sedentary species (Podgórski *et al.*, 2013) with stable group home ranges rarely exceeding 50 square kilometres. Possible longer-range movements during which an infectious (incubating plus disease phases) animal might spread the virus would last for a limited time of about five to seven days (for example, young males during dispersion period or adult males in pursuit of females in heat).

In the course of a week, wild boars (particularly when undisturbed and sick) are highly unlikely to cross large distances. Hence, long-range incursions of ASF are most obviously caused by human activities, although their unintended or illegal nature (often because of the lack of awareness of the sources of the virus and its transmission mechanisms) make it difficult to prove this with sufficient epidemiological evidence.

The epidemiological pattern described above is often complicated by other factors, including the role of hunting activities in the spread of the virus (for example, driven hunts, human attendance at feeding locations, disposal of contaminated offal, involvement of fomites) or the presence of locally infected domestic pigs, such as live free-range animals or carcasses illegally disposed of in the environment, with which wild boars may come in contact.

FIGURE 4
**Endemic transmission cycle of ASF**




The figure shows the endemic transmission cycle of ASF in a large continuous wild boar population and main natural mechanisms and factors facilitating sustained year-round circulation and progressive geographical spread.

*Note:* Roman numerals denote months of the year

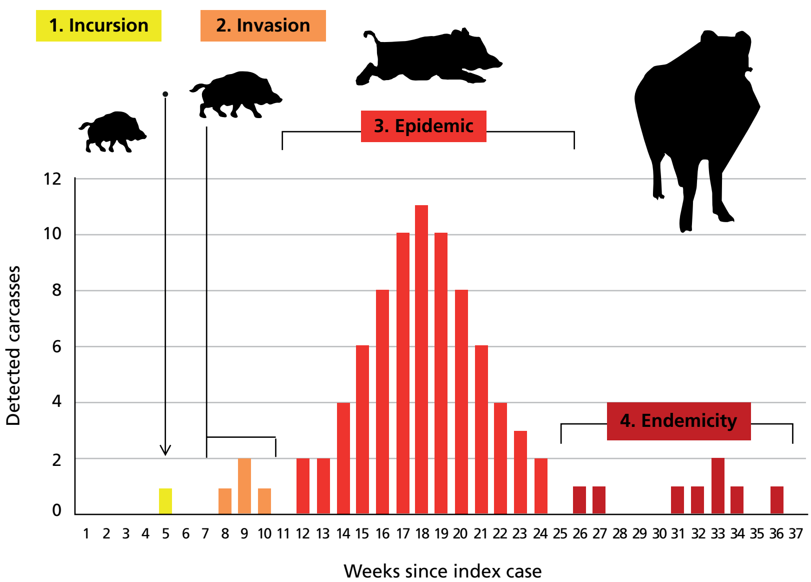
## ASF DYNAMICS AND WILD BOAR POPULATION DENSITY

Understanding the relationship between ASFV and the wild boar population density is of paramount importance since major efforts in controlling the infection are based on population density and size reduction. The natural history of infectious diseases (Burnet and White, 1972) highlights the quantitative relationship between a transmissible disease agent and the host population. Four main phases of the infection dynamics at the population level are recognized: introduction (or incursion), invasion, epidemic and endemic persistence (Figure 5).

**Incursion phase:** This is the initial introduction of the virus into a disease-free, susceptible wild boar population. The incursion can happen through a virus spread from a neighbouring infected wild boar population or through accidental release of the virus with contaminated materials (often mediated by humans). The probability of an incursion occurrence is independent of the size and density of the local wild boar population.

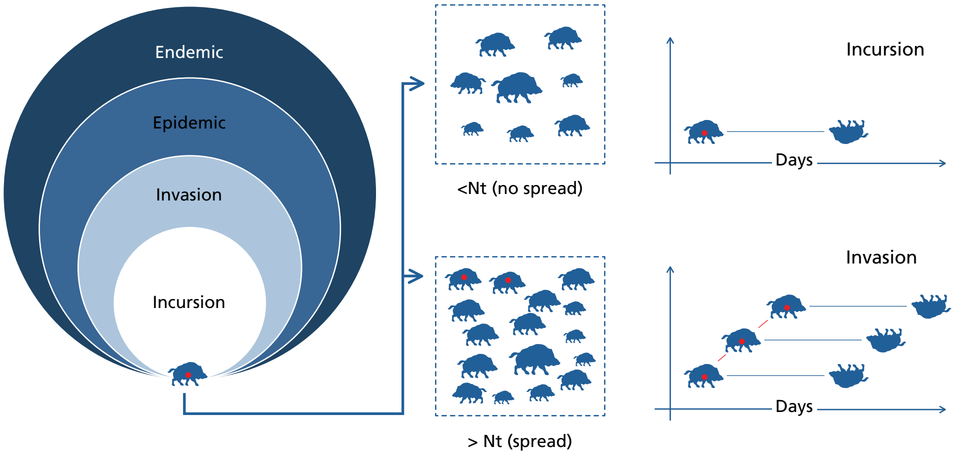
**Invasion phase:** This is the successful initial spread of the virus in a susceptible wild boar population following an incursion. The probability that an infected wild boar will spread the virus depends on the availability of susceptible hosts. Any virus will spread when a large number of susceptible hosts are available. Conversely, in the absence of any susceptible hosts, the virus will become extinct, so the numbers and the density of available hosts will determine the outcome of the invasion (Figure 6).

FIGURE 5
**Hypothetical example of the four phases of the infection dynamic in a population of wild boars**




The graph illustrates the four phases through the weekly-detected number of carcasses

FIGURE 6
**Four possible phases of ASF infection and two different outcomes of an incursion in the population**




*Note:* density < Nt and > Nt

For infections whose dynamic is density dependent it is possible to estimate the minimum number of susceptible animals needed to trigger a successful invasion. This number is called host threshold density (Nt). Nt can be defined as the host density at which an infectious individual fails to encounter any susceptible individual in due time in order to transmit the infection (Anderson and May, 1991; Lloyd-Smith *et al.*, 2005). It is important to underline that the Nt value is mainly determined by the virus characteristics. Its practical use is restricted to the initial spread of an infection (that is, the invasion phase) and not to epidemic or endemic situations (Deredec and Courtchamp, 2003; Lloyd-Smith *et al.*, 2005).

Among other methods to control disease, one might try to bring host population density to a level where disease incursion would not be able to develop into an invasion and eventual epidemic. The Nt can be reached through depopulation or the direct elimination of all the animal categories, including those animals who are susceptible, infected and immune. Vaccination and immunization are also means of reducing the number of susceptible individuals though, unlike depopulation, the host population's size and density will remain unaffected. In the case of ASF, no vaccine is currently available so the only option is reduction of the population size and density.

The values of all the epidemiological parameters needed to estimate Nt are usually obtained from the analyses of field data from infected wild boar populations. At present, such data are collected in the populations in which two different mixed transmission mechanisms, such as direct contact plus carcass-mediated infection, co-occur. This makes any mathematical estimation of Nt almost impossible or highly imprecise. Another limiting factor for the calculation of an accurate value for Nt is the lack of reliable estimates of wild boar population sizes for affected populations. At present they are available only for a few, ad hoc investigated populations, most of which are outside of ASF occurrence range.

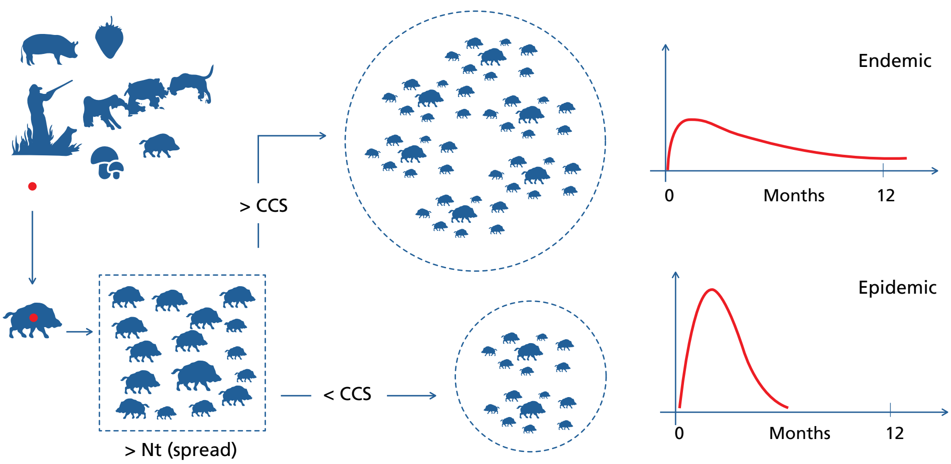
In general, wild boar population size data are very poor, obtained using unstandardized methodologies with unknown error variability and as such are mainly useful for describing trends rather than real population densities or sizes.

The practical application of the Nt approach is justified in wild boar populations at risk of ASF **as a preventive measure**. The logic behind using the Nt-oriented population management approach is that even if the virus incursion cannot be prevented, its further successful spread in the population with density below the Nt will be unlikely because of insufficient numbers of susceptible wild boars.

**Epidemic phase:** This phase follows a successful invasion. The host population density is above Nt and thus the virus can spread and progressively invade the local wild boar population. The epidemic phase is described by a typical epidemic curve, the slope and wideness of which depend on the quantitative relation between the virus and the host populations. At high host density the epidemic curve is steep and narrow, while it is flat and wider at the lower host density. The number of contacts between infectious and susceptible animals drives the shape of the epidemic curve (Figure 7, right-hand graphs).

During the epidemic period, the disease independent mortality (DIM) plays an important role in disease progression and can be used to modulate its outcome. Since the most common source of DIM in wild boars is hunting, it is, therefore, theoretically possible to modify the natural course of the infection by simply reducing the numbers and eventually the contact rate between susceptible and infectious wild boars. The main effect of hunting is to accelerate the evolution of an epidemic into an endemic situation, which would normally take longer without DIM (Swinton *et al.*, 2002; Choisy and Rohani, 2006). However, in shaping a longer lasting epidemic, the recruitment rate of new susceptible individuals

FIGURE 7
**Incursion of ASF into wild boar population**




*Note:* When the number of wild boars is above Nt the virus spreads; the infection evolves endemic when the infected wild boar community is above a critical size. In small fragmented communities (<CCS) the infection dies out naturally while in large, unfragmented communities (>CCS) the virus becomes endemic.

through reproduction or immigration plays a crucial role and should be accounted for. Failure to keep numbers below Nt may, again, result in a recurrent epidemic.

Managing ASF during the epidemic phase is a prohibitive task. At the onset of the epidemic the number of infected individuals is higher than in any other phase and any depopulation effort hardly matches the rate at which the virus spreads. During the epidemic phase, the probability of having a successful chain of ASF cases is exponentially determined by the number of infectious individuals (I) that are present in that specific time (t) according to $p = 1-(1/R0)It$ (Lloyd-Smith *et al.*, 2005) where R0 is the number of secondary infections determined by each infected wild boar (Anderson and May, 1991); during the epidemic phase, the probability of eradicating the infection is almost zero due to the large number of infectious individuals. Moreover, since depopulation activities are not selective towards infectious animals (that is, not all infected animals are shot and removed from the hunting ground), they will die and, as infected carcasses, will further contribute to the maintenance of the virus in the area. Both theory and field evidence show that any intervention during the epidemic phase is likely to enhance those host population resilience mechanisms that facilitate infection persistence (Swinton *et al.*, 2002; Choisy and Rohani, 2006).

Moreover, only a small percentage of carcasses (< 10 percent) are found and safely destroyed in most kinds of wild boar habitats (EFSA, 2015); thus, the virus is detected rather late, and usually during the epidemic period following a successful invasion. In practice, what is perceived as the invasion phase (for example, the very first detection of an infected carcass) is, in reality, the onset, or sometimes even the peak, of a silent epidemic with a large number of infected carcasses already extensively present in the area. However, in the infected area, the number and timing of detected carcasses is the sole available tool for following the entire spread process including individuation of the different phases of the infection evolution.

**Endemic phase:** After the epidemic peak, any disease either becomes endemic or fades out. Endemic evolution does not depend merely on host density (as described above for Nt), but on the availability of a host's critical community size (CCS). The CCS is defined as the minimum population size, rather than density, with which a pathogen has 50 percent probability of fading out spontaneously (Bailey, 1975; Nasell, 2005).

The value of the CCS is variable for different pathogens and host species. In cases of ASF it is mainly determined by wild boar biology and, in particular, by the main demographic characteristics of its population. Smaller CCSs would sustain epidemics when the host population has a high turnover, short life span, and high reproductive rates (which is the case for wild boars). The size of the CCS cannot be estimated using mathematic formulas but can be obtained only through ad hoc computer simulations (McCallum *et al.*, 2001).

During the endemic phase, the ASFV and the wild boar population reach equilibrium. Breaking this equilibrium through management interventions could be a way to make such populations unsuitable for sustained virus transmission, thereby eradicating ASF. However, multiple factors contribute to the endemic persistence of the infection, such as the real size of the wild boar population, the continuity of its distribution, population turnover, fertility and, thus, the recruitment rate. Up to now, the relative contribution of each factor to the endemic transmission cycle of ASF has not been properly evaluated. The strong contribution of the infected carcasses to the local maintenance of the disease cycle additionally complicates understanding of the whole dynamic of this novel host–pathogen–environment system. Intuitively, with the possible overwintering of the virus in infected carcasses, a simple depopulation approach aimed at reducing population density of animals is highly likely to fail to eradicate the disease. At a sufficiently low wild boar density (which is usually the aim of the depopulation efforts carried out during the epidemic phase), the infected carcasses would assume the role of the main epidemiological reservoir of ASFV. In this case, wild boar density becomes of ancillary importance in the cycle.

Ideally, during the endemic phase, an ad hoc hunting pressure together with the prompt removal of carcasses could increase the likelihood of virus eradication. However, these activities are extremely difficult to coordinate given large affected spatial scales (see Figure 4). Various quantitative data are needed in order to evaluate the feasibility of such efforts. Those data are currently lacking, which makes it difficult to implement practical disease control measures with the required level of accuracy and efficiency to ensure a high probability of successful eradication.

## KEY MESSAGES

1. ASFV survives in the wild boar population inhabiting northeast Europe without any help from domestic pigs or ticks.
2. ASFV is highly resistant in any matrix and low temperatures increase its survival.
3. The infection spreads through both direct and indirect contact. Carcasses of infected wild boars maintain the live virus for a long time, especially during winter, allowing for indirect transmission when in contact with susceptible wild boars.
4. Due to the epidemiological role played by the carcasses the simple mechanistic reduction of the wild boar population size has an ancillary value if carcasses are not removed and safely disposed; infected carcass presence allows for the persistence of the virus even if the infected wild boar population is managed at extremely low density, as the virus will persist even without wild boars.
5. The imprecise estimates of the wild boar population size and density together with the lack of knowledge of the main epidemiological parameters of the transmission cycle prevent any estimate of a possible density threshold of infection fade out, and the critical size of the wild boar community required to modulate disease dynamics.
6. Any depopulation approach should consider that:
    i. The introduction phase can be avoided only by interventions and preventive measures implemented at the source population and never in the receiving one.
    ii. A successful invasion can be prevented or minimized by managing a wild boar population at the lowest possible density, but only before introduction has taken place.
    iii. During the epidemic phase, chances are low (if any) to eradicate the disease simply due to the high number of infectious wild boars present, whereas the risk to promote further geographical spread of the virus is high.

iv. During the endemic phase the infection has a certain probability to be eradicated if and when the host population is reduced as much as possible together with carcass removal under strict biosecurity measures.
v. A continuous passive surveillance is the main tool for understanding the evolution of the disease (phase identification, geographical spread etc.).

Chapter 2
# Some aspects of wild boar biology and demography relevant to the control of African swine fever

**Sergei Khomenko and Vittorio Guberti**

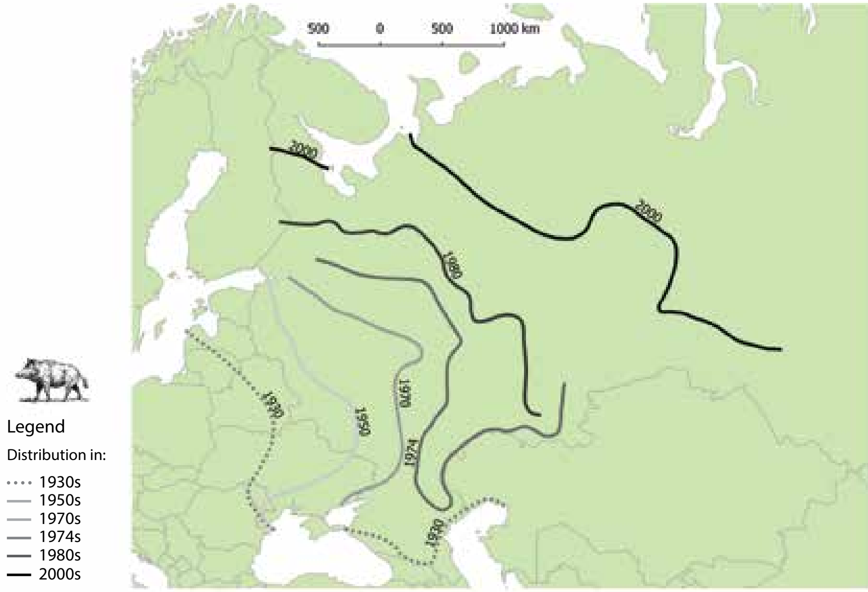
*Wild boars are a native ungulate of Eurasia, which have recovered their historical occurrence range in eastern Europe and increased in numbers throughout the European continent. Although trends in their population dynamics are not very well monitored, there is substantial evidence to implicate climate change, human activities and game management practices in this significant increase. Along with other associated problems, large numbers of wild boars are increasingly involved in the transmission of livestock diseases, of which ASF is probably the most concerning one. This chapter briefly reviews selected aspects of biology and demography of this species relevant to the control of ASF and explains why and how some of the common game management approaches (particularly supplementary feeding) affect wild boar population dynamics and contribute to the population's growth and epidemiological significance of this species.*

## WHY WILD BOAR DISTRIBUTION CHANGES

Wild boars are a native species of the majority of natural zones on the continent, which were exterminated from parts of northern and eastern Europe mainly due to heavy hunting, competition with livestock, or domestication. Occurrence range of this species has been historically fluctuating in size under the influence of climate (Sludskiy, 1956; Fadeev, 1982), but in the last centuries human influence has been affecting it most significantly. In eastern Europe, the most recent contraction of wild boar range had occurred in the 1930s (Danilkin, 2002). In the following decades, the species has recovered its former historical distribution and in some areas in the Russian Federation it has expanded even beyond known fossil records (Figure 8).

Several factors cumulatively contributed to the successful comeback of wild boars. Massive developments of industrial agriculture and favourable landscape changes provided additional feeding resources and shelter to this omnivorous species in both the north and south. This also coincided with large-scale reintroduction efforts (including stock originating from other geographical populations), facilitated by protection, predator control and supplementary winter feeding (Danilkin, 2002). Widespread vaccination of domestic pigs and wild boars against Classical swine fever (CSF), decreases in poaching, and moderated hunting pressure, as well as the general decline of rural populations occurring towards the final decades of the last millennium also contributed to the growing number of wild boars. Further geographical expansion and the increase of wild boar populations throughout Europe were additionally facilitated by milder winters (Figure 12), prompting their better

FIGURE 8
**Changes in wild boar distribution range in the ex-USSR**




The map illustrates the latest population contraction episodes at the beginning of the twentieth century

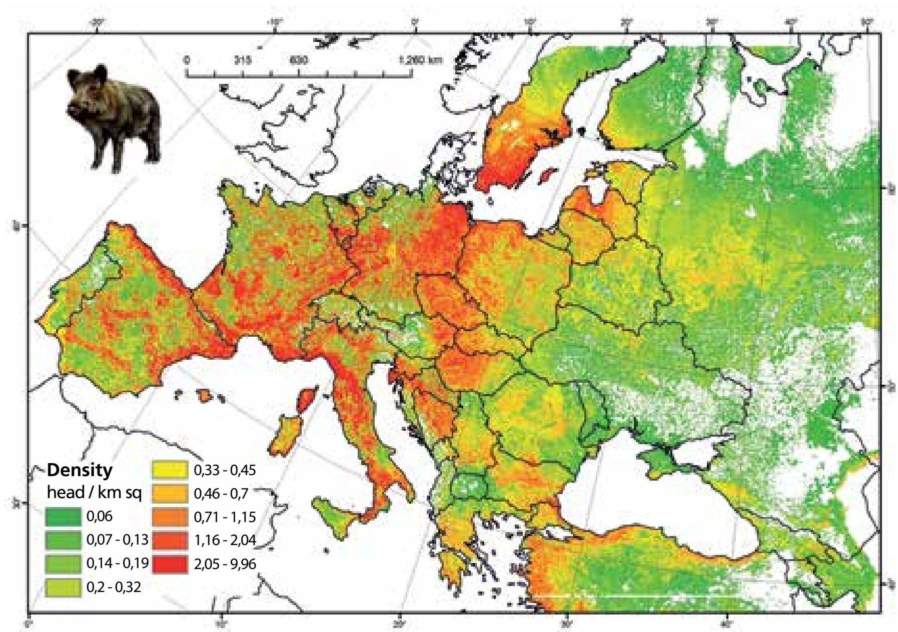
*Source:* Redrawn from Danilkin, 2002

survival and reproduction. While the relative contribution of each of these factors might have varied in timing, as well as from place to place, the cumulative effect now is that wild boars have successfully re-established themselves all over northern and eastern Europe. Their numbers continue to increase (Massei *et al.*, 2015) and are in some areas already regarded as excessive (Figure 9).

## CAN WE MEASURE WILD BOAR NUMBERS RELIABLY?

One of the problems with sustainable management of wild boars is the difficulty in assessing population sizes of this species. Even if official statistical hunting data are available for most countries, their reliability is often questionable. Scientists and practitioners have developed many different methods of measuring the relative abundance of wild boar under conditions of particular natural zones or habitats, but there is no standardized reproducible approach that could give comparable results on larger spatial scales, fit all situations and be logistically feasible and cost efficient (Engeman *et al.*, 2013). For example, in the countries with stable snow cover, approaches such as track counts with correction indexes, or closed transect surveys repeated two to three times, are often used. These approaches can be supplemented with counts at the feeding locations, driven counts (especially in the snow free areas) and camera traps. In other countries, only hunting bag statistics are available

FIGURE 9
**Modelled wild boar population density map**

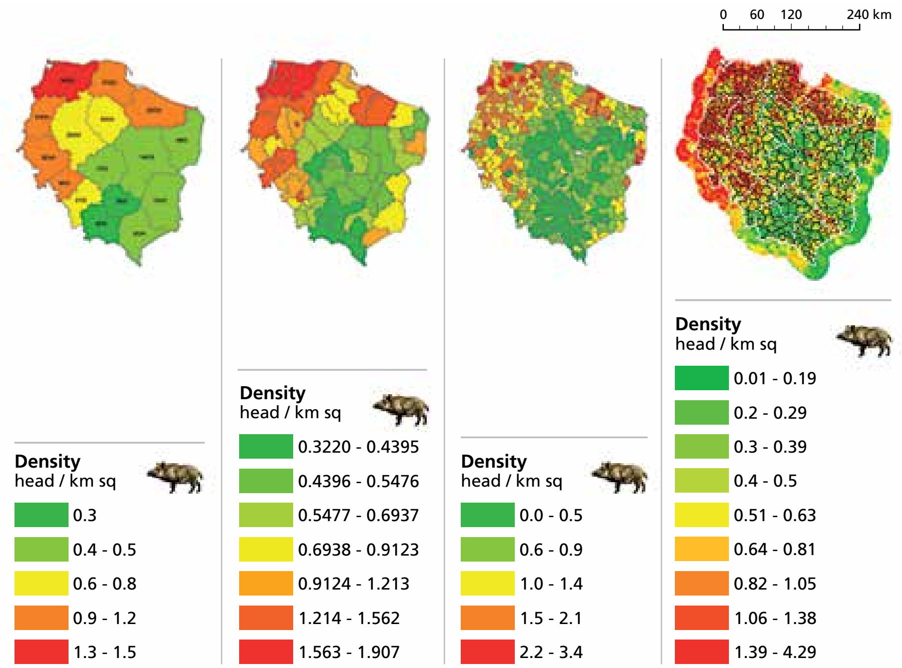



The map is based on official hunting statistic and population estimates for the period from 2000 to 2010.
*Source:* FAO/Targeted research effort on African swine fever (ASFORCE), 2015; Pittiglio *et al.*, 2018

for analysis as a relative measure of wild boar abundance. Existing population estimates differ by methods, timing, accuracy and reliability from country to country and even place to place in the same country. Census data coming from the hunting grounds are usually self-reported by hunters and gamekeepers who are not always well coordinated and adequately trained to carry out such surveys using standardized methods.

Furthermore, population data obtained with a mixture of unreliable methods are routinely summed up for administration purposes to give a generalized picture for a country or region at some level of aggregation. Interpretation of such aggregated statistics can be very misleading as it shows averaged (normalized or levelled) wild boar population density estimates, which can be an acceptable metrics of relative abundance for comparison with other areas, but are not very helpful for informing decisions or management interventions on the local scale (Figure 10). For this reason, whichever census methods are used, wild boar population data should be collected and analysed at the highest spatial resolution, preferably at the level of individual hunting grounds in the smallest census and management units. Sufficient granularity of population data is a particularly important prerequisite for developing realistic interventions for wild boar populations in the ASF-affected areas. Hunting communities should be encouraged to involve wildlife biologists and experts in wildlife disease epidemiology in order to improve their monitoring methods and to obtain more objective, reliable and comparable population estimates.

FIGURE 10
**Different ways to visualise population density of wild boars in Poland**




Such maps might be very misleading if inappropriate scale and resolution of data are chosen to inform population control interventions.

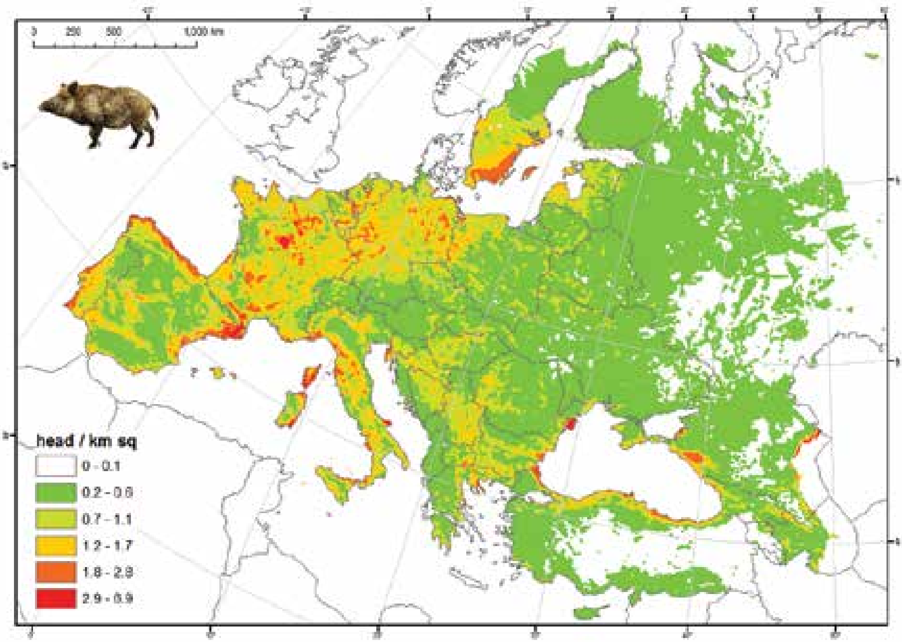
*Source:* Polish Statistics Office, EFSA and the Government of Poland, FAO/ASFORCE, 2015

## HOW MANY WILD BOARS ARE "TOO MANY"?

The ecological capacity of habitats varies widely across the European continent and is dependent on environmental conditions. It is also complicated by a high level of habitat transformation, the seasonal availability of crops, climate and weather change patterns and hunting management practices. Studies suggest that the main factor naturally limiting wild boar abundance is winter temperature (Melis *et al.*, 2006). The warmer it is in winter, the higher and more stable is the population of wild boars (Figures 9 and 11). Availability of water is another factor limiting wild boar abundance in the more arid climates (Danilkin, 2002). However, long-term climatic and land cover characteristics can explain approximately 50 percent of variance in wild boar population abundance (Figure 11), while the rest is mainly related to *in situ* factors, such as population management, food availability and variability of climatic conditions (Pittiglio *et al.*, 2018).

Due to the extensive distribution and high ecological plasticity of wild boars, there is no standard or average density that could be universally recommended as 'optimal' across Europe. Wild boars have evolved as a species adapted to pulsing feeding resource availability, such as variation in beech and oak productivity (Groot Bruinderink *et al.*, 1994; Selva *et al.*, 2014). Their numbers fluctuate remarkably between years, responding to such things as weather conditions, habitat productivity, hunting pressure, predation and disease (Bieber

FIGURE 11
**Predicted map of wild boar abundance**




The predicted map illustrates data as anticipated by statistical analysis of the most important long-term climatic and land cover characteristics.

*Note:* Wild boar abundance (in head per km$^2$; long-term average before reproduction season)

*Source:* FAO/ASFORCE, 2015; Pittiglio *et al.*, 2018

and Ruf, 2005; see Figure 13). Sharp between-year variations in animal density are particularly characteristic for northern or more continental populations, strongly limited by climatic factors. Analysis of the role of climatic and land cover variables on the relative abundance of wild boars in Europe showed that they generally account for about 50 percent of its spatial variation (Pittiglio *et al.*, 2018). When projected, correlations predict some parts of Europe to be particularly suitable for the species, while others can support much lower numbers of animals (Figure 11). Abundance of wild boars is a fluctuating parameter and local variations within a range of some 60 percent of their average pre-reproduction numbers are a common occurrence dependant on weather conditions in winter, supplementary feeding, disease and hunting pressure (see Figure 13). For example, under conditions of stable climate and without artificial feeding, an average long-term population density of 1.0 head/km$^2$ would fluctuate within the range of some 0.7–1.3 head/km$^2$.

However, in the last few decades, over most of Europe, wild boars demonstrate positive long-term population trends (Massei *et al.*, 2015).

## WHY DO WILD BOAR POPULATIONS INCREASE EVERYWHERE IN EUROPE?

Wild boars have a very high natural reproduction potential. Litter size in this species has a wide range of variation (on average from 3 to 7, and sometimes from 11 to 15) and is largest among all European ungulates. Litter size largely depends on age and the body condition of the female. It is generally smaller in younger females and bigger in adult ones. Average litter sizes vary across northern and eastern Europe, and are generally larger in warmer climates. Litter sizes also vary between years, and are larger in years with warmer winters and mast (years with abundant seeds such as acorns, chestnuts and alike). In addition to this, animals can extend the duration of their reproduction season well beyond spring months and, under particularly favourable conditions, they can potentially breed year-round. In some parts of Europe, a proportion of females can deliver two litters a year. Participation of a considerable number of the first-year females in reproduction is also increasingly common in many European countries.

Although mortality levels in juvenile wild boars are also high, they apparently do not compensate for the increased productivity. Wild boars have no natural predators over most of Western Europe, while some eastern European populations do experience some level of predation by wolf (*Canis lupus*). Unless affected by disease such as CSF or tuberculosis (EFSA, 2017), the fertility and survival of wild boars do not seem to be density dependent and dispersion rates decrease rather than increase with growing numbers (Truvé *et al.*, 2014). Therefore, at the population density levels generally encountered in Europe their population growth does not seem to be self-limiting and is barely controlled by current levels of recreational hunting (Massei *et al.*, 2015).

A number of recent studies suggest that the increase of wild boar populations in Europe is strongly driven by climate change (Vetter *et al.*, 2015) and this trend appears to be irresponsive to the existing levels of hunting pressure in Europe (Massei *et al.* 2015). Although population growth is reportedly associated with increasingly warmer winter conditions everywhere (Figure 12), its rate was highest in the colder climates (Vetter *et al.* 2015). In other words, eastern European populations of wild boars were more responsive to favourable changes in winter weather and reached maturity more quickly. Whether this result is due to better adaptation of "northern" wild boars to the cold or is related to the widespread practice of providing supplementary feeding remains to be investigated. But it is very likely that winter feeding of animals in colder climates makes a significant contribution to the better survival and reproduction rates of wild boars and should be considered in the analysis of population growth.

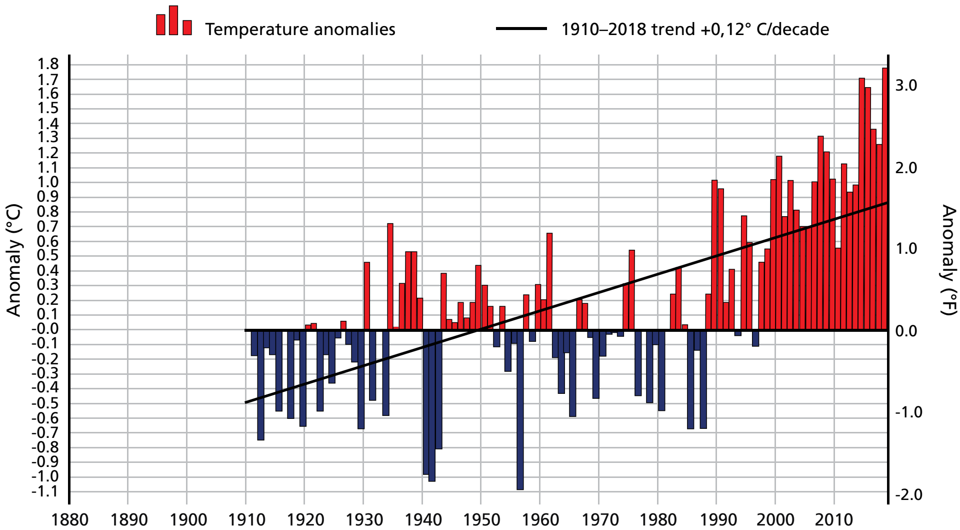
## HOW SUPPLEMENTARY FEEDING AFFECTS POPULATIONS OF WILD BOARS

In general, supplementary feeding means that additional food is provided for wild animals in their natural habitat. For wild boars, supplementary feeding is done for a number of reasons such as: keeping animals away from crops, attracting them to particular locations for hunting, or even fully supporting their nutritional needs on a year-round or seasonal basis. Supplementary feeding is commonplace everywhere in northern and eastern Europe, but it is not very well documented and until recently was not properly regulated. Research has shown that supplementary feeding on the scale and in the amount it is currently practiced in many European countries is excessive (particularly in view of the sustained decrease in the severity of winters) and significantly contributes to the increase of wild boar populations.

The impact is strongest in eastern Europe, where provision of winter food has long been promoted as a key game management approach. Long-term observations such as, for example, those conducted in Belovezhskaya Pushcha in Belarus from 1890 to 1980 (that

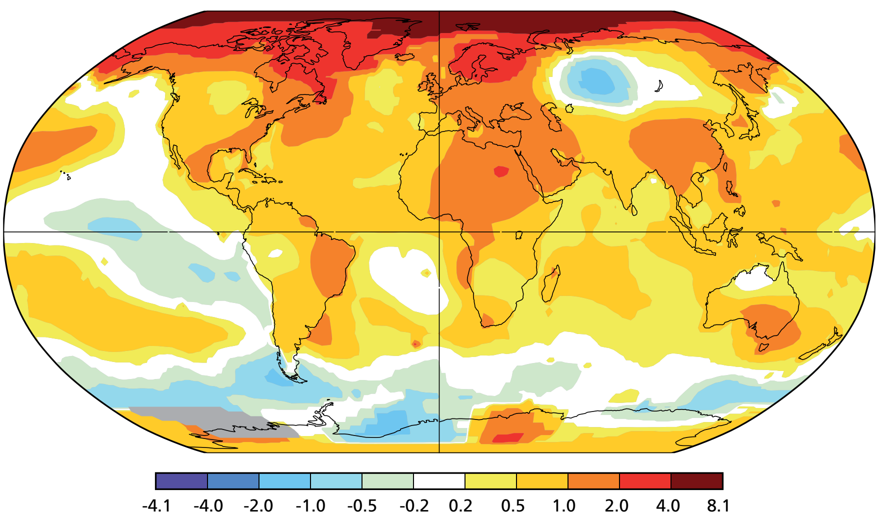
FIGURE 12
**Winter temperature anomalies**

Europe (January-December)




Global map of average winter temperature change

Dec–Jan–Feb Land-Ocean Temperature Index (°C) change 1980–2018 0.63




*Source:* NASA/GISS/GISTEMP (bottom figure) is, before recent climate warming could have had a positive effect on population dynamics), illustrate that provision of food in winter was capable of doubling average population density (Figure 13).

Supplementary feeding has been shown to seriously interfere with conservation of other species and habitats, including protected nature reserves and national parks. In many countries, regular provision of food to wild boars develops into commercial game farming aimed at increasing revenues at the expense of an unlimited population growth potential of this species. Supplementary feeding can be provided on a year-round basis (Photos 2 and 3) and sometimes consists not only of cereals or root vegetables, but also of expired or unsold foodstuff from shops. Some hunting grounds grow crops such as potato or maize to feed wild boars and keep them from raiding commercial fields and residential gardens.

## HOW SUPPLEMENTARY FEEDING INTERFERES WITH CONTROL OF ASF

The chain of negative implications for population management of wild boars due to unbalanced or excessive supplementary feeding can be generically summarized as follows. Feeding enhances reproduction rates to a level which cannot be achieved by animals under natural conditions. The improved nutritional status of females speeds up their population recruitment. Animals start breeding earlier and more females become pregnant. They have larger litters, and may also reproduce outside of the normal breeding period.

The average fertility of females may double and the average proportion of young animals significantly increases at the population level. Such an elevated population surplus due to favourable environmental conditions would be likely to happen naturally only once in three to four years, but in the populations receiving regular supplementary feeding, animals enjoy 'good years' all the time (Groot Bruinderink *et al.*, 1994). On the other hand, artificial feeding reduces or completely removes the natural regulatory effect of limited food availability in winter, which is when most mortality of wild boars should naturally occur. Maintenance of this practice over years leads to an increase of population density beyond the carrying capacity of the natural environment, and drives emigration of animals to the neighbouring areas, which is often counterbalanced by provision of even more supplementary food.

**Photo 2**
*A winter feeding location for wild boars in Romania*

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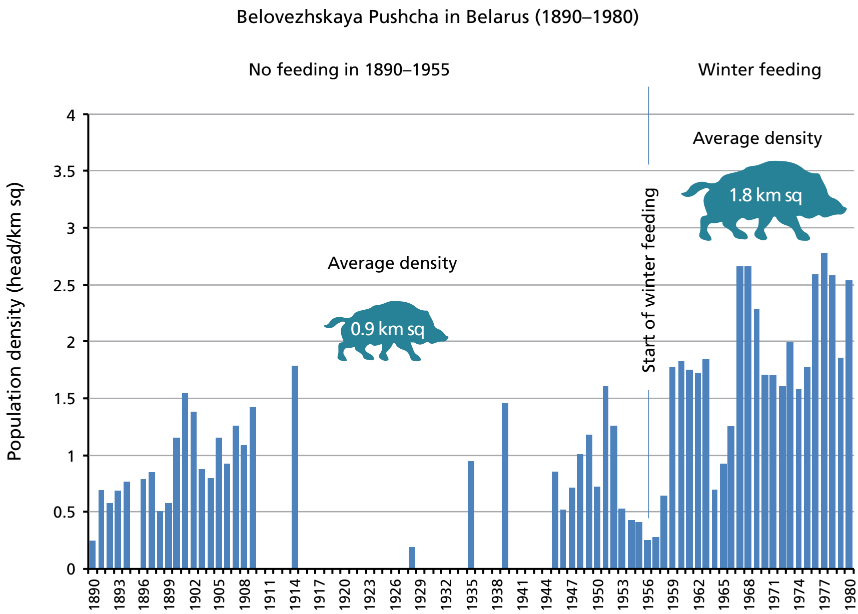
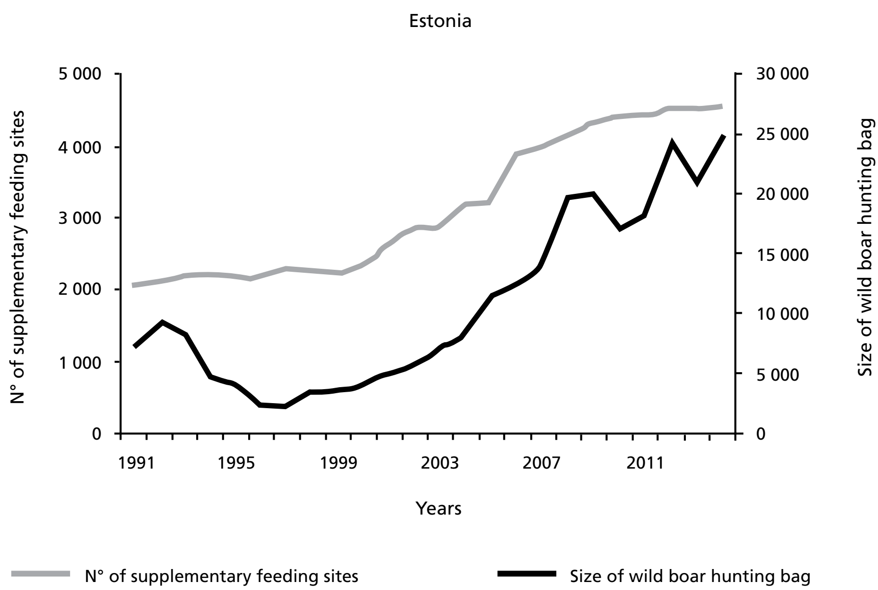
FIGURE 13
**Long-term population density and the correlation between wild boar hunting bags and the number of supplementary feeding sites**




*Source:* Top figure based on data from Danilkin, 2002; bottom figure based on Oja *et al.* 2014, 2015


**Photo 3**
*A feeding point designed to provide supplementary food to piglets in summer*

Wild boars take advantage of seasonally abundant natural feed, such as cereals, acorns, beechnuts or other appreciated foods. Therefore, another very important implication of supplementary feeding is that it significantly changes behaviour, territorial structure and patterns of social interaction in the population. This effect is particularly common in the colder climates during cold spells and snowy weather. Feeding locations become places regularly attended by several family groups of animals, and some animals or groups visit more than one feeding station, even during a single day. Both direct and indirect contact occurs, whether among groups feeding at the same time, or between groups attending the same feeding site (Figure 14). Such space-use patterns particularly intensify during winter when more food is given to animals both in order to support their diet and to make them available for hunting. Rates of interaction are much higher than they would normally be in the population without supplementary feeding and cause serious concerns in the context of transmission of infections, including ASF.

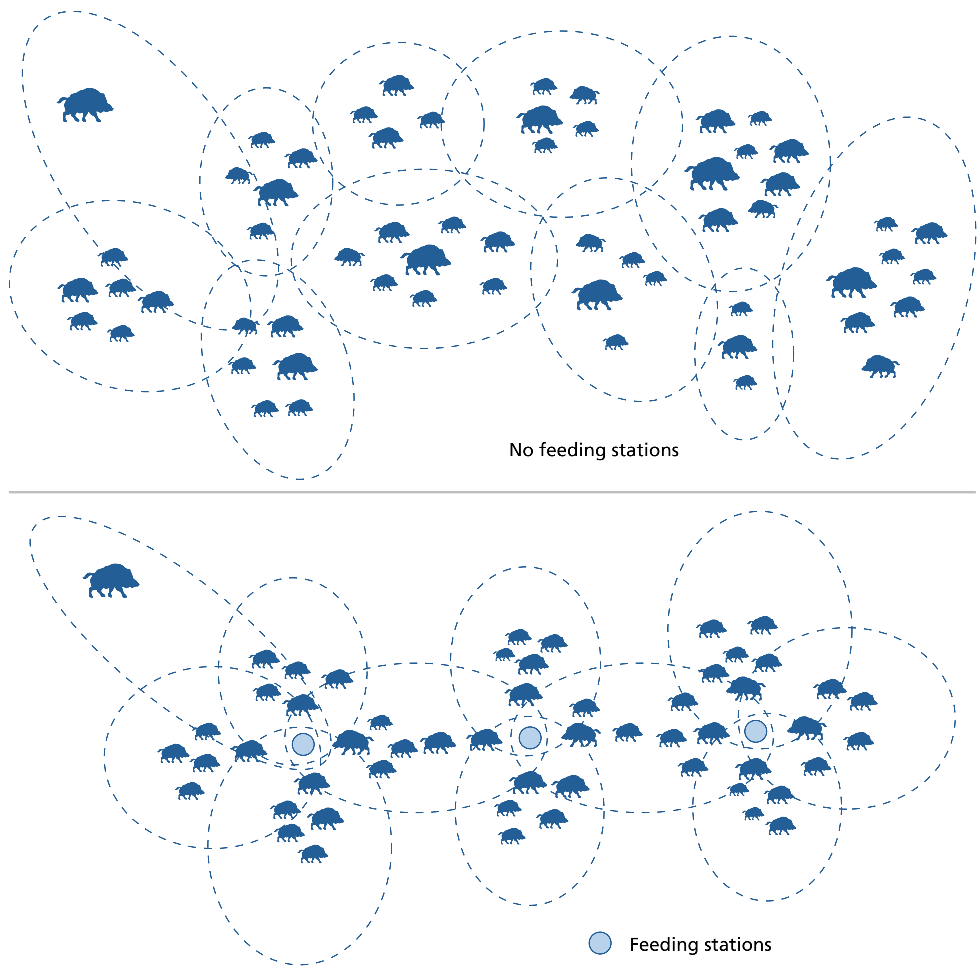
Studies have shown that the practice of supplementary feeding results in increased risk of contamination of feeding locations with endogenous parasites (Oja *et al.* 2014, 2015). Historically, in eastern Europe, most devastating outbreaks of CSF in wild boars were associated with local overabundance of animals and increased interaction rates, both of which often resulted from supplementary feeding or under natural conditions during mast years (Danilkin, 2002). Current understanding of the epidemiology of ASF suggests that inflated and clustered populations of wild boars maintained under regular supplementary feeding are more susceptible to invasion of the virus which finds higher Nt density (see Chapter 1) and, therefore, can spread more easily (Sorensen *et al.*, 2014). Moreover, once introduced, the disease has better chances of developing into a persistent problem in the areas where networks of feeding sites exist. This is driven not only by the more frequent interactions and indirect contacts between live animals, but also because of heavy contamination of the environment with the virus and accumulation of carcasses of dead animals which remain infective for long periods of time.

## WHY HUNTERS NEED TO REVISE WILD BOAR POPULATION MANAGEMENT SYSTEMS

Risk of ASF and its devastating effects on wild boars and the swine industry are not the only reasons for improvements in the way this species is managed by the hunting community in those regions with excessive population of these animals. Growing numbers of wild boars are increasingly regarded as a problem for agriculture, forestry and wildlife conservation (Massei *et al.*, 2011). They cause a large number of transport collisions, particularly in western and central Europe, but also in some eastern European countries. At the same time, wild boars constitute an important economic resource for many landowners and hunting organizers and are important game for many hunters.

The emergence and spread of ASF from 2007 to 2017 has provided an extra justification to consider wiser and more sustainable management solutions for the wild boar problem.

FIGURE 14
**Schematic representation of changes in the territorial behaviour of wild boars related to attendance at supplementary feeding stations**



Their considerable involvement in the transmission cycle of ASF in parts of Europe (see Chapter 1) is a new and escalating challenge for the veterinary services of the affected countries. Although it is not clear if and how much population control can help, there are expectations that lowering wild populations through changing hunting management approaches could slow down the pace of its geographical spread and help to reduce risk of introduction of the virus into the pig production sector. There is little doubt that spread of ASF in Europe will remain a threat for the pig production sector and will complicate operations of the hunting sector for quite some time. These problems do not have a simple and quick solution, and likely require a long-term change of the wildlife management paradigm and practice.

Countries affected by the disease have already adopted some decisions aimed at reducing or stabilizing wild boar numbers, which have a number of implications for hunters and hunting or wildlife management authorities. It is important that the aims, purpose and rationale behind suggested management solutions are well understood and accepted by hunters. It also needs to be recognized that the problem of ASF negatively affects hunters, as well as local companies that produce different products from the wild boars shot in local areas. Therefore, it is reasonable to have a broad perspective when addressing issues related to ASF, including an exploration of the various ways hunters might be compensated for losses.

## KEY MESSAGES

1. Recent expansion of wild boars and re-occupation of their historical range in Europe is a result of multiple factors acting synergistically (climate, agriculture, management, protection).
2. Efforts are needed to standardize and improve monitoring of wild boar populations across Europe as a baseline prerequisite for more sustainable management of this species and effective control of diseases such as ASF.
3. Large between-year variations in numbers of wild boars are a normal feature of their demography as a species adapted to pulsing resources and harsh climates.
4. Some parts of Europe have better climatic and environmental conditions for wild boars (which generally follow the gradient of winter temperatures) and can sustain large population densities of this species.
5. Climate change and excessive supplementary feeding are two major factors that are likely to account for local overabundance of wild boars.
6. The practice of supplementary feeding under climatic conditions that are becoming increasingly more favourable for the survival and reproduction of wild boars should be reconsidered and abandoned where species population has increased too much.
7. Wiser game management and better population control can contribute to reducing risks related to the spread of ASF by wild boars, for which an understanding of the aims, objectives and principles of proposed disease control interventions by hunters and game managers are of paramount importance.

# Chapter 3
# Approaches to wild boar population management in the areas affected by African swine fever

**Sergei Khomenko and Vittorio Guberti**

*The problem of controlling wild boar numbers should not be mixed with the complex set of issues surrounding circulation of ASFV and control of its spread in this species in Europe. Reduction of wild boar populations is just a part of a wider complex of measures needed to minimize the implications of disease presence and spread. This chapter reviews different approaches to wild boar population management in the areas already affected by the disease. Some of them have been applied and tested in the infected countries, while others are currently considered and hotly debated by stakeholders. Non-lethal methods aimed at restriction of animal movements (fencing, distraction with odours), impacting on wild boar demography and survival, as well as lethal approaches aimed at more or less intensive removal of animals from the population are briefly described, specifically in the context of ASF presence in the populations with indications of their pros, cons and limitations.*

## CAN ERADICATION OF WILD BOARS BE A SOLUTION?

In light of the expanding epidemic of ASF in Europe, voices have been raised in favour of extermination of wild boars as a pest or an invasive species (as in the United States of America, Australia and other areas outside of its native range in Eurasia). In some of the affected European countries this question has already provoked hot debate in media, among game management professionals, hunters and veterinarians. This is not surprising considering that in northern and eastern Europe wild boars are a highly appreciated game species, whose extermination is quite reasonably opposed by the hunting community. That community is perceived to be responsible for the management of game species, and veterinary authorities often make formal requests that they carry out depopulation or extermination campaigns.

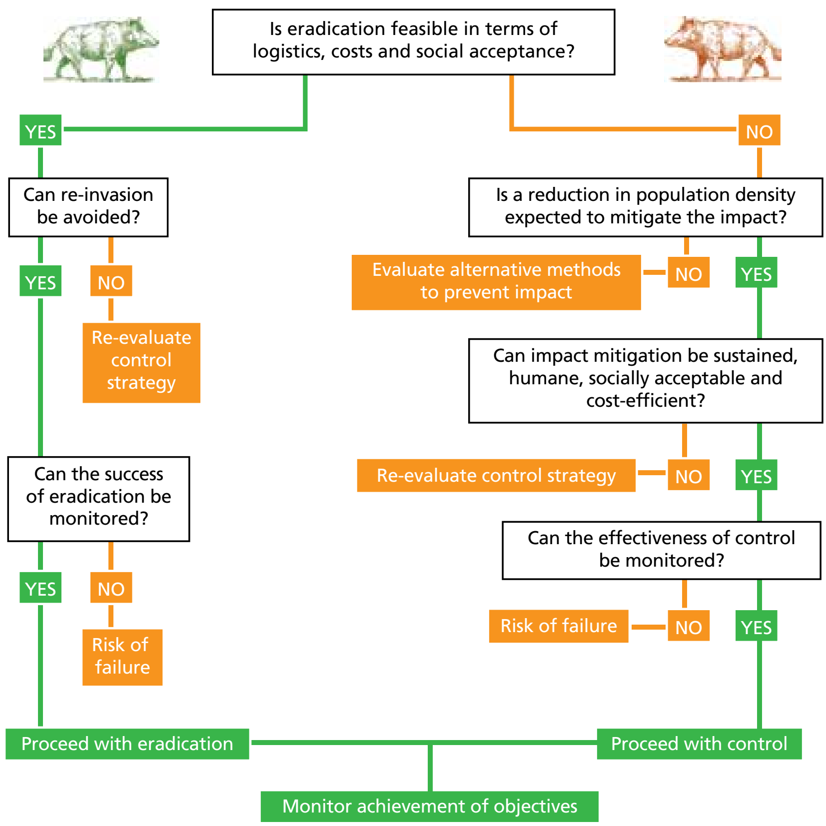
Past experience shows that extermination of wild boars was feasible only on islands and as a well-organized, systematic and long-term effort (Massei *et al.*, 2011). The main lessons to learn from attempts to eradicate this species are that they can succeed only when: (a) social acceptance; and (b) logistical and economic prerequisites for such a campaign are in place; and when (c) re-invasion of this species can be effectively avoided; and (d) monitoring of eradication success can be ensured (Figure 15). In northern and eastern Europe fulfilment of these four basic requirements cannot be achieved, with even less likelihood of achievement in western Europe.

In the biological sense, wild boars are not an invasive, or non-native, species of the northern and eastern European ecosystems (Heptner *et al.*, 1961); therefore, their eradication inevitably conflicts with national nature and wildlife conservation legislation. Consensus on these issues among the respective authorities, academia and non-governmental organizations is difficult to reach (Danilkin, 2017). Although local extinction of wild boars can be achieved, reinvasions from other areas will occur, quickly decimating all eradication efforts. Existing population monitoring methods are not sensitive to low densities of animals and cannot verify the success of eradication with the required level of confidence.

In some eastern European countries ASF is endemic in the pig populations (EFSA, 2010a, 2010b; Khomenko *et al.*, 2013; EFSA, 2014, 2015, 2017); thus, even when wild boars are absent, the infection can remain a threat for long periods of time in domestic pigs and contaminated sub-products.

Therefore, based on ecological, epidemiological, practical and ethical considerations, extermination of wild boars as a species anywhere in northern and eastern Europe should not be viewed as a principal or a key solution for ASF. Rather than making decisions that

FIGURE 15
**Decision tree to evaluate control options to decrease the impact of overabundant populations of feral hogs or wild boars on human interests**




*Source:* Reproduced from Massei *et al.*, 2011 create a complex collision of interests among stakeholders, it is more appropriate to try to change hunting management practices, to reduce the size of the wild boar population for a period of time to manage the situation with ASF, and to take precautionary measures to avoid spread of disease (see what follows and Chapters 4 and 5).

## WHY CONVENTIONAL HUNTING FAILS TO LEVEL WILD BOAR POPULATION GROWTH

The exact demographic mechanisms behind positive population balance of wild boars may differ between parts of Europe (Gamelon *et al.*, 2011; Servanty *et al.*, 2011). In general, though, it is evident that the contemporary hunting pressure, which is the main source of mortality in wild boars, cannot stop population growth of this species. In spite of the fact that in some countries hunting wild boars is authorized without restrictions and occurs all year round, the feasibility of a significant increase in hunting bags seems to be low (Massei *et al.*, 2015). Apart from the demographic aspects, the natural resilience of wild boars to hunting pressure is facilitated by complex behavioural responses such as: individual learning to avoid risk, changing activity patterns, home range sizes and habitat preferences. Wild boars often take advantage of the network of protected areas, and concentrate around urban or buffer zones along state borders where hunting is prohibited, restricted or otherwise problematic. Large crop fields, particularly those of ripening maize, are another type of shelter where animals can avoid hunters and stay out of reach for extended periods of time.

In the temperate forests of northern and eastern Europe, hunting wild boars is recreational and occurs mainly during autumn and winter, when it is more practical and efficient. The most effective hunting occurs in a relatively narrow window of three to four months. Even if hunting takes place all the year round, the bulk of the hunting bag is nonetheless shot during the traditional winter gaming season. For the majority, hunting is a recreational activity and added business for the gamekeepers and hunting organizations. For the latter, wild boars are an important economic resource that is purposely managed, protected and exploited, often with remarkable investments of money, time and labour.

In this particular system, non-professional hunters expect easy and predictable encounters with wild boars with little investment of time dedicated to searching for animals. Therefore, game managers typically aim at increasing the density and survival of wild boar populations and in this way ensure stable services, attractiveness and the economic sustainability of their seasonal hunting business. The most widespread management approach to achieve these results with the free-living populations is provision of supplementary feeding.

## IS POPULATION CONTROL OF WILD BOARS A PANACEA FOR ASF ERADICATION?

So far, there is no empirical evidence that eradication of ASF from wild boar populations **on a large spatial scale** can be achieved through a significant reduction of their numbers. The experience from Czechia (see Annex) is the only example of successful eradication of ASF from wild boars following focal introduction and localized spread. It requires extraordinary effort, resources and an unprecedented level of coordination. However, population management and hunting practices in Europe need to account for the presence of this important pig disease in the ecosystems in order to minimize the negative impact of risky activities and to prevent virus spread among wild boars, as well as its introduction into the domestic pig population, and vice versa.

The most challenging aspect of ASF epidemiology is the capacity of the virus to survive for a long time in the environment, particularly in or in association with carcasses of wild boars that have died of the infection. Because of this tricky complication, the disease transmission cycle only partially depends on the density and interaction patterns of live animals. Apparently, both long-term survival of the virus and involvement of the carcass-to-animal transmission mechanism make it possible for the disease to circulate even at low wild boar population densities.

Research and statistical simulations based on current understanding of ASF epidemiology in wild boars showed that population management measures potentially available to limit spread of ASF should be exceptionally drastic (EFSA, 2017). Under the conditions found in the disease-affected countries in Europe, to prevent the spread of the virus in still-free areas – having an average abundance of one to two animals per square kilometre – a preventive reduction by 80 percent of the **actual, real number** of wild boars in the area over four months within a zone of 50 kilometres adjacent to the infected area would be required to prevent the propagation of the virus. **In the areas where ASF is already endemic the same de-population level cannot guarantee the eradication of the disease due to the presence of infected carcasses.**

Alternatively, targeted hunting of reproductive females and a ban on supplementary feeding could be applied for a minimum of three years in a buffer zone of 100 to 200 kilometres surrounding ASF-infected areas in order to halt the geographical spread of the infection to the free areas. However, it needs to be stressed that there is limited experimental evidence regarding the success of either of these approaches in the control of ASF in wild boars. Furthermore, no minimum population density threshold to stop transmission of ASF has been reliably identified to date (see Chapter 1).

The general lesson from the computer simulations is that a combination of several measures most suitable/feasible for a particular context should be applied at the same time (EFSA, 2017) as a potential solution for lowering wild boar numbers where this is considered beneficial for reducing the risk of infection.

It has to be stressed that population reduction and control are the measures that can help to decrease disease burden and the risk of its spread only in combination with a complex of other interventions, including strict biosecurity during hunting, removal and safe disposal of infected carcasses, effective surveillance, and overall good cooperation and coordination of efforts among wildlife authorities, game managers, hunters and veterinary professionals.

## REVIEW OF APPROACHES TO WILD BOAR POPULATION MANAGEMENT IN AN INFECTED AREA

Coordinated efficient reduction of wild boar numbers on considerably large spatial scales (for example, thousands of square kilometres) is extremely difficult to achieve and to be maintained over the years, as might be required given the persistent nature of the disease. It is a very complex and challenging task in the areas where wild boar populations demonstrate strong population growth. Systematic collection of demographic and population data for wild boars is a very important baseline component of a sustainable, coherent management strategy.

Various population management and control approaches (Massei *et al.*, 2011) and ways of mitigating the role of hunting in the spread of ASF should be considered based on local knowledge, situation and disease-spread risk assessments, rather than the adoption of a simple solution for the whole country or region. Different parts of the country, and even different hunting grounds, may require different methods and/or their combinations that might be more efficient for limiting the implications of ASF in the long-term or at particular times of the year. Some of the available options, including some radical or potential solutions such as poisoning and immune-contraception (not currently allowed by legislation, but which are being discussed in some countries), are briefly reviewed below in light of their applicability for managing risks of ASF related to virus circulation in wild boar populations.

## NON-LETHAL METHODS INVOLVING MOVEMENT RESTRICTION

Permanent boar-proof fencing. Construction of reliable long-lasting boar-proof fencing requires resources, time and effort. Such fences are usually made of woven wire mesh and need to be a minimum 1.5 to 1.8 metres high and buried to a depth of 0.4 to 0.6 metres in order to provide effective movement restriction for wild boars. The fences can be fitted with strands of barbed wire on the top and sides of the mesh net. Electrification of fences increases their effectiveness. The fence design also depends on whether the task is to keep animals in or out of the fenced area. A number of specifications have been identified (see http://www.wild-boar.org.uk/) for building wild boar-proof fencing and those need to be carefully considered before making any decisions.

As a measure aiming at physical prevention of any movements of animals between infected and disease-free areas, the fence design should also account for irregular factors such as: the presence of oestrus females or a desirable food source/hunger and a requirement for cover for farrowing or the population's desire to escape from threats such as hunting or other means of persecution. Where terrain is rough, stony or otherwise difficult to navigate, such as wetlands or densely forested areas, fence building is problematic, and its prompt erection in response to ASF wild boar cases would be challenging or unfeasible.

Fences will not prevent the long-distance spread of the virus since biological materials and contaminated fomites would still have enormous potential to introduce disease well behind the fence (Photo 4). Effective prevention of the spread of ASF and the long-term ecological implications of the large-scale permanent fencing need to be carefully evaluated particularly given that such measures are unaligned with nature and wildlife conservation concepts (Trouwborst *et al.*, 2016; Linnell *et al.*, 2016). Temporary fencing can provide certain assistance when there is a focal introduction and localized spread of the virus as was the case in Czechia and Belgium (see Annex). They help to reduce the contact rate among individuals and groups of wild boars by creating some habitat fragmentation effect and thus potentially slowing down the speed of the geographical spread of the virus and increasing the window of opportunities for local disease eradication.

**Electric fencing.** Different types of deterrent electric fencing designs are available on the market for wild boar distraction. Both permanent and portable solutions exist including solar powered autonomous systems. Most electric fences are developed for use in populated

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**Photo 4**
*An example of a fence aimed – unsuccessfully – at halting ASF spread in the wild boar population*

areas in order to seasonally protect relatively small parcels of land with crops, gardens and property from damage due to invasions of wild boars. Although electric fencing is often reported to prevent crop damage effectively, it cannot provide long-term protection of larger and more uninhabited areas (Reidy *et al.*, 2008). Electric fencing requires construction efforts, a system for regular power supply, dedicated daily supervision and maintenance. Their year-round use is problematic in the climatic conditions of the temperate north and east European forests with their snow and freezing temperatures. Functionality of the fencing can also be severely compromised by larger species of wild ungulates, such as deer or elk. Electric fences do not withstand high pressure and do not completely block movements of animals. They may reduce the overall amount of movements, but will not stop animals motivated by hunger, persecution and sexual interest.

**Other deterrents.** Deterrents can be chemical, visual, acoustic or a combination of these options. Studies and practical experience in several affected countries generally find use of detergents a rather inefficient means of distracting wild boars and reducing crop damage (Schlageter and Haag-Wackernagel, 2012). Closer investigations demonstrated that commercial products of this kind produced effects that were negligible or statistically insignificant (Schlageter, 2015). Deterrents are unlikely to be of significant help with the long-term prevention of wild boar movements and the potential spread of infection. Even if some effect can be achieved initially, wild boars quickly adapt to them. They can be a temporary solution to contain focal incursions of the virus to new areas (see Annex) but are useless as a long-term strategy for broader scale disease eradication.

## NON-LETHAL METHODS WITH IMPACT ON POPULATION DEMOGRAPHY

**Regulation of supplementary feeding.** Supplementary feeding is a widespread and very popular population management practice known to contribute significantly to the growth of wild boar populations (Selva *et al.*, 2014; see also Chapter 2). Whenever the strategic management goal is to reduce wild boar numbers significantly, strict regulation of supplementary feeding should be considered as the first and the most feasible intervention. In order to facilitate hunting from towers, provision of food as bait (and not for subsistence) might be needed, but its amounts should be reduced dramatically. For example, in the EU, guidelines set a limit of ten kilograms per square kilometre per month which can be used as an indicative amount in most parts of northern and eastern Europe (see EC, 2018). Commercially available automatic feeders are particularly useful as they can help to reduce the amount of food provided at any one time, and can decrease human attendance at feeding stations. These feeders are beneficial for the organization of hunting, and they minimize disturbance to animals as well as the risk of spreading infection from site to site by people. Baiting of hunting sites with salt licks, which can often effectively attract wild boars, can be used instead of massive provision of food or other smelly attractants such as diesel, creosote or commercially available products (Lavelle *et al.* 2017). Another solution to attract and retain animals in one location while reducing their food uptake, is to use devices that complicate access to food, such as hog pipes. Ban of supplementary feeding is the least destructive population management approach, and it should be part of standard wild boar management. Ban of supplementary feeding will drive the local wild boar population to a more natural relation with the environment, though it could include winter mortality, and the decreasing fitness and fertility of reproductive females. Natural regulation might prove to be a more efficient means of population control than hunting. Other areas of concern are a possible increase of damage to winter crops and the extended home ranges of animals. The effects of a feeding ban will depend on winter weather conditions and are likely to be most prominent in the colder climates and during less favourable years.

**Contraception.** Contraception is a promising non-lethal method of reducing the productivity of animals that could potentially help with many human-wildlife conflicts, including the wild boar problem. The general public, who often criticize lethal methods

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**Photo 5**
*An electric fence powered with a solar cell in Italy aimed at protecting vineyards from wild boar damage*

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**Photo 6**
*Electric fence in Czechia, Zlin district, set up in response to an ASF inclusion event in 2017*

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**Photo 7**
*The odour-producing agent is the foam contained in the plastic glass placed on the ground at about four metre intervals; an electric fence is visible in front*

of population control (Massei and Cowan, 2014), find contraception more humane and ethical. However, a fully operational method of contraception for wildlife species should fulfil a number of principal characteristics without which it is not likely to be accepted and adopted practically. It should:

- be effective when orally administered;
- be strictly species specific;
- have high efficacy (70 to 80 percent);
- prevent reproduction in both sexes;
- be environmentally safe;
- remain stable and effective within a wide range of environmental conditions (temperature, sunlight, precipitation etc.);
- have no negative impact on the behaviour and welfare of the treated species.

As of now, such an ideal method of contraception remains the subject of ongoing research and is neither commercially available nor officially allowed in wildlife population control programs in any of the affected northern and eastern European countries, or anywhere else in Europe.

Three classes of contraceptives have been developed for application in different wild species: hormonal, chemical and immunising. To date, only immune-contraceptives (IC) have been successfully tested in wild boars (Massei *et al.*, 2008). The method involves vaccines that, when administered to animals, will induce immune responses suppressing their reproduction activity. The effect is based on inducing antibodies against proteins or hormones essential for reproduction. This prevents production of sex hormones and thus makes ovulation and spermatogenesis impossible (Massei *et al.*, 2008). Regarding wild boars or feral pigs, specifically, fertility control methods have to overcome several major difficulties and complications standing in the way of practical implementation of IC in the free-living populations of this species. They are briefly discussed in what follows.

Currently, commercially registered ICs have only an injectable formulation and require capture and manual injection of the vaccine, thus strongly limiting its applicability in wild boars. Of course, availability of oral delivery systems for IC could open a way to use this approach to attain desirable population levels in a much more effective way. However, delivery methods are not the only (and not even the most important) limitation to the application of IC vaccines in wild boar population control.

In the European context, achieving species specificity of IC (that is, making sure they affect only wild boars) is strongly desirable, but wild boar-specific oral formulations are not yet available for use beyond experimental conditions. Without this important quality of species specificity, the potential risk of negatively affecting fertility of various non-target species with ICs is too high. Unfortunately, the range of potentially susceptible animals includes all mammals. Therefore, the conservation implications of extensive systematic application of IC, and their effect on populations of endangered or endemic species, in particular, are of strong and well-justified concern.

Another way to deal with this problem is to develop species-specific IC delivery systems, which would preclude access of non-target species to vaccine-treated bait. Research and experiments with boar operated system (BOS) feeders show that this can be achieved in principle (Ferretti *et al.*, 2018). However, the use of BOS relies on a network of feeding locations. In addition, the application of this method on large spatial scales is much more labour-intensive than any aerial or unrestricted manual bait distribution scheme. It is also not quite clear if BOS can ensure required individual dosage and population coverage, considering territoriality, strong hierarchical relationships and competition for food both between and within family groups of wild boars. As with any other bait-based vaccine delivery system for wildlife, various factors are likely to have an impact on the success of the approach. All of those factors have to be experimentally evaluated in order to account for possible variations due to geographical, climatic and ecological conditions encountered throughout the population range of wild boars in Europe.

The absence of oral formulations of IC, their currently perceived ecological risk and a number of uncertainties concerning such aspects as the effectiveness of their dosage, duration of immunity and required population coverage, mean that **years of research and experimental work will be needed before immune-contraception could be adopted and officially approved for use in the European context.**

## MANAGEMENT APPROACH THROUGH A BAN ON BOTH HUNTING AND FEEDING OF WILD BOARS

The termination of wild boar hunting in an infected area or its parts is a reasonable solution to disesase management where compliance with hunting biosecurity is problematic; for example, when the preservation of carcasses until exclusion/confirmation of infection or the safe destruction of infected material are impossible. This measure can help to reduce the probability of spreading disease beyond the infected area in two ways: (a) by avoiding the disturbance and movements of animals and (b) through the total exclusion of risks related to dressing and transportation of killed animals. This approach should be supplemented with the search for, removal and safe destruction of wild boar carcasses to reduce the environmental load of infection. A ban on hunting is a management approach that can be put into effect quickly and feasibly; however, the hunting community might not easily accept it. The possible side-effects, such as an increase in agricultural damage, a mid-term increase in population and a lack of diagnostic material from hunted animals, are always mitigated because of the high mortality determined by ASF. Under certain circumstances, particularly in low resource settings, stopping both the feeding and hunting of animals is a relatively safe and inexpensive management solution for a hunting ground affected by ASF compared to other approaches involving active population reduction and requiring costly biosecurity measures.

## LETHAL METHODS INVOLVING REDUCTION OF THE POPULATION

**Driven hunts.** If hunting in an infected area continues, careful consideration should be given to the hunting methods used (Thurfjell *et al.*, 2013). Recent experience and knowledge of the behavioural response of wild boars to driven hunts suggest that heavy persecution of animals in the areas with active circulation of ASFV are likely to cause further spread of the infection. Intensive, driven hunts, particularly with dogs, may lead to large-scale dispersion of animals and an increase in their home ranges which can be counterproductive for disease control (Keuling *et al.*, 2008; Ohashi *et al.*, 2013). Therefore, a ban on driven hunts is another hunting limitation generally recommended when ASF is present in wild boar populations.

**Targeted hunting of reproductive females.** Conventional hunting bags usually consist of about 50 to 60 percent of the first-year animals (piglets), about 20 to 30 percent of sub-adult (yearlings or second-year) wild boars and about 10 to 20 percent of adult animals (one year and more). Such age distribution of animals in the hunting bag roughly reflects the proportion of each category in an over-age population. However, hunting from towers, which usually comprises three-quarters of total kill in northern and eastern European countries, gives more opportunities for hunters to have an impact on the demography of local populations and purposely decreases its reproduction potential (Bieber and Ruf, 2005). Selective removal of **second year females** (sub-adults) beyond normal proportion can help to reduce wild boar numbers, but only if such an approach is maintained over several years (five or more). In the countries where early recruitment of female wild boars into the reproduction cycle occurs normally, it might be worthwhile to target first-year females as well, although in the field, practically speaking, discriminating between ages and sexes is difficult. For this reason, targeted hunting of all females is generally carried out.

Of course, successful implementation of targeted hunting would perform best when the demographic structure of the local population is known and accounted for (Bieber and Ruf, 2005). Targeted hunting is also more time-consuming compared to non-selective harvesting methods, such as driven hunts, for example, up to an average of 30 hours per individual (Schlageter, 2015). This approach is most relevant and feasible at those hunting grounds where wild boar numbers are above regional average density and where animals regularly attend baiting sites and are more accessible.

The drawback of selective hunting is that the social structure of family groups disintegrates, particularly after the removal of leading saws, with the potential of the regrouping and redistribution of remaining animals. Therefore, it is advisable to avoid killing dominant (oldest) saws, especially at the beginning of the hunting season, as this is usually likely to compromise successful targeted hunting efforts (Massei *et al.*, 2011). Also, in the longer run, systematic overharvesting of females may lead to earlier adaptive recruitment of younger females and can stimulate larger litters in the older animals. At the moment, empirical data on the population response of wild boars to selective hunting is very limited, but it is likely to differ depending on the cumulative roles of other factors such as climate, predation and supplementary feeding.

**Trapping with euthanasia.** From the standpoint of disease control, trapping is probably the least destructive way of removing animals from the population, but it is also the least feasible. It requires massive investment in trap construction, baiting, daily maintenance and operation. The positive sides of catching, rather than shooting the animals, are that large coral traps might allow for the capture of whole family groups of wild boar. However, traps may also increase capture-related stress and mortality (Fenati *et al.* 2008). Trapping animals in groups helps to avoid those social perturbations, which may lead to increased disease transmission and encourage long-distance movements. However, from a practical point of view, the trapping of wild boars is a very costly and time-consuming population management approach. It is only effective occasionally when natural feeding resources are scarce. In general, it has a high probability of failure and may easily turn out to be cost inefficient.

Use of trapping is regulated by wildlife conservation laws or hunting legislation. Regulations on trapping wild boars vary dramatically between different countries in northern and eastern Europe. In some countries, such hunting is not allowed at all, while in others only certain trapping methods are illegal. Some trapping methods, such as snaring, that are inhumane and cause suffering are entirely prohibited. Changes in regulations might be required if hunting with traps is to be pursued as a population control method as these must fully comply with welfare, ethical and biosafety requirements.

In northern and eastern Europe, wild boar trapping is most successful in winter and early spring, that is, primarily during the hunting season. Therefore, it can rarely substitute for hunting as it does not occur in seasons outside of the conventional game harvesting period.

Operations in the ASF-affected area would require the same biosecurity measures as during normal hunting. Logistical arrangements should account for the fact that a proportion (up to seven percent, but in case of an infected family group even more) of captured animals might be infected subclinically. Precautionary biosecurity measures, therefore, have to be developed and strictly adhered to during trapping campaigns in order to avoid spread of the disease between trapping locations and its introduction to domestic pigs. Practical ways to euthanize, transport, keep and, when needed, destroy carcasses that prove to be ASF-positive need to be considered.

Catching wild boars with mobile traps or cages can help in those residential areas and public parks where no other population control option is available. The successful application of trapping of wild boar as part of a disease management strategy was demonstrated in a small population affected by CSF in Bulgaria (Alexandrov *et al.* 2011).

**Increase of overall hunting pressure.** The general increase of hunting rates is recommended or officially prescribed to the hunting associations as a primary wild boar population control approach. Though wild boar hunting bags all over Europe have been growing, these cannot compensate for population increases (Vetter *et al.* 2015; Massei *et al.* 2015). Despite bigger hunting bags, in recent decades, there have been indications that the number of hunters in many European countries are steadily declining and that the overall interest in wild boar hunting has also decreased. Research suggests that under these conditions in central Europe, the removal of up to **80 percent of wild boar piglets** would be needed to keep populations stable (Bieber and Ruf, 2005). This figure might be slightly lower for more continental wild boar populations such as those in eastern Europe, but this result can be rarely achieved in practice.

Where feasible, a general increase of hunting bags can be a strategy for population control; however, it is usually difficult to significantly increase hunting pressure without deploying more effective or destructive hunting methods, such as driven hunts, killing from helicopters or use of mounted night vision equipment to facilitate location of game.

Intensification of driven hunts is only possible to a certain degree, after which the dispersion and redistribution of animals are inevitable. In some areas, driven hunts can be organized in a way that reduces the risk of dispersion, provided that the hunt is performed over a very large area with many different hunters, hunting clubs and landowners involved, though this approach increases the cost and time required to achieve success. Also, with declining population density, encountering animals and hunting them by whatever the method, becomes more difficult and time-consuming for the hunters.

Aerial hunting under conditions of temperate forest and forest steppe with moderate to high human population is problematic due to dense foliage and is also dangerous to humans. Hunting with night vision devices is regulated in many European countries. Under environmental conditions of temperate European forests, extension of the hunting season beyond the cold part of the year does not always lead to increased hunting bags. In the spring, wild boars become difficult to track due to farrowing, while green foliage during this season strongly complicates the location of game.

In some countries, the involvement of the army or other armed corps has been implemented. Apart from the legal constraints, it is clear that intense actions limited by time and space are less effective than continuous coordinated efforts carried out in large geographical areas when wild boar abundance is decreasing. Experience from Czechia has shown that even if professional snipers get involved in the hunt, their knowledge of the area and habits of wild boars are critically important for the success of shooting.

In general, the increase of hunting pressure using conventional recreational hunting methods can only succeed as a population control approach with stable or rather slowly increasing populations. Unconventional hunting involving armed forces and special troops is not likely to help with extensive long-term population control programs, which require sustained systematic effort and a complex of locally applicable measures.

**Wild boar poisoning.** The application of poisonous substances as the means of radically increasing the mortality of wild boars has been proposed in several ASF-affected countries as a potential, and seemingly very attractive solution, to their population control. These considerations are fuelled by attempts in other countries to apply biocides in order to manage overabundant populations, such as feral pigs in Australia or wild boars as an invasive species in the United States of America. At the moment, poisoning is legally prohibited in all countries of northern and eastern Europe.

Considering the EU countries as examples, the use of biocides is strictly regulated (Regulation N. 528/201). The legislation poses several restrictions on the use of any biocide outside of its authorized purposes and means of distribution. Though derogations to the law could be obtained (art. 55) it is very difficult to minimize all the risks posed by the intensive use of biocides on a large scale in natural conditions.

Apart from the ethical dimension, a specific plan should be designed underlining: motivation, feasibility, probability of success and risk factors linked to the operations. Any possible risk has to be clearly considered and minimized. Lack of data and experience would make any attempt to poison wild boars a hazard, as the risks are currently very difficult to evaluate and manage. **At present, it is absolutely impossible to promptly design and implement an effective and safe large-scale wild boar poisoning program in any of the European countries.**

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**Photo 8**
*Left: A large coral trap for catching wild boars baited with maize; Right: Immobilizing leading sow (upper) captured together with several litters (lower) in Strandzha, Bulgaria*

Any biocide aimed at poisoning wild boars in the natural environment should fulfil a number of characteristics in order to be legalized, officially accepted and practically applied in population control programs. The substance used has to be species specific to kill only the targeted species, without any secondary/accidental poisoning of non-target species, such as brown bear, wolf or birds. It has to be highly attractive for the wild boars and easily accepted by them. An effective antidote should be available both for humans and domestic animals in case of its large-scale application. The biocide has to cause minimal pain and suffering to the animals after consumption and must be sufficiently safe for people involved in the field operations. Its complete and safe degradation in the environment, including soil, ground and surface water, and invertebrate biocenosis has to be guaranteed. The poison itself, as well as its distribution and delivery systems to the target species, all have to be reasonably priced in order to be used repeatedly on large spatial scales to achieve sufficient long-term reduction of the target species populations.

Practical experience with application of several biocides for control of wildlife populations is available from the Americas and Oceania (Cowled *et al.*, 2008). In those areas, warfarin, phosphorus, 1080 and sodium nitrite were the most used. Both warfarin and phosphorus failed to meet welfare requirements and were abandoned. The environmental risk linked with 1080, particularly in terms of secondary poisoning of non-target species, is also unacceptable. Nitrites were shown to be the least dangerous of the options and were capable of fulfilling some of the requirements.

Apart from the choice of effective and safe poison, implementation of a large-scale wild boar population control programs in the countries of northern and eastern Europe based on biocides would face many problems, some of which are identified in what follows, while others remain unknown.

Any type of poison will need to be incorporated into baits ingestible by wild boars. The baits will always attract a large number of non-target species, particularly birds and mammals, which will vary depending on the type of environment, habitat and season. In order to prevent their poisoning, the baits should be delivered exclusively to wild boars by using species-specific systems (see Contraception). Such bait delivering devices (BDDs) have never been tested in the areas inhabited by brown bear, bison, wolf, jackals etc., nor have they been used across a wider spectrum of European environments and animal communities.

At least one BDD per every 300 hectares should be foreseen. At present, the area of ASF occurrence in wild boar populations is more than 300 000 square kilometres, which implies the manual installation of a large number of BDDs (more than 70 000). This dramatically increases the probability of the poisoning of various non-target species (including those with high conservation status), unpredictable involuntary accidents and environmental contamination. Ensuring an individual dosage of poison, considering the highly hierarchical social structure of wild boar family groups and the different mobility patterns of animals depending on sex, age and season, might prove problematic, as is the case with oral contraceptives. Other issues worthy of consideration are persistence in the food web chain and accumulation in specific substrates.

## KEY MESSAGES

1. Large-scale extermination of wild boars as a species in order to eradicate ASF is an unrealistic, unacceptable and unfeasible task based on ecological, epidemiological, practical and ethical considerations.
2. Failure of conventional recreational hunting to level population growth of wild boars is to a large extent related to the widespread practice of providing supplementary feeding as well as to the highly adaptive behaviour of wild boars, favourable changes in climate and agriculture.
3. Restriction of wild boar movements using various types of fencing or odour repellents is not a reliable approach to prevent ASF spread, even if the fence is boar-proof. Such methods might be useful in an isolated virus incursion; restriction of wild boar movements on a large spatial scale and over an extended period of time is problematic and expensive, with low effectiveness in terms of disease control.
4. **A set of lethal approaches** aimed at active reduction of wild boar numbers includes: carefully organized driven hunts (which should be avoided if they are likely to increase animal dispersion); the selective shooting of reproductive females; trapping with euthanasia (which requires complicated logistical and biosecurity arrangements); and an increase of hunting pressure through application of more effective game location or shooting methods.
5. Contraception and poisoning are, respectively, non-lethal and lethal population management methods, both of which are the subject of ongoing research, testing and evaluation. At the moment they are not ready for use in the temperate European forests and years of efforts are needed to develop

them into fully operational, environmentally safe and ethically accepted alternatives to currently available solutions.

6. The reduction of the population density of wild boars is part of a complex series of measures that could break the transmission cycle of ASF and thus serve as a reliable tool to eradicate the disease. Due to environmental persistence of ASFV in infected carcasses, the virus transmission can continue at very low wild boar population densities.
7. Computer simulations show that to prevent the spread of ASF to still-free areas, 80 percent of the actual number of wild boars in a 50 kilometre wide strip of habitats would need to be killed or otherwise removed from the population within just four months. For a number of reasons, this aim is almost impossible to attain and the method has never been practically tested.
8. Theoretically, prevention can be achieved through a slower population reduction method based on the targeted hunting of reproductive females and a ban on supplementary feeding, but this would require targeted hunting efforts over a minimum of three years and in a much wider (100 to 200 kilometre) area. Given the current occurrence range of the disease in wild boars, this approach would also be extremely difficult to test empirically.
9. It is more realistic to consider the application of different strategic and area specific population management approaches based on local knowledge and epidemiological information, trying to mitigate risk through the application of a complex series of approaches that include hunting, biosecurity measures, the safe disposal of infected carcasses and awareness campaigns.

# Chapter 4
# Biosecurity in affected forests

**Vittorio Guberti and Marius Masiulis**

*In forests, the presence of infected wild boar carcasses increases the environmental viral load enhancing local, long-term persistence of the virus. This chapter outlines the different methods to dispose of infected wild boars and how to minimize the risk of mechanical transportation of the virus outside infected forests through human activities.*

## ASF DETECTION IN FREE AREAS

Usually, ASF in wild boars in free areas is first detected in dead animals. Initially, a practical carcass management plan is rarely available, so the veterinary services should immediately lead the field operations. After the first detection, the infected area should be defined through an active search for carcasses. This search will help to identify the geographic extent of ASF and will allow for designation of the infected area. The border of the infected area should follow the borders of the involved hunting ground since they will represent the main wild boar management units.

A general disposal strategy has to be developed. It should consider the availability of paved and unpaved roads, to facilitate transport; soil characteristics, including its texture, permeability, surface fragments, depth to water table, depth to bedrock and hydrological properties, and proximity to water bodies, wells, public areas, dwellings, residences etc. At the local level, the landscape of each hunting ground should be considered in order to implement the strategy.

The personnel in charge of carcass disposal or transport have to be trained on ASF and biosecurity. They have to be equipped appropriately; that is, they must wear disposable clothes and overshoes, or clothes and shoes which are easy to clean and disinfect. Involved personnel must not have any direct contact with healthy pigs for 48 hours.

## DETECTION OF CARCASSES OF DEAD WILD BOARS

In the control/eradication of any animal diseases, the effective and safe disposal of infectious carcasses of dead animals plays a crucial role. Safe disposal of carcasses is even more relevant for ASF due to their role in the epidemiology of the disease. Since early 2015, the role of carcasses has been highlighted and their detection and safe disposal is included in the list of the measures to control ASF in wild boars in the EU (EC, 2018). The first step to detect carcasses is to raise awareness among hunters and other stakeholders, particularly foresters and forest workers, and to include the general public. The awareness campaign should clearly address the procedure to be applied when finding a wild boar carcass.

Awareness campaigns should be carried out using all possible information modalities (that is, face to face meetings, mass media, posters, leaflets, radio and TV shows). Different actors should be informed including hunters and hunter associations, the general public through municipalities and non-governmental organizations, veterinary practitioners, forest

BOX 3

**ASF DNA in soil samples collected from the sites of discovery of wild boar carcasses in Estonia**

By A. Viltrop, I. Nurmoja, H. Kirik, M. Jürisson, L. Tummeleht
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In Estonia, soil samples were collected after removal of ASF-infected wild boar carcasses from beneath the place of their discovery. The samples were collected in seven different locations in all four seasons, from underneath two to three carcasses of various levels of degradation in every season. Samples were collected from a total of ten sites of discovery, including three samples per site with an interval of one to three weeks and tested for the presence of ASF viral DNA by the rt-PCR test. The rt-PCR signal of ASFV was considered positive at a ct value below 40.0.

In the samples collected in July 2016 from three sites of discovery of wild boar carcasses, the DNA of the ASFV was detected in two sites up to one and two weeks after the discovery and removal of the carcasses.

On the sites of discovery of carcasses found in October 2016 (n=5), the DNA of the virus persisted the longest – up to six weeks on one site.

On one of the two sites discovered on 8 February 2017 (n=2), the DNA of the virus persisted for four months, until the end of May 2017.

The persistence of the DNA of the virus was dependent on the level of the decomposition of the carcasses and was longer on those sites where the fresher carcasses were discovered.

workers and forest management bodies, with the aim of increasing the reporting of dead wild boar findings. Any person who could potentially find a dead wild boar should know the basic rules and how to behave around the carcass:

- Do not touch the carcass.
- Make the spot where the carcass has been found visible or communicate the exact coordinates (any smart phone can be used).
- Inform the authority in charge of the carcass management, without delay.

Competent authorities must facilitate communication, and reports of wild boar carcasses should never be considered a nuisance; on the contrary, those who report should be rewarded. The rapid detection and removal of contaminated carcasses is regarded as one of the pillars for the eradication of ASF in wild boars (EFSA, 2017).

**It is well known that nothing is easier than to ignore a rotten, smelly wild boar carcass in a forest.**

The availability of a free 24-hour phone line (green line) simplifies the collection of information even when received from different areas of the country. Financial motivation is a way to increase the likelihood of carcass reporting and a specific procedure should be developed in the country before ASF will be detected. Several countries used to reward only hunters who are usually paid through their official hunting associations.

Local hunters play a pivotal role in carcass detection since they are among the main experts of the infected area. Following an ASF diagnosis in a wild boar population, hunters and foresters should actively search and regularly patrol the area especially near wild boar resting and feeding areas, and natural or artificial water bodies (rivers, ponds, lakes). Sick wild boars usually hide in swamps or densely covered areas, where they can avoid disturbance.

Under normal conditions, even for hunted populations, natural mortality in wild boars is ten percent of the population (Keuling *et al.*, 2013; Toïgo *et al.*, 2008); the reliability of the carcass reporting system, and, hence, ASF detection, is measured through the number of dead wild boars reported in the absence of ASF. **A desirable goal is to report ten percent of the carcasses that account for approximately one percent of the whole estimated wild boar population;** that is, 10 reported dead wild boars out of 1 000 estimated wild boars indicates good efficiency of passive surveillance.

## PRECAUTIONARY MEASURES

Once an ASF-positive carcass is reported, there are several methods to dispose of it and thus inactivate the virus. It is a country's choice which method of carcass disposal should be applied, based on such factors as local facilities, the environmental situation and constraints, and costs.

Local burning or burying of the carcass has to be authorized by competent authorities in order to prevent a negative impact on the environment. At the onset of the epidemic, the legal competence of each involved entity is often not clearly defined. Therefore, the country at high risk should organize carcass disposal authorization protocols before the first case of ASF detection. The disposal of large numbers of wild boar carcasses poses both logistical and environmental problems, especially when carried out in mountains or wetland areas, and should be planned well in advance, particularly where the density of wild boars is high.

Countries at risk should define which service or agency is responsible for carcass collection and disposal. Veterinary, forestry or environmental services, municipalities or even local hunters or their associations could be in charge of the disposal of carcasses. However,



**Photo 9**

*Transport of wild boar carcasses should minimize the risk of further spread of the virus*

BOX 4

**Experience of Latvia in relation to ASF in wild boars and biosecurity during hunting**

By E. Olševskis and M. Serzants

*Food and Veterinary Service in Riga, Latvia.*

The first ASF biosecurity requirements that were implemented in Latvia for hunters were:

- storage of the carcass of a hunted wild boar until laboratory results became available;
- prohibition to leave offal in the forest.

These requirements were implemented a few days after ASF had been confirmed in wild boars in June 2014 (Olševskis *et al.*, 2016). This requirement was established by order of the Chief Veterinary Officer (CVO) on hunting in ASF-affected territories.

It is worth mentioning that from October 2014 to October 2015 driven hunts were prohibited in areas within a 20-kilometre radius of each ASF case in wild boars. From November 2015, driven hunts were prohibited at a distance of ten kilometres on both sides of the line separating ASF-affected areas from ASF risk zones (between Part I and Part II). From November 2016, driven hunts in ASF-affected areas are allowed only when biosecurity requirements are respected as defined by order of the State Forest Service (as suggested by the CVO). The following biosecurity requirements were established:

**I. Before a driven hunt, the leader of the hunt must ensure a place and equipment for:**

- destruction of by-products from hunted wild boars;
- carcass dressing and storage;
- washing and disinfection of transport, boots, knives and other equipment.

Before each driven hunt, the hunting leader must instruct all hunters on the mandatory biosecurity and hygiene requirements to be followed during hunting and after.

**II. Requirements for wild boar by-products:**

It is prohibited to leave any wild boar by-products including internal organs, offal or skin in the forest. The hunting leader ensures the destruction of all wild boar by-products by burial, burning or collection in specific places or containers.

**III. Requirements for carcass dressing and storage:**

The hunting leader ensures:

- that the primary treatment of a hunted wild boar takes place only in a place where its disinfection is possible afterwards;
- that the hunted wild boar is stored in appropriate premises until laboratory results are available and the identification of the wild boar carcass is done;
- that there is no division or consumption of the carcass before a negative laboratory test result for ASFV and antibodies is received.

**IV. Requirements for washing and disinfection:**

The hunting leader ensures:

- disinfection of transport or parts of the transport that have been in contact with the hunted wild boar or blood;
- disinfection of the equipment that has been used for the transportation of the hunted wild boars or material that has been used for covering the carcass during transportation;
- washing and disinfection of hunters' boots before leaving the hunting lodge;
- washing and disinfection of the equipment that has been in contact with the

- hunted wild boars, including ropes, hooks, knives, aprons etc.;
- use of only those disinfectants which inactivate ASFV;
- that each hunter washes his clothes after hunting if he plans to hunt outside the ASF-affected area.
- that vehicles previously used for the transportation of hunted wild boars or hunting equipment are allowed for the transport of feed or for agricultural purposes only after appropriate cleaning, washing and disinfection.

**V. Use of hunting dogs:**

The use of hunting dogs in ASF-free areas is allowed only when at least five days have passed after they had been used in ASF-infected areas.

The State Forest Service carries out random controls on the implementation of biosecurity requirements during driven hunting.

**Latvian experience shows that the main difficulties for the majority of hunters are:**

- lack of equipment for storage of carcasses of hunted wild boars especially during the summer (coolers, refrigerators etc.);
- acceptance of the concept of hunting biosecurity;
- rapid adaptation to new conditions and requirements;
- change of previous traditions and attitudes.

**Help and assistance provided to hunters:**

- One year before ASF introduction in Latvia, the joint stock company, Latvia's State Forests, donated one million euros for ASF prevention and readiness. After long discussions, a decision was taken to use most of the money for the purchase of refrigerators for hunting clubs in ASF-risk areas. A small part of the donation was used for training and to increase awareness of hunters all over the country, which was provided by hunting associations;
- Initially, the Food and Veterinary Service provided hunters with disinfectants.

**National legislation on hunting biosecurity:**

The regulation of the Cabinet of Ministers on biosecurity requirements for hunting wild boars was prepared, agreed with hunters and was adopted at the beginning of 2018. In general, the regulation includes the requirements that are currently set by order of the State Forest Service. In addition, a clearly defined procedure for controls on the implementation of hunting biosecurity requirements will be established through the collaboration of the State Forest Service and the Food and Veterinary Service.


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**Photo 10**
*Simple tools can be used to safely transport hunted wild boars or those animals who have been found dead*


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**Photo 11**
*Single burial; note the disinfectant on the carcass and around the burial area*

the veterinary service should always be responsible for the supervision of carcass disposal and for taking samples.

In each country, it is advisable to involve the forestry services and local hunters, including hunting clubs or associations, as fundamental partners in providing information and help during collection and disposal of carcasses on the spot.

## CARCASS DISPOSAL

Due to the epidemiological evolution of ASF in Eurasia, each wild boar carcass, even if detected hundreds of kilometres away from the nearest infected areas, should be considered as an ASF-suspect case unless the presence of the virus is ruled out through laboratory testing. All precautionary measures aimed at limiting the possible further spread of the virus should be taken on the site where carcasses are found and while waiting for laboratory test results. Following the ASFV detection, all the appropriated biosecurity measures will be promptly implemented for each detected carcass. The primary aim of carcass disposal is to reduce the probability of the local maintenance of the virus.

The movement of carcasses within the infected area, from the finding spot to the designated carcass collection point, has to be done to prevent any further spread of the virus. The burial or burning area has to be located considering the availability of facilities for disinfection of vehicles, personnel and equipment. Vehicles (particularly the underside or the bed, if carcasses are transported in the cab) and personnel (shoes, equipment etc.) should be cleaned and disinfected before leaving the infected area.

Carcasses are first placed in durable plastic bags and then transported into plastic or metal tanks suitable for repeated disinfections. The tanks will allow for easier movement of the carcasses in the forest. Stones, snow or vegetation will not damage the plastic bags and infected fluids will not leak-out. Vehicles will be disinfected before leaving the infected area. The re-use of containers requires regular cleaning and disinfection.

The carcass and the spot where it has been found should be disinfected in order to minimize the ASF viral load. These procedures are easy to implement during all seasons with the exception of winter when carcasses are frozen, often covered with snow, and temperatures are below 0 °C and the disinfectant freezes. In such situations, anti-freezing agent is added to prevent disinfectant freezing. Propylene glycol can be used as a diluent.

Each country has approved and/or authorized a list of biocides effective against the ASFV and thus only authorized biocides will be used according to the producer's instructions.

## CARCASSES MIGHT BE DELIVERED TO A RENDERING PLANT OR INCINERATOR, BURNT OR BURIED ON THE SPOT

Incineration or rendering is the most effective and easy way to dispose of carcasses.

Rendering is a process that converts waste animal tissue into stable, usable materials. Rendering is a closed system for mechanical and thermal treatment of animal tissues leading to stable, sterilized products; for example, animal fat and dried animal protein. Rendering grinds the tissue and sterilizes it by heat under pressure.

Rendering is the most economical method to dispose of carcasses, however, the movement of infected carcasses to the rendering plant may pose a certain risk of disease spread, so precautions must be taken. Not all countries have rendering plants or the existing rendering plants may not always accept the carcasses of wild animals. For this reason, agreements with rendering plants should be sought beforehand or other alternative methods of carcass disposal are to be used. Finally, carcasses can be sampled directly in the rendering plant minimizing the risk of local viral contamination.

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**Photo 12**
*Disinfection of the burial area*

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**Photo 13**
*Wild boar carcasses are placed in plastic bags and carried to the nearest road*


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**Photo 14**
*Carcasses are then transported to the carcass collection point*

Incineration is a treatment process that involves the combustion of organic substances contained in waste materials, or carcasses, in our case. During the incineration of carcasses, they are converted into ash, flue gas and heat.

## CONTAINERS

The carcasses can be managed by the use of containers. Special containers (with a 400 to 600 litre capacity) are strategically distributed close to the nearest paved roads. Carcasses are placed in the containers directly by hunters using appropriate vehicles and following biosecurity procedures. Hunters inform the local veterinary service that then plans the disposal of the carcasses. Usually, the company that manages the rendering plant or incinerator directly collects carcasses; however, the veterinary service supervises all procedures. The containers have to be robust, lockable and leak-proof. The use of containers is relatively easy and quick to be implemented; containers, when strategically placed, help to prevent the spread of ASFV outside the infected area.

## BURNING ON THE SPOT

Any burning has to minimize environmental pollution and comply with fire safety regulations. Additionally, it might be forbidden in many countries. The burning of carcasses in an outdoor area using combustible materials as a primary fuel source can be done in several ways: pyre burning, pit burning, above-ground incineration (fireboxes or a mobile incineration device) or a combination of these methods.

When constructing a pyre or digging a pit for burning carcasses, it is important to maximize the airflow. The primary fuel sources are combustible materials such as dry wood or coal briquettes having a low or negligible environmental impact. Plastics, tires and other potentially toxic inflammable materials can be used with the approval of the competent authorities (usually the Ministry of Environment). Straw or hay should be used only as a fire starter, due to the smoke they produce; often liquid fuels are required to initiate the burning.

Trained personnel have to be involved and the burning area has to be carefully selected and cleared; activities must be carried out when firefighting tools and related facilities are


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**Photo 15**
*In Latvia, an incinerator was placed in the highly infected area*

available. On-the-spot carcass burning is a slow process; time is required to select and clear the area, transport large quantities of hardwood, complete burning of carcasses and prevent fires.

The complete burning of a wild boar carcass can take up to 68 hours. After the carcass has been burned, ashes should be buried and the potentially contaminated surroundings disinfected.

**Burial** The other method of choice is burial on the spot. The procedure should be agreed with the environmental service and clear instructions on how to bury the carcass should be made available.

**Single pit** This method is used when individual dead wild boars are found. Burial pits should be deep enough to ensure a soil layer of at least one metre above the carcass to prevent scavenging. The bottom of the pit has to be at least one metre over the seasonal maximum groundwater level to avoid contamination. The availability of ground water maps and instructions would help in minimizing risks. Carcass decomposition is faster when plastic bags are removed as plastic bags require years to decompose. The minimum distance between the pit and watercourses, lakes or ponds has to be indicated by the environmental protection service. When in the pit, the carcasses should be disinfected and covered by pressed soil.


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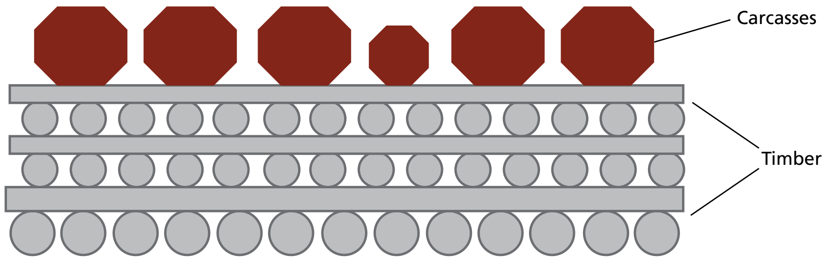
**Photo 16**
*In some highly infected areas, pyres were prepared in advance*

FIGURE 16
**Sketch of the construction of the burning place**




*Source:* Animal Health Australia (2015). Operational manual: Disposal (Version 3.1). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3, National Biosecurity Committee, Canberra, ACT.

**Trench burial on site** is generally used when several carcasses are found in the same locality or when weather conditions prevent the digging of several single pits (i.e. in the winter, when the ground is frozen). An excavator usually digs the trench; carcasses are placed on the bottom of the trench and covered with soil. The high number of carcasses requires a formal environmental authorization. To avoid the re-use of trenches, their location must be registered using geographical coordinates. The number of carcasses disposable in a single trench has no limits; however, the trench has to be dug to the required size and depth, that is, from 1.8 to 2 times the entire volume of the carcasses to be disposed of with at least one metre of soil cover and at the prescribed distance from groundwater. Before covering the trench with soil, carcasses have to be disinfected. Plastic bags are not recommended because of their lengthy decomposition rates.

**Mass burial** applies the same rules set for domestic pigs in commercial farms. Mass burial is appropriate when the local geological characteristics prevent leakage and when transport to the incinerator or rendering plant is not possible. The burial area and the carcasses have to be disinfected with appropriate disinfectants. The abdomen of fresh carcasses has to be opened to limit the side-effects of gas production during putrefaction.

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**Photo 17**
*Carcass burning in a trench*

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**Photo 18**
*Trench burial needs the use of an excavator*

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**Photo 19**
*Plastic containers; note the informative documents about wild boars on the top of the containers*

## INDIRECT CONTAMINATION OF THE HABITAT WITH THE ASFV

In any environment infected with ASF, the virus might be present in several matrices. Infected material, such as faeces, blood, grass and mushrooms, is likely to be mechanically transported outside the infected area thus representing an indirect risk for further spread of the virus. Mushroom or forest berry collectors, as well as forest workers and hunters, are the most at risk to play a role in the indirect spread of the virus.

Previous data on infectivity of faeces have been recently reconsidered (Davies, 2017; Olesen, 2018; EFSA, 2010a). Most recent research demonstrated that only ten percent of the faeces from an infected wild boar contain the virus, while its survival is relatively short at room temperature (higher than 18 °C). According to these data, the probability of stepping on infected faeces and carrying the virus outside infected areas during the summer or early autumn is negligible. However, during the winter months, the risk in northern and eastern European countries might be higher since low temperatures allow longer survival of the virus (that is, weeks or months instead of a few days) and more virus-contaminated faeces may accumulate over the cold period of the year. During winter, wild boars are also more likely to cluster around feeding/baiting points; their daily home ranges are reduced and thus the environment has a higher probability to be locally contaminated with infected faeces. It is known that 50 percent of wild boar faeces are located in a small area (up to 0.4 hectares) surrounding feeding points (Plhal *et al.*, 2014). Hunters often visit feeding or baiting points to refill or check them or to set up cameras to estimate the size of the wild boar population. In such circumstances, the probability of stepping on infected material and transporting the virus outside the infected area is increased and should be avoided and managed.

Non-hunters (visitors or workers of the infected forest or infected area) should be informed about the possibility of being contaminated by the virus during exploitation of the infected forest or area, whereas backyard pig owners exploiting the area should be

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**Photo 20**
*Wild boars in containers*

informed about the risk of mechanical transmission of the virus in the framework of pig biosecurity. Information in the form of posters or signs in front of the entrance to the infected area with bullet points about the mitigation of the risk of ASF would be very useful.

An easy and, probably, already largely applied measure is the use of different clothes and boots while visiting an infected or at-risk area that should be changed before leaving the area. Boots should be placed in a robust plastic bag to avoid any contamination of cars while driving home and then brushed and washed with soap and hot water until the soles are clean. Hunters should be aware that a number of activities carried out in the infected area are at risk to mechanically transport the ASFV outside the habitat. Some precautionary measures should be applied: avoid use of a private car for transportation of feeding stuffs directly to the spot. Also, carefully disinfect boots and any possible contaminated materials on return to the hunting lodge or to the dressing facilities.

## KEY MESSAGES

1. Countries at risk should develop a clear strategy for carcass finding (passive surveillance) and disposal before the introduction of the virus.
2. Competent authorities have to facilitate the reporting of carcasses, raise awareness and organize effective communication channels.
3. In infected areas rendering is an easy and effective method to dispose of carcasses; containers could help in the temporary storage of carcasses; carcasses are sampled at the rendering plant by an official/authorized veterinarian.
4. Other disposal methods include incineration, burning and burial.
5. The human exploitation of forest resources poses a risk for the mechanical transport of the virus outside the infected forest; very simple and basic biosecurity measures can minimize this risk.

# Chapter 5
# Biosecurity during hunting

**Marius Masiulis and Vittorio Guberti**

*Large numbers of wild boars are hunted in infected forests each year. Without biosecurity measures they represent an important risk of spreading infection as a source of the virus. During hunting, the virus can contaminate cars, boots or objects and then the virus can be mechanically transported outside the infected forests. This chapter describes the main strategies and the logistic organization that – implemented at hunting ground level – can minimize the risk of spread of the virus when hunting in infected forests.*

## ASF DETECTION IN FREE AREAS

Hunting is usually regulated by environmental or forestry services; veterinary services are rarely involved unless transmissible animal diseases are detected in the wild animal populations. Several diseases affecting both the wildlife and livestock, such as ASF, are regulated by veterinary legislative acts. The role of the veterinary service is primarily related to ensuring that all the appropriate procedures to confirm or rule out the presence of the disease are followed. Veterinary services are also in charge of providing information to pig owners and hunters, conducting epidemiological investigations in the case of suspicions (wild boars showing abnormal behaviour or found dead), including laboratory testing.

When ASF is confirmed in wild boars, the control of the virus is attempted through specific management of the infected wild boar population. In addition, EU countries have to develop an eradication plan that includes the establishment of biosecurity measures to be enforced during hunting. It is recommended that countries (independent of the presence of ASF) develop and implement basic hunting biosecurity measures. The development



**Photo 21**
*Hunting lodge with a separate dressing and storage room (right)*

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**Photo 22**
*In ASF-infected areas and areas at risk, hunted wild boars should be safely transported to avoid further spread of the virus*

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**Photo 23**
*Blood drops contain a very large amount of the virus*

of a proper biosecurity approach during hunting needs time and resources and might be difficult to organize in an emergency situation.

Close communication with hunters is important. Although the hunting of wild boars could represent a useful ASF management tool, hunting infected wild boars poses the threat of further spreading of the virus. Hundreds of infected wild boars were hunted in recent years in eastern and northern Europe. In such an epidemiological landscape, hunters act as a link between the wild infected habitat and the anthropogenic one, increasing the risk of disease outbreaks in domestic pigs.

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**Photo 24**
*In field conditions it is often difficult to limit the viral contamination of objects, tools etc.*

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**Photo 25**
*Will the fox follow the same procedures applied for ASF in wild boars?*
*Or will it be skinned at home despite the fact that the fur is contaminated with wild boar blood?*

## MANAGEMENT PLAN FOR WILD BOAR HUNTING

Each hunting ground (irrespective of its size) should develop its own basic and simple biosecurity plan.

The biosecurity plan should consider the road network, location of the hunting towers, feeding/baiting points, availability of hunting lodges and related animal dressing facilities and storage of offal (containers or animal waste pits).

Hunters in the infected area should address the following points (Bellini *et al.*, 2016):

- training on ASF preventive measures;
- wild boar transportation from the hunting spot to the dressing facility;
- dressing room/area requirements and equipment;
- proper disposal of offal;
- safe onsite storage of hunted wild boars until tested ASF-negative;
- procedures for the disposal of ASFV-positive wild boars;
- procedures for cleansing and disinfecting facilities.

## THE HUNTING GROUND BIOSECURITY PLAN MINIMIZES THE PROBABILITY THAT THE VIRUS WILL SPREAD OUTSIDE THE INFECTED AREA THROUGH HUNTING ACTIVITIES

In ASF-infected and at-risk areas it is not known if an individual hunted wild boar is ASF-positive or not; hence, all the hunted wild boars have to be managed as possibly infected, which means that a complete set of feasible and sustainable biosecurity measures has to be applied during any phase of hunting.

## WILD BOAR TRANSPORT FROM THE HUNTING SPOT TO THE DRESSING FACILITY

Any part of the wild boar should remain in the hunting ground. It should be strictly forbidden to open the abdomen and to leave the inner organs on the hunting spot. The entire body of the hunted wild boar should be safely transported to the dressing area or facilities. Safe transport will prevent the flow of liquids (in particular blood) that might contain ASFV. Plastic or metal tanks are recommended whereas plastic bags are often damaged by vegetation.

Dedicated vehicles should transport hunted wild boars from the spot to the dressing area. The vehicles should never leave the infected hunting ground or infected area.

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**Photo 26**
*A normal pickup can transport wild boars minimizing the risk of further spread of the virus*

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**Photo 27**
*Non-fenced open-air dressing area; note the disposal pit*

Whenever the dedicated vehicles are not available, trailers or inexpensive external animal transport devices can be used. The means of transport, which were used for collection of hunted wild boars, must be easily cleaned and disinfected following each hunt.

The use of private cars for transport of wild boars inside the infected hunting ground should be forbidden since they might be contaminated and thus indirectly spread the ASFV over great distances. It is recommended that private cars are to be parked outside the area where the dressing procedures are performed, and preferably on a paved road.

## REQUIREMENTS AND EQUIPMENT FOR THE DRESSING AREA/FACILITIES

In each hunting ground, at least one dressing area or dressing facility, authorized by the competent veterinary authority, has to be equipped. The dressing area can be open-air or a closed facility. It must be dedicated exclusively to animal dressing. The dressing area must be easily recognizable and only those in charge of dressing the animal should use it.

**An open-air dressing area should be:**

1. set in an area with permanent dry soil, having a roof protecting it from rain, snow and sun; and organized in such a way so as to prevent contamination of the surrounding areas with infected blood, fluids etc.;

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**Photo 28**
*Basic fenced open-air dressing area; note the disposal pit*

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**Photo 29**
*Fenced disposal pit*

2. fenced with lockable gates to prevent the entry of wild boars, scavengers and unauthorized persons;
3. provided with water;
4. provided with a disposal pit or container for offal and waste;

Another type of dressing area can be a **closed dressing facility**, which hunters usually equip in a part of the hunting lodge or close to it.

**A closed dressing area should:**

1. prevent access of domestic and wild animals;
2. have walls and floors that can be easily cleaned and disinfected;
3. have an area for the cleaning and disinfection of the dressing tools and equipment;
4. have a container for the storage of animal by-products before their disposal;
5. have disinfection barriers (mats) at the entrance, filled with disinfectant;

**Persons in charge of dressing should:**

1. wear disposable or washable and easy to be disinfected clothes and boots;
2. use tools exclusively dedicated for dressing, and should clean and disinfect them after use and not bring them outside the hunting ground;
3. wash and disinfect each tool, apron and footwear used in the dressing area before exiting the fenced area;
4. place all the disposables in plastic bags and dispose of them;
5. use only authorized disinfectants.

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**Photo 30**
*Closed, well-equipped dressing room*

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**Photo 31**
*Closed dressing room with storage facilities*

## PROPER DISPOSAL OF OFFAL

The offal of wild boars infected by ASF is the source of the ASFV and, if not handled under biosecurity, it can be a source of virus spread.

All leftovers have to be removed from the forest; the easiest way is to bury them in a designated pit that has to be approved by the environment protection authority or the veterinary service. The pit should be close to the dressing area and directly excavated in the ground with consideration of the ground water level. Its size has to be able to contain the expected number of offal per hunting season and must be deep enough to prevent access of wild animals (including wild boars) to offal. The pit area should be fenced and have a lockable gate. This method of offal disposal is practical wherever digging is possible.

When completely full, a pit can be closed and a new one excavated. Alternatively, and where allowed, its contents are removed under the supervision of the veterinary service and safely disposed of.

A valid alternative to pits is the use of containers. Usually plastic containers (500 to 600 litres in size), sealed and leak proof, are placed close to dressing areas and then emptied when needed following the instruction provided by the veterinary service.

Re-used pits or containers are of evident advantage when rendering plants accept animal waste and offal.

## SAFE ONSITE STORAGE OF HUNTED WILD BOARS UNTIL TESTED ASF-NEGATIVE

In the ASF-infected areas all the hunted wild boars cannot leave the hunting ground without being tested ASF-negative. The ASF test has to be carried out by official veterinary laboratories. The results obtained by commercial kits available on the market in some countries are completely unreliable and their use is inappropriate for the eradication of the infection.

Each hunting ground should be equipped with refrigerators in which, after dressing and sampling, the entire wild boar is stored and individually identified. While not recommended, if the carcass is divided into several pieces, each piece has to be clearly identified and the number of pieces obtained from a single wild boar has to be registered.

No part of the animal (including trophy) can leave the hunting ground before the hunted wild boar is tested ASF-negative.



**Photo 32**
*Wild boars individually marked (blue mark on the chest) waiting for laboratory results*



**Photo 33**
*Storage of wild boar pieces; tracing individual wild boars is more complex*


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**Photo 34**
*In Poland, transportable storage rooms were provided by the veterinary service; wild boars can be dressed outside the room and offal collected in containers while stored animals will wait until laboratory results are communicated*

It is important to organize storage and sample activities in order to avoid the release of animals that have tested ASF-negative while other individuals are still stored waiting for test results. Animals should be stored as batches and released only when each entire batch tests ASF-negative. The procedure is easy to manage when hunting is carried out exclusively during weekends; otherwise, the different timings (hunting, sampling, testing and releasing ASF-negative animals) have to be carefully planned.

Cold storage facilities or refrigerators for keeping carcasses of hunted wild boars can be installed in closed dressing facilities or in a hunting lodge. Cold storage facilities or refrigerators should be cleaned after the removal of hunted wild boar carcasses or meat.

## PROCEDURES FOR THE DISPOSAL OF ASFV-POSITIVE WILD BOAR AND FOR CLEANING AND DISINFECTING FACILITIES

In the case of a positive result for ASF, all the stored carcasses (or pieces of meat) have to be safely disposed of by the veterinary service. The dressing area, cold storage facilities or refrigerator also have to be cleaned and disinfected. The inactivation of the virus in the dressing area, in refrigerators and from clothes, vehicles, tools, is based on cleaning and disinfection; hence, hunters should be trained and provided with written instructions.

It is important to point out that preliminary cleansing is needed before the use of any disinfectants. Mechanical brushing with a detergent solution is highly effective in cleaning contaminated surfaces and objects and is important to achieve an effective disinfection. Only freshly prepared disinfectant solutions should be used and for the required time necessary to be effective (that is, up to 60 minutes contact time).

Disinfectants recommended for African swine fever virus

The following list of disinfectants are recommended (see Haas *et al.* 1995; Heckert *et al.* 1997; Shirai *et al.*, 1997, 2000):

- chlorine (sodium hypochlorite);
- iodine (potassium tetraglicine triiodide);
- quaternary ammonium compound (didecyldimethylammonium chloride);
- vapor-phase hydrogen peroxide (VPHP);
- aldehydes (formaldehyde);

TABLE 1
**Registered commercial disinfectants**

| Product name | Active components | Use |
|---|---|---|
| Virkon S® | Sodium chloride;<br>Potassium peroxymonosulfate. | ASFV in animal feeding/watering equipment, livestock barns, pens, stalls, stables, equipment, hog farrowing pen premises, hog barns/houses/parlors/pens, animal quarters, animal transport vehicles, agricultural premises and equipment, and human footwear. |
| Ecocid® S | Triple salt of potassium monopersulphate;<br>Sulphamic acid;<br>Malic acid;<br>Sodium hexametaphosphate;<br>Sodium dodecyl benzene;<br>sulphonate. | Surface and water system disinfectant;<br>Any type of animal housing;<br>Greenhouses and veterinary surgeries. |
| Virocid® | Alkyl dimethyl benzyl ammonium chloride;<br>Didecyl dimethyl ammonium chloride;<br>Glutaraldehyde. | Wide application range for the daily disinfection of:<br>Animal houses and material;<br>Animal transport and materials;<br>Storage and processing rooms for feed and food;<br>Food transport;<br>Boots and wheels via dipping baths. |

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**Photo 35**
*In some infected hunting grounds, hunters are always equipped with disinfectants*

- organic acids;
- oxidizing acids (peracetic acid);
- alkalis (calcium hydroxide and sodium hydroxide);
- ether and chloroform.

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**Photo 36**
*Disinfection of an open-air dressing area*

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**Photo 37**
*Disinfection of a storage facility*


**Photo 38**
*Disinfection of boots*

## KEY MESSAGES

1. In the infected areas, each hunting ground has to develop a simple, basic, biosecurity management plan. The main goal is to prevent the viral contamination of the environment and the mechanical transport of the virus outside the hunting ground through hunting and related activities.
2. Each hunting ground has to organize a wild boar dressing area, offal and wild boar storage facilities.
3. Hunted wild boars are individually identified and safely stored in the hunting ground until tested ASF-negative.
4. If a hunted wild boar tests ASF-positive, all the stored animals, whatever the species, are disposed of under the veterinary service control.
5. Hunting will be re-authorised when cleansing and disinfection of the infected hunting ground facilities are completed.

# Chapter 6
# Data collection

**Vittorio Guberti, Sergei Khomenko and Marius Masiulis**

*The quality and standardization of the data accompanying samples is relevant since it makes a better understanding of the epidemiology of ASF in wild boar populations possible; high quality data allow appropriate comparisons to be made among areas and countries, as well as assessment of the efficiency of the applied control measures. This chapter describes the main data to be collected and how to harmonize them when obtained from different sources.*

## WILD BOAR DATA ACCOMPANYING SAMPLES

The aim of data collection is to improve our understanding of animal diseases and the capacity to control and eradicate them. Data collection and analyses are an essential part of any animal disease surveillance program and thus a tool to measure the efficacy of control/eradication strategies and – eventually – a way to highlight weak points.

In such a framework a standardized data collection protocol would benefit any analyses and decision. Standardized data would also allow us to understand better how the infected population behave with respect to ASF presence, and the management strategy to manage the disease.

Standardized data collection might be an added workload for both hunters and veterinary services; however, unstandardized methods reduce data reliability and prevent comparability among infected countries.

A possible sample collection form that includes the essential data to be collected follows. In addition to the essential data, it is important to include the latitude and longitude of the spot where the animal has been shot or found dead. Geographic data are relevant when studying the spatio-temporal evolution of the infection. Latitude and longitude are easy to register using a basic smartphone; in affected hunting grounds, hunting towers could be georeferenced and thus used as a proxy for the spot of interest. Specialized mobile applications can be a very helpful solution facilitating the reporting process by hunters whenever it comes to collection of samples from hunter-harvested animals or carcass findings.

## STANDARDIZED AGE CLASSES

At present, wild boar carcasses or hunted wild boars are aged using several methods that are highly affected by observer judgment and the individual variability of wild boars. Estimating the age of a wild boar by its weight or colour increases the unreliability of the reporting system as such methods are not objective or standardized.

Teeth eruption is the most robust age estimator in any wild boar population. The main aim is to distinguish the age class and not the specific age of an individual. Due to high hunting pressure, the average life span of a wild boar belonging to a hunted population is very low. In hunted wild boar populations the average life expectancy is about two years.

A typical population of hunted, wild boars is composed of 50 percent animals that are younger than two years and 50 percent of those who are older than two years, but rarely older than four years. Due to the negligible number of "old" animals it is not relevant to determine their age using more complex methods, such as cementum annuli[1] counts. According to the simplest application of the tooth eruption method, four age classes can be defined:

a) no definitive molars are present;
b) one definitive molar is present;
c) two definitive molars are present;
d) three definitive molars are present.

Definitive molars are easily counted in any field condition and animal; the approach does not need any technical tool and gives standardized age classes that are easily comparable in the same population, among different populations, and in different years and seasons.

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**Photo 39**
*One definitive molar (second molars have not yet completely erupted)*

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**Photo 40**
*Two definitive molars*

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**Photo 41**
*Three definitive molars*

[1] The cementum annuli (CA) aging technique is based on the annual addition of cementum, a specialized calcified substance deposited on the roots of teeth in many mammals. Layers of cementum produce "rings" similar to those in trees.

## FECUNDITY

Fecundity could be defined as the percentage of pregnant females in a specific population. Fecundity data should be collected according to the age class category of the females in order to follow the reproductive performances of the infected population. Increased hunting could enhance the early recruitment of young females (< 1 year old) in the reproductive population, thus limiting the efficiency of this population management strategy. The suggested ASF control measures include the selective hunting of adult females where it is possible to collect fecundity data. While dressing animals, the uterus can be opened and the presence of a foetus can be observed. Pregnancy is easier to be seen at the end of the winter when the delivery season is approaching and foetuses are visible.

## FERTILITY

Fertility can be defined as the average number of foetuses or piglets for fecund females. Counting the number of foetuses in any pregnant shot female is extremely simple and can be easily done during dressing. During wild boar observation, the sight of each saw and the number of accompanying piglets (striped only) should be recorded and made available as raw data, at the end of the main hunting season.

Age-related fecundity and fertility data give an indication of the actual reproductive capacity of the involved wild boar population and thus predict its future trends. This data will also indicate shifts in the first age of reproduction or an increase in the average fertility offering a better understanding of the resilience to ASF. Ultimately, this data will be used to assess the effectiveness of the wild boar population management strategy that is in place.

## STANDARDIZED DATING OF CARCASSES (RATE OF CARCASS DECOMPOSITION)

The role of carcasses in the epidemiology of ASF in wild boars has been previously highlighted. Currently, the date of carcass finding is set as the date of the infection despite the fact that carcasses could be very old. This method can lead to imprecision in the dating of the infection and wrong epidemiological assessment of the situation. Temperature, humidity, sunlight and the presence of scavengers (both invertebrate and vertebrate) can accelerate or reduce the time of carcass decomposition. However, if the decomposition status of animals is recorded in a standardized way and is coupled with the date of finding it would be possible to avoid significant discrepancies in the dating of the infection, especially in infected areas and when carcass search is a planned and organized rather than an opportunistic activity. A simple designation of three decomposition categories could be included in the data collection form when a carcass is found (see Table 2).

A standardized approach toward dating of carcasses should be included in the training of hunters in ASF-infected areas/hunting grounds. However, it has to be highlighted that a defined procedure to reliably date wild boar carcasses has not yet been developed. An obstacle to this is the seasonal variability in the rate and character of the decomposition processes itself. In summer, biological decay of carcasses is rather quick, facilitated also by scavenging insects and their larvae. In winter, vertebrate scavengers, whose species composition and activity may also vary from place to place and time to time, mainly destroy carcasses. As a result, carcasses with very different ages can have the same aspect (stage)

TABLE 2
**CHARACTERISTICS OF WILD BOAR CARCASSES AT VARIOUS STAGES OF DECOMPOSITION**

| Stage | Characteristics |
|---|---|
| 1) Fresh | No odour, fresh |
| 2) Decomposed | Bloated abdomen, presence of maggots, odour from moderate to strong;<br>liquefaction of tissue until black putrefaction;<br>removal of the flesh from bones |
| 3) Dry | Little or no odour, dried skin, exposed bones |


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**Photo 42**
*Decomposed carcass*


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**Photo 43**
*Decomposed carcass*


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**Photo 44**
*Dry carcass*


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**Photo 45**
*Dry carcass (note the presence of scavenger insects)*

when found. In complicated cases, exclusively specific analyses (i.e. entomological forensic approach) could help to precisely determine age. In general, in areas persistently endemic for ASF carcasses, the process of dating can be strongly compromised. Therefore, doubtful carcasses (particularly common early in spring) should be identified as "uncertain date" to enable their exclusion from the analyses in future.

FIGURE 17
**Example of template for wild boar data collection**

WILD BOAR N. __________

MUNICIPALITY ____________________________________________

LOCALITY ____________________________________________

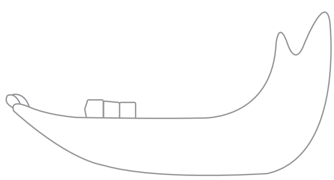
HUNTING GROUND ____________________________________________

PERSON COLLECTING SAMPLES: ____________________________________________

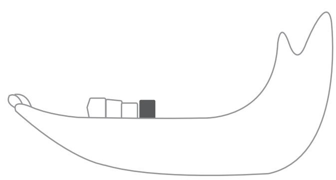
LATITUDE AND LONGITUDE ____________________________________________

DATE: ____________________________________________

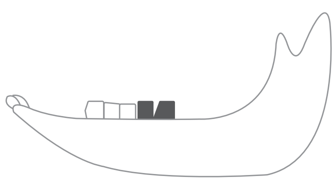
| | **Wild boar data** | | **Gender** | | **Sampled organs** |
|---|---|---|---|---|---|
| N. laboratory ________ | Wild boar data | ☐ | Male | ☐ | |
| | Single hunt from tower | ☐ | | | |
| | Single hunt by searching | ☐ | | | |
| | Found dead | ☐ | Female | ☐ | |
| | Shot healthy | ☐ | Pregnant | ☐ | |
| N. hunted wild boar ________ | Shot abnormal behavior | ☐ | N. fetus ________ | | |
| | Decomposition stage | | 1) | | |
| | | | 2) | | |
| | | | 3) | | |
| | | | 4) | | |
| | | | 5) | | |



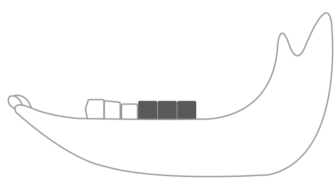
No definitive molar = age class A



1 definitive molar = age class B



2 definitive molars = age class C



3 definitive molars = age class D

## KEY MESSAGES

1. Each hunted wild boar or carcass found dead has to be individually sampled and accompanied by a specific set of data.
2. The age of the animal has to be determined by teeth eruption only.
3. Pregnancy and the number of foetuses have to be carefully recorded; the data will allow for a better understanding of the evolution of the wild boar population dynamic in affected areas.
4. The decomposition stage of carcasses has to be identified in order to help in approximating the date of death of the infected individual.

Chapter 7

# Effective communications between veterinary services and hunters

**Suzanne Kerba**

*Given that ASF is a highly contagious infectious disease with no cure and no vaccination options, effective risk communications and educational initiatives are critical tools in preventing its spread (Costard et al., 2015). This chapter considers these tools.*

The aim of data collection is to improve our understanding of animal diseases and the capacity to control and eradicate them. Data collection and analyses are an essential part of any animal disease surveillance program and thus a tool to measure the efficacy of control/eradication strategies and – eventually – a way to highlight weak points.

In such a framework a standardized data collection protocol would benefit any analyses and decision. Standardized data would also allow us to understand better how the infected population behave with respect to ASF presence, and the management strategy to manage the disease.

Standardized data collection might be an added workload for both hunters and veterinary services; however, unstandardized methods reduce data reliability and prevent comparability among infected countries.

A possible sample collection form that includes the essential data to be collected is offered below. In addition to the essential data, it is important to include the latitude and longitude of the spot where the animal has been shot or found dead. Geographic data are relevant when studying the spatio-temporal evolution of the infection. Latitude and longitude are easy to register using a basic smartphone; in affected hunting grounds, hunting towers could be georeferenced and thus used as a proxy for the spot of interest. Specialized mobile applications can be a very helpful solution facilitating the reporting process by hunters whenever it comes to collection of samples from hunter-harvested animals or carcass findings. So how can veterinary services effectively communicate with hunters about ASF? Responsible hunting and disposal practices will ensure that boar populations continue to thrive and serve as a source of sport and food in the years to come. These same practices support a healthy environment for agriculture and domestic pig farming (De Nardi *et al.*, 2017). Engaging hunters is critical as we work toward the eradication of ASF disease.

It is critical to identify your goals in communicating with hunters. Establishing a Single Overarching Communications Outcome (SOCO) provides a roadmap for sharing technical information and guidance (OIE, 2015). This roadmap represents the actions you want to see implemented by your target population as a result of your communication. To establish your SOCO, you need to answer three main questions:

**1. Why do veterinary services want to stop the spread of ASF?**

- *ASF represents a serious threat to pig farmers worldwide.*
- *There are no treatments or vaccines for ASF.*
- *The disease can cause massive economic losses.*
- *The disease has been spreading in eastern Europe and the EU.*

**2. What is the change veterinary services want to see as a result?**

- *An increased awareness of the dangers of ASF among farmers, hunters, transporters and the general public;*
- *An increase in surveillance and reporting among farmers and hunters;*
- *An increase in practices of ASF prevention;*
- *No more introduction of ASF into countries and regions free of disease.*

**3. Why communicate now?**

- *There has been notification of an outbreak in the country.*
- *There has been notification of an outbreak in the neighbouring country or in the region.*

Based on this example, your SOCO could be: **Hunters take appropriate actions to monitor, prevent and control a potential ASF outbreak.**

Risk communication is the real-time exchange of information, advice and opinion between experts or officials and people who face a threat (from a hazard) to their survival, health, economic or social well-being (Stoto *et al.*, 2017). In the context of ASF, the role of veterinary services in risk communications is to provide information, listen to hunters, and to communicate in ways that recognize and respect the important role that hunters play in ASF prevention and eradication.

Communicating for behavioural change requires knowledge of what motivates our target audiences (Ueland, 2018). Thus, knowing what hunters believe is critical to understanding how best to communicate with them about ASF and their role in stopping the spread of disease. Using formative research in the design and planning of communications helps us understand our audiences and what motivates them (Snyder, 2007). This information will help you to tailor adequate messages and choose relevant channels of communication and education to ensure a successful risk communication.

What do we know about boar hunters? Research shows that they perceive the following issues as barriers to reporting the discovery of illness in boars (Vergne, 2014):

- lack of awareness of the possibility of reporting;
- lack of knowledge about how to report;
- lack of a level of agreement that a reason for them to report a hunted wild boar is because it shows suspicious lesions or disease;
- perception that the act of reporting is troublesome.

## BUILDING STRONG COMMUNICATIONS MESSAGES TO HUNTERS

Based on previously described insights, veterinary services will draft adequate messages to be delivered to hunters.

For example, these messages could be:

- *You are important and valued partners in efforts to eradicate ASF.*
- *Your use of responsible hunting, reporting and disposal practices has a direct impact on the success of efforts to prevent the spread of ASF disease.*

It is then necessary to **adapt** these messages to hunters in such a way as to reinforce their value and importance as stakeholders. Potential messages may include:

- *Responsible boar hunting, reporting, and disposal practices reflect the honourable role of hunters as stewards of nature and its resources.*
- *To be a hunter is to belong to a group that is connected to the environment in a unique and integral way.*
- *Success in eradicating ASF requires the active involvement of the hunting community – both individually and as a group.*

Characteristics of a strong risk communications message include these elements:

**Complete and specific**

- *Gives hunters what they need to know to make an informed decision*

**Relevant**

- *Appropriate to the situation; timely*

**Concise**

- *Short and to the point*

**Understandable**

- *Encoded (adapted) in such a way that hunters understand it*

**Memorable**

- *Encoded (adapted) in such a way that hunters remember it*

**Positive**

- *Empathetic and encouraging*
- *Courteous and respectful of hunters' culture, values and beliefs*

To be efficient, messages need also to take into account:

**The context** and environment in which hunters and veterinary services are communicating:

- *Is there an outbreak of ASF disease or an event that may heighten awareness and prompt action?*
- *Do hunters feel any sense of urgency about ASF?*

**Potential interference** getting in the way of ASF messages from veterinary services to hunters:

- *Are rumours or misinformation undermining accurate messages from veterinary services to hunters?*
- *Are veterinarians listening to hunters and being proactive in responding to rumours or misinformation?*

## TWO-WAY COMMUNICATIONS

As scientists and veterinarians, we often act as if knowledge alone is enough to produce results. We deliver evidence and guidelines, and we expect people to understand and follow the information we provide (Brownell *et al.*, 2013). However, what people know and think affects how they act. People's perceptions, motivations and skills all influence their behaviour. To be effective, scientific communications must reflect both facts and values (Dietz, 2013).

As sources of ASF communications with hunters, veterinary services must establish themselves as trustworthy providers of reliable information, respectful of the role of hunters and taking care to actively talk to them in clear, understandable ways.

Characteristics of an effective communicator (WHO, 2015)
**Expertise** – *you are knowledgeable; you know what you are talking about;*
**Good character** – *you are trustworthy – honest and open in your communications;*
**Goodwill** – *you express empathy, and you are respectful of people in your audience, how they feel and what they believe;*
**Identification** – *you communicate with people in a way that makes them identify with you and relate to you.*

Relationships between veterinary services and hunters must support an environment of trust and confidence. Best practices for effective risk communications (Peters *et al.*, 2013) include these elements:

**Create and maintain trust**
- *You care about me.*
- *You know and address my concerns.*
- *You are reliable.*

**Acknowledge and communicate – even in uncertainty**
- *You are not concealing information from me.*

**Coordinate your communications**
- *You agree with other credible experts.*

**Be transparent and accurate with all communications**
- *You are telling me the truth.*
- *You are seeking solutions.*

**Always include messages of self-efficacy**
- *I have an active role in making an informed decision.*

Two-way communication includes the importance of listening to the target audience to better understand them (rumour listening etc), as well as to evaluate the impact of your risk communication effort. For this to be effective, you need to **establish in advance a mapping of your stakeholders and of their influencers,** and to **collect feedback** on how hunters respond to ASF messages and guidance.

- *What are hunters saying to veterinary services in response to their communications about ASF?*
- *Are veterinary services listening to hunters and using their feedback to improve future communications?*
- *Are messages from veterinary services motivating hunters to follow guidance and implement responsible hunting, reporting and disposal practices? If not, why?*

Stakeholder mapping involves identifying key audiences, and determining the priorities, challenges and values important to each of them. The process also involves identifying the most influential stakeholders and working to ensure that their input is used to shape communications efforts. Relationships between stakeholders, and the strength of those relationships, impact the perceptions and behaviours of everyone involved. Two-way communication between appropriate shareholders provides a balance of opinions, increasing the likelihood that hunters and veterinary services reach a common ground in their efforts to stop the spread of ASF.

## CHOOSING COMMUNICATIONS CHANNELS

Once you have crafted your communications messages to hunters, it is time to determine the tactics and channels you will use to reach them. Channels may include:

- *Radio, television, print materials*
- *Word of mouth*
- *Communications with clubs and organizations*
- *Social media*
- *Awareness campaigns*
- *Stakeholder engagement*
- *Partner engagement*
- *Social mobilization*
- *Community engagement*

Not all channels will be appropriate for communications associated with ASF. As you go about putting together a plan for ASF communications aimed at hunters, consider the channels that meet hunters where they are – respecting their language, recognizing their social networks and honouring their cultural values.

The following questions can help you identify risk communications channels that will effectively help to reach hunters:

**1. Will this channel help me reach hunters?**

- *Am I using a channel they respect and/or pay attention to?*

**2. What level of impact does this channel have on hunters?**

- *Do they see value in this channel's position in the community?*

**3. Will using this channel advance my goals?**

- *Prevent the introduction of ASF into countries and zones free of disease*
- *Build awareness of ASF and its risks*
- *Inform on signs and symptoms*
- *Advise on prevention techniques*
- *Outline hygiene regulations and practices*
- *Encourage the adoption of mitigation strategies*
- *Enhance biosecurity*
- *Increase reporting hunters*

## RISK COMMUNICATIONS AND STIGMA

Whenever there is an outbreak of ASF or the discovery of an infected pig or boar, people invariably seek information about the origin of the disease. Where did this outbreak start? Which forests or farms are implicated? These are legitimate concerns, and veterinary services have an obligation to actively listen and to respond promptly and honestly.

As they respond, veterinary services must also consider the possibility that hunters who report infected animals may face stigma, which means they may become needlessly associated with the threat of ASF. People experiencing stigma may face criticism, and they may suffer stress, anxiety and emotional pain from social rejection (Smith, 2007). Fear of stigma may also make farmers hesitant to report disease (Guinat *et al.*, 2016).

People who stigmatize others generally feel that the problem facing someone else is a problem that they themselves can control (Reynolds and Seeger, 2005). For example, a farmer who stigmatizes another farmer whose pigs have contracted ASF may believe that he can control an outbreak himself. Entire regions and communities (including hunters) may be stigmatized if people start identifying them with a perceived risk.

It is the role of veterinary services to balance the real risk of ASF with the needless association of one person or identifiable group with the disease itself. Veterinary services must take an active role in dispelling misconceptions and correcting faulty assumptions. When stigma arises, it is the responsibility of veterinary services to counter it with scientific facts and appeals for fairness. Hunters who face stigma associated with ASF must be able to rely upon veterinary services for proactive support.

This includes using messages such as:

- *"The discovery of illness demonstrates that we are ALL at risk of ASF."*
- *"These circumstances are not defined by any one group in a particular place or area."*
- *"This situation reinforces the importance of using responsible biosecurity and disposal practices. We must all work together to stop the spread of ASF."*

## KEY MESSAGES

1. Successful communications between veterinary services and the boar-hunting community are critical as we work together toward the eradication of ASF disease.
2. Risk communications and community engagement involve hunters in creating effective solutions that support their efforts to use responsible biosecurity and disposal practices. Working together in a coordinated way enhances the likelihood that we are successful in our shared vision of a world free from the threat of ASF.

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Annex

# Experience of controlling localized outbreaks of ASF in wild boar populations in Czechia and Belgium

The control of ASF following the focal introduction in both Zlin District, Czechia and, lately, in Etalle, Belgium was largely based on the epidemiological considerations and principles described in Chapters 1 to 4. The approach was implemented and fine-tuned according to the local epidemiological landscape and was adjusted following evolution of the disease. Experience in Czechia is so far the only successful example of ASF eradication from the wild boar population in Europe, illustrating the complexity of the task. The measures and rationale behind the eradication are briefly described below:

a) **Active search of wild boar carcasses** (passive surveillance) was immediately put in place in order to better understand spatial patterns of infection around the index case. The logic behind this search was that the first detection of ASFV likely represented the tip of an iceberg. It was thought that there had been more carcasses in the area that probably escaped detection (Figure 18);
b) All detections of ASF virus in carcasses were **fine-scale mapped and a buffer area around them was identified** based on: a) average annual home range of a wild boar; or b) the expected speed of the epidemic wave (currently estimated at about 2 to 3 km/month). This area was considered to be infected (Figure 18, zones 0 and 1). The procedure was repeated whenever new positive detections outside the infected area (zones 0 and 1) were reported and zonation updated accordingly. Around parts of the buffer zone and the infected area with ASF detections inside of it, attempts were made to **restrict or minimize movements of wild boar** through erecting a combination of barriers (boar-proof, electric, or odour fences; Figure 18, red line between zones 1 and 2). The rationale behind the erection of these barriers was to slow down the speed of the initial epidemic wave so that the endemic phase would be reached locally, without geographic progression of the disease.
c) In order to avoid disturbance, prevent long distance movements of wild boar and limit virus contamination of hunting tools, vehicles and dressing rooms etc., **all hunting activities were completely banned** in the infected area (Figure 18, zones 0 and 1).
d) **Feeding was strictly prohibited** throughout all zones to minimize contact rates between animals attending feeding sites and to **annihilate any positive demographic effects** on the wild boar population related to supplementary

feeding. Baiting of traps and hunting locations through distribution of limited amounts of food outside of the infected area (zones 2 and 3) was allowed in quantities sufficient to facilitate activities aimed at population reduction.

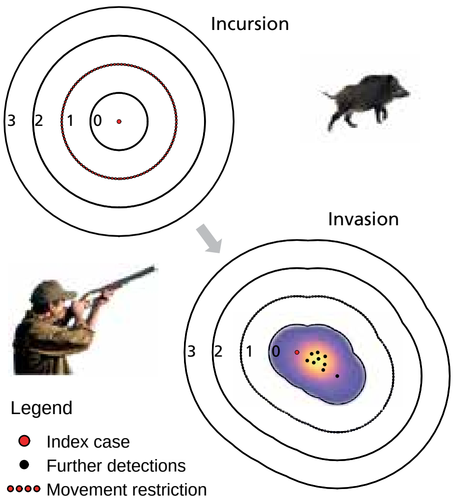
e) In the area adjacent to the infected zone (Figure 18, zone 2), size and exact borders were defined according to the landscape characteristics (i.e. artificial barriers as highways or natural barriers as rivers). Targeted hunting of adult and sub-adult female wild boar was conducted in order **to achieve sustained reduction of population density** decreasing probability of possible virus invasions.

f) Logistics and biosecurity measures were identified and implemented in order to ensure **removal of carcasses** from the infected area (Figure 18, zones 0 and 1). **Hunting or culling of wild boars** in the areas adjacent to it (Figure 18, zone 2) was **done in a safe way to minimize the risk of disease spread** outside of the outbreak area.

g) In the areas free from the infection (Figure 18, zone 3 and beyond), the hunting of wild boars using conventional methods was intensified in order to decrease the probability of invasion and epidemic spread caused from disease escaping the control zones;

FIGURE 18

**Delineation of zones in case of a focal introduction of ASF to wild boar populations**




**DISEASE CONTROL**

| ZONE | PASSIVE SURVEILLANCE | ACTIVE SURVEILLANCE | CARCASS REMOVAL |
|---|---|---|---|
| 0 | *** | - | *** |
| 1 | *** | - | *** |
| 2 | *** | *** | ** |
| 3 | *** | ** | * |

PRIORITY: * low | ** intermediate | *** high

**POPULATION MANAGEMENT**

| ZONE | INTERVENTIONS |
|---|---|
| 0 | No hunting, no feeding |
| 1 | No hunting, no feeding |
| 2 | Targeted hunting + biosecurity |
| 3 | Intensive hunting, no biosecurity |

Please, note that this is a hypothetical example provided to illustrate disease control principles; the exact configuration and size of the zones will be country and epidemiologic situation specific

*Note:* 0 – zone encompassing all findings of ASF-positive carcasses (e.g. 100 percent kernel density contour); 1 – buffer zone set up in an effort to anticipate further epidemic progression of the infection (based on epidemiological evaluation and local landscape; optionally fenced off to restrict movements); 2 – area adjacent to the infected zone where population is reduced as quickly as possible to achieve density below Nt (involved strong biosecurity measures); 3 – zone recognized as free of infection ("business as usual" or as prescribed by the country's control measures and regulations for the areas free of ASF).

h) At the final stages of eradication, and only once the numbers of detected ASF-positive carcasses confirm that the situation has evolved into the endemic phase, all the remaining live animals in zones 0 and 1 should be culled if there is a way to do it safely (Figure 18).

TABLE

**Summary of recommended control measures and associated activities during eradication of a focal incursion of ASF to wild boar. Please note that these measures are not (fully) applicable in the areas where ASF is endemic and its occurrence range is extensive.**

| | Free areas (zone 3 and beyond) | Free area adjacent to the infected area (zone 2) | Infected area (zones 0 and 1) |
|---|---|---|---|
| **Supplementary feeding** | Banned | Banned | Banned |
| **Baiting** | Only for trapping | Only for trapping and culling | Only for trapping and culling |
| **Hunting** <br> **(Activity carried out by hunters; wild boar meat might be consumed)** | Normal hunting <br> Increased hunting bag <br> Target female and sub-adults (qualitative effort) <br> Activities coordinated and facilitated by competent authority (CA) | Increase hunting bag by every efficient hunting methods <br> Public and private partnership to reach the lowest achievable wild boar density <br> Hunters play an essential role in the development of the strategy | Banned |
| **Culling** <br> **(Activity carried out by/under the supervision of CA; culled wild boar are always disposed)** | Up to CA | Up to CA | Allowed to eradicate under the supervision of CA when the endemic phase has been reached (after the epidemic phase) |
| **Biosecurity** | Encouraged by CA | To be applied | To be applied |
| **Public access restriction** | None | CA decision according to the epidemiological situation and specific procedures | Area is restricted <br> Only authorized staff in the area <br> Farmland can have access on the basis of derogation |
| **Trapping** | Activity authorized by CA <br> Testing carcass for personal consumption if negative | Culling and testing by CA <br> Negative carcass for personal consumption | Culling and testing by CA <br> Carcasses safely disposed |
| **Fencing** | | Up to the Country <br> Fences to delimit small areas could facilitate intensive hunting | Defined areas <br> Built in a timely manner to slow down the disease spread and anticipate progression of the epidemic wave |
| **Disposal of wild boar found dead** | CA define procedure | Safe disposal of all carcasses | Safe disposal of all carcasses |
| **Surveillance** | Promote passive surveillance <br> All wild boar found dead sampled and tested <br> Results of tests max 72h from sampling | Promote passive surveillance <br> Active patrolling to find dead wild boar at the border with infected area <br> All dead wild boar tested:results of tests max 72h from sampling | Promote passive surveillance <br> Active patrolling to find dead wild boar and all dead wild boar tested |
| **Testing** | Ag detection | Ag detection | Ag detection + Ab detection |

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African swine fever (ASF) is a devastating haemorrhagic viral disease affecting domestic pigs and wild boars of all ages and sexes. This disease causes major economic losses, threatens food security and trade, and presents a serious challenge to sustained pig production in affected countries. Since the emergence of ASF in Georgia in 2007, the disease has spread to many countries in Europe and in 2018 it was detected in China which has the highest domestic pig inventories. By August 2019, ASF had spread within and beyond China to Mongolia, Viet Nam, Cambodia, Laos and Myanmar. Wherever wild boar populations are affected, the control and eradication of ASF is a challenging task for veterinary authorities given the transboundary and multi-sectoral nature of ASF and the complexity of the wild boar-domestic pig interface. The lack of experience in managing  wild, susceptible populations exacerbates the risk of the endemic persistence of the virus in wild boars, making the eradication process in domestic pig populations more challenging. This publication provides an overview of the epidemiological features and ecology of ASF and offers some recent experiences in the prevention and control of the disease in wild boars in Europe.

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