Standing Group of Experts on African swine fever in Europe
under the GF-TADs umbrella

Handbook on African Swine Fever in wild boar and biosecurity during hunting

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Summary

Introduction

In 2007 African Swine Fever (ASF), was introduced in the Caucasus and since then spread over several countries of Eastern and Northern Europe. The large-scale epidemic went 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 2014-15 it became evident that circulation of this virus in the natural ecosystems developed into a self-sustained epidemiological cycle. By now, the disease already became endemic in wild boar populations in several countries and continues to expand its range in Europe, causing very serious concerns. Controlling this sylvatic epidemic of ASF is a very challenging task for the veterinary authorities, given complexity of disease epidemiology, lack of previous experience, unprecedented geographical scope of the problem, its transboundary and multi-sectoral nature.

This handbook was prepared following recommendations of Standing Group of Experts on African swine fever in the Baltic and Eastern Europe region (hereafter referred as 'SGE ASF ') was set up under the GF-TADs umbrella to build up a closer cooperation among countries affected by African swine fever (ASF) and thereby, address the disease in a more collaborative and harmonised manner across the Baltic and Eastern Europe sub-region. At the Eighth meeting SGE ASF (SGE ASF8) in Chisinau, Moldova, on 20-21 September 2017 it was decided that OIE, FAO and the EU should cooperate in preparing technical, but, at the same time, practically usable, document containing a comendium of information about hunting management, biosecurity and wild boar carcass disposal.

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

In order to reduce risks and prevent negative implications of now widespread presence of ASF in the ecosystems of Northern and Eastern Europe, close and continuous cross-sectoral collaboration is a key. Veterinary authorities, forestry and wildlife management agencies, nature conservation and hunting bodies, organisations, 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 handbook includes a rather broad range of potential readers, whose decisions or actions on national or local scale are concerned with controlling ASF in wild boar and mitigating negative implications of this devastating disease for agriculture, as well as forestry and game management sectors.

Geographical scope of the handbook and most of the information or examples provided are intentionally limited to the countries of Northern and Eastern Europe, which share similar environments, argo-ecological and wildlife management system, as well as experience the same kind of a novel sylvatic transmission cycle of ASF, which emerged a few years ago. As the epidemiological situation in Europe remains to be very dynamic and the knowledge on ASF epidemiology in wild boar is far from being complete, the handbook will require revisions and updates in future in order to reflect new findings, experiences and lessons to learn.

The handbook consists of seven chapters. It starts from description of the epidemiological cycle of ASF in wild boar as it is currently perceived by expert and research community and details on the main risk factors related to circulation of the virus in the ecosystems of the Northern and Eastern Europe. Chapters 2 and 3 briefly reflect on some questions and issues (some of which are rather controversial) that are typically raised and debated in relation to wild boar biology and population management in the context of ASF control. Further 2 chapters (4 and 5) are dedicated to detailed description of practical implementation of the key elements of biosecurity strategy recommended at the level of hunting grounds. Those are based on the experience gained by affected countries the Northern and Eastern Europe under the conditions of ongoing sylvatic epidemic of ASF. The handbook is concluded by two more chapters: one 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; and the last one – on risk communication strategies and approaches, crucially important for effective cross-sectoral collaboration among stakeholders dealing with such a complex problem as spread of ASF in wild boar. Each chapter starts with a short paragraph briefly introducing the contents and is concluded with the major take away points discussed in the main text of the chapter. List of references and suggested further reading are provided for those who want to familiarise themselves with the more in-depth information and peer-reviewed publications on the matters reviewed in each chapter.

Chapter 1. Epidemiology of ASF in wild boar populations

The chapter describes the epidemiology of African swine fever in the wild boar populations living in north Europe. The aim is to focus the most successful determinants of the virus – wild boar ecological system. The evolution of the virus in its journey from Africa to North Europe, its environmental resistance and the effects that an active wild boar management are likely to achieve in the epidemiology of ASF have been described. The final aim is to individuate specific points, which correctly addressed and managed would help in ASF control/eradication.

1. 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 transmission cycle of this virus for unlimited time. It is a well-established natural host-vector-pathogen system, so called "sylvatic transmission cycle of ASF" (Penrith and Voslo, 2009), whose distribution is restricted to parts of the African continent. Warthogs are naturally resistant to the ASF virus and usually do not develop clinical disease. They get infected when piglets and develop life-long immunity .

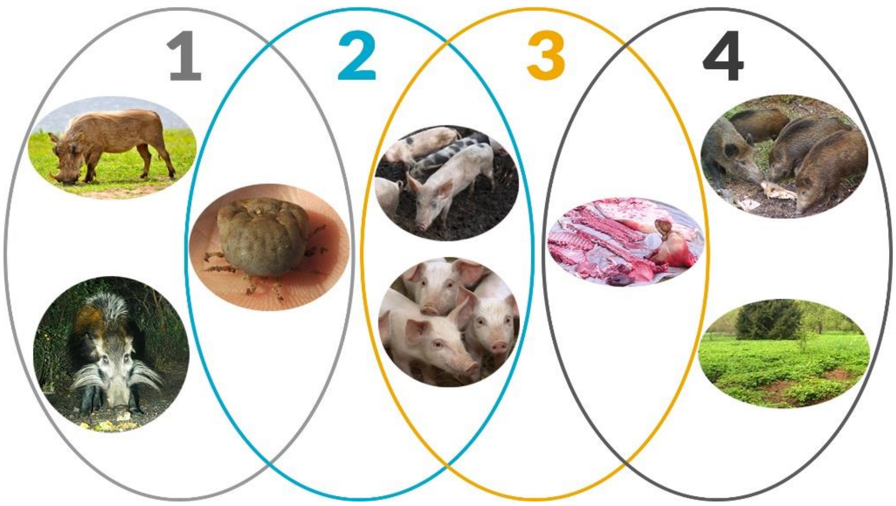


Figure 1.1. From Warthogs to Wild Boar: adaptive modification of ASFV transmission cycles on the way from Africa to Europe. 1) the natural African sylvatic cycle; 2) the anthropogenic cycle involving ticks (Africa and Iberian Peninsula); 3) the pure anthropogenic cycle (W Africa, Eastern Europe and Sardinia); 4) wild boar - habitat cycle (NE Europe, 2014-now) (Source: Chenais et al., 2018)

Already in Africa the virus has shown a trend to shift towards a more anthropogenic cycle (Fig. 1, cycle 2) in which domestic pigs instead of warthogs assumed the role of epidemiological reservoir with occasional involvement of *Ornithodoros* ticks. Such kind of transmission cycle was also reported in the past 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 does not involve ticks or warthogs anymore (Fig. 1.1, cycle 3). The virus spread in domestic pigs is facilitated by human activities. Movements of animals due to trade, sale of infected meat and live animals and free-range pig rising are the main risk factors in this system (Fig. 2). A similar, purely domestic pig cycle, has also evolved in the Caucasus starting from 2007 (EFSA 2010, 2015) when the genotype II virus was first introduced in Georgia and thereafter spread mainly in the domestic pig population northwards from the Caucasian countries to the Russian Federation, Belarus, Ukraine and then to other European countries (Gogin et al., 2013; Fig. 3 and 4).

Figure 1.2: Free ranging domestic pigs in Georgia feeding next to a waste bin, illustrating one of the main mechanisms of disease spread in domestic pigs.

Finally, the most recent step in the evolution of biological cycle of ASFV and its geographical spread is related to formation of the so-called “wild boar - habitat cycle” (Fig. 1.1, cycle 4), which evolved in Northern and Eastern Europe (e.g. since 2014 in the Baltic states, Poland and more recently in the Czech Republic (Khomenko et al., 2013; EFSA, 2017) followed by Hungary and Romania. This novel host-pathogen-environment system emerged and now steadily expands its range in Europe (EFSA, 2017) to a large degree due to the exceptional stability and resilience of ASF virus in the environment and carcasses of animals.This cycle is characterised by continuous presence of the virus in the affected wild boar populations, which represents a real challenge for the pig production sector and wildlife management authorities, as well as hunters. In the last 4 years ASF had become endemic in wild boar over remarkably large areas (Fig. 1.4) and the problem grew up in scale into what is regarded now as the major threat to the European pig production sector (Fig. 1.3).

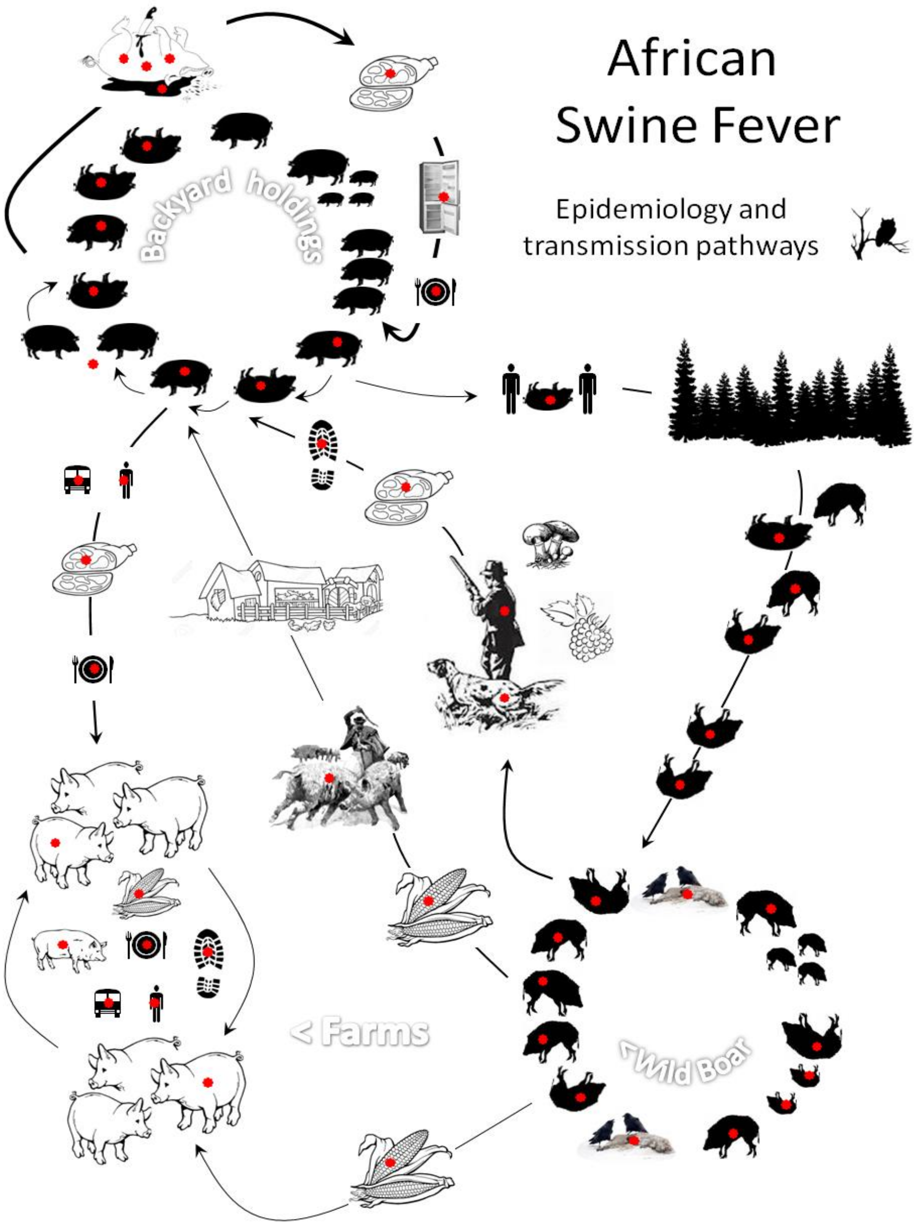


Figure 1.3. Complex of epidemiological factors and transmission pathways involved in sustaining endemicity and geographical expansion of ASFV in Eastern Europe (cycles 3 and 4, Fig. 1.1)

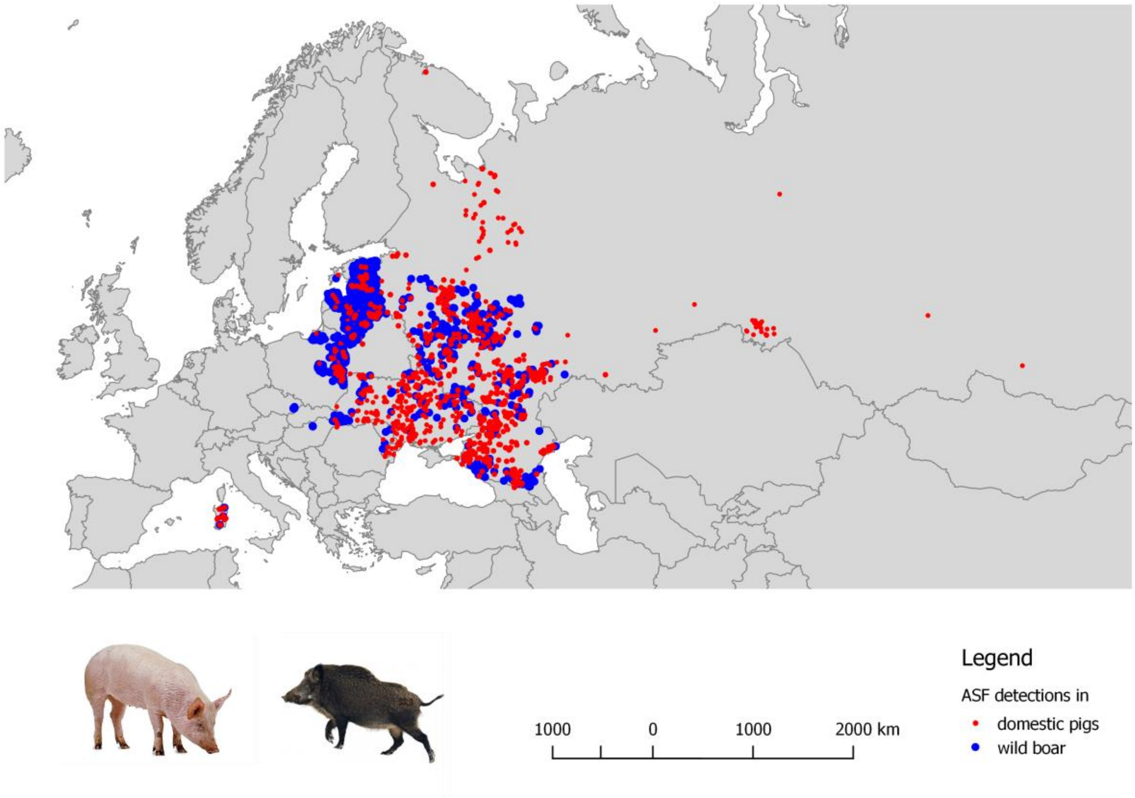


Figure 4. Geographical occurrence of ASF in domestic pigs and wild boar based on official notifications to OIE in 2008-2018 (as of 31.05.2018).

2. Characteristics of the ASF virus circulating in Eurasia

African swine fever is caused by a DNA virus belonging to *Asfarviridae* family. It affects only species belonging to the family Suidae. In Europe those are domestic pigs and wild boar that are the sole susceptible species. They show similar clinical signs and case fatality rates. Although a total of twenty-three genotypes of the virus are known to circulate in Africa, only two of them currently occur in Europe. Genotype II, since 2007 spread extensively in Eastern Europe, while Genotype I is reported in Sardinia, Italy only (Gabriel et al, 2011). The Genotype II virus circulating in Europe has a very high case fatality rate and in almost any infected pig, irrespective of whether they are wild or domestic ones, the disease is fatal. 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 aid.

2.1 Environmental resistance

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

BOX 1: Role of different matrices for secondary spread of ASF

Oral-nasal excretes/secretes. The virus is present in both nasal and oral secretes of infected animals and can be detected even before its appearance in blood and clinical signs; the amount of shed virus is relatively low, however, sufficient to trigger new infections. In the oral-nasal fluids, the virus is shed for a few days (2-4) 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 boar at 2-5 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 long when frozen. The blood contamination of soil, hunting premises and tools including knives, clothes and cars used for transport of infected hunted animals is an important source 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 3 months in the meat and offal. It remains infective for almost one year in dry meat and fat and survives indefinitely long in the frozen meat. Also the meat represents an important source for both the local maintenance and possible further spread of the virus. Frozen meat of positive wild boar can ensure survival of the virus for years and thus represents a possible source for the new epidemics.

Carcasses. As in meat, the virus can survive in the 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 re-start new transmission cycle when the defrosted carcasses are visited next spring by susceptible wild boar. In the natural history of ASF in 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 extended period of time. In such 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 hardly possible.

Offal. The virus survival rates in offal is similar to 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 virus. Particularly in winter, when hunting activities take place, improperly disposed offal has a strong potential to increase risk of secondary infections and spread of the disease.

Faeces and urine. Both excretions are infectious and the half-life of the virus in them is driven by the environmental temperature. The genotype II ASF virus survives longer in the urine compared to 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 8 at 4° C to 5 days at 21°C. Half-life of other genotypes of ASF in faces is longer: ranging from 2 to 4 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, infected faeces and urines increase viral contamination of the habitat and thus contribute to the risk of the possible secondary spread of the virus through indirectly contaminated boots, tyres, hunting tools etc. At the feeding stations, attended by many animals, contamination by infected faeces or urine is likely to increase rates of secondary infections even if all infective carcasses have been safely disposed.

Soil. Viral DNA has been detected in the soil after the removal of the body of infected wild boar; also the soil underneath the colliquated carcass could be virus contaminated even after the whole carcass had disappeared. Survival of virus in these conditions is likely dependant on ambient temperature and soil properties, but more research is needed to understand this kind of risk factors in disease transmission cycle.

Scavenging insects. It has been hypothesized that ASF virus 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 Blu bottle fly (*Calliphora vicina*) were found to be contaminated with the DNA, the infectiousness of virus could not be proved (EFSA, 2010, Forth et al., 2018). It is not known if the virus maintains its infectivity in other scavenging invertebrates. Since wild boar often forage on scavenging insects, their presence could be attractive and increase contact rates between infectious carcass and the susceptible wild boar.

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

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

Food/kitchen waste. Due to high resistance of the virus, thermally untreated food (sausages, salami, ham etc) as well as food leftovers originating from infected animals (both domestic pig and wild boar) 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 boar could contaminate fresh vegetables (i.e. green corn plants damaged by wild boar); the feeding of domestic pigs feed with green vegetables is forbidden in any ASF wild boar infected areas.

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.

Susceptible: a healthy individual that has never been infected by ASF virus and thus is susceptible to it. Such animals normally comprise the largest part of the population. Numbers of susceptible animals changes seasonally because of reproduction and mortality (largely due to hunting, but also predation, starvation and disease may contribute).

Incubating: an 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 2) before showing evident signs of the disease. The number of incubating animals is usually very small (expected <2%) and is dependent on the phase of virus invasion (see further below), season and other factors. The only way to find out if a hunted wild boar is in 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. Usually, wild boar shows clinical signs for 3-5 days before death; 90-95% of the diseased animals die (Pietschmann et al., 2015).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. Proportion of sick animals in the population can be underrepresented in the hunting bag. This happens because behaviour of sick animals may deviate from normal and animals change their daily routines, loose appetite, and shift to inaccessible parts of their territory etc. Only laboratory test can verify if sick wild boar is infected with ASF or any other pathogen and is to be destroyed. Sick animals have higher probability of car collision and probably also more prone to predation. For this reason any wild boar killed in a road accident in ASF affected or at risk areas should be ASF tested.

Seropositive: animals that survived to the disease and developed antibodies against the ASF virus (usually about 0,5-2% of the whole hunting bag). 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 (amount of shed virus, duration of the infectious period etc.). There is no evidence that seropositive animals that survived infection with genotype II ASF virus became effective long term spreader of the virus (Petrov et al., 2018). However, thee virus was found to be viable in the lymph nodes of seropositive animals (EFSA, 2010), hence they have to be considered as virus positive individuals and safely destroyed when occasionally hunted and tested positive.

Dead: majority of wild boar infected with AFS virus die (90-95%) and remain in the environment for some time providing important source of infection to healthy conspecifics. Discovery of carcasses by hunters or other people visiting wild boar habitats is most frequent way of detecting disease in ASF free areas. Any dead wild boar should be removed from the forest and safely destroyed, as well as tested for presence of ASF virus or other pathogens. Although in any wild boar population there is always a proportion of animals that die naturally (Keuling et al., 2013), in case of ASF numbers of carcasses would usually remarkably increase, thus signalling the virus incursion or (more often) an on-going epidemic. In Europe, the apparent frequency of ASF infected carcass detection increases in winter and late spring-early summer, while proportion of infected dead animals (and carcasses) peaks mainly during July-August. This reflects 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 probability of their detection by people.

3. Infection routes and mechanisms involved

1. **Direct horizontal transmission**

   The usual physical contacts among wild boar in the same group and sometimes with individuals from other groups provide 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.

2. **Local indirect transmission through contaminated environment**

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

   a) **Excretions and remnants of infected animals.** The virus excreted with urine and faces contaminates wild boar habitats and during favourable periods (winter, low temperatures) can be transmitted to susceptible animals. Offal abandoned by hunters when dressing infected animals on the hunting spot plays also a relevant role by increasing virus loads in the environment. A susceptible wild boar living in a contaminated habitat has a high probability to come in contact with an infective dose of the virus. In the proximity of wild boar feeding points, the environmental contamination could be of higher importance. In winter, provided with regular supplementary feeding, wild boar tend to reduce their home ranges and move within just some 200-300 meters around the feeding point. This, along with increasing probability to encounter other individuals and thus being infected through direct contact (see: 1. Direct horizontal transmission), also makes indirect transmission of the virus more likely.

b) **Infected carcasses.** the indirect transmission via infected carcasses of wild boar (or domestic pig) is considered to play a pivotal role in the epidemiology of ASF (see results of a first study into the topic in Box 2). Infectious carcasses have capacity to maintain live virus in the habitat for a much longer period of time compared to excretions and offal (months), especially during winter, thus making wild boar population density and contact rates irrelevant for long-term maintenance of ASF transmission cycle. They can also be attractive to other animals, particularly in summer, after carcasses pass through the first stages of decomposition and provide good conditions for development of rich communities of invertebrate insects.

3. **Long-distance indirect transmission involving humans**. Contaminated meat and other sub-products (skins, sculls, tusks or other trophies etc) can be transported by people over large distances. Irrespective of whether the virus originates from domestic pigs or wild boar this mechanisms provides the means (most often unintended and 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 boar. There were many occasions, including those in Europe, when indirect long-distance spread of the virus initiated new isolated clusters of infection in wild boar (as well as in domestic pigs), some of which have developed now into long-lasting outbreaks (see Fig. 1.4). The most recent examples of the role indirect long-distance transmission can play in the geographical expansion of the disease are the localised epidemics of ASF in Czech Republic (Zlin district), in Poland (Warsaw) and recent virus incursion to Heves County in Hungary.

Box 2. Role of wild boar carcasses in ASF epidemiology (extract from Probst et al, 2017)

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 4ºC for over a year in blood, several months in boned meat and years in frozen carcasses(Sanchez-Vizcaino, Martinez-Lopez et al. 2009, Health 2015). ASF-infected wild boar usually dies from the infection. Their carcasses become thus exposed to scavengers, including ASF-susceptible wild boar. The decomposition process may vary substantially depending on a variety of factors including the weight of the dead animal, season and weather conditions. Especially in winter, it may take several months until the carcass, including large bones, is skeletonized and fully decomposed.

However, little was known about the behaviour of wild boar towards their dead fellows, particularly regarding the question if wild boar feed on wild boar carcasses. So far no published studies in the wild explicitly focused on interaction patterns, the frequency and intensity of contacts, potential cannibalism and the conditions that may trigger these phenomena among wild boar 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 boar 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 nine study sites in northeast Germany were monitored under field conditions by photo-trapping during 13 months (from October 2015 until October 2016). Depending on the temperature and the size of the carcass, it took between 4 days (young female in summer) and three months (adult male in winter) until 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; thereof 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 contacts consisted in sniffing and poking on the carcass (without leaving any signs of cannibalism, e.g. bite marks), chewing on bare ribs and in rooting on the soft soil that had formed after decomposition of several carcasses on the same spot. In general wild boar regardless of their age were more interested in this particular soil surrounding and underneath the carcasses than in the carcasses themselves. Especially young animals displayed obvious signs of excitement (e.g. bristling neck hairs). In winter, wild boars were exclusively observed in the dark and 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 for intra-species scavenging (cannibalism). However, it must be assumed that all above mentioned types of contacts may represent a risk of ASFV transmission.

The high resistance of ASFV and the relatively long time, remnants of dead wild boar may remain in the environment, are likely to contribute substantially to the contamination of the habitat and to the presence of infectious ASFV 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 in the environment need to be developed. Hunters should be appropriately trained and involved in ASF contingency measures.

4. 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 is the spread of the virus, the sooner it leads a relatively rapid decline of the wild boar population. If such affected population is at the same time hunted for sanitary or recreational purposes, the reduction of wild boar numbers might become evident even quicker. As a result of decreasing population, the number of interspecific contacts also declines and the epidemic turns into an endemic phase (Figure 1.6). Often, at hunting ground level, a fade out of the virus is apparent but its re-appearance within months thereafter is a common occurrence. Re-appearance 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, again by direct contact, into the yet unaffected, neighbouring wild boar groups.

Therefore, epidemiological cycle of ASF in wild boar is characterised by a combination of local, endemic persistence with a simultaneous steady geographical spread 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 1-2 km/months resulting in 12-25 km expansion of the endemic zone in a year (EFSA, 2017) although differences among infected areas are observed and are probably determined by different local wild boar densities, timing of incursion, type 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, whereas following the wild boar population declines, the indirect mode of transmission – through infectious carcasses and/or contaminated habitat – becomes increasingly more important for local maintenance of infection. Intensification of direct transmission might also occur episodically following the reproductive season when the host population size almost doubles and newborn individuals (2-6 months) explore the habitat increasing interspecific contacts, as well as when regrouping or aggregation (e.g. at the maize fields and alike) of herds takes place.

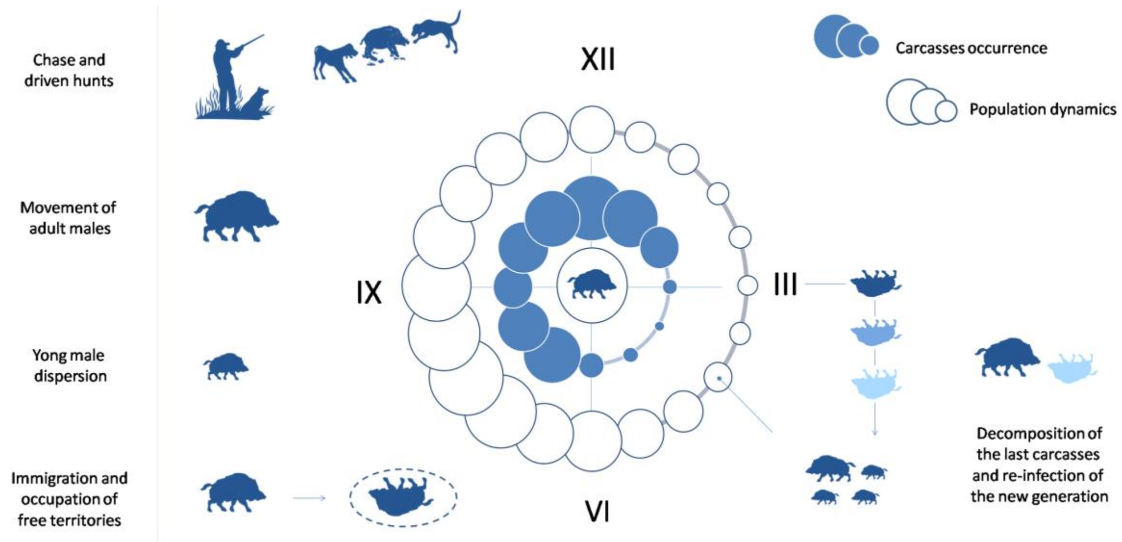


Figure 1.5: Endemic transmission cycle of ASF in a large continuous wild boar population and main natural mechanisms and factors facilitating sustained year-round circulation and progressive geographical spread

ASF dynamics in wild boar has been also characterised by occasional episodes of long-distance spread of the virus beyond normal movement range of wild boar (see 3. Transmission routes and mechanisms). Despite some very occasional long-distance movements (i.e. approximately 100 km in 6 months time: Jerina et al, 2014), wild boar is generally a sedentary species (Podgórski et al., 2013) with stable group home ranges rarely exceeding 50 square km. Possible longer range movements during which an infectious (incubating + disease phases) animal might spread the virus (e.g. young males during dispersion period or adult males in pursuit of females in heat) would last only a few days (5-7). During one week's time wild boar (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 additionally complicated by other factors, including role of hunting activities (driven hunts, attendance of feeding location by humans, disposal of contaminated offal, involvement of fomites) in increased spread of the virus; presence of locally infected domestic pigs (live free-range or carcasses illegally disposed in the environment) in contact with wild boars etc.

5. ASF dynamics and wild boar population density

Understanding the relationship between ASF virus 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 recognised: introduction (or incursion), invasion, epidemic and endemic persistence (Figure 1.6).

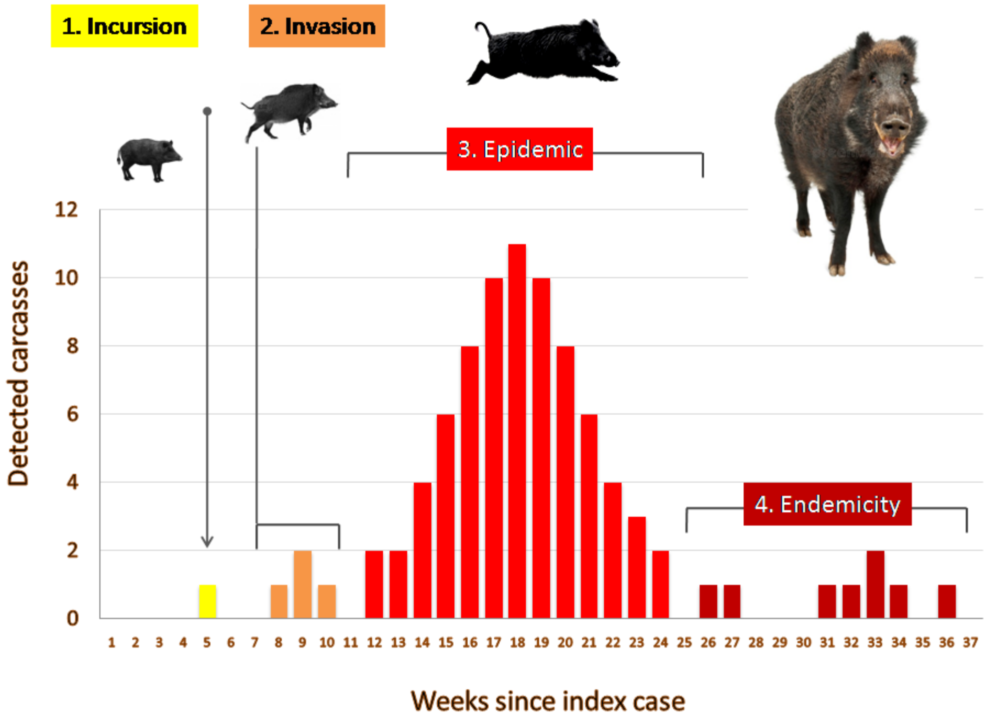


Figure 1.6. Hypothetical example of the 4 phases of the infection dynamic in a population of wild boar illustrated through the number of weekly-detected number of carcasses.

Incursion phase: 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 (e.g. human mediated) release of the virus with contaminated materials. The probability of an incursion occurrence is totally independent from the local wild boar population size and density.

Invasion phase: 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. Intuitively, any virus will spread when a large number of susceptible hosts will be available. Vice versa, in the absence of any susceptible hosts, the virus will go extinct; so the numbers and the density of available hosts will determine the outcome of the invasion (Fig. 1.7).

For infections whose dynamic is density dependent it is possible to estimate the minimum number of susceptible animals needed to trigger a successful invasion. Such 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 Nt value is mainly determined by the virus characteristics. Its practical use is restricted to the initial spread of an infection (the invasion phase) and not to epidemic or endemic situations. (Deredec and Courtchamp, 2003; Lloyd Smith et al., 2005).

Among other methods of disease control one might try to bring host population density to the level when disease incursion would not be able to develop into an invasion, and thus prevent further epidemic. The Nt can be reached through depopulation (direct elimination of all the animal categories: susceptible, infected, immune) or through vaccination (thus reducing only the number of susceptible individuals by immunizing them). In case of the latter the host population size / density will remain unaffected, while the former involves such a change. In case of ASF only reduction of the population size / density is applicable, since no vaccine against the disease is available.

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 (e.g. direct contacts plus carcasses mediated infections) co-occur. This makes any mathematical estimation of Nt almost impossible or highly imprecise. Another limiting factor in calculating realistic value of Nt is the lack of reliable estimates of the wild boar population sizes for the 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 (see Chapter 2).

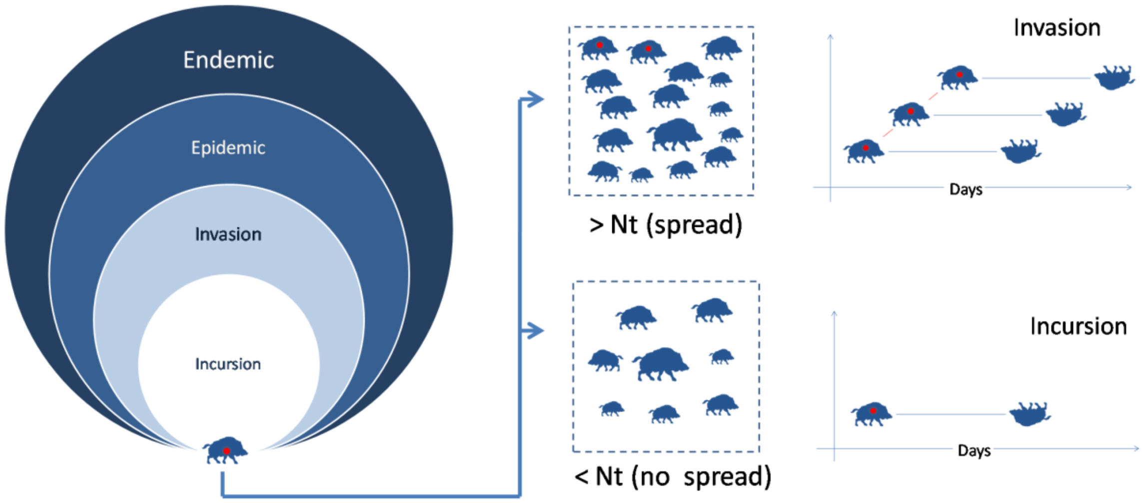


Figure 1.7: Four possible phases of ASF infection and two different outcomes of an incursion in the population with density <Nt and >Nt (Burnet and White, 1972?)

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 boar.

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 typical epidemic curve, which slope and wideness 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 wider at the lower host density. The number of contacts between infectious and susceptible animals drives the shape of the epidemic curves (Figure 1.8, right 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 boar is hunting, it is therefore possible to modify the natural course of the infection by simply reducing the numbers and eventually contact rate between susceptible and infectious wild boar. 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 through reproduction or immigration plays a crucial role and should be accounted for. Failure to keep numbers below Nt may again result in 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 equates the rate at which the virus spreads. During the epidemic phase, the probability of having a successful chain of ASF cases is shared by each infectious individuals (I) according to $p=(1/R_0)^{It}$ (Lloyd-Smith et al., 2005); during the epidemic phase, the probability to eradicate the infectionis "quasi zero" due to the high number of infectious individuals. Moreover, since depopulation activities are not selective towards infectious animals (i.e. not all infected animals are shot and removed from the hunting ground), they will die and, as infected carcasses, will further contribute in maintaining 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 – at the last – facilitate infection persistence (Swinton et al., 2002; Choisy and Rohani, 2006).

Moreover only a small percentage of carcasses (<10%) is normally found and safely destroyed in most kinds of wild boar habitats (EFSA, 2015) thus the virus is detected rather late, already during the epidemic period following a successful invasion. In practice, what is perceived as the invasion phase (e.g. 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.

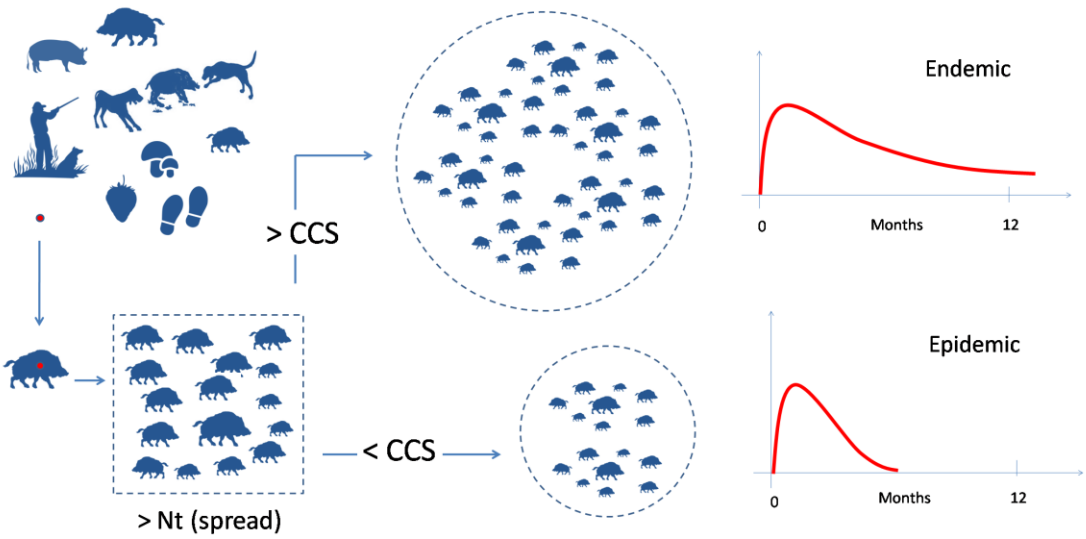


Figure 1.8: Incursion of ASF into wild boar population with densities above Nt (infection spreads) and implications of critical community size for evolution of epidemiological situation. In small fragmented communities infection (<CCS) dies out naturally, while in large un-fragmented populations (>CCS) it persists and becomes endemic.

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 "critical community size" (CCS). The CCS is defined as the minimum population size (rather than density!) with which a pathogen has 50% probability to fade out spontaneously (Bailey, 1975).

The value of the CCS is variable for different pathogens and host species. In case of ASF it is mainly determined by the wild boar biology and in particular by the main demographic characteristics of its population. Smaller CCSs would sustain epidemic when the host population has a high turnover, short life span, and high reproductive rates (which is the case of wild boar). 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 ASF virus and the wild boar population reach equilibrium. Breaking this equilibrium through some management interventions could be a potential way to make such population unsuitable for sustained virus transmission and thus finally eradicate ASF. However, multiple factors such the real size of the wild boar population, continuity of its distribution, population turnover, fertility and thus the recruitment rate – all of those play their respective roles in the endemic persistence of the infection. Up to now, 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 aiming at reducing population density of animals is highly likely fail to eradicate the disease. At the 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 ASF virus. 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 on the large spatial scales (i.e. considering already very large areas affected; see Fig. 4). Various quantitative data are needed in order to evaluate feasibility of such efforts. Those are currently lacking, which makes it impossible to implement practical disease control measures in a strategic way, and with required level of accuracy and efficiency.

- *ASF virus survives in the wild boar population inhabiting North East Europe without any help from domestic pigs or ticks*
- *ASF virus is highly resistant in any matrix and low temperatures increase its survival;*
- *The infection spreads through both direct and indirect contacts. Carcasses of infected wild boar maintain the live virus for long time especially during winter allowing indirect transmission when in contact with susceptible wild boar;*
- *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 the persistence of the virus even if the infected wild boar population is managed at extreme low density. No wild boars but still the virus.*
- *The imprecise estimates of the wild boar population size and density together with the lack of knowledge of the main epidemiological parameters of transmission cycle prevent*

any estimate of a possible density threshold of infection fade out and critical size of wild boar community required to modulate disease dynamics; however any depopulation approach should consider that:

1. *The introduction phase can be avoided only by interventions and preventing measures implemented at the source population and never in the receiving one;*
2. *A successful invasion can be prevented or minimized by managing a wild boar population at the lowest possible density, but only before introduction took place;*
3. *During the epidemic phase, chances are low (if any) to eradicate disease simply due to the high number of infectious wild boar present; whereas the risk to promote further geographical spread of the virus is high;*
4. *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 and under strict biosecurity measures;*
5. *A continuous passive surveillance is the main tool for understanding the evolution of the disease (i.e. phase identification, geographical spread etc.).*

Chapter 2. Some aspects of wild boar biology and demography relevant to control of ASF

Wild boar is a native ungulate of Eurasia which has recovered its historical occurrence range in Eastern Europe and increased in numbers throughout European continent. Although trends in its 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 boar are getting increasingly involved in transmission of livestock diseases, of which ASF is probably the most concerning one. The chapter briefly reviews selected aspects of biology and demography of this species relevant to control of ASF and explains why and how some of the widespread in the Northern and Eastern Europe game management approaches (particularly supplementary feeding) affect wild boar population dynamics and contribute to its growing numbers and epidemiological significance.

Why wild boar distribution changes?

Wild boar it is native species of the majority of natural zones on the continent, which was 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, 1981; Fadeev, 1982), but in the last centuries human influence has been affecting it most significantly. In the Eastern Europe, most recent contraction of wild boar range had occurred in the 30s (Danilkin, 2002). In the following decades, the species has recovered its former historical distribution and in some areas in the Russian Federation expanded beyond known fossil records (Fig. 2.1).

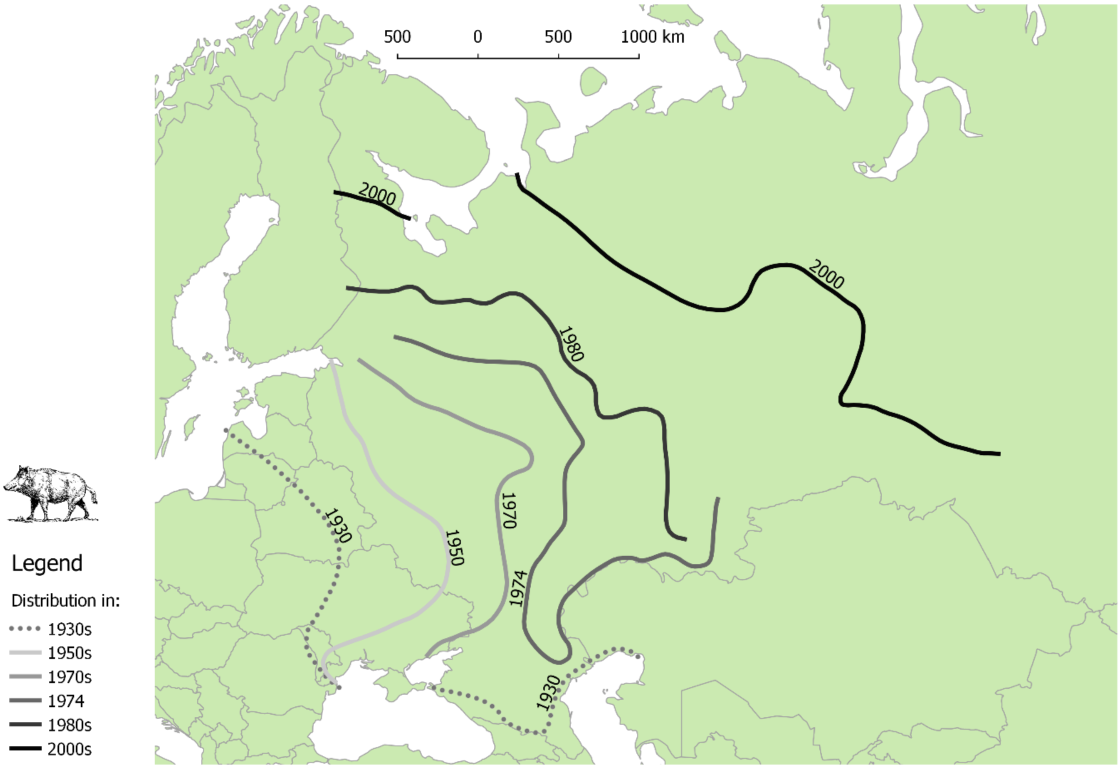


Figure 2.1. Changes in wild boar distribution range in the ex-USSR following latest population contraction episode in the beginning of the XX century (re-drawn after: Danilkin, 2002).

Several factors cumulatively contributed to successful comeback of wild boar. Massive development 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 re-introduction 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 boar against classical swine fever, decrease of poaching, and moderated hunting pressure, as well as general decline of rural populations occurring towards the final decades of the last millennium, also contributed to growing numbers of wild boar. Further geographical expansion and increase of wild boar population throughout Europe were additionally facilitated by milder winters (Fig.2.5), prompting their better survival and reproduction. While 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 boar successfully re-established itself all over Northern and Eastern Europe.Their numbers continue increasing (Massei et al., 2015) and are in some areas already regarded as excessive (Fig. 2.2).

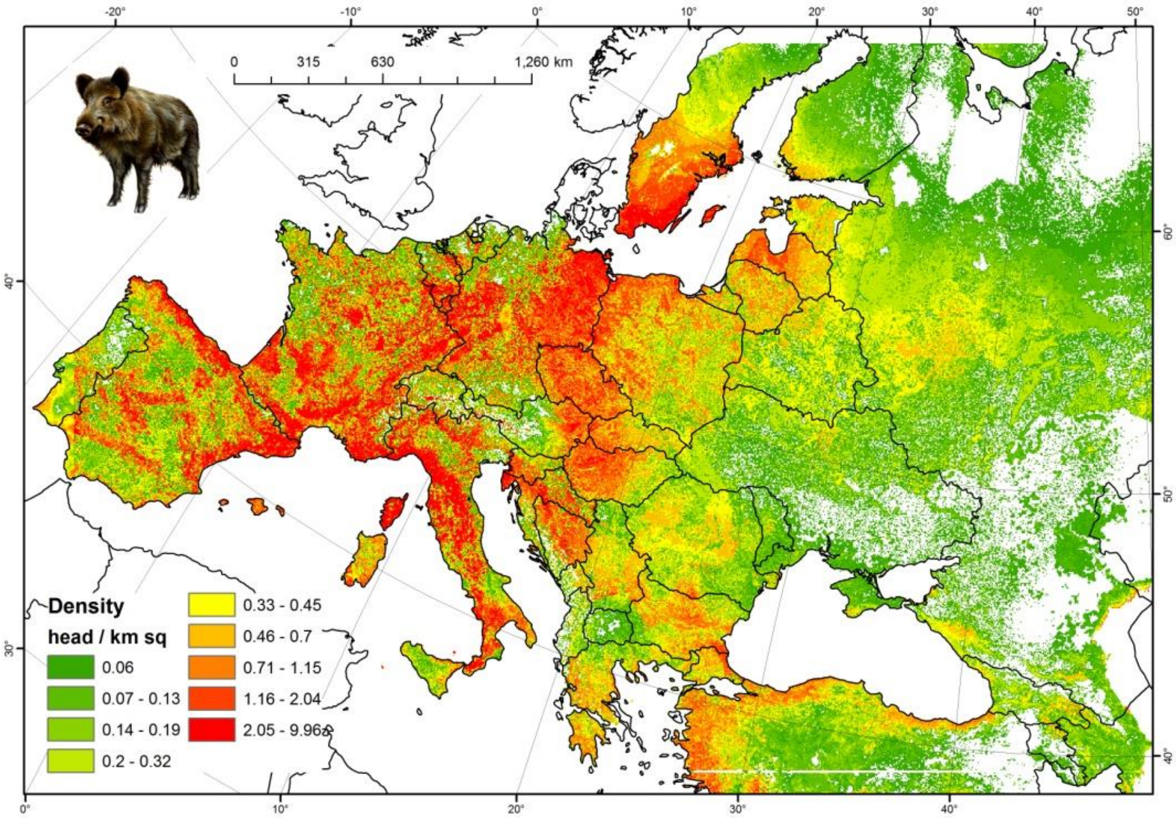
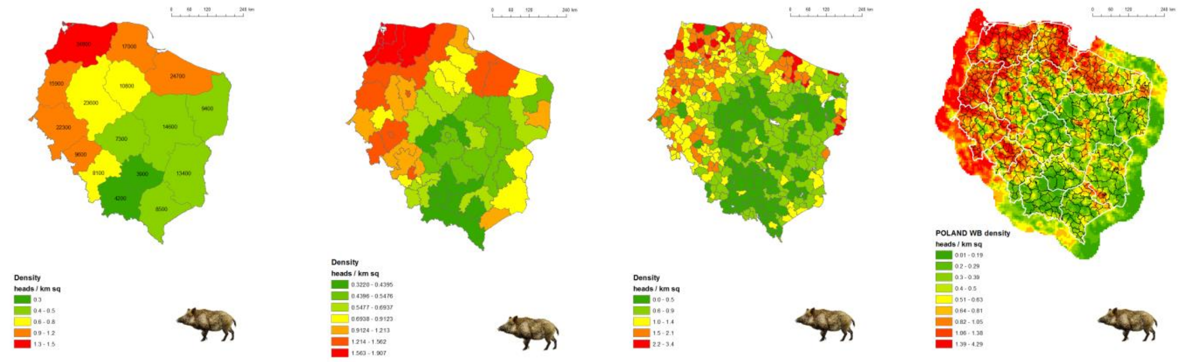


Figure 2.2. Modelled wild boar population density map based on official hunting statistic and population estimates for the period 2000-2010 (Source: FAO/ASFORCE, 2015; Pittiglio, Khomenko, Alcrudo, 2018)

Can we measure wild boar numbers reliably?

One of the problems with sustainable management of wild boar is the difficulty in assessing population sizes of this species. Even if official statistical hunting data is available for most countries, their reliability is often questionable. Scientists and practitioners have developed many different methods of measuring relative abundance of wild boar under conditions of particular natural zone or habitats, but there is no standardized reproducible approach that could give comparable resultson 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 2-3 times repeated closed transect surveys are often used. This can be supplemented or not with counts at the feeding locations, driven counts (especially in the snow free areas), camera-traps etc. In other countries, only hunting bag statistics is available 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 game keepers who are not always well coordinated and adequately trained to carry out such surveys using standardized methods.



Voivodeships (n=11) | Eurostat regions (n=66) | Forestry districts (n=429) | Predicted density

Figure 2.3. Different ways to visualise population density of wild boar in Poland. Such maps might be very misleading if inappropriate scale and resolution of data are chosen to inform population control interventions (Source: Polish Statistic Office, EFSA & Polish Govt, FAO/ASFORCE, 2015)

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 not very helpful for informing decisions or management interventions on the local scale (Fig. 2.3). 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 as the smallest census and management units. Sufficient granularity of population data is 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 order to improve their monitoring methods and obtain more objective, reliable, and comparable population estimates.

How many wild boar are "too many"?

Ecological capacity of habitats varies widely across European continent dependent on environmental conditions. It is also complicated by high level of habitat transformation, seasonal availability of crops, climate and weather change patterns and hunting management practices in place. 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 boar (Fig. 2.2 & 2.4). Availability of water is another factor in wild boar is another factor limiting its abundance in the more arid climates (Danilkin, 2002). However, long-term climatic and land cover characteristics can explain approximately 50 % of variance in wild boar population abundance (Fig. 2.4), while the rest is mainly related to *in situ* factors, such as population management, food availability and variability of climatic conditions (Pittiglio, Khomenko, Alcrudo, 2018).

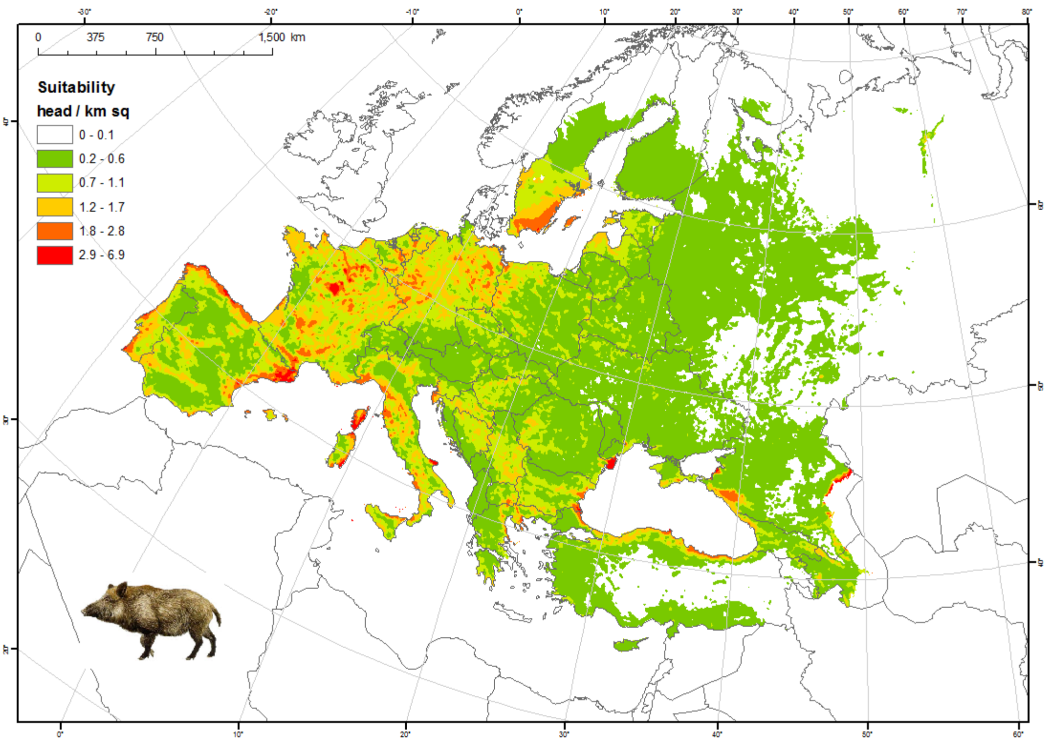


Figure 2.4. Predicted map of wild boar abundance (in head per km^2, long-term average before reproduction season), as anticipated by statistical analysis of most important long-term climatic and land cover characteristics (Source: FAO/ASFORCE, 2015; Pittiglio, Khomenko, Alcrudo, 2018)

Due to extensive distribution and high ecological plasticity of wild boar, there is no standard or average density that could be universally recommended as "optimal" across Europe. Wild boar has 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 normally remarkably fluctuate between years dependent on weather conditions, habitat productivity, hunting pressure, predation, diseases etc. (Bieber & Ruf, 2005, Fig. 2.6). Sharp between-year variations in animal density are particularly characteristic for "northern" or more continental populations, stronger limited by climatic factors. Analysis of the role of climatic and land cover variables on relative abundance of wild boar in Europe showed that they generally account for about 50 % of its spatial variation (Pittiglio, Khomenko, Alcrudo, 2018). When projected, the found correlations predict some parts of Europe to be particularly suitable for the species, while others can support much lower numbers of animals (Fig 2.4). Abundance of wild boar is a fluctuating parameter and local variations within a range of some 60 % of their average pre-reproduction numbers are common occurrence dependant on weather conditions in winter, supplementary feeding, disease and hunting pressure (see, for example, Fig. 2.6). For example, under the conditions of stable climate and without artificial feeding an average long-term population density of 1.0 head per 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 boar demonstrate positive long-term population trends (Massei et al, 2015).

Why do wild boar populations increase everywhere in Europe?

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

Although mortality levels in juvenile wild boar are also high, they apparently do not compensate for the grown up productivity. Wild boar has 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 diseases (e.g. CSF or tuberculosis, EFSA, 2017), fertility and survival of wild boar 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, 2015).

A number of recent studies suggest that increase of wild boar population 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 (Fig. 2.5), its rate was highest in the colder climates (Vetter et al, 2015). In other words, Eastern European populations of wild boar were more responsive to favourable changes in winter weather and grew up quicker. Whenever this is due to better adaptation of "northern" wild boar to the cold or is related to widespread practice of providing supplementary feeding remains to be investigated. But it is very likely that winter feeding of animals in colder climates contributes a lot to better survival and reproduction of wild boar and should be implicated in the increase too.

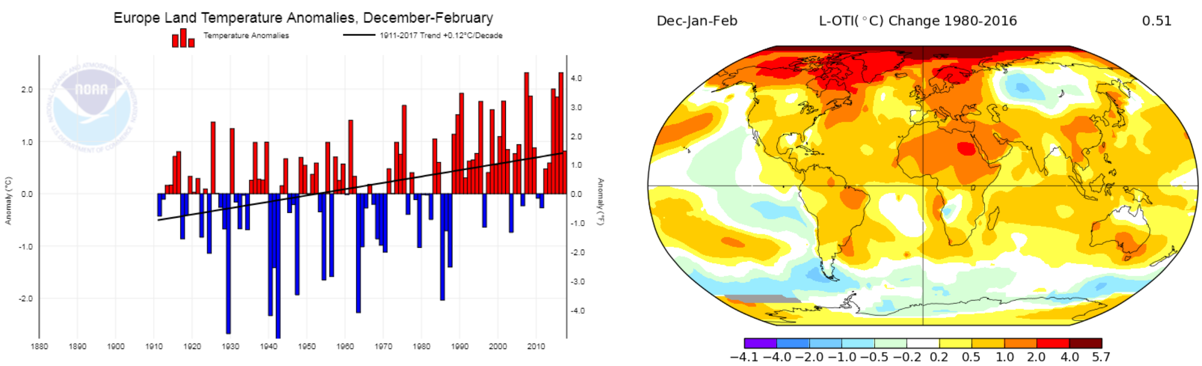


Figure 2.5. Winter temperature anomalies in Europe from 1910 to 2017 (left side) and global map of average winter temperature change (right side) (Source: NOAA)

How supplementary feeding affects populations of wild boar?

Supplementary feeding in general means that additional food is provided for wild animals in their natural habitat. For wild boar this is usually done for a number of reasons: such as keeping animals away from crops, attracting them to particular location 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 amounts it is currently practiced in many European countries is excessive (particularly in the view of on-going decrease in the severity of winters) and significantly contributes to increase of wild boar population.

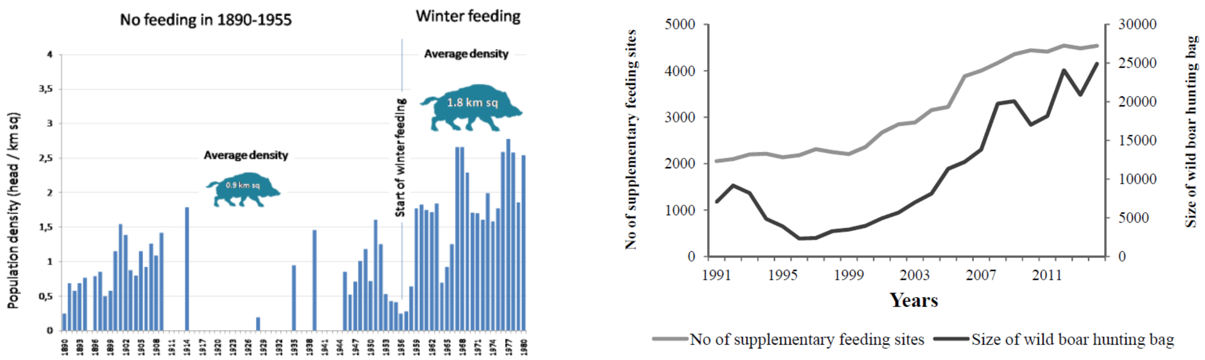


Figure 2.6. Long-term population density estimates in Belovezhskaya Pushcha in Belarus in 1890-1980 (left side, based on data from Danilkin, 2002) and correlation between wild boar hunting bag and number of supplementary feeding sites in Estonia (from: Oja, 2014, 2015)

The impact is strongest in Eastern Europe, where provision of winter food has been traditionally long promoted as a key game management approach. Long-term observations such as, for example, those conducted in Belovezhskaya Pushcha in Belarus in 1890-1980 (e.g. before recent climate warming could have had positive effect on population dynamics), illustrate well that provision of food in winter was capable of doubling average population density (Fig. 2.6).

Supplementary feeding has been shown to seriously interfere with conservation of other species and habitats, including protected nature reserves, national parks. It is quite commonin many countries that regular provision of food to wild boar develops essentially into commercial game farming aiming at increasing revenues at the expense of unlimited population growth potential of this species. Supplementary feeding can be provided on a year-round basis (Fig. 2.7 & 2.8) and sometimes may consist not only of cereals or root vegetables, but also of expired or unsold foodstuff from the shops, etc. Some hunting grounds practice growing crops (potato, maize) with the purpose of feeding wild boar and keeping them from raiding commercial fields and residential gardens.

Figure 2.7: A winter feeding location for wild boar in Romania (Photo: VG)

How supplementary feeding interferes with control of ASF?

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

Figure 2.8. A feeding point designed to provide supplementary food to piglets in summer (Photo: VG)

Average individual fertility of females in such population may double and average proportion of young animals significantly grows up. Such elevated population surplus due to favourable environmental conditions would be likely to happen naturally only once in 3-4 years, but in the populations receiving regular supplementary feeding animals enjoy "good years" all the time (Groot Bruinderink et al., 1992). On the other hand, artificial feeding reduces or totally removes natural regulatory effect of limited food availability in winter, which is when most of natural mortality of wild boar should normally occur. Maintenance of this practice over years leads to increase of population density beyond carrying capacity of the natural environment, and drives emigration of animals to the neighbouring areas, which is often counter balanced by provision of even more supplementary food.

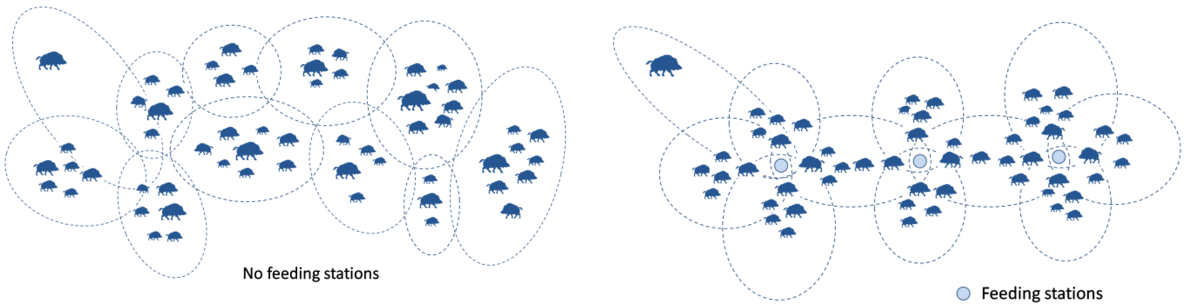


Figure 2.9. Schematic representation of changes in territorial behaviour of wild boar related to attendance of supplementary feeding station

Wild boars are very well known to take advantage of seasonally abound 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, some animals or groups visit more than one feeding station, sometimes even during one day. Both direct contacts among groups feeding at the same time, or indirect interactions because of attending feeding sites group after group happen (Fig. 2.9). 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 practice of supplementary feeding results in increased risk of contamination of feeding locations with endogenous parasites (Hoja 2014; 2015). Historically, in Eastern Europe most devastating outbreaks of CSF in wild boar were associated with local overabundance of animals and increased interaction rates both of which often resulted from supplementary feeding or under natural condition during mast years (Danilkin, 2002). Current understanding of epidemiology of ASF suggests that inflated and clustered populations of wild boar 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 easier (Sorensen et al., 2014). Moreover, once introduced, the disease has better chances of developing into 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 boar and swine industry are not the only reasons, which urge for improvements in the way this species is managed by hunting community in the regions having excessive populations of this species. Growing numbers wild boars are increasingly regarded as a problem to 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 boar constitutes an important economic resource for many landowners and hunting organizers, and is an important game for many hunters.

Emergence and spread of ASF in 2007-2017 has provided an extra justification to consider wiser and more sustainable management solutions for the wild boar problem. 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 quite clear at the moment 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 complicate operation of 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 aiming towards reducing or stabilizing wild boar numbers, which involve 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 needs to be also recognized that the problem of ASF also brought the losses that affect the hunters, as well as the local companies that produce different products of the wild boar shot in the local area.

Therefore, it is reasonable to address issues in a broader perspective including also exploring various ways in order compensate the hunters for the losses that arise.

- *Recent expansion of wild boar and re-occupation of its historical range in Europe is a result of multiple factors acting synergistically (climate, agriculture, management, protection).*
- *Efforts are needed to standardise 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.*
- *Large between-year variations in numbers of wild boar are a normal feature of their demography as a species adapted to pulsing resources and harsh climates.*
- *Some parts of Europe have better climatic and environmental conditions for wild boar (which generally follows gradient of winter temperatures) and can sustain large population densities of this species.*
- *Climate change and excessive supplementary feeding are two major factors that are likely to account for local overabundance of wild boar.*
- *Practice of supplementary feeding under climatic conditions becoming increasingly more favourable for survival and reproduction of wild boar should be reconsidered and abandoned where species population increased too much.*
- *Wiser game management and better population control can contribute to reducing risks related to spread of ASF by wild boar, for which understanding of 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 ASF

The problem of controlling wild boar numbers should not be mixed with the complex of issues surrounding circulation of ASF virus and control of its spread in this species in Europe. Reduction of wild boar population is just a part of a wider complex of measures needed to minimise 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 already applied and tested in the infected countries, while others are currently considered and hotly debated by stakeholders. Non-lethal methods aiming at restriction of animal movements (fencing, distraction with odours), impacting on wild boar demography and survival, as well as lethal approaches aiming at more or less intensive removal of animals from the population are briefly described specifically in the context and in the light of ASF presence in the populations with indications of their pros/contras and limitations.

Can wild boar eradication be a solution?

In the light of expanding epidemic of ASF in Europe voices are increasingly raised in favour of extermination of wild boar as a pest or an invasive species (as in the US, Australia and other areas outside of its native range in Eurasia). In some of the affected European countries this question has already provoked hot debates in media, among game management professionals, hunters and veterinarians. This not surprising considering that in the Northern and Eastern Europe wild boar is a highly appreciated game species, whose extermination is quite reasonably opposed by hunting community, which is seen to be responsible for management of game species and often formally requested to carry out depopulation or extermination campaigns by the veterinary authorities.

Past experience shows that extermination of wild boar was feasible only on islands and as a well organised, 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; (c) re-invasion of this species can be effectively avoided; (d) monitoring of eradication success can be ensured (Fig. 17). In Northern and Eastern Europe fulfilling these four basic requirements definitively cannot be achieved, and even less so in the Western Europe.

In the biological sense, wild boar is not an invasive (e.g. non-native species) of the Northern and Eastern European ecosystems (Heptner et al., 1961), therefore its eradication inevitably gets in strong dissonance 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 boar can theoretically be achieved, reinvasions from other areas will shortly after occur and quickly decimate all eradication efforts. Existing population monitoring methods are not sensitive to low densities of animal and cannot verify success of eradication with the required level of confidence.
In some Eastern European countries ASF is endemic in the pig populations (EFSA, 2010; Khomenko et al., 2013; EFSA, 2014; 2015; 2017) thus, even in the absence of any wild boar, 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 boar as a species anywhere in Northern and Eastern Europe should not be viewed as a principal or a key solution for ASF problem, whereas it appears** more appropriate to aim at changing hunting management practices, reducing the size of the wild boar population for a period of time to manage the situation with ASF and take precautionary measures to avoid spread of disease (see below and Chapters 4 & 5), rather than take decisions, which create complex collisions of interest among stakeholders involved.

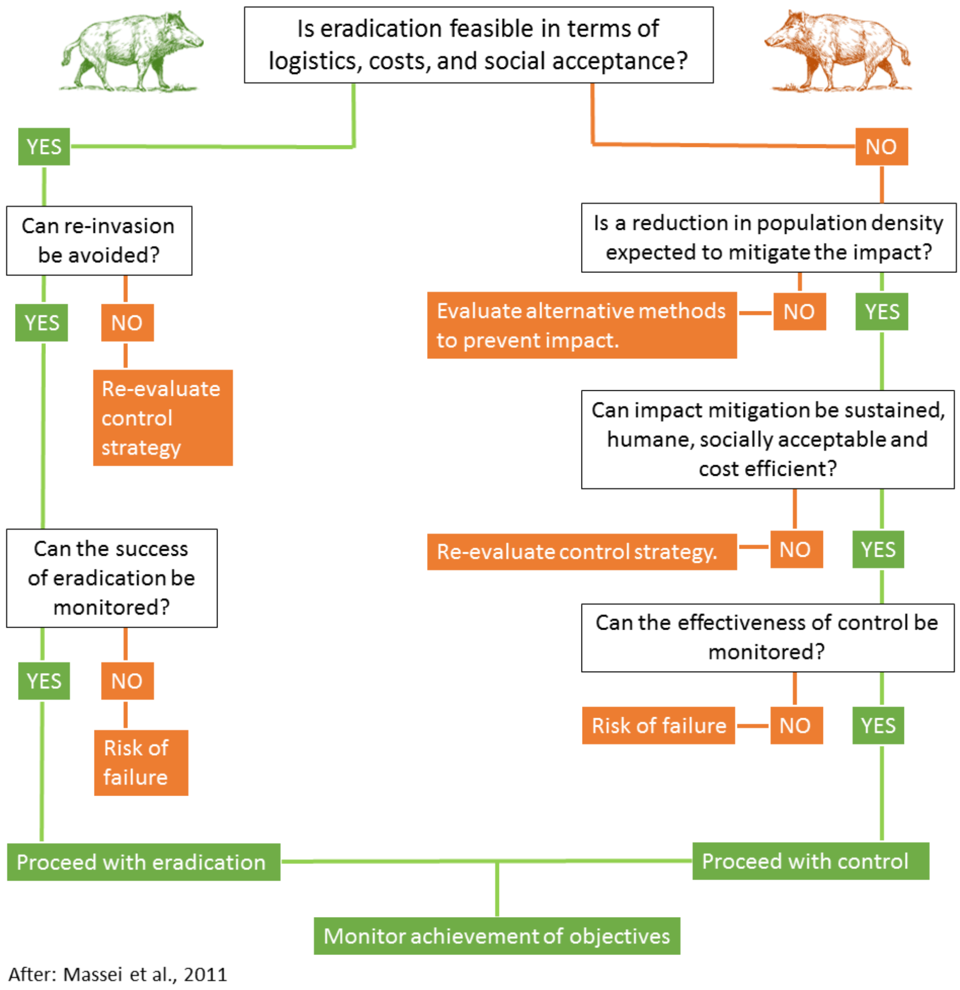


Figure 3.1. Decision tree to evaluate control options to decrease the impact of overabundant populations of feral hogs or wild boar on human interests (after Massei et al, 2011).

Why conventional hunting fails to level wild boar population growth?

The exact demographic mechanisms behind positive population balance of wild boar may differ between parts of Europe (Gamelon et al., 2011; Servanty et al., 2011), but in general it is evident that the nowadays-applied hunting pressure, which is the main source of mortality in wild boar, cannot stop population growth of this species. In spite of the fact that in some countries hunting wild boar is authorised without restrictions and all year round, feasibility of significant increase of hunting bags seems to be low (Massei et al., 2015). Apart from the demographic aspects, natural resilience of wild boar to hunting pressure is facilitated by complex behavioural responses such as: individual learning to avoid risk, changing activity pattern, home range sizes and habitat preferences. Wild boar often take advantage of the network of protected areas, 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 shelters where animals can avoid hunting and stay out of reach for extended periods of time.

In the temperate forests of Northern and Eastern Europe hunting wild boar is recreational and mostly occurs during autumn and winter, when it is more practical and efficient. It provides a relatively narrow window of 3-4 months for the most effective hunting. Even if it takes place all the year round, the bulk of the hunting bag is nonetheless shot during the traditional winter gaming season. For absolute majority of hunters it is a recreational activity and added business for the game keepers and hunting organisations. For the latter wild boar is an economically important resource that is purposely managed, protected and exploited, often with remarkable investment of money, time and labour.

In this particular system non-professional hunters expect easy and predictable encounters with wild boar with little investment of time for searching animals. Therefore, game managers typically aim at increasing density and survival of wild boar populations and in this way ensure stable proposition of services, attractiveness and economical 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 boar a panacea for ASF eradication?

So far, there is no empirical evidence that eradication of ASF from wild boar populations can be achieved through significant reduction of their numbers. However, population management and hunting practices need to account for the presence of this important pig disease in the ecosystems in order to minimise negative impact of risky activities and prevent virus spread among wild boar, as well as its introduction in to domestic pigs 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 boar that died of 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 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 boar 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 verage abundance around 1-2 animals/km^2- a preventive reduction by 80% of the **actual, real number** of wild boar in the area over 4 months within a zone of 50 km adjacent to the infected area would be 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 ban of supplementary feeding could be applied for a minimum of 3 year in a buffer zone of 100 – 200 km surrounding ASF infected area 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 boar. 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 risk of infection.

It has to be stressed that population reduction and control are the measures that can help to decrease disease burden and 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 (e.g. thousands of km^2) is extremely difficult to achieve and to be maintained over years, - as might be required given persistent nature of the disease such as ASF. It is a very complex and challenging task in the areas where wild boar populations demonstrate strongly positive population dynamic. Systematic collection of demographic and population data for wild boar 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 that adopting 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 implications of ASF in a long term perspective 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 already being discussed in some countries), are briefly reviewed below in the light of their applicability for managing risks of ASF related to virus circulation in wild boar populations.

1. Non-lethal methods involving movement restriction

1.1. 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 would need to be minimum 1.5-1.8 m high and buried to a depth of 0.4-0.6 m in order to be an effective movement restriction for wild boar. It can be fitted with strands of barbed wire on the top and sides of the mesh net. Electrification of fence 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 fence and those need to be carefully considered before making any decisions about fencing.

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 likely pressure on it due to irregular factors such as: presence of oestrus females or a desirable food source/hunger, a requirement for cover for farrowing or desire to escape from threats such as hunting or other means of prosecution. Where terrain is rough, stony or otherwise difficult to operate (e.g. wetlands, densely forested areas and alike), building such fence is problematic, and its prompt erection in response to ASF wild boar cases would be challenging or unfeasible.

In any case, fences will not prevent the long-distance spread of the virus. Biological materials and contaminated fomites would still have a huge potential to introduce disease well behind the fence (Fig. 3.2). Effectiveness for preventing spread of ASF and long-term ecological implications of large scale fencing needs to be carefully evaluated also considering that such measures are in a disagreement with nature and wildlife conservation concepts (Trouwborst at al, 2016; Linnell et al, 2016).

Figure 3.2. An example of a fence aimed – unsuccessfully – in halting ASF spread in the wild boar population. (Source V.G.)

1.2. 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 areas in order to seasonally protect relatively small parcels of land with crops, gardens and property from damage due to invasions of wild boar. Although electric fencing is often reported to effectively prevent crop damage, it cannot provide long-term protection of larger and more uninhabited areas (Reids et al., 2008). Electric fencing requires construction effort, a system for regular power supply, dedicated daily supervision and maintenance. Their year-round use in the climatic conditions of temperate North and East European forests with snow and freezing temperatures is problematic. Functionality of the fencing can be also strongly 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 overall amount of movements, but will not stop animals motivated by hunger, prosecution and sexual interest.

Figure 3.3. Italy: electric fence powered with solar cell in Italy aimed at protecting vineyards from Wild boar damages (Source VG) Figure 20: Electric fence in Czech Republic, Zlin district set up in response to ASF inclusion event in 2017 (Source VG)

3.3. Other deterrents. Deterrents can be chemical, visual, acoustic, or their combinations. Studies and practical experience in several affected countries generally find use of detergents rather inefficient means of distracting wild boar and reducing crop damage (Schlageter and Wackernagel, 2012). Closer investigations demonstrated negligible or statistically insignificant effect of most commercial products of this kind (Schlageter, 2015). All kinds of detergents are unlikely to be of any remarkable help with prevention of wild boar movements and spread of infection. Even if some effect can be achieved initially, wild boars usually get used to them quickly.

Figure 3.4. Odour fence set up in Zlin district in Czech Republic. The odour producing agent is the foam contained in the plastic glass placed on the ground at about 4 meters distance from one to another. Electric fence is visible in the front (Source VG).

2. Non-lethal methods with impact on population demography

2.1. Regulation of supplementary feeding. Supplementary feeding is a widespread and very popular population management practice known to significantly contribute to growth of wild boar populations (Selva et al., 2014 see also Chapter 2). Whenever the strategic management goal is to significantly reduce wild boar numbers, 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 dramatically reduced. For example, in the EU MS guidelines sets a limit of 10 kg per 1 km^2 per month (See: EU Guidelines: WORKING DOCUMENT SANTE/7113/2015), which can be used as an indicative amount in the most parts of the Northern and Eastern Europe. Commercially available automatic feeders are particularly useful, as they can help to reduce amount of food provided at a time, and decrease attendance of feeding stations by people, which is beneficial for organisation of hunting, as well as minimising disturbance to animals and risks of spreading infection from site to site by people. Baiting of hunting sites with salt licks, which can often effectively attract wild boar, can be used instead of massive provision of food, as well as other smelly attractants such as diesel, creosote or commercially available products (see review by: Lavelle et al, 2017). Another solution to reduce the food uptake, but keep animals attracted and stay on the spot longer is to use devices that complicate access to food (e.g. “hog pipes” and alike).

Ban of supplementary feeding is the least destructive population management approach, and it should be part of the standard wild bora management. Ban of supplementary feeding will drive the local wild boar population to a more natural relation with the environment despite it could include winter mortality, and decreasing fitness and fertility of reproductive females. Natural regulation might prove to be more efficient means of population control compared to hunting. Other implications of concern are possible increase of damage to winter crops, extended home ranges of animals. Effect of feeding ban will strongly depend on winter weather conditions and is likely to be most prominent in the colder climates and during less favourable years, which may not immediately follow its introduction.

2.2. Contraception. Contraception is a promising non-lethal method of reducing productivity of animals that could potentially help with many human-wildlife conflicts, including wild boar problem. General public, often criticizing lethal methods (Massei and Cowan, 2014), find contraception more human 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:

1) Be effective when orally administrated;
2) Strictly species specific;
3) Have high efficacy (70-80%);
4) Prevent reproduction in both sexes;
5) Be environmentally safe;
6) Remain stable and effective within a wide range of environmental conditions (temperature, sunlight, precipitation etc.)
7) Have no negative impact on the behaviour and welfare of the treated species;

As of now, such an ideal method of contraception remain to be subject of on going research and is neither commercially available nor officially allowed in wildlife population control programs in any of the Northern and Eastern European countries, as well as anywhere else in Europe.

Three classes of contraceptives have been developed for application in different wild species: hormonal, chemical and immunising. Until present, only immune-contraceptives (IC) have been successfully tested in wild boar (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 specifically wild boar (or feral pig) fertility control methods have to overcome several major difficulties and complications standing on the way to achieving practical implementation of IC in the free-living populations of this species. They are briefly discussed below.

Currently, commercially registered ICs have only injectable formulation and require capture and manual injection of the vaccine, thus strongly limiting its applicability in Wild boar. Of course, availability of oral delivery system for IC could open a way to use this approach on the population level in a potentially much more effective manner. However, this is not the only (and currently even not the most important) limitation to the application of IC vaccines in wild boar population control.

In the European context achieving species specificity of IC (e.g. making sure they affect only wild boar) is strongly desirable, but wild boar specific oral formulations are not yet available for use beyond experimental conditions. Without this important quality 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, conservation implications of extensive systematic application of IC, in particular effect on populations of endangered or endemic species, are of strong and well-justified concern.

Another way to deal with this problem is to develop species-specific IC delivery system, which would preclude access of non-target species to vaccine treated bait. Research and experiments with boar operated feeders (BOS) show that this can be achieved in principle (Ferretti et al., 2017). However, use of the BOS implies strong reliance on a network of feeding locations and makes application of this method on the large spatial scales much more labour intensive than any aerial or unrestricted manual bait distribution scheme would have been. 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 boar. Likewise with any other bait based vaccine delivery system for wildlife, various factors are likely to have impact on the success of the approach. All of those have to be experimentally evaluated in order to account for possible variations due to geographical, climatic, and ecological conditions encountered throughout population range of wild boar in Europe.

Absence of oral formulations of IC, their currently perceived ecological risk and a number of uncertainties concerning effectiveness of their dosage, duration of immunity, required population coverage, etc. 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**.

3. Management approach through ban of both hunting and feeding wild boar

Termination of hunting wild boar in an infected area or its parts is a reasonable solution where compliance with hunting biosecurity is problematic: e.g. either preservation of carcasses until exclusion/confirmation of infection or safe destruction of infected material are impossible. This measure can help to reduce probability of spreading disease beyond the infected area in two ways: (a) by avoiding disturbance and movements of animals and through (b) total exclusion of risk related to dressing and transportation of killed animals. This approach should be supplemented with searching, removing and safe destruction of wild boar carcasses in order to reduce environmental load of infection. Ban on hunting is a management approach with high promptness and feasibility; however, hunting community might not easily accept it. The possible side affects (increase of agricultural damages, mid-term increase of population and lack of diagnostic material from hunted animals) are always mitigated because of the high mortality determined by ASF. Under certain circumstances, particularly in the low resource settings, stopping both feeding and hunting 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.

4. Lethal methods involving reduction of the population

4.1. Driven hunts. If hunting in an infected area is continued, careful consideration should be given to the hunting methods (Thurfjell et al., 2013). Experience of the last years and knowledge of wild boar's behavioural response to driven hunts suggest that heavy persecution of animals in the areas with active circulation of ASF virus are likely to further spread the infection. Intensive driven hunts, particularly with dogs, may lead to large scale dispersion of animals, remarkably increase their home ranges and turn out to be counterproductive for disease control (Keuling et al., 2008; Ohashi et al., 2013). Therefore, ban of driven hunts is another hunting limitation generally recommended when ASF is present in wild boar populations.

4.2. Targeted hunting of reproductive females. Conventional hunting bags usually consist of ~50-60 % of the first-year animals (piglets), ~20-30 % of sub-adult (yearlings or second-year) wild boar and ~10-20 % of adult animals (one year and more). Such age distribution of animals in the hunting bag roughly reflects proportion of each category in an overage population. However, hunting from towers, which usually comprises ¾ of total kill in the Northern and Eastern European countries, gives more opportunities for hunters to impact on the local population demography and purposely decrease 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 approach is maintained over several years (5 or more). In the countries where early recruitment of female wild boar into reproduction cycle occurs normally, it might be worthwhile to target first-year females as well, although in the field discriminating between ages and sexes is rather difficult practically. For this reason, targeted hunting of all females is generally carried out.

Of course, successful implementation of targeted hunting would perform best when 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 (e.g. up to average of 30 h per individual, Schlageter, 2015). It is most relevant and feasible approach at the hunting grounds where wild boar numbers are above regional average density and animals regularly attend baiting sites and are more accessible.

Drawback of selective hunting are that social structure of family groups, particularly after removal of leading saws, gets distracted potentiating re-grouping and redistribution of remaining animals. Therefore, it is advisable to avoid killing dominant (oldest) saws, especially in the beginning of hunting season, as this is usually likely to compromise successful targeted hunting effort (Massei et al 2011). Also, on the longer run, systematic overharvesting of females may lead to earlier adaptive recruitment of younger females and stimulate larger litters in the older animals. At the moment, empirical data on the population response of wild boar to selective hunting is very limited, but it is likely that it will be different dependent on the cumulative roles of other factors (climate, predation, supplementary feeding).

4.3. Trapping with euthanasia. Although, from the standpoint of disease control, it is probably the least destructive way of removing animals from the population, it is also the least feasible. It requires massive investment in trap construction, baiting, daily maintenance and operation. Positive sides of catching, rather than shooting the animals, are that large coral traps might allow for capturing the whole family group(s) of wild boar. However, they may also increase capture related stress and mortality (Fenati et al, 2008). Trapping animals in groups helps to avoid social perturbations, which may lead to increasing disease transmission and encourage long-distance movements. However, in practical sense, it has to be taken into consideration that trapping of wild boar is a very costly and time-consuming population management approach. It can only be effective occasionally when natural feeding resources are scarce and, in general, it has 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 boar vary a lot between different countries of Northern and Eastern Europe. In some countries such hunting is not allowed at all, while in others only certain trapping methods are illegible. Some trapping methods that are inhumane and cause a lot of suffering are entirely prohibited (e.g. snaring). Changes in regulations might be required if hunting with traps is to be pursued as a population control method and make sure those fully comply with welfare, ethical and biosafety requirements.

In the conditions of Northern and Eastern Europe wild boar trapping is most successful in winter and early spring, e.g. mostly during the hunting season. Therefore, it can rarely substitute hunting by allowing taking animals during seasons other than conventional game harvesting period.

Operations in the ASF affected area would require same biosecurity measures as during normal hunting. Logistical arrangements should account for the fact that a proportion (up to 7 %, but in case of an infected family group even more) of captured animals might be subclinical infected. This implies that precautionary biosecurity measures have to be developed and strictly followed during trapping campaigns in order to avoid spread of disease between trapping locations and its introduction to domestic pigs. Practical ways to euthanize, transport, keep and also (whenever needed) destroy carcasses that prove to be ASF positive have to be foreseen.

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

Figure 3.5. Left: A large coral trap for catching wild boar baited with maize; Right: Immobilizing leading sow (upper) captured together with several litters (lower) in Strandzha, Bulgaria (Source: Sergei Khomenko)

4.4. Increase of overall hunting pressure. General increase of hunting rates is recommended or officially prescribed to the hunting associations as a primary wild boar population control approach. However, wild boar hunting bags all over Europe have been growing continuously almost all the time, and could not compensate for population increase (Vetter, et al, 2015; Massei et al, 2015). There are indications that numbers of hunters in many European countries are steadily declining over the last decades, and overall interest in wild boar hunting also goes down. Research suggests that under the conditions of Central Europe removal of up **80 % of wild boar piglets** would be needed to keep population stable (Bieber and Ruf, 2005). This figure might be slightly lower for more continental wild boar populations (Eastern Europe), but still rarely achieved in practice.

Where feasible, a general increase of hunting bags can work out, 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 dispersion and redistribution of animals are almost inevitable. In some areas driven hunts can be organized in a way that reduces risk of dispersion, provided that the hunt is performed over a very large area with many different hunters, hunting clubs and landowners involved, which increases the cost and time required to achieve success. Also with declining population density encountering animals and hunting them using whichever methods become increasingly more difficult and involve exponentially growing time costs 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 also dangerous to humans. Hunting with night vision devices is regulated in many European countries. Under environmental conditions of temperate European forests extension of hunting season beyond cold part of the year not always leads to increased hunting bags. In spring wild boar become cryptic due to farrowing, while green foliage strongly complicates location of game throughout vegetation period.

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

In general, 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.

4.5. Wild boar poisoning. Application of poisonous substances as the means of radically increasing mortality of wild boar 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 to apply biocides in order to manage overabundant populations of feral pigs in Australia and similar ongoing efforts in the USA , where wild boar is an invasive species and is managed for the reasons that are different from control of ASF. At the moment, poisoning is legally prohibited in all countries of Northern and Eastern Europe.
Considering the EU country as example, the use of biocides is strictly regulated (Regulation N. 528/201). The legislation poses several restrictions to the use of any biocide outside its authorised purposes and means of distributions. Despite derogations could be obtained (art. 55), it is very difficult (if and when possible) 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 experiences would make any attempts of poisoning wild boar into a hazard, risks of which are currently very hard 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.**

Any biocide aimed at poisoning wild boar in the natural environment should fulfil a number of characteristics in order to be legalised, officially accepted and practically applied in the population control programs. The substance used has to be species specific, e.g. is kill only the target species only, without any secondary/accidental poisoning of non-target species (i.e. brown bear, wolf, birds etc.). It has to be highly attractive for the wild boar and easily accepted by it. An effective antidote should be available both for humans and domestic animals in case of large scale application. The biocide has to be causing minimal pain and suffering to the animals after consumption, be sufficiently safe for people involved in the field operations. Its complete and safe degradation in the environment, including soil, ground and surface water, invertebrate biocoenosis, etc has to be warranted. Poison itself, as well as its distribution and delivery systems to the target species have to be reasonably priced in order to be repeatedly used on large spatial scales and 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 Americas and Oceania (Cowled et al., 2008). Warfarin, Phosphorus, 1080 and Sodium nitrite were the most used. Both Warfarin and Phosphorus failed to meet welfare requirements and were thus abandoned. It has been concluded that the environmental risk linked with 1080, particularly secondary poisoning of non-target species, is unacceptable too. Only nitrites were shown to be less dangerous and capable of fulfilling some of the above-described characteristics.

Apart from the choice of effective and safe poison, implementation of the large scale wild boar population control program in the countries of Northern and Eastern Europe based on biocides would face many problems, some of which are pointed at below, while others are still hard even to perceive with sufficient confidence.

Any type of poison will need to be incorporated into baits ingestible by wild boar. The baits will always attract a large number of non-target species (particularly birds and mammals), which will vary dependent on type of environment, habitat and season. In order to prevent their poisoning the baits should be delivered exclusively to wild boar by using species specific system (see contraception section). Such bait delivering devices (BDD) have never been tested in the areas inhabited by brown bear, bison, wolf, jackals etc., as well as generally across wider spectrum of European environments and animal community types.

At least one BDD per each 300 ha should be foreseen. At present, area of ASF occurrence in wild boar populations is more than 200.000 km^2, which implies manual installation of a huge number of BDDs (more than 70.000). This dramatically increases probability of poisoning various non-target species (including those with high conservation status), unpredictable involuntary accidents, environmental contamination etc. Ensuring individual dosage of poison, provided with highly hierarchical social structure of wild boar family groups and different mobility patterns of animals dependent of sex, age and season, might be problematic too (in the same way as with oral contraceptives). Other issues worth consideration are persistence in the food web chain and accumulation in specific substrates.

- *Large-scale extermination of wild boar as a species in order to eradicate ASF is unrealistic, unacceptable and unfeasible task based on ecological, epidemiological, practical and ethical considerations.*
- *Failure of conventional recreational hunting to level population growth of wild boar is to a large extent related to widespread practice of providing supplementary feeding as well as to the highly adaptive behaviour of wild boar, favourable changes in climate and agriculture.*
- *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 large spatial scale and over an extended period of time is problematic and expensive, while effect is not high.*
- ***A set of lethal approaches** aiming at active reduction of wild boar numbers includes carefully organized driven hunts (sometimes those should be avoided if likely to increase dispersion of animals), selective shooting of reproductive females, trapping with euthanasia (requires complicated logistical and biosecurity arrangements) and increase of hunting pressure through application of more effective game location or shooting methods.*
- *Contraception and poisoning are non-lethal and lethal population management methods respectively, both of which are 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 alternative to currently available solutions.*
- *Reduction of population density of wild boar is part of the complex 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 ASF virus in infected carcasse, the virus transmission can continue at very low Wild boar population densities.*
- *Computer simulations showed that to prevent spread of ASF to still free areas, 80% of the **actual number** of wild boar in a 50 km wide strip of habitats would need to be killed or*

otherwise removed from the population within just 4 months. For a number of reasons this aim is almost impossible to reach and the method has never been practically tested.

- *Theoretically, the same preventive task can be achieved with a slower population reduction method based of targeted hunting of reproductive females and ban of supplementary feeding, but would require targeted hunting effort over a minimum of 3 year and in a much wider (100 - 200 km) area. Provided with current occurrence range of the disease in wild boar, this approach would also be extremely difficult to test empirically.*
- *It is more realistic to consider application of different strategic and area specific population management approaches based on local knowledge and epidemiological information, trying to mitigate risk through application of complex of hunting biosecurity measures, safe disposal of infected carcasses and awareness campaigns.*

Chapter 4. Biosecurity in infected forests

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 found infected Wild boar and how to minimize the risk of mechanic transport of the virus outside infected forests through human activities.

ASF detection in free areas

Usually ASF in Wild boar in free areas is firstly detected through in dead wild boar; initially a practical carcass management plan is rarely available thus the Veterinary Service should immediately lead the field operations.

After the first detection, the infected area should be defined through active search of carcasses. This will help to identify the geographic extent of ASF and design 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, which could facilitate transport; soil (texture, permeability, surface fragments, depth to water table, depth to bedrock) and hydrological properties, 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, appropriately equipped (i.e. wear disposable clothes and overshoes or clothes and shoes, which would be easy to clean and disinfect). Involved personnel will not have any direct contact with pigs for 48 hours.

Detection of carcasses of dead wild boar

In the control/eradication of any animal diseases, the effective and safe disposal of infectious carcasses of dead animals (hereafter – carcasses) plays a crucial role. Safe disposal of carcasses is even more relevant for ASF due 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 boar in the EU (EU guidelines on African Swine Fever

Strategy for Eastern Part of the EU is available at https://ec.europa.eu/food/sites/food/files/animals/docs/ad_control-measures_asf_wrk-doc-sante-2015-7113.pdf).

The first step to detect carcasses is to raise awareness among hunters and other stakeholders (foresters and forest workers mainly) including 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 (face to face meetings, mass media, posters, leaflets, radio and TV shows) and different actors should be informed including hunters and hunter associations, general public through municipalities and non-governmental organisation, Veterinary practitioners, forest workers and forest management bodies with the aim of increasing the reporting of dead wild boar findings.

Any person that could potentially find a dead wild boar should know the basic rules and how to properly behave:

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

BOX 3**:** ASF DNA in soil samples collected from the sites of discovery of WB carcasses in Estonia

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In Estonia soil samples were collected after removal of ASF infected wild boar carcasses from the places the carcasses were lying. The samples were collected in 7 different locations in all four seasons, from underneath of 2-3 carcasses of various level of degradation in every season. Samples were collected in total from 10 sites of discovery - 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 ASF virus was detected in two sites until 1 and 2 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 for – 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 month, 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 being longer on sites, where the fresher carcasses were discovered.

Competent Authorities have to facilitate the communication: the report on finding a wild boar carcass should never represent a nuisance; on the contrary, it 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 boar (EFSA, 2017).

It is well known that nothing is easier than
to ignore a rotten, smelly wild boar carcasses 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; the 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 award only the hunters that are usually paid through their official hunting associations. Despite the administrative procedures are facilitated, a large part of the population would be excluded from being motivated, however it is important that motivation does not shift into business.
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, natural or artificial water bodies (rivers, ponds, lakes). Sick wild boar usually hides in swamps, densely covered areas, where they can avoid disturbance.
In a peace time, including hunted populations, the wild boar natural mortality accounts for about 10 % (Keuling et al., 2013; Toigo et al., 2008); the reliability of the carcass reporting system, and hence ASF detection, is measured through the number of dead wild boar reported in the absence of ASF. A desirable goal is to have reported 10% of the carcasses that account approximately for 1% of the whole estimated wild boar population. The yearly report of one dead wild boar out of 100-estimated wild boars indicates good efficiency of passive surveillance.

Precautionary measures

Once a 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 the local facilities, environmental situation and constrains, costs etc.

Local burning or burying 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 mountain or wetland areas and should be planned well in advance, particularly, where the density of wild boar is high.

Countries at risk should define which Service/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, the Veterinary Service should be always responsible for the supervision of carcass disposal and for taking samples.

In each country, it is advisable to involve both the Forestry Service and local hunters (Hunting Clubs or Associations) as fundamental partners in providing information and helping during collection and disposal of carcasses on the spot.

Carcass disposal

The primary aim of carcass disposal is to reduce the probability of the local maintenance of the virus. 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 of finding.

BOX 4: EXPERIENCE OF LATVIA IN ASF IN WILD BOAR AND BIOSECURITY DURING HUNTING

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

(i) **storage of the carcass of a hunted wild boar until laboratory results become available and**

(ii) **prohibition to leave offal in the forest**.

These requirements were implemented a few days after ASF has been confirmed in wild boar – 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 in the radius of 20 km around each ASF case in wild boar. From November 2015, driven hunts were prohibited at a distance of 10 km 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 State Forest Service (as suggested by 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, knifes 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 the hunting and after.

II. Requirements for wild boar by-products:

It is prohibited to leave any wild boar by-products – internal organs, offal, skin etc. 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,

The hunted wild boar is stored in appropriate premises until laboratory results are available and the identification of the wild boar carcass is done.

It is prohibited to divide the carcass and consume it before the negative laboratory test result (to ASF virus 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 boar 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 boar, incl. ropes, hooks, knives, aprons etc.

Only a disinfectant, which inactivates the ASF virus, must be used.

Each hunter must wash his clothes after hunting if he plans to go for hunting outside the ASF affected area.

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 accurate 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 majority of hunters are:

No equipment for storage of carcases of hunted wild boar – especially during the summer (coolers, refrigerators etc.);

Acceptance of the concept of hunting biosecurity;

Rapid adaptation to new conditions and requirements (ASF);

Change of previous traditions and attitude.

Help and assistance provided to hunters:

One year before ASF introduction in Latvia, the Joint Stock Company "Latvia's State Forests" donated 1 million EUR 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. Small part of the donation was used for training and awareness of hunters all over the country that 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 boar is prepared, agreed with hunters and will be adopted in the beginning of 2018. In general, the regulation will include 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 State Forest Service and Food and Veterinary Service.

The movement of carcasses within the infected area (i.e. from the finding spot to the designated carcass collection point) has 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.

Figure 23: transport of wild boar carcasses should minimize the risk of further spread of the virus;

Figure 24: simple tools can be used to safely transport hunted or found dead wild boars;

Carcasses are firstly placed in durable plastic bags and then transported into plastic or metal tanks suitable for repeated disinfections. In this case, it will be easier to move the carcasses in the forest and 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.

Figure 25: single burial; note the disinfectant of the carcass and around the burial area;

Figure 26: disinfection of the burial area;

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, 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 ASF virus and thus only authorized biocides will be used according to the producer's instructions.

Figure 27: wild boar carcasses are placed in plastic bags and carried to the nearest road;

Figure 28: carcasses are then transported to the carcass collection point;

Carcasses might be delivered to a
Rendering plant or incinerator, burnt or buried on the spot.

The 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 can refer to any processing of animal products into more useful materials, or, more specifically, to the rendering of the whole animal fatty tissue into purified fats like lard or tallow. Rendering is a closed system for mechanical and thermal treatment of animal tissues leading to stable, sterilized products, e. g., animal fat and dried animal protein and it grinds the tissue and sterilizes it by heat under pressure.

Rendering is the most economical method to dispose carcasses, however, the movement of infected carcasses to the rendering plant may pose a certain risk of spreading the disease, so preventive precautions must be taken. Not all countries have rendering plants or the existing rendering plants not always accept 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.

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

Figure 29: in Latvia an incinerator was placed in the highly infected area;

Containers

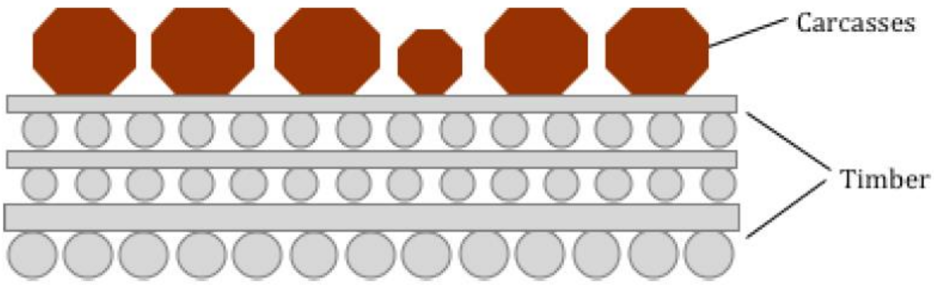
The carcasses can be managed by the use of containers. Special containers (400-600 litres capacity) are strategically distributed close to the nearest paved roads; carcasses are placed into the containers directly by hunters using appropriate vehicles and following biosecurity procedures. Hunters inform directly the local Veterinary Service that 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 the procedures. The containers have to be robust, lockable, and leak-proof. The use of containers is relatively easy and rapid to be implemented; containers, when strategically placed, help to prevent the spread of the ASF virus 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 the above methods.

Figure 30: in some highly infected areas,
pyres were prepared in advance;

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 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.



Sketch 1 Construction of the burning place

(https://www.animalhealthaustralia.com.au/wp-content/uploads/2015/09/DISP-08-FINAL24Aug15.pdf)

Trained personnel have to be involved and the burning area has to be carefully selected, cleared; activities carried out when fire fighting tools and related facilities are 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.

Figure 31: carcass burning in a trench;

Burial

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

Single pit. The method is used when individual dead wild boars are found. Burial pits should be deep enough to ensure a soil layer of at least 1 m above the carcass to prevent scavenging. The bottom of the pit has to be at least 1 m over the seasonal maximum groundwater level to avoid contamination. The availability of ground water maps and instructions would help in minimizing risks. Carcasses decomposition is faster when plastic bags are removed (plastic bags need years to be decomposed). 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.

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. Due to the high number of carcasses it is needed a formal environmental authorization. To avoid re-use 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 dig with appropriate size and deepness i.e. considering to 1,8-2 times the entire volume of the carcasses to be disposed plus 1 m of soil cover and the prescribe distance from groundwater. Before covering the trench with soil, carcasses have to be disinfected. It is not recommended to use plastic bags due to the long decomposing process.

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. Abdomen of fresh carcasses has to be totally opened to limit the side effects of the putrefaction gas production.

Figure 32: Trench burial needs the use of an excavator;

Figure 33: plastic containers; note that informative documents on the wild boar on the top of the containers;

Figure 34: wild boar in containers

Indirect contamination of the habitat with the ASFV

In any environment infected with ASF, the virus might be present in several matrixes; infected material (faeces, blood, grass, mushrooms etc.) is likely to be mechanically transported outside the infected area thus representing an indirect risk for further spreading 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 re-considered (Davies, 2017; Olesen, 2018, EFSA, 2010). Most recent research demonstrated that only 10% 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 to step on infected faeces and carry the virus outside infected areas during the summer – early autumn season is negligible.

However, during the winter months, the risk in the Northern and Eastern European countries might be higher since low temperatures allow longer survival of the virus (weeks/months instead of a few days) and more virus-contaminated faeces may get accumulated over the cold period of the year. During winter, wild boar are also more likely to cluster around feeding / baiting points; their daily home ranges are reduced and thus the environment has higher probability to be locally contaminated with infected faeces. It is known that 50% of wild boar faeces are located in a small area (up to 0,4 ha) surrounding feeding points (Plhal et al., 2014). Hunters often visit feeding /

baiting points to refill, check them, set cameras to estimate the size of the wild boar population, etc. In such circumstances, the probability to step on infected material and transport the virus outside the infected area is increased and worth effort to manage.

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 informed about the risk of mechanical transmission of the virus in the framework of pig biosecurity. Information in the framework of posters or signs in front of the entrance into 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 wearing different boots while visiting an infected or at risk area and change them before leaving the area. Boots should be placed in a robust plastic bag to avoid any contamination of cars while driving at home and the brushed and washed with soap and hot water until the sole is clean.

Hunters should be aware that a number of activities carried out in the infected area are at risk to mechanically transport the ASF virus outside the habitat. Some precautionary measures should be applied: avoid using the private car for transporting feeding stuffs directly to the spot, carefully disinfect boots and any possible contaminated materials when back to the hunting lodge or the dressing facilities.

- *Countries at risk should develop a clear strategy for carcass finding and disposal before the introduction of the virus;*
- *Competent Authorities have to facilitate the report of carcasses rising awareness and organizing effective communication channels;*
- *Rendering is an easy and effective method to dispose carcasses; containers could help in the temporary storage of carcasses; carcasses are sampled at the rendering plant by an official/authorized Veterinarian;*
- *Other disposal methods include: incineration, burning and burial;*
- *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 it.*

Chapter 5. Biosecurity during hunting

In infected forests, hundreds of wild boars are hunted each year; they represent the main source of the virus. During hunting the virus can contaminate cars, boots, object etc. and then it can be mechanically transported outside the infected forests. The chapter describes the main strategies and the logistic organization that – implemented at hunting ground level – can minimize the risk of spreading the virus when hunting in infected forests.

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 and the role of the Veterinary Service is mainly related to ensure that all the appropriate procedures to confirm or rule out the presence of the disease are followed. Veterinary Services are also in charge to provide information to pig owners and hunters, conducting epidemiological investigations in case of suspicions (wild boar showing abnormal behaviour or found), including laboratory testing.

When ASF is confirmed in the wild boar population an ASF wild boar addressed management is requested. In addition, EU countries have to develop an eradication plan. In case of ASF, when the virus is confirmed in a wild boar population, an infected area is established together with several control measures, including appropriate biosecurity procedures to be applied at the time of hunting.

It is recommended that the countries (independently from the presence of ASF) develop and implement basic hunting biosecurity measures. The development of a proper biosecurity approach during hunting needs time and resources and might be difficult to be organized in an emergency situation.

Close communication with hunters is important; although the hunting of wild boar could represent a useful ASF management tool, hunting infected wild boar poses a threat of further spreading of the virus. Hundreds of infected wild boars were hunted during past years in Eastern and Northern Europe; in such epidemiological landscape, hunters act as a link between the wild infected habitat and the anthropogenic one increasing the risk of domestic pig outbreaks.

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, 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 boar until tested ASF negative;
- Procedures for the disposal of ASF virus positive wild boar;
- 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.

Figure 35: hunting lodge with a separate dressing and storage room (right)

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 the ASF virus. Plastic or metal tanks are recommended whereas plastic bags are often damaged by vegetation.

Dedicated vehicles should transport hunted wild boar from spot to the dressing area. The vehicles should never leave the infected hunting ground or infected area. 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 the transportation of hunted wild boar, must be easily cleaned and disinfected following each hunt.

The use of private cars for transport of wild boar inside the infected hunting ground should be forbidden since they might be contaminated and thus indirectly spread the ASF virus at long distances. It is recommended to park private cars outside the area where the dressing procedures are performed, and preferably on a paved road.

Figure 36: in ASF infected areas and areas at risk, hunted wild boar should be safely transported to avoid further spreading of the virus

Figure 37: blood drops contain a very large amount of the virus

Figure 38: in the field conditions it is often difficult to limit the viral contamination of objects, tools etc.

Figure 39: will the fox follow the same procedures applied for ASF in wild boars?
Or will it be skinned at home despite the fur is contaminated with wild boar blood?

Figure 40: a normal pick up can transport wild boars minimizing the risk of further spread of the virus

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 in closed facilities, it is dedicated exclusively for animal dressing. The dressing area must be easy recognizable and only persons 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 from rain/snow/sun; and organised in a way to prevent contamination of the surrounding areas with infected blood, fluids etc.;
2. Fenced with lockable gates to prevent wild boars, scavengers and unauthorized persons entrance;
3. Provided with water;
4. Provided with a disposal pit or container for offal and waste;

Figure 41: non-fenced open-air dressing area; note the disposal pit

Figure 42: basic fenced open-air dressing area; note the disposal pit

Figure 43: fenced disposal pit

Another type of the dressing area can be **a closed dressing facilities**, which hunters usually equipped in a part of the hunting lodges or close to it.

A closed dressing area should:

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

Figure 44: closed, well-equipped dressing room

Figure 45: closed dressing room with storage facilities

Persons in charge of dressing should

a) Wear disposable or washable and easy to be disinfected clothes and boots;
b) Use tools exclusively dedicated for dressing, clean and disinfect them after use and not bring outside the hunting round;
c) Wash and disinfected each tool, apron and footwear used in the dressing area before exiting the fenced area;
d) Place all the disposables in plastic bags and dispose them;
e) Use only authorized disinfectants.

Proper disposal of offal

The offal of wild boar infected by ASF is the source of the ASF virus 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 considering the ground water level; it size has to contain the expected number of offal per hunting season and deep enough to prevent that wild animals (including wild boar) have access to offal; the pit must be filled in not more than 1 meter until the top. The pit area should be fenced and have lockable gate. This method of offal disposal is practical wherever digging is possible.

When completed filled, a pit can be closed and a new one excavated; alternatively and where allowed its content is removed under the supervision of the veterinary service and safely disposed.

A valid alternative to pits is containers. Usually plastic container (500-600 liters 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 boar until tested ASF negative

In the ASF infected areas all the hunted wild boar cannot leave the hunting ground without being tested ASF negative; 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 totally unreliable and their use is totally inappropriate for the eradication of the infection.

Figure 46: wild boar individually marked (blue mark on the chest) waiting for laboratory results

Figure 47: storage of wild boar pieces; tracing individual wild boars is more complex

Each hunting ground, should be equipped with refrigerator(s) in which, after dressing and sampling, the entire wild boar is stored and individually identified. In case (not recommended) 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) has to leave the hunting ground before the hunted wild boar is tested ASF negative.

It is important to organize storage and sample activities in order to avoid the releasing of animals ASF tested negative while other individuals are still stored waiting for test results. Animals should be stored as batches and only when the entire batch tests ASF negative it will be released. 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 for keeping carcasses of hunted wild boar or refrigerators 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.

Figure 48: in Poland, transportable storage rooms were provided by the Veterinary Service; wild boar can be dressed outside the room, offal collected in containers while stored animals will wait until laboratory results are communicate

Procedures for the disposal of ASFV positive wild boar and for cleansing and disinfecting facilities

In a case of a positive result for ASF, all the stored carcasses (or pieces of meat) have to be safely disposed by the Veterinary Service; the dressing area, cold storage facilities or refrigerator 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.

Figure 49: in some infected hunting grounds, hunters are always equipped with disinfectants (but also with a dog)

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 thus to achieve an effective disinfection.

Only freshly prepared disinfectant solutions should be used in order considering also that they required time to be effective (up to 60 minutes contact time).

Disinfectants recommended for African Swine Fever Virus:

Based on: 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).
- Organic acids.

- Oxidising acids (peracetic acid).
- Alkalis (calcium hydroxide and sodium hydroxide)
- Ether and chloroform

Registered commercial disinfectants:

Product Name	Active components	Use
Virkon S®	Sodium chloride 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 premise and equipment, and human footwear
Ecocid® S	Triple salt of potassium monopersulphate Sulphamic acid Malic acid Sodium hexametaphosphate - Sodium dodecyl benzene sulphonate	surface and water system disinfectant Any types of animal housing, greenhouses and veterinary surgeries
Virocid®	Alkyl dimethyl benzyl ammonium chloride; Didecyl dimethyl ammonium chloride; Glutaraldehyde;	Wide application range for the daily disinfection of: Animal houses and material; Animal transport and materials; Storage and processing rooms for feed and food; Food transport; Boots and wheels via dipping baths.

Figure 50: disinfection of an open-air dressing area

Figure 51: disinfection of a storage facility

Figure 52: disinfection of boots

- *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.*
- *Each hunting ground has to organize a wild boar dressing area, offal and wild boar storage facilities;*
- *Hunted wild boars are individually identified and safely stored in the hunting ground till tested ASF negative;*
- *If a hunted wild boar results ASF positive, all the stored animals (all species;) are disposed under the Veterinary Service control;*
- *Hunting will be re-authorised when cleansing and disinfection of the infected hunting ground facilities will be completed;*

Chapter 6. Effective communications between veterinary services and hunters

African Swine Fever (ASF) is a highly contagious infectious disease affecting domestic pigs and wild boars. Since there is no cure for ASF and no options for vaccination, effective risk communications and educational initiatives are critical tools in preventing the spread of disease. (Costard, Zagmutt, Porphyre, & Pfeiffer, 2015)

So how can veterinary services effectively communicate with hunters about ASF? Responsible hunting and disposal practices ensure that boar populations continue to thrive, and continue to 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.

A great place to start is 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). It 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 to 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 communicating now?

- *An outbreak has been notified in the country.*
- *An outbreak has been notified in the neighboring country, or in the region.*

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

Risk communications is the real-time exchange of information, advice, and opinions between experts or officials and people who face a threat (from a hazard) to their survival, health, economic, or social wellbeing. (Stoto, Nelson, Savoia, Ljungqvist, & Ciotti, 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 to best communicate with them about ASF and their role in stopping the spread of disease. Using formative research in design and planning of communications helps us know about 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 these issues as barriers to reporting the discovery of illness in boars: (Vergne T, 2014)

- Lack of awareness of the possibility of reporting
- Lack of knowledge about how to report
- Level of agreement that a reason for them to report a hunted wild boar is because it shows suspicious lesions of disease
- The act of reporting is troublesome

Building strong communications message 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. It could be done as follow:

- *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.*

Below are listed characteristics of a strong risk communications message:

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, Price, & Steinman, 2013) However, what people know ***and*** think affects how they act. People's perceptions, motivations, and skills all influence their behaviour. To be effective, science 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 actively talking to hunters in clear, understandable ways.

What are the characteristics of an effective communicator?

- **Expertise** – *you're knowledgeable; you know what you're talking about*
- **Good character** – *you're 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, Ruiter, & Kok, 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.*

The 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, you need to **establish in advance a mapping of your stakeholders and of their influencers**, and to **collect feedbacks** on how do 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?*

Choosing Communications Channels

Once you've crafted your communications messages to hunters, it's time to determine the tactics and channels you'll use to reach them. Channels may include:

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

- *Community engagement*

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

The following questions can help you identify risk communications channels that will effectively help 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*
    - *Signs and symptoms*
    - *Prevention techniques*
    - *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 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 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, Wall, Dixon, & Pfeiffer, 2016)

People who stigmatize others generally feel that the problem facing someone else is a problem he himself can control. (Reynolds & W. 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 to 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."*

- *Successful communications between veterinary services and the boar-hunting community are critical as we work together toward the eradication of ASF disease.*
- *Risk communications and community engagement involves 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.*

Chapter 7. Data collection

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

Wild boar data accompanying samples

Data collection is aimed in improving of animal diseases understanding and capacity to control/eradicate the disease. Data collection and analyses is an essential part of any animal disease surveillance program and thus a tool to measure the efficacy of control/eradication strategies and – eventually – highlight weak points.

In such a framework a standardized data collection protocol would benefit any following analyses and decision. Standardised data would help also in understanding on how the infected population behave in respect to ASF presence and the addressed management.

Standardised data collection might be an additive workload for both hunters and Veterinary Services, however it is intuitive that unstandardized methods reduce data reliability and prevent to compare them among infected countries.

A possible sample collection form that includes the essential data to be collected is offered below. Beside the usual provided information 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 ground, hunting towers could be georeferenced and thus used as a proxy of the spot of interest.

Standardized age classes

At present, wild boar carcasses or hunted wild boar are aged using several methods that are highly affected by observer judgment and wild boar individual variability. Ageing a wild boar through its weight or colour increases the error of the reporting system since such methods are nor objectives nor 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 the high hunting pressure, the average life span on a wild boar belonging to a hunted population is very low. In hunted wild boar populations the average life expectancy is about 2 year. In practice a typical, hunted, wild boar population consists of 50% of animals younger than 2 years and 50% of animals older than 2 year; rarely animals are older than 4 years. Due to the negligible number of "old" animals it is not very relevant to determine their age using more complex methods (i.e. cementum annuli counts). According to the simplest application of the tooth eruption method, 4 age classes can be defined:

a) no definitive molars are present;
b) 1 definitive molar;
c) 2 definitive molars
d) 3 definitive molars.

Definitive molars are easy to be counted in any field condition and animals; the approach does not need any technical tool and gives standardized age classes easy to be compared in the same population, among different populations and in different years and seasons.

Figure 53: one definitive molar (second molars are not yet completely erupted

Figure 54: two definitive molars

Figure 55: three definitive molars

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. An increased hunting effort could enhance the early recruitment of young females (<1 year old) in the reproductive population and thus limiting the efficiency of population management strategy. The suggested ASF control measures include the selective hunting of adult females and thus it is now possible to collect fecundity data. Uterus, while dressing animals, can be opened and the presence of foetus will be observed. Pregnancy is more easy to be seen at the end of the winter when the delivering season is approaching and foetuses are well visible.

Fertility

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

Age related fecundity and fertility data gives an indication of the actual reproductive capacity of the involved wild boar population and thus predict its future trends; it will also indicate shifts in the first age of reproduction or an increase of the average fertility offering a better understanding on the resilience to ASF and wild boar population management at population level.

Standardized dating of carcasses (rate of carcass decomposition)

The role of carcasses in the epidemiology of ASF in wild boar has been previously highlighted. At present the date of carcass finding is set at the date of the infection despite carcasses could be very old and thus ultimately leading to an imprecise dating of the infection. Temperature, humidity, sunlight, presence of scavengers (both invertebrate and vertebrate) can accelerate or reduce the time during which carcass decompose. However if the decomposition status of a carcass would be recorded with a standardised approach and coupled with the date of finding it would be possible to avoid huge discrepancies in dating the infection. A simple 3 decomposition categories could be included in the data collection form when a carcass is found.

Stage	Characteristics
1) Fresh	No odour, fresh;
2) Decomposed	Bloated abdomen, presence of maggots, odour from moderate to strong; liquefaction of tissue till black putrefaction; Removal of flesh from bones;
3) Dry	Little or no odour, dried skin, exposed bones;

A standardized dating of carcasses should be included in the training of hunters hunting in ASF infected areas/hunting grounds; however, at present, a defined procedure to date wild boar carcasses has not yet developed also considering the seasonal variability across the year.

WILD BOAR **N.** ___________

MUNICIPALITY _____________________________

LOCALITY___________________________________

HUNTING GROUND ________________________

PERSON COLLECTING SAMPLES: _________________________

LATITUDE AND LONGITUDE ______________________________

DATE: ______________________

	Wild boar data	Gender	Sampled organs
N. laboratory ____________	Driven hunts Single hunt from tower Single hunt by searching	Male	
N. hunted wild boar ____________	Found dead Shot healthy Shot abnormal behavior	Female Pregnant N. Fetus _____	
	Decomposition stage	1) 2) 3) 4) 5)	

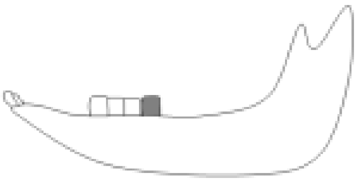
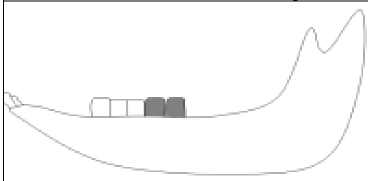
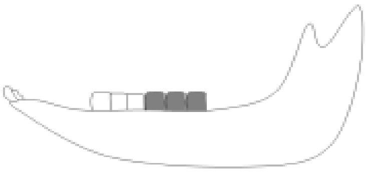
 No defintive molar = age class A	 1 definitive molar = age class B
 2 definitive molars = age class C	 3 definitve molars = age class D

Figure 56: decomposed carcass

Figure 57: decomposed

Figure 58: dry carcass

Figure 59: dry carcass (note scavenger insects still present)

- *Each hunted Wild boar or dead found carcass has to be individually sampled and accompanied by a specific set of data;*
- *The age of the animal has to be determined by teeth eruption only;*
- *Pregnancy and number of foetus have to be carefully recorded; the data will allow the understanding of the evolution of the wild boar population dynamic in affected areas;*
- *The decomposition stage of carcasses has to be ranked in order to approximate the period of death of the infected individual.*

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