SCIENTIFIC OPINION

Control and eradication of Classic Swine Fever in wild boar

Scientific opinion of the Panel on Animal Health and Welfare

(Question No EFSA-Q-2007-200)

Adopted on 12 December 2008

PANEL MEMBERS

Summary

Classical swine fever (CSF) is a disease that has been causing major socio-economic damages in the EU during the last decades. Although considerable progress has been made in the eradication and prevention of the disease, the threat for an epidemic still exists.

The virus is endemic in the wild boar population of several member states (MS). Wild boar cannot be managed as domestic pigs. Hunting and vaccination have been tentatively used in order to stop transmission by reducing the number of susceptibles. Oral vaccination of wild boar with modified live vaccine based on the C-strain (the only suitable) is used; this vaccine does not allow serological differentiation between vaccinated and infected animals.

The aim of the control measures for CSF in wild boar is to reduce the risk of transmission to domestic pigs, to prevent an “endemic phase evolution” or to reduce the endemic phase duration.

In order to support and to improve the control and eradication measures as regards CSF in wild boar, EFSA was requested by the Commission to provide scientific advice on the efficacy of the available surveillance, hunting and vaccination measures to control and eradicate CSF in feral pig populations (wild boar), considering the possible use of new diagnostic tests and vaccines.

In order to reply to the mandate data were collected from MS through two questionnaires (CSF vaccines, hunting practices and CSF vaccination in wild boar). Data were also extracted from the EU CSF wild boar data base, after requesting permission from the participating MS.

Considering that the data received were rather limited and not comparable, the WG decided to use a model in order to fill the gaps in the available knowledge. For the evaluation of the efficacy of CSF control in wild boar a continuous metapopulation compartmental model developed in an EU research project (FP6-5015599-CSFVACCINE&WILDBOAR) was applied.

Although the disease manifests in the same manner in both domestic pig and wild boar it is more difficult to identify in wild boar because clinical monitoring of these is hardly possible. Wild boar found dead constitutes the main alert sign of CSF. Hunters and gamekeepers should be instructed to report the finding of each dead wild boar to the competent authority at all times. In case of high-risk situations, a passive surveillance should be complemented by an active serological surveillance. The active sampling of wild boar is not as efficient as in domestic pigs considering that hunting is the sole practical system to obtain samples and that the aim of hunting is quite different.

Consequently, the sample size is not controlled by authorities and fits rarely the aim of the survey in terms of detecting the presence of disease at a certain level. In addition, the interpretation of serological results is confounded by maternal derived antibodies (until the 6th month of age), vaccination and the sampling quality.

There is no definition at EU level of spatial and temporal units for surveillance, neither for criteria defining a disease free wild boar population. The sample size is not the only factor that dictates the overall sensitivity of surveillance systems. Indeed, wild boar habitat, hunting patterns, and disease distribution should be included when assessing surveillance system sensitivity.

After a vaccination campaign, PCR positive animals can be due to modified live vaccines (MLV) but these MLV-vaccinated animals can be cross-checked for wild type CSF virus (genetic DIVA – discriminatory PCR). A positive PCR diagnosis should be considered to indicate that an animal is or has been infected with the wild type or MLV virus but it is not necessarily still infectious.
According to previous field experience and to model simulations of a CSF epidemic in a wild boar population and the possible outcomes regarding vaccination:

- the disease will fade out without any additional control measures in small populations (between 1000 and 1500);
- hunting is not efficient for CSF control and should not exceed the normal 45% per year. Hunting is currently needed for sampling;
- vaccination:
  - increases population immunity progressively. The maximum population immunity is only reached after three double campaigns;
  - by one isolated campaign cannot increase population immunity adequately to control CSF and might even aggravate the persistence of CSF;
  - mainly prevents the spread of the infection in neighbouring vaccinated patches;
  - promotes long-term eradication through a progressive reduction of virus transmission to neighbouring areas;
  - always reduces the epidemic peak (number of infected animals/time). Endemic evolution of infection may occur when a low rate of vaccination is achieved;
  - in both infected and not yet infected areas, reaching a minimum target of 40 % of susceptible animals is necessary to obtain a positive control effect, below 20% - will increase probability of endemic stability, above 60% - will always eradicate the infection.

Key words: classical swine fever, wild boar, surveillance, control, monitoring, vaccination, hunting, modelling, ecology, epidemiology.
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GLOSSARY
- Age classes: for the purpose of this report four age classes of wild boar were distinguished: 0-6 months, 6 months-1 year, 1 year-2 year >2 years.
- Emergency vaccination: vaccination to control infectious animal diseases that might be implemented in a protective (vaccination-to-live) or a suppressive (vaccination-to-kill) way.
  - Protective vaccination (vaccination-to-live): means that vaccinated animals are allowed to live out their normal economic lives and their meat is commercialised.
  - Suppressive vaccination (vaccination-to-kill, or vaccination-to-die): means that animals around an infected farm are vaccinated to reduce the spread of infection and eventually are destructed.
- Endemic: any disease showing a predictable number of cases relatively stable both in time and space.
- Feral pigs: pigs that grown in free environment all of their life without any direct dependence from human beings. Feral pigs do not exist in any part of Europe. However, to be consistent with the terminology used in EU legislation, the notion "feral pig" is used to address feral wild boar.
- Free ranging pigs: owned domestic pigs allowed to range free.
- Wild boar: the wild boar and the domestic pig are members of the same species Sus scrofa. Wild boar are native wild mammals in Europe but they can mate with domestic pigs, so fertile cross-bred exist. Domestic pigs can also become feral. This report is concerned with uncontrolled populations of pigs in the wild, principally wild boar.

ABREVIATIONS
- AHAW: Animal Health and Animal Welfare
- Commission: European Commision
- CSF: Classical swine fever
- CSFV: Classical swine fever virus
- DIVA: differentiation infected from vaccinated animals
- EFSA: European Food Safety Authority
- MLV: modified live vaccine
- MOSS: Monitoring and surveillance systems
- MS: Member States
- OIE: Office International des Epizooties (World organization for Animal health)
- rRT-PCR: real-time RT-PCR
- RT-PCR: Reverse transcriptase polymerase chain reaction
- SCAHAW: Scientific Committee on Animal Health and Animal Welfare
BACKGROUND AS PROVIDED BY THE COMMISSION

Classical swine fever (CSF) is one of the diseases that has caused major socio-economic damages in the EU during the last decades. Although during the last years considerable progress has been made in the eradication and prevention of the disease, the threat for an epidemic still exists. The main reasons are that CSF virus is still present in feral pigs of some Member States (MSs) and that the virus is endemic in the Balkan region, including the MSs Bulgaria and Romania. Control measures are in place for those areas within the EU but this situation remains a constant threat for new outbreaks in the domestic pig population.


- Eradication measures, based on stamping-out in case CSF is suspected and confirmed on pig holdings. Emergency vaccination with 'conventional' live attenuated vaccine or marker vaccine can be used as an additional tool to eradicate the disease.

- Control measures in case of the presence of CSF in feral pigs. Emergency vaccination with baits containing a live attenuated vaccine can also been used as an additional tool to control the disease.

Two previous opinions of the former Scientific Committee on Animal Health and Animal Welfare (SCAHAW) laid down in following reports are relevant for the above strategy:


Oral vaccination of feral pigs has been used by several MSs (DE, FR, LU, SK) as an additional tool to control the disease and was assumed to have been mostly beneficial. Emergency vaccination of domestic pigs after an outbreak has not been used in the EU, except transitionally at the moment in Romania. One of the main reasons for this is that fresh meat from vaccinated animals as a generic rule (a derogation is possible in case of vaccination with a marker vaccine) cannot be traded.

Scientific progress has been made since in diagnostic tools and experiences have been gained in the implementation of the control and eradication measures.

Two issues however remain critical in regard to the control and eradication of CSF:

1. The efficacy of the control and eradication in infected feral pig populations with or without additional use of emergency vaccination.

2. The usefulness of emergency vaccination with 'conventional' live attenuated or marker vaccine after an outbreak in domestic pigs in order to limit excessive killings of pigs and the destruction of products and limit the economic damages.

In order to support the Commission and the Member States in improving the control and eradication measures as regards classical swine fever in feral and domestic pigs, scientific advice from EFSA would be required in this area.
TERMS OF REFERENCE AS PROVIDED BY THE COMMISSION

In view of the above, and in accordance with Article 29 of Regulation (EC) N° 178/2002, the Commission asks EFSA:

– To provide an opinion on the efficacy of the available surveillance, hunting and vaccination measures to control and eradicate CSF in feral pig populations, considering the possible use of new diagnostic tests and vaccines;

– To provide an opinion on the safety of fresh meat derived from vaccinated pigs for animal health, both from marker and conventional vaccines, taking into account the different control, eradication and surveillance measures required, including the use of new tools and techniques, such as the RT-PCR.

a) What is the risk that wild type virus is present in fresh meat obtained from pigs vaccinated in an emergency situation during an outbreak?

b) What are the sampling schemes and testing procedures needed to be applied to detect field virus in fresh meat derived from pigs vaccinated following an emergency vaccination during an outbreak? Pig vaccination status considers both marker and conventional vaccines.
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In accordance with the provisions of Article 30 of the Regulation 178/2002 and Article 59 of Regulation 726/2004, the European Food Safety Agency (EFSA) involved the European Medicines Agency (EMEA) in the preparation of this report. The Panel for Animal Health and Welfare (AHAW) of the EFSA is very grateful for the constructive input from EMEA in this report.

Scientific co-ordination for this mandate from the AHAW unit: Sandra Correia Rodeia, Milen Georgiev and Per Have.

ASSESSMENT

1. CONTROL MEASURES OF CSF IN WILD BOAR

1.1. Aim of control

1.1.1. Conclusions

- The aim of control measures in wild boar is to reduce the risk of transmission of CSFV to domestic pig, to prevent the “endemic phase evolution” or to reduce the endemic phase duration
- The main purpose of vaccination of wild boars is to limit the risk to transmit CSF virus to domestic pigs.
- The source of infection of CSF in wild boar is difficult to be determined. Therefore, the investigation and prevention of these outbreaks is very difficult to achieve
- The disease will fade out in small populations (between 1000 and 1500)
- The persistence of CSF depend on epidemiological and ecological factors such as the proportion of individuals that recover from infection, the occurrence of chronic infections, the social structure and dimension of the population. In particular CSF may persist several years among areas comprising more than 2000 shot wild boars.
- Wild boar cannot be managed as domestic pigs, i.e. using an exhaustive culling or vaccination strategy, because individual handling is impossible and because wild boar populations are highly dynamic (i.e. producing new susceptible animals). Alternatively hunting and vaccination can be used in order to stop transmission by reducing the number of susceptibles.

1.1.2. Recommendations for future research

- Modelling exploring potential factors of CSF persistence such as landscape structure and the farrowing period should be encouraged

1.2. Hunting as a control tool

1.2.1. Conclusions

- Hunting is not efficient for CSF control but is needed for sampling. This low efficiency is mainly due to:
  - increase in turnover;
  - non achievable hunting intensity required under field situations;
  - short sustainability of the measures.
  - not related and incompatible purposes of hunting and disease control

There is insufficient scientific knowledge to assess the effect of hunting on spread of the disease, but according to the model developed in the report (simulation of a CSF epidemic in a wild boar population and the possible outcomes regarding vaccination):
the absence of hunting doesn’t produce significant changes in virus persistence or spread
small increase in hunting rates (<60%) can promote virus persistence and spread
very high, impractical, hunting rates > 70-80% would reduce significantly the virus spread by local extinction of wild boar

1.2.2. Recommendations
- Control measures should not be based on hunting.
- Hunting pressure in infected areas should not exceed the normal 45% per year.

1.2.3. Recommendations for future research
- Research evaluating the effect of hunting on disease spreading should be performed, more particularly at the level of the barriers delimiting the infected areas.
- Alternative tools to control the number of susceptible wild boar have to be explored.

1.3. Vaccination as a control tool

1.3.1. Conclusions
- There is no sufficient scientific evidence that vaccination alone leads to eradication, however vaccination represents a potential tool to control the spreading and intensity of infection under certain circumstances. In combination with immunity generated by circulation of field virus, vaccination decreases virus circulation which finally might end up in elimination of the virus in an area.
- Areas to be vaccinated should be designed according to the landscape structure (forested areas, motorways, rivers, lakes...etc) and the wild boar spatial distribution connectivity, rather than relying on administrative boundaries. Vaccination strategies have also to strictly define the epidemiological and sampling units.
- The vaccination scheme applied since the 2000’s has been empirically improved to maximize the population immunity: baits including a C-strain vaccine are delivered according a three double-vaccination scheme.
- The vaccination process increases population immunity progressively: the maximum population immunity is only reached after three double campaigns. Then, the quick turnover requires a continuous vaccination effort to maintain population immunity. By maintaining a high level of immunity in the population the present vaccination scheme limits the intensity of infection and the consecutive risk of transmission to the domestic pig.
- Therefore one isolated vaccination campaign cannot increase population immunity adequately in order to control CSF. Furthermore theoretical approaches suggest that one isolated vaccination campaign would even aggravate the persistence of CSF.
- In the field, the average proportion of immune animals is often up to 60% but immunity is much lower in animals less than one year old due to the failure of piglets less 6 months to consume the vaccine baits currently on the market. The consecutive low immunity observed in 3-12 months old wild boar might explain partly the persistence of wild type virus in vaccinated populations.
Control and eradication of CSF in wild boar

At the moment vaccination is based on the delivery of baits by hands, which require a strong and long-term mobilisation of hunters.

Currently it is recommended to administer on average 40 baits on each of the 2 vaccination places per km². But given the absence of a reliable estimate of the number of wild boar and rate of bait uptake, the number of baits delivered in the field can not be adapted to the local number of wild boar.

Given the difficulty of surveillance, particularly in vaccinated areas with the C-Strain (in absence of sero-DIVA or bio-marker) the only way to ensure disease freedom is to monitor both virus and antibodies during the subsequent hunting seasons.

After a vaccination campaign, PCR positives can be due to MLV vaccines but these MLV-vaccinated animals can be cross-checked for wild type CSFV (genetic DIVA – discriminatory PCR)

Besides oral vaccination of infected areas in some field trials an immunisation cordon surrounding or bordering the infected area (“cordon sanitaire”) was established to build up a vaccination barrier in a non-infected area to stop the further spread of disease in unaffected territories, but the outcome was unclear.

There is insufficient scientific knowledge to assess the efficiency of vaccination in the field, but according to the model developed in the report (simulation of a CSF epidemic in a wild boar population and the possible outcomes regarding vaccination):

- Vaccination mainly prevents the spread of the infection in neighbouring vaccinated patches (by promoting population immunity also in free areas);
- Promotes long-term eradication through a progressive reduction of virus efficiency to spread by a neighbouring infection chain;
- Always reduces the epidemic peak (number of infected animals/time); Endemic evolution of infection could occur when a low rate of vaccination is achieved;
- Vaccination of about 20% of susceptible animals results in an increased probability of endemic stability (the infection can spread in neighbouring patches with low incidence);
- A minimum target of 40% of vaccinated animals should be achieved (40% of susceptible animals), considering the common infection and population parameters;
- 60% of vaccinated animals will always eradicate the infection

1.3.2. Recommendations

- The area to be vaccinated should be designed according to the spatial distribution of the wild boar population, its size and the landscape structure (forested areas, motorways, rivers, lakes, etc). The vaccination area should be as large as the wild boar population is spatially connected.
- It is important to take into account that C-strain vaccinated animals can not be differentiated from infected and for this reason, a long-term monitoring during and after vaccination programs is required.
- According to the model, assuming that vaccination starts 150 days after virus introduction, the optimal vaccination scheme, should be to immunise at least 40% of the still susceptible animals ideally achieved during the first trial;
A better understanding of the exact distribution and geographical spread of wildlife diseases in the primarily defined infected area when a “cordon sanitaire” is applied is required.

### 1.3.3. Recommendations for future research

- Research should be encouraged to understand better how vaccination contributes to eradication.
- More information concerning the geographical spread of the infection is needed, to adjust the size of the vaccination belt in order to effectively apply preventive vaccination among yet free areas.
- New baits that optimize the uptake in animals 3-6 months old should be developed and their use by vaccine-producers should be encouraged.
- Field studies exploring the mechanisms of the bait uptake (including the possibility of adding markers for bait uptake) and estimating the local abundance of wild boar should be encouraged.
- Alternative methods for the administration of vaccines should be developed considering the current limitation of the delivery by hand by hunters and focussing on uptake by piglets.

### 2. SURVEILLANCE OF CSF IN WILD BOAR

#### 2.1. Conclusions

The efficiency of the current surveillance schemes is low, as illustrated by the two main sources of data:

a) Collected through the questionnaires to the MS:

- Official data regarding wild boar population density are often inconsistent when compared with the actual annual hunting data; hunting data often indicate that the wild boar population size is larger than expected/foreseen.
- The actual sampling is mainly derived from hunted animals (% of hunted animals in EU data base with respect to any other sources) and therefore, the sample size is not designed to detect certain – prefixed – level of actual prevalence (design prevalence), either through viral isolation or seroprevalence, with a certain level of confidence.
- The number of positive animals detected by viral isolation is always low compared to the number of the sero positive animals. Nevertheless sample size does not reflect the difference between these two estimations.

b) Extracted from the EU CSF data base:

- The actual sampling system is based on an opportunistic approach mainly focussed on hunted animals (% of hunted animals).
- The advantage of this data base is that data is reported in a harmonised way, which may facilitate the surveillance and the control of the disease.
This data base is still restricted only to five MS.

The identification of CSF through the clinical monitoring in wild boar is more difficult than in domestic pigs although the disease manifests in the same manner.

The difficulty to identify a suspect case of CSF in wild boar may leave the infection undetected for long time in the environment.

The passive sampling of CSF in wild boar found dead constitutes the main sign of alert.

Passive sampling is not devoted as monitoring method once the disease is found in an area since in the field it may be difficult to find the dead animals when the infection evolves to endemic stability.

The active sampling of wild boar is not as efficient as in domestic pigs.

The interpretation of serological results is confused by exposure to field virus, by maternal derived antibodies (until the 6th month of age), vaccination and the sampling quality.

Hunting is the sole practical system to obtain samples, but the aim of hunting is quite a different one. Consequently, the sample size is not controlled by authorities and fits rarely the aim of the survey (i.e. detect at least one viral positive animal or to estimate serological prevalence).

The calculation of an optimal sample size is hampered because the true number of wild boar is uncertain; it can only be approximated using the hunting bag of the hunted areas.

At EU level there is no definition of spatial and temporal units for surveillance (sampling units). Consequently, sampling intensities are not related to a defined sampling unit but to a very different population sizes. As a result there is no standardised way to interpret CSF related data on wild boar populations.

It is difficult to use biological meaningful borders to determine the infected areas, which are most of time defined according administrative and political borders rather than according the structure of wild boar metapopulations. The absent link between host ecology and infected areas often leads to a difficult interpretation of the collected data.

An official definition of a CSF freedom in a wild boar population, applied at EU level, is still lacking. Sampling strategies cannot be fully addressed and evaluated in respect to the goal of demonstrating a wild boar CSF free area. At present, an infected area is considered free when a series of time of negative virological tests are obtained but it is not possible to prove the absence of virus in the wildlife just considering the results of the virological examination.

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

The simulation-based assessment of the sensitivity of surveillance systems (SeSS) with regard to effects of varying wild boar habitat, hunting patterns, and disease distribution revealed:

The sample size is not the only factor that dictates the overall the sensitivity of surveillance systems (SeSS) but also wild boar habitat, hunting patterns, and disease distribution.
• The uncontrolled and mostly unknown variability of the SeSS attributable to heterogeneous distribution of wild boars, samples, and disease might exceed the change in SeSS introduced by increasing sampling intensity.

2.2. Recommendations

• An EU level and centralised data base like the current EU CSF data base for wild boar would improve the knowledge of the CSF situation and its evolution.

• A positive PCR diagnosis should be considered to indicate that an animal has been in contact/exposed to infectious virus.

• Among vaccinated populations further analyses have to be performed using additional PCRs differentiating C-strain from wild type CSFV as well as new techniques for the demonstration of the presence of full-length CSFV genomes.

• During all year a passive surveillance system should be in place for vigilance with the aim of an early detection of the virus. Any carcasse that is found needs to be declared to the sanitary competent authority. The authority according to the evaluation of the epidemiological situation will proceed to sample and address laboratory test.

• Hunters and gamekeepers should be instructed to report the finding of each dead wild boar to the competent authority.

• In case of high-risk situations, a passive surveillance should be complemented by an active serological surveillance. 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 two times a year.

• A clear, biologically sounding, definition of sampling unit should be provided. The first step for any evaluation of the surveillance system in wildlife is the sampling unit definition.

• Forested areas and physical barrier influence the home-range and possible contact between wild boar. It is thus necessary to take them into account to define the infected and monitoring areas.

• The estimation of population size should be based on data from long term biological studies and these studies should be promoted in different EU ecoregions.

• CSF spreads along green corridors and some physical barrier seem efficient to stop CSF spreading. Therefore landscape structure (forested areas, motorways, rivers, lakes…etc) has to be taken into account in the definition of infected and monitoring areas, rather than relying on administrative boundaries.

• New customized and validated MOSS should be developed in order to estimate virus or antibodies presence (or prevalence) using time prolonged but small sampling intensities.

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

• A correct estimation of the viral and seroprevalence, however, is of paramount importance to understand the CSF infection evolution and to validate interventions.

• Two main sampling strategies can be applied in large areas:
1) The most reliable (to derive epidemiological conclusion) is to divide the whole infected area in several small areas, sample size is calculated in relation to each small area, and findings are inferred on small areas;

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

- In the case of unavailable population size and prevalence estimates, the calculation of sample sizes should assume 50% of prevalence and a confidence level at 95%.
- The sample size in C-strain vaccinated areas should be calculated in order to assess the stability (or the increasing) of population immunity at desired level of seroprevalence or its expected prevalence variation (i.e. before and after any intervention).
- An harmonised European database to collect standardised data on CSF in wild boar should be established
- Definition of CSF free wild boar population is needed considering the natural barriers, social structure, political situation, MOSS, and the disease control infrastructure system.
- A possible definition of a CSF free wild boar population should consider:
  o The antibody prevalence at a certain age class (young wild boar) below a certain level of detection;
  o The virus prevalence detected by virus isolation or rRT-PCR (in animals belonging to the high risk age classes), below a certain level of detection;
  o The evolution of the antibody prevalence (in defined age classes) after the completion of oral vaccination, below a certain level of detection.
- Area specific data about wild boar structure, spatial and temporal hunting regime, or disease history may enhance the efficacy of the surveillance system by a better estimate of its sensitivity.

2.3. Recommendations for further research

- The development of the so called non invasive techniques for faeces coupled with well establish wild life census techniques such us line transects or pellet counts would enormously improve the knowledge about the host and the virus populations.
- A new technique to calculate to estimate virus or antibodies presence (or the errors in detecting them) using time prolonged low sampling intensities should be developed in order to better evaluate the virological and serological prevalence in the field before, during and after the outbreak. The required sample size should include time and sampling intensity factors.

3. DIAGNOSIS OF CSF IN WILD BOAR

3.1. Conclusions

- Depending on the virulence of the strain, and the tests and samples used, virus can already be detected from 24 hours after infection.
- In general highly sensitive and specific diagnostic assays are available to diagnose CSF.
- rRT-PCR is currently the most suitable diagnostic tool.
Control and eradication of CSF in wild boar

- A positive PCR diagnosis indicates that an animal has been exposed to CSFV, not necessarily that it is infectious at the time of detection.
- Because of the high sensitivity of rRT-PCR, samples can be pooled up to 10 samples without decreasing the sensitivity of the test.
- Antibody detection tests are mainly suitable for monitoring and surveillance purposes, but not for diagnosis of suspicions.
- The estimated sensitivity and specificity for rRT-PCR is between 99.9 to 100%

3.2. Recommendations

- Further research should be developed in order to allow a better differentiation between animals with CSF positive serology and animals with non-CSF pestivirus serology in particular for double infections.

4. POSSIBLE USE OF NEW DIAGNOSTIC TEST INCLUDING PCR

4.1. Conclusions

- rRT-PCR is the current most reliable diagnostic test but limitations come from the sampling
- The available DIVA vaccine cannot be orally administered hence new DIVA-diagnostics are not applicable in wild boar.

5. POSSIBLE USE OF NEW VACCINES

5.1. Conclusions

- E2subV have to be administered parenterally and can not be used for oral immunization
- DIVA qualified live vaccine to be administered orally to wild boar will improve CSF surveillance and the assessment of vaccination efficacy; the latter cannot be evaluated properly when C strain vaccine is used. The main goal of using DIVA vaccine will be the capability to develop a correct methodology to stop vaccination at right time and thus lowering the risk to observe re-emergency/re-occurrence of the virus with possible spread of CSF to domestic pigs.
- Chimeric pestiviruses (MLV vaccines with DIVA properties) are the most promising next generation marker vaccine prototypes;
- Serological confirmation tests will be needed in case of large-scale use of these tests.
- DIVA vaccines that rely on E2 for differentiation, and for which the already available E2-ELISA’s can be used as DIVA tests therefore offer a better perspective for the future.
- Biomarkers can be an alternative to the unavailability of marker vaccines

5.2. Recommendations

- The novel live marker vaccine strategies should be further evaluated and the most promising strategies should be submitted for possible market authorisation at EU level.
• The development of live marker vaccine for field vaccination and companion tests for both virological and serological examination should be encouraged to improve the surveillance and epidemiological evaluation of vaccination efficacy.