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Guidelines on surveillance/monitoring, control and eradication of classical swine fever in wild boar

1. Introduction

The role of the wild boar in the classical swine fever (CSF) problematic is primarily of epidemiological interest since wild boar are regarded as a reservoir for CSF virus and as possible source of infection for domestic pigs. Therefore the main aims of controlling CSF in wild boar are to reduce the risk of transmission of the disease to domestic pigs, to prevent it becoming endemic, or to reduce the duration of the endemic phase, and finally to eradicate the disease in wild boar. These goals may be achieved by several measures including hunting as an attempted to reduce the wild boar population and/or vaccination of wild boar to increase the overall immunity of the population.

Principally, CSF virus can persist in a wild boar population only when there is a viraemic animal which transmits the virus to at least one further susceptible wild boar (R>1). When analysing the epidemiology of CSF in wild boar the following three interacting complexes have to be considered: (i) the biology of the wild boar population (e.g. age structure of the population, reproduction rate, carrying capacity of the habitat, etc.), (ii) the disease biology (e.g. course of the infection, immunity, mortality, virulence of the virus, etc.) and (iii) the human interference (e.g. feeding, hunting, vaccination, agriculture). However, monitoring and understanding a disease in an open ecosystem is rather a complex exercise because several parameters of interest e.g. the population structure and dynamics, the population size or the herd immunity remain unknown or can only be roughly estimated due to permanent changes within the population.

While the disease will fade out in small wild boar populations (between 1 000 and 1 500) it may become endemic in larger populations (>2 000) and may persist for several years in areas with a high wild boar density. The persistence of CSF depends on epidemiological and ecological factors such as the proportion of animals that recover from infection, the occurrence of chronic infections, as well as the social structure and size of the population.

Wild boar obviously cannot be managed like domestic pigs, i.e. using exhaustive culling or a conventional vaccination strategy, as individual handling is impossible, and wild boar populations are highly dynamic (i.e. producing new susceptible animals). However, hunting and vaccination can be used to stop transmission by reducing the number of susceptible animals, though inadequate hunting or inappropriate vaccine strategies may reinforce CSF persistence.

Council Directive 2001/89/EC of 23 October 2001 on Community measures for the control of classical swine fever[1] introduces minimum Community measures for the control of the disease. It lays down the measures to be taken in the event of a CSF outbreak. Those measures include plans by Member States for the eradication of CSF from a wild boar population and emergency vaccination of wild boar under certain conditions.

Monitoring and sampling procedures in areas where CSF occurs in wild boar are set out in the Diagnostic manual for CSF (Commission Decision 2002/106/EC[2]).

The objective of this paper is to provide guidance to the Member States as regards different options for controlling the disease, including vaccination of wild boar and hunting measures.

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1 OJ L 316, 1.12.2001, p. 5.

2 OJ L 39, 9.2.2002, p. 71.

The guidelines are based on:

- the requirements of Articles 15 and 16 of Directive 2001/89/EC;
- the Chapter IV, (H) of the Annex of Commission Decision 2002/106
- The EFSA Scientific Opinion of the Panel on AHAW on a request from Commission on 'Control and eradication of Classic Swine Fever in wild boar'[3].

General provisions in case of suspicion and confirmation of CSF in wild boar

A Member State has to submit a written plan of measures to eradicate CSF from a defined infected area to the Commission within 90 days of confirmation of a primary case. The plan mast contain information on monitoring measures to be enforced after a period of at least 12 months has elapsed from the date of the last confirmed case. These monitoring measures must be maintained for at least 12 months.

Appropriate control and eradication measures have to be decided and applied in an infected area. These may include suspension of hunting and a ban in feeding wild boar.

All wild boar shot or found dead in the defined infected area have to be inspected by an official veterinarian and examined for CSF in accordance with the diagnostic manual. Parts not intended for human consumption and carcasses of all animals found positive have to be processed under official supervision.

In accordance with Article 4(1)(a)(v) of Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by-products not intended for human consumption[4], all body parts, including hides and skins, of wild animals, when suspected of being infected with diseases, are classified as Category 1 material. Such material is to be disposed of or processed in accordance with Article 4(2) of that Regulation. Accordingly, viscera and other parts of wild boar shot or found dead in the areas listed in the Annex to Decision 2008/855/EC, and suspected of being infected with classical swine fever, are to be disposed of or processed in accordance with Article 4(2) of Regulation (EC) No 1774/2002.

2. Vaccination measures

Vaccination is a important tool to control the spread and intensity of infection under certain circumstances. In combination with immunity generated by the circulation of field virus, vaccination decreases virus circulation, and may eliminate the virus in a given area. However vaccination alone, when not supported by other measures, may also fail to reach the desired results.

Areas in which vaccination is to be carried out should be defined according to the landscape structure (e.g., forested areas, motorways, rivers, lakes) and wild boar spatial distribution and connectivity, rather than relying on administrative boundaries. Vaccination strategies also have to strictly define the epidemiological and sampling units.

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3 *The EFSA Journal* (2009) 932, 1-18.

4 OJ L 273, 10.10.2002, p. 1.

The vaccination process increases population immunity progressively: maximum immunity is only reached after three double campaigns. Thereafter, a continuous vaccination scheme is required to maintain population immunity. By maintaining a high level of immunity, a vaccination scheme limits the intensity of infection and the risk of transmission to the domestic pig.

In the field, the average proportion of immune animals is often up to 60 %, but immunity is much lower in animals less than a year old, as piglets under the age of six months do not eat the vaccine baits currently on the market. The low immunity observed in 3-12 month old wild boar might partially explain the persistence of wild-type virus in vaccinated populations.

At present, vaccination is based on the delivery of baits by hand. This needs strong, long-term mobilisation of hunters, as well as thorough preparation and training. It requires an interdisciplinary approach involving hunters, wildlife biologists and veterinarians.

The vaccination scheme applied since the 2000s has been empirically improved to maximise the immunity of the population. At present, there is a definitive vaccination strategy. This consists of at least two repeated vaccinations, using at least 30-50 baits per 1 km^2 of forest. The baits are delivered by double vaccination three times a year: in spring, summer and autumn. Double vaccination consists of two campaigns, with an interval of about four weeks between them. The schedule aims to maximise the individual antibody titre, and to reach young wild boar that do not eat regular baits before the age of at least 4.5 months. The current recommendation is to administer on average 40 baits in each of two vaccination places per km^2. But given the absence of a reliable estimate of the number of wild boar and the rate of bait uptake, the number of baits delivered in the field in any given place cannot be adapted to the number of wild boar with any accuracy.

Vaccination has to be continued for at least a year after the last detection of a CSFV-positive animal.

A single, isolated vaccination campaign cannot increase population immunity enough to control CSF. Furthermore, theoretical approaches suggest that a one-off vaccination campaign would even aggravate the persistence of CSF.

It is important to take into account that C-strain vaccinated animals cannot be differentiated serologically from infected animals. That is why long-term virological monitoring during and after vaccination programmes is required. Given the difficulty of surveillance, particularly in vaccinated areas with the C-Strain (in the absence of conventional-DIVA or bio-marker) the only way to ensure an area is disease-free is to monitor both the virus and antibodies during subsequent hunting seasons.

After a vaccination campaign, PCR positive animals can be diagnosed. These animals might be positive due either to vaccine virus or field virus. They can be cross-checked and their status clarified with a discriminatory PCR for wild-type CSF virus (genetic DIVA - discriminatory PCR) as recommended by the EU Reference Laboratory for CSF.

In a simulation model of a CSF epidemic in a wild boar population[5] the following characteristics regarding vaccination were seen:

[5] *The EFSA Journal* (2009) 932, 1-18.

- Vaccination mainly prevents the spread of infection into neighbouring vaccinated areas (by promoting population immunity in disease-free areas);
- It promotes long-term eradication through progressively reducing the ability of the virus to spread to neighbouring areas;
- It always reduces the epidemic peak (number of infected animals/time); endemic evolution of infection may occur when only a low rate of vaccination is achieved;
- Vaccination of about 20 % of susceptible animals results in an increased probability of endemic stability (there is a low incidence of the infection spreading in neighbouring patches);
- Campaigns should achieve a minimum target of 40 % of susceptible animals;
- If 60 % of susceptible animals are vaccinated, this may lead to the eradication of the infection.

According to the model, assuming that vaccination starts 150 days after the virus is introduced, an optimal vaccination scheme should aim to immunise at least 40 % of susceptible animals, ideally to be achieved within the first round of vaccination.

3. Hunting measures

Given that CSF virus transmission theoretically depends on the number of susceptible wild boar, and that hunting can reduce the population (after births) by half per year, one could draw the conclusion that hunting is a simple and direct way to manage the number of animals and eradicate CSF. However, there is little evidence that hunting is an efficient disease management tool. This may be because hunting has a complex effect on population dynamics, depending on the age and sex of the animals targeted. Below are the theoretical effects of two possible targeted hunting scenarios:

Targeting mainly **young wild boar (**under a year old) is assumed to decrease temporarily the number of susceptible animals. However, harvesting juveniles may leave enough breeding females to maintain a high birth rate, yielding susceptible animals that enable CSF to persist. It has been shown that even if hunting rules are implemented, the result remains far from the goal of reducing the number of juveniles by 85 %; the figure achieved was usually closer to 50 %.

Alternatively, targeting **breeding females** would decrease the population long-term. However, it might temporarily increase the turnover of the population, providing ideal conditions for CSF to spread further. This may be particularly critical in dense populations that ‘react’ by flexibly increasing their breeding capacity (density-dependence).

Thus, the use of targeted hunting to control CSF is not a simple issue and may even generate the opposite effect.

Intensified, non-discriminatory hunting has never been shown to be efficient in controlling or eradicating CSF, other than in very small and geographically isolated wild boar populations. The main problem is understanding the complex population dynamics of wild boar groups, and devising hunting schemes that are practical, while achieving the desired result from the point of view of CSF epidemiology as regards high-risk animals. Hunting alone is not sufficient to cut the virus transmission chain; it may indeed favour perpetuation of the virus.

To summarise, focusing hunting on high-risk classes by age (juvenile) or sex (breeding female) has not proved feasible. Targeting the immune or less susceptible subpopulation by removing

adult wild boars (especially if combined with vaccination measures) did not accomplish the aim of fully eradicating the disease either.

The low efficiency of hunting for CSF control is mainly due to:

- increase in turnover;
- non-achievable hunting intensity required in field situations;
- short impact rather than sustainable effects;
- different (even sometimes counteracting) purposes of hunting and disease control, though animals need to be hunted for sampling purposes.

There is insufficient scientific knowledge to assess the effect of hunting on the spread of CSF, but according to the above model (simulation of a CSF epidemic in a wild boar population and possible outcomes regarding vaccination):

- normal hunting (reaching 45% of the population) does not produce significant changes in virus persistence or spread;
- a small increase in hunting rates (<60 %) can promote virus persistence and spread;
- very high, impractical, hunting rates > 70-80 % would reduce virus spread significantly, but result in local extinction of wild boar.

4. Surveillance/monitoring and sampling: general considerations and specific recommendations

The active sampling of wild boar for CSF is obviously difficult. Where CSF has been confirmed in a Member State in the previous three years, a **passive surveillance system** should be put in place, with the aim of early detecting of reoccurrence of the virus in wild boar. Hunters and gamekeepers should be instructed to report the finding of all dead wild boars to the competent authority. Any carcass that is found should be declared to the authority, which should take samples and carry out laboratory tests according to its evaluation of the epidemiological situation.

Hunting is the sole practical system to obtain samples for active monitoring of vaccination and disease freedom, but the normal aim of hunting is obviously not disease control. Consequently, the sample size is not controlled by the authorities and rarely fits the aims of an epidemiological survey (i.e. detect at least one viral positive animal, or estimate serological prevalence).

In the case of high-risk situations, passive surveillance should be complemented by **active serological surveillance** (additional hunting). Ideally, the sample size should be large enough to detect 5% (with 95% CI) of seroprevalence per time and per spatial unit. Sampling activities should be intensified and repeated at least twice a year.

CSF may spreads along green corridors, and some physical barriers seem efficient in stopping its spread. Therefore landscape structure (forested areas, motorways, rivers, lakes…etc) influences contacts among wild boar from different populations and has to be taken into account in defining infected and monitoring areas, rather than relying on administrative boundaries. If biologically meaningful borders are not available to determine infected areas, interpretation of data may become difficult.

Repeated sampling over several hunting seasons will increase the probability of detecting persistent cycling of the infection/virus.

The surveillance strategy and evaluation of results should always consider the epidemiological situation/development of the infection and vaccination status.

Correct estimation of the viral and seroprevalence, however, is of paramount importance to understand the pattern of CSF infection and to validate interventions.

Two main sampling strategies can be applied in large areas:

1) The most reliable (to derive epidemiological conclusions) is to divide the whole infected area into several small areas. Sample size is then calculated for each small area, and findings are inferred from small areas;

2) The whole infected area is surveyed, sample size is calculated in relation to the entire area, and findings are inferred accordingly.

If population size and prevalence estimates are not available, the calculation of sample sizes should assume 5% of prevalence and a confidence level at 95%.

The sample size in C-strain vaccinated areas should be calculated to assess the stability (or the increasing) of population immunity at the desired level of seroprevalence or its expected prevalence variation (i.e. before and after any intervention).

Area-specific data about the wild boar population structure, hunting regime, or disease history can contribute to the sensitivity of a surveillance system, thereby yielding better estimates.

5.1. Monitoring in case of suspicion and confirmation of CSF in wild boar

Serological and virological monitoring has to be performed. The size and the geographical area of the target population to be sampled should be defined in advance to establish the number of samples to be taken. Sample size must be established as a function of the estimated number of living animals.

If data on population density and size are not available, the geographical area within which to sample must be identified, taking into account the continuous presence of wild boar and the presence of natural or artificial barriers that effectively prevent the animals moving freely. If there are no such barriers, or in case of large areas, identifying sampling areas of not more than 200 km^2, with an established population of about 400 to 1000 wild boar, is recommended.

The minimum number of animals to be sampled within a defined sampling area must allow detection of 5% seroprevalence with 95% confidence. To achieve this, at least 59 animals must be sampled in each area identified.

In Member States with a small population of wild boar, due to the difficulties of surveillance as set out above, the Member State should adapt based on epidemiological advice their proposed surveillance plan in wild boar to the local conditions.

It is also recommended that:

- in areas where hunting pressure is higher and regularly occurs, or selective hunting is carried out as a disease control measure, about half the sampled animals should be aged between three months and one year, 35% should be one to two years old, and 15% over two years old;

- in areas where hunting pressure is very low or absent, at least 32 animals should be sampled for each of the three age classes;
- sampling should be performed over a short period, preferably not more than one month;
- the age of sampled animals should be identified according to their teeth.

When virological monitoring on shot animals is deemed necessary, it must be primarily carried out on animals three months to one year old. All samples to be sent to a laboratory must be accompanied by the questionnaire referred to in Article 16(3)(1) of Directive 2001/89/EC.

5.2 Monitoring after oral immunisation

After completing oral immunisation, the age class of wild boar that should be examined serologically to detect a new or re-emerging infection depends on the season in which vaccination was completed and the length of time since completion.

In the second year after an oral immunisation campaign, piglets younger than six months might still have maternal antibodies, and boars older than 12 (or 18) months probably still have vaccination antibodies. Hence, a wild boar population is CSF-free if the antibody prevalence in the age class 6-12 (or 18) months is below a certain detection level (i.e. <5 %, 95 % CI).

In the third and subsequent years after oral vaccination, animals aged 6 to 24 months should be free from CSFV antibodies. Animals older than three years will probably be serologically positive due to vaccination, and animals <6 months might have maternal antibodies.

After the end of the vaccination campaign the following monitoring plan is proposed:

- 1st year after vaccination (0-12 months after completion of the campaign): no serological monitoring, focus on virological testing;
- 2nd year after vaccination (13-24 months after completion of the campaign): serological monitoring of wild boar piglets (6–12 months of age);
- 3rd – 5th year after vaccination (25-60 months): year after vaccination: serological monitoring of piglets and young wild boar (6–24 months of age).

Minimum number of samples per district (or metapopulation) each year: 59 (5 % prevalence with 95 % confidence)

5 years after completion of an oral immunisation campaign the wild boar population is likely to be replaced thoroughly by naive animals. Therefore, the population should be considered as fully susceptible again. It has to be kept in mind that antibodies due to vaccination can still be detected if serologically examined animals are older than 60 months.

In addition to serological examinations, **virological tests** should be conducted in all age classes. However, emphasis has to be put on **piglets**, on all **diseased wild boar** and on **animals found dead**. If CSF is suspected, all shot wild boar within a radius of 3 to 5 km have to be examined virologically for at least one month.