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- (71) Applicant(s)
Boehringer Ingelheim Vetmedica GmbH
- (72) Inventor(s)
Klocke, Sonja;Cool, Robert Thomas;Edwards, Curtis Robert;Haddadin, Fuad Tawfiq;Haiwick, Gregory Brian;Kaiser, Troy James;Kroll, Jeremy;Malburg, Sonia Regina Cantisano;Noguera Serrat, Marta;Schaeffer, Merrill Lynn;Starks, Andrea J. Headrick;Stewart, Michael Landon;Vaughn, Eric Martin;Zhao, Guosong
- (74) Agent / Attorney
FB Rice Pty Ltd, L 33 477 Collins Street, Melbourne, VIC, 3000, AU
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(71) Applicant: BOEHRINGER INGELHEIM VETMEDICA GMBH [DE/DE]; Binger Strasse 173, 55216 Ingelheim am Rhein (DE).

(72) Inventors: **KLOCKE, Sonja**; Boehringer Ingelheim GmbH, Corporate Patents, Binger Straße 173, 55216 Ingelheim am Rhein (DE). **COOL, Robert, Thomas**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **EDWARDS, Curtis, Robert**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **HADDADIN, Fuad, Tawfiq**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **HAIWICK, Gregory, Brian**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **KAISER, Troy, James**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **KROLL, Jeremy**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **MALBURG, Sonia, Regina, Cantisano**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, CT 06877-0368 Ridgefield (BR). **NOGUERA SERRAT, Marta**; Boehringer Ingelheim GmbH, Corporate Patents, Binger Straße 173, 55216 Ingelheim am Rhein (ES). **SCHAEFFER, Merrill, Lynn**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **STARKS, Andrea, J, Headrick**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **STEWART, Michael, Landon**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **VAUGHN, Eric, Martin**; c/o VP, IP, Legal, Boehringer Ingelheim USA

Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US). **ZHAO, Guosong**; c/o VP, IP, Legal, Boehringer Ingelheim USA Corp. 900 Ridgebury Road, P.O. Box 368, Ridgefield, CT 06877-0368 (US).

(74) Agent: **SIMON, Elke** et al.; Boehringer Ingelheim GmbH, Corporate Patents, Binger Straße 173, 55216 Ingelheim am Rhein (DE).

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(54) Title: VACCINE AGAINST PORCINE PARVOVIRUS AND PORCINE REPRODUCTIVE AND RESPIRATORY SYNDROME VIRUS AND METHODS OF PRODUCTION THEREOF

(57) Abstract: The present invention relates to a porcine parvovirus and porcine reproductive and respiratory syndrome virus vaccine for protecting a subject, preferably swine, against diseases associated with porcine parvovirus and porcine reproductive and respiratory syndrome virus. The present invention further relates to methods of producing immunogenic compositions as well as such immunogenic compositions exhibiting reduced virucidal activity.



VACCINE AGAINST PORCINE PARVOVIRUS AND
PORCINE REPRODUCTIVE AND RESPIRATORY SYNDROME VIRUS AND
METHODS OF PRODUCTION THEREOF

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SEQUENCE LISTING

[0001] This application contains a sequence listing in accordance with 37 C.F.R. 1.821 – 1.825. The sequence listing accompanying this application is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

10 A. Field of the Invention

[0002] In a first consideration, the present invention relates to a porcine parvovirus and porcine reproductive and respiratory syndrome virus vaccine specific to the isolates which are capable of reducing clinical signs of disease caused by porcine parvovirus and/or porcine reproductive and respiratory syndrome virus. In a second consideration, the present invention further relates to methods
15 of producing immunogenic compositions as well as such immunogenic compositions exhibiting reduced virucidal activity.

B. Description of the Related Art

[0003] Porcine reproductive and respiratory syndrome virus (PRRSV) is a member of the virus family *Arteriviridae* and belongs, together with the *Coronaviridae*, to the virus order *Nidovirales*.
20 PRRSV is an enveloped virus with a single-stranded, positive-sense RNA genome of about 15 kilobases comprising nine open reading frames (ORFs), namely ORF1a, ORF1ab, ORF2a, ORF 2ab, and ORFs 3 through ORF7. ORFs 1a and 1ab encode large polyproteins that are processed into the viral nonstructural proteins (nsp) by auto- and trans-cleavages of viral proteases nsp1, nsp2, and nsp4 (Snijder and Meulenberg, 1998). ORF4 encodes a minor glycoprotein (GP4) which is, next to a major
25 glycoprotein (GP5) and two other minor glycoproteins (GP2a and GP3), found in the viral envelope, wherein all of said glycoproteins are important for infectious virus production.

[0004] PRRSV is considered one of the economically most important infectious agents in pigs causing late-term reproductive failure in sows and respiratory disease in growing pigs. Often, PRRSV infection is complicated by secondary bacterial infections being attributed to the immunosuppressive
30 nature of the virus. Also, PRRSV viremia lasts for weeks, and virus then still can be detected in lymphoid organs for several months, demonstrating difficulties or failure of the host's immune response to clear the virus (Allende et al., 2000).

[0005] There are two distinct viral PRRSV genotypes causing similar clinical symptoms that diverge by about 40 % on nucleotide sequence level, genotype I (EU) and genotype II (US). The North American (US) prototype strain is VR-2332, while the European (EU) prototype strain is Lelystad virus.

5 [0006] Porcine parvovirus is an autonomous replicating virus of the *Parvovirinae* subfamily of the genus *Protoparvovirus* within the family *Parvoviridae* containing a single stranded DNA molecule of about 5100 nucleotides (Cotmore et al., 2014: Arch Virol.: 159(5): 1239–1247; Molitor et al., 1984: Virology: 137(2):241-54.). Only the minus strand of the DNA is packaged into virions. The genome of the virus encodes three capsid proteins (VP1, VP2, VP3) and one non-structural protein
10 (NS1). The capsid of parvovirus is about 22-25 nanometers in diameter and is comprised of VP1 and VP2 subunits. These proteins are derived from alternatively spliced versions of the same RNA molecule and thus overlap in sequence. Further, porcine parvovirus exhibits a high level of sequence similarity to feline panleukopenia virus, canine parvoviruses and rodent parvovirus (Ranz et al., 1989: J. gen. Virol: 70:2541-2553).

15 [0007] Although there are differences in porcine parvovirus strains, some being extremely pathogenic and others being less pathogenic or totally non-pathogenic, when the virus becomes established or endemic in a country, the pathogenic strains appear to circulate in the population.

[0008] Porcine parvovirus (PPV) infection is a common cause of reproductive failure in breeding pigs throughout the world. Serological studies show that porcine parvovirus is widespread in
20 all swine producing regions of the world with up to 80 % of animals showing seroconversion.

[0009] The Porcine Parvovirus (PPV) causes reproductive failure in swine, resulting in death and fetal mummification, still births and other reproductive failures in pregnant sows. (Joo & Johnson. 1976. Veterinary Bulletin 46, 653-660; Mengeling. 1978. J. Am. Vet. Med. Assoc. 172, 1291-1294).

[0010] The PPV induces reproductive failure when susceptible (non-immune) gilts and sows
25 are infected during pregnancy. This is the only time the virus causes disease. Infection in the pig occurs following ingestion or inhalation of the virus. The PPV then circulates in the bloodstream and in the pregnant pig crosses the placenta and infects the developing embryos and fetuses. Following natural infection, active immunity develops that probably lasts for the life of the pig. If active immunity occurs before pregnancy then the developing piglets are not affected. At birth the piglets
30 receive maternal immunity in the colostrum from the sow and this maternal immunity lasts for up to 20 weeks of age. The greater the level of active immunity in the sow, the more maternal immunity that she passes onto her piglets. Thereafter, natural infection with PPV can occur.

[0011] The disease caused by PPV in pigs is often referred to as a SMEDI (an acronym of stillbirth, mummification, embryonic death, and infertility). If infection occurs at days 0-30 of pregnancy, embryonic mortality can occur resulting in decreased litter size. The most obvious feature following infection at 30-70 days of pregnancy is the birth of mummified piglets. Mummification is the process of sterile digestion of the tissues of the piglets that die in the uterus after the skeleton has started to solidify. PPV infection is also associated with stillbirths and weak born pigs if infection occurs in the later stages of pregnancy. Abortion can also be the result of PPV infection, but is not a common clinical sign of this disease. Overall, PPV infection decreases the number of pigs born per sow per year.

[0012] Currently available PPV vaccines are produced by growing native virus on primary cells of porcine origin or in established cell lines. After this, infectious virus is isolated and inactivated with chemical agents to end up with a whole cell killed virus vaccine. However, such processes of growing native infectious virus are problematic for biosecurity and safety considerations.

[0013] Subunit vaccines based on recombinant proteins can suffer from poor immunogenicity owing to incorrect folding of the target protein or poor presentation to the immune system. Further, whole cell killed vaccines present all antigens of the native virus, whereas in a subunit vaccine there is a limitation to a specific amino acid sequence.

[0014] Recombinant PPV vaccines have already been described in the prior art. However, until now only whole cell killed vaccines are commercially available. Thus, it seems that so far no appropriate recombinant PPV subunit vaccines have been developed and shown to be effective and safe. The recombinant PPV subunit vaccines described so far have not been tested in controlled, laboratory challenge experiments. The recombinant PPV subunit vaccines that have been evaluated, have not worked as well as whole cell killed PPV vaccines or the recombinant PPV subunit vaccines have not been safe (shown adverse reactions).

[0015] Field isolates of PPV have been identified that differ genetically and antigenically from the vaccine strains. PPV Genotype 2 virus, PPV-27a, is highly virulent in pregnant gilts after experimental infection, as demonstrated by the high mortality among the fetuses of sows infected with PPV-27a (85 %) compared with sows infected with the other strains of PPV, e.g. PPV-NADL-2. However, the currently available commercial vaccines against PPV are based on inactivated whole-virus preparations of PPV genotype 1 strains isolated some 30 years ago (Jozwik et al 2009; Journal of General Virology; 90; 2437–2441).

[0016] Further prior art is as follows:

- [0017] Adriaan F.G. Antonis. "A novel recombinant virus-like particle vaccine for prevention of porcine parvovirus-induced reproductive failure" Vaccine 24 (2006) 5481-5490.
- [0018] Chen Y. Guo W. "A novel recombinant pseudorabies virus expressing parvovirus VP2 gene: Immunogenicity and protective efficacy in swine" Virology Journal 2011, 8:307.
- 5 [0019] Merenga et al. "Large scale production and downstream processing of a recombinant porcine parvovirus vaccine" Appl Microbiol Biotechnol. 2002 Jun;59(1):45-50. Epub 2002 Apr 16.
- [0020] A. Jozwik, J. Manteufel, H.-J. Selbitz and U. Truyen. Vaccination against porcine parvovirus protects against disease, but does not prevent infection and virus shedding after challenge infection with a heterologous virus strain. Journal of General Virology (2009), 90, 2437–2441.
- 10 [0021] Chinese patent application CN 102 488 895 A discloses a triplex virus-like particle vaccine consisting of porcine circovirus, porcine parvovirus and PRRSV. This triple VLP vaccine contains PCV-2 major structural protein CAP protein, PPV VP2 protein epitope and PRRSV GP5 protein epitope.
- [0022] Russian patent application RU 2004108484 A discloses an inactivated vaccine against
- 15 PRRSV and PPV. This inactivated vaccine contains antigenic material from PRRS virus strain, reproduced in passaged cell culture Marc-145 and inactivated with aminoethylethyleneimine (AEI) and antigenic material from PPV strain reproduced in passaged YPK cell culture and inactivated with AEI.
- [0023] Chinese patent application CN 104 288 760 A discloses a vaccine composition
- 20 comprising an immune amount of a porcine circovirus type 2 antigen, an immune amount of a PRRSV antigen and a PPV antigen.
- [0024] Chinese patent application CN 102 727 881 A discloses a highly pathogenic PRRS JXAI-R strain and PPV bigeminal live vaccine.
- [0025] Puig et al. (<http://info.hipra.com/DOCS/UNISTRAN/PUBLICATIONS/ESPHM-2015/1-Clinical-protection.pdf>) relate to vaccination of the mixed administration of the inactivated ERYSENG Parvo and inactivated UNISTRAN PRRS vaccines manufactured by Hipra.
- 25 [0026] Zeew EIJ et al. (Journal of General Virology 2007, 88(2): 420-427) describes a study of the virulence and cross-neutralization capability of recent parvovirus field isolates and vaccine viruses in experimentally infected pregnant gilts.

[0027] US patent application US 2014/0322267 A1 relates to ORF2 protein of PCV2 subtype A (PCV2A) for use in cross-protection.

[0028] EP patent application EP 2 460 818 A2 relates to PCV2 immunogenic compositions and methods of producing such compositions.

5 [0029] US patent US 7,700,285 B1 relates to PCV2 immunogenic compositions and methods of producing such compositions.

[0030] PCT patent application WO 2013/024113 relates to influenza H5 vaccines.

[0031] US patent application US 2015/0283229 A1 relates to porcine epidemic diarrhea virus vaccine.

10 [0032] Disadvantages of the prior art are, for instance, (i) concerns that the PPV component in a conventional killed vaccine is not completely inactivated (which would then introduce live PPV into a herd); (ii) lack of cross-protection against heterologous strains of PPV; lack of vaccination scheme that protects breeding age gilts and sows and fetuses from PPV and PRRSV associated reproductive disease.

15 [0033] There is a need for new combination and/or associated use vaccines of PRRSV and PPV that can be successfully employed against infections with PRRSV and/or PPV. There is also a need for novel methods of reducing the virucidal activity of compositions that would normally exhibit some degree of virucidal activity; as well as for immunogenic compositions with reduced or no virucidal activity.

20 SUMMARY OF THE INVENTION

[0034] The solution to the above technical problem(s) is achieved by the description and the embodiments characterized in the claims and clauses disclosed herein.

[0035] Thus, the invention in its different aspects is implemented according to the claims and clauses disclosed herein.

25 [0036] **First consideration of the present invention**

[0037] In a first consideration the present invention relates to an immunogenic composition or a combination vaccine or a combination comprising

- a) at least one porcine parvo virus (PPV) antigen, wherein the at least one PPV antigen is any antigen contained in PPV, and

b) at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen, wherein the at least one PRRS virus antigen is any antigen contained in PRRS virus.

5 [0037A] In a particular embodiment, the present invention relates to a combination vaccine comprising:

a) at least one porcine parvo virus (PPV) antigen, wherein the at least one PPV antigen is one or more PPV subunit(s) and the at least one PPV subunit(s) is PPV viral protein 2 (VP2), wherein the PPV VP2 consists of an amino acid sequence having at least 99% sequence identity with the amino acid sequence of SEQ ID NO:2, and

10 b) at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen, wherein the at least one PRRS virus antigen is a live attenuated/modified live PRRS virus selected from the group consisting of live attenuated/modified live PRRS virus type 1 genotype, live attenuated/modified live PRRS virus type 2 genotype, live attenuated/modified live PRRS virus strain 94881 and PRRS virus strain ATCC deposit VR-2332.

15 [0038] The present invention further relates to a kit comprising the immunogenic composition or combination vaccine or combination as herein described and/or claimed.

[0039] The present invention further relates to the use of the immunogenic composition or combination vaccine or combination as herein described and/or claimed or the kit as herein described and/or claimed for the preparation of a medicament, preferably of a vaccine.

20 [0039A] The present invention further relates to a method of treatment and/or prevention of an infection with PPV and/or PRRS virus, the reduction, prevention or treatment of clinical signs caused by an infection with PPV and/or PRRS virus, or for the treatment and/or prevention of a disease caused by an infection with PPV and/or PRRS virus by administration to a swine of the combination vaccine as described herein.

25 [0040] Advantageously, the experimental data provided by the present invention disclose that the PPV VP2 subunit vaccine component of the present invention is safe and efficacious in preventing viremia and PPV infection in fetuses. Further, the experimental data provided by the present invention disclose that the PPV VP2 subunit vaccine component of the present invention has a broad protection spectrum as the vaccine protects against heterologous North American as well as heterologous
30 European challenge strains.

[0041] Advantageously, the experimental data provided by the present invention disclose that the PPV VP2 subunit vaccine component of the present invention is as efficacious as the whole killed virus. Extensive inactivation processes (which are necessary for inactivating native PPV when

generating whole killed virus vaccines) could be avoided by utilizing a recombinant subunit vaccine comprised of PPV VP2.

[0042] Further advantages of the underlying invention are, for instance, (i) reduction of the number of vaccine injections administered to animals, thus increasing animal welfare reducing the stress for the animals; (ii) reduction of manpower; (iii) same efficacy as a single administration; (iv) vaccine timing as both components address reproductive disease in pregnant swine; (v) prevention of PPV viremia in vaccinated gilts post-challenge with a heterologous PPV strain; (vi) reduction in the number of stillbirths and mummified piglets in the vaccinated groups after PPV challenge; (vii) increase in the total number of fetuses in the PPV vaccinated sows; (viii) 100% of PPV vaccinated piglets are protected after PPV challenge; (ix) duration of immunity (DOI): 6 months; (x) both ReproCyc® PRRS EU and mixed ReproCyc® PRRS EU + PPV VP2 were efficacious based on reduction of viral load and proportion viremic post-challenge; (xi) lack of interference with efficacy against PRRSV vaccination was demonstrated; (xii) four-week onset of immunity can be established for ReproCyc® PRRS EU; (xiii) a combination vaccine (PPV VP2 10 µg + Ery) with Ingelvac® PRRS MLV was demonstrated to be efficacious in preventing viremia and PPV infection of fetuses at day 40 after gestation (40 dG).

[0043] Second consideration of the present invention

[0044] In a second consideration the present invention relates to a method of producing an immunogenic composition comprising a recombinant protein, wherein the method comprises the steps
5 in the following order:

- (i) providing/obtaining a mixture comprising
 - a first liquid,
 - recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein, and
 - 10 - a vector comprising a nucleic acid sequence encoding said recombinant protein;
- (ii) adding a second liquid to the mixture of step (i), wherein the second liquid is different from the first liquid;
- (iii) washing, and optionally finally concentrating, the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein in the mixture by further
15 adding additional second liquid to the mixture resulting from step (ii) and removing a portion of the first and/or second liquid from such combined mixture;
- (iv) inactivating the vector by adding an inactivating agent to the mixture resulting from step (iii);
- (v) neutralizing the inactivating agent by adding a neutralizing agent to the mixture resulting
20 from step (iv).

[0045] The present invention further relates to the method as herein described and/or claimed, wherein the mixture of step (i) supra is obtainable by a procedure comprising the steps of

- (a) permitting infection of susceptible cells in culture with a vector comprising a nucleic acid sequence encoding said recombinant protein and/or quaternary structures composed of a
25 plurality of said recombinant protein, wherein said recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein is expressed by said vector,
- (b) thereafter recovering the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein from the cell culture, wherein preferably cell debris is separated from the recombinant protein and/or quaternary structures composed of a plurality of
30 said recombinant protein via a separation step, preferably including a micro filtration through at least one filter, more preferably two filters, wherein the at least one filter preferably has a pore size larger than the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein, in particular has a pore size of about 0.1 μm to about 4 μm .

5 [0046] As for PPV antigen preparations, when the Baculovirus inactivation at 37°C was performed after clarification and before diafiltration a heavy degree of precipitation (aggregation) was observed. This aggregation, although not related to the PPV antigen, is thought to interfere with inactivation kinetics and virucidal testing. Preliminary data suggest that a diafiltration process after culture clarification and before Baculovirus inactivation considerably reduces the degree of aggregation in the PPV virus-like-particles (VLP) harvest during the inactivation process. Data show that the degree of aggregation is intensified at higher temperature (37° C.), and minimized at lower temperatures (27° C. or 4° C.) over time: a diafiltration process before Baculovirus inactivation at 37° C. additionally eliminates the virucidal activity of the inactivants neutralization agent sodium thiosulfate and ExCell 10 420 media reaction. The validated process confirms that an inactivated Baculovirus expressed PPV VLP product has been consistently non-virucidal to PRRSV vaccine. Such PPV VLP vaccine possesses in particular an advantageous long term stability after mixing with PRRSV based on the missing virucidal effect thereby rendering it possible to mix both PPV and PRRSV components freshly before administration and/or to commercialize a ready-to-use administration form (e.g. combination vaccine or kit). 15

[0046A] Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

20 [0046B] Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present disclosure as it existed before the priority date of each of the appended claims.

25 BRIEF DESCRIPTION OF THE DRAWINGS

[0047] The following drawings form part of the present specification and are included to further demonstrate certain aspects of the present invention. The invention may be better understood by reference to one or more of these drawings in combination with the detailed description of specific embodiments presented herein.

30 [0048] FIG. 1 shows PRRSV Viraemia (qPCR, log₁₀ GE/mL) by Group and Day.

[0049] FIG. 2 shows Area Under the Curve (AUC) of PRRSV Viraemia (qPCR, log₁₀ GE/mL) by Group.

[0050] FIG. 3 shows the geometric mean PPV HI titers by Group and Day.

DETAILED DESCRIPTION

[0051] Before the aspects of the present invention are described, it must be noted that as used
5 herein and in the appended claims, the singular forms "a", "an", and "the" include plural reference unless
the context clearly dictates otherwise. Thus, for example, reference to "an antigen" includes a plurality
of antigens; reference to the "virus" is a reference to one or more viruses and equivalents thereof known
to those skilled in the art, and so forth. Unless defined otherwise, all technical and scientific terms used
herein have the same meanings as commonly understood by one of ordinary skill in the art to which
10 this invention belongs. Although any methods and materials similar or equivalent.

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to those described herein can be used in the practice or testing of the present invention, the preferred methods, devices, and materials are now described. All publications mentioned herein are incorporated herein by reference for the purpose of describing and disclosing the cell lines, vectors, and methodologies as reported in the publications which might be used in connection with the invention. Nothing herein is to be construed as an admission that the invention is not entitled to antedate such disclosure by virtue of prior invention.

[0052] First consideration of the present invention

[0053] In one aspect, the present invention concerns an immunogenic composition or a combination vaccine or a combination comprising

10 (a) at least one porcine parvo virus (PPV) antigen, wherein the at least one PPV antigen is any antigen contained in PPV, and

(b) at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen, wherein the at least one PRRS virus antigen is any antigen contained in PRRS virus.

[0054] The term “porcine parvovirus” or “PPV” is well known to the person skilled in the art. However, “porcine parvovirus” is an autonomous replicating virus of the genus parvovirus within the family Parvoviridae containing a single stranded DNA molecule. The genome of the virus encodes three capsid proteins (VP1, VP2, VP3) and one non-structural protein (NS1). The disease caused by PPV in pigs is often referred to as a SMEDI (an acronym of stillbirth, mummification, embryonic death, and infertility). The term “Porcine parvovirus” in the scope of the present invention encompasses all strains, genotypes and serotypes of the porcine parvovirus as well as of the parvovirinae subfamily of the genus Protoparvovirus within the family Parvoviridae.

[0055] The terms “porcine reproductive and respiratory syndrome virus” or “PRRS virus” or “PRRSV” is well known to the person skilled in the art. “Porcine reproductive and respiratory syndrome virus” is a member of the virus family *Arteriviridae*, belongs together with the *Coronaviridae* to the virus order *Nidovirales*, and is an enveloped virus with a single-stranded, positive-sense RNA genome of about 15 kilobases comprising nine open reading frames (ORFs), namely ORF1a, ORF1ab, ORF2a, ORF 2ab, and ORFs 3 through ORF7. ORFs 1a and 1ab encode large polyproteins that are processed into the viral nonstructural proteins (nsp) by auto- and trans-cleavages of viral proteases nsp1, nsp2, and nsp4 (Snijder and Meulenberg, 1998). ORF4 encodes a minor glycoprotein (GP4) which is, next to a major glycoprotein (GP5) and two other minor glycoproteins (GP2a and GP3), found in the viral envelope, wherein all of said glycoproteins are important for infectious virus production. There are two distinct viral PRRSV genotypes causing similar clinical symptoms that diverge by about 40 % on nucleotide sequence level, genotype I (EU)

and genotype II (US). The North American (US) prototype strain is VR-2332, while the European (EU) prototype strain is Lelystad virus. The term “porcine reproductive and respiratory syndrome virus” in the scope of the present invention encompasses all strains, genotypes and serotypes of the PRRSV.

5 [0056] In connection with PRRSV it is understood that the terms “genotype I” and “genotype II” are equivalent to the terms “genotype 1” and “genotype 2” or to the terms “type 1” and “type 2”, as frequently used in the literature in the context of PRRSV.

[0057] The terms “at least one porcine parvo virus (PPV) antigen” and “at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen” in the scope of the present invention
10 encompasses every antigen(s) from single PPV and/or PRRSV antigens to whole viruses comprising a multitude of antigens.

[0058] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein described and claimed, wherein the PPV is selected from the group consisting of: live attenuated/modified live PPV virus, killed/inactivated PPV virus,
15 killed/inactivated PPV strain 014, German field isolates of Porcine parvovirus PPV-27a and PPV-143a, and Porcine parvovirus vaccine viruses PPV-NADL-2 and PPV-IDT (MSV).

[0059] The terms “live attenuated” and “modified live” are interchangeably used in the course of the present invention and particularly relate to a reduced virulence of a PPV and/or PRRSV, in particular of a wild type PPV and/or PRRS virus, which is achieved by conventional multiple cell-line
20 passaging of the PPV and/or PRRSV and/or which is achieved by genetic engineering, wherein “virulence” is understood to be the degree of pathogenicity, and wherein “pathogenicity” is directed to the ability of the virus to induce clinical signs in the host or the offspring of the host, such as for instance reproductive failure.

[0060] The terms “killed” or “inactivated” in the scope of the present invention relate to a PPV
25 and/or PRRSV not having the ability of infecting an appropriate subject (as opposed to a live virus) and/or whose infectivity is not given as compared to a native virus. In particular, a killed/inactivated virus cannot infect its native host cells (anymore).

[0061] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein described and claimed, wherein the at least one PPV
30 antigen is one or more PPV subunit(s).

[0062] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein described and claimed, wherein the at least one PPV subunit(s) is PPV viral protein 2 (VP2), wherein preferably the PPV VP2 is the only PPV antigen.

[0063] The term “viral protein 2” or “VP2” relates to the capsid protein VP2 of the porcine parvovirus. The term “viral protein 2” or “VP2” is well known to the person skilled in the art.

[0064] The term “protein”, “amino acid” and “polypeptide” are used interchangeably. The term “protein” refers to a sequence of amino acid residues composed of the natural occurring amino acids as well as derivatives thereof. The naturally occurring amino acids are well known in the art and are described in standard text books of biochemistry. Within the amino acid sequence the amino acid residues are connected by peptide bonds. Further, the two ends of the amino acid sequence are referred to as the carboxyl terminus (C-terminus) and the amino terminus (N-terminus). The term “protein” encompasses essentially purified proteins or protein preparations comprising other proteins in addition. Further, the term also relates to protein fragments. Moreover, it includes chemically modified proteins. Such modifications may be artificial modifications or naturally occurring modifications such as phosphorylation, glycosylation, myristylation and the like.

[0065] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein described and claimed, wherein the PPV VP2 has

- at amino acid position 228 a glutamic acid residue or a glutamate residue, and/or
- at amino acid position 414 a serine residue, and/or
- at amino acid position 419 a glutamine residue, and/or
- at amino acid position 436 a threonine residue,

wherein the numbering of the amino acid positions refers to the amino acid sequence of wild type PPV VP2.

[0066] The term “wherein the numbering of the amino acid positions refers to the amino acid sequence of wild type PPV VP2” relates to the numbering of amino acid positions referring to the amino acid sequence of full length wild type PPV VP2 protein. Preferably, the numbering of the amino positions as mentioned herein is with reference to a wild type PPV VP2 protein sequence having 579 amino acid residues, including a methionine residue at the (N-terminal) amino acid position 1. The term “wherein the numbering of the amino acid positions refers to the amino acid sequence of wild type PPV VP2” encompasses wild type PPV VP2 as exemplarily given in SEQ ID NO:1 (PPV 27a VP2).

[0067] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination according as herein described and claimed, wherein the PPV VP2 further has

- at amino acid position 25 an isoleucine residue, and/or
- 5 - at amino acid position 36 a serine residue, and/or
- at amino acid position 37 an isoleucine residue,

wherein the numbering of the amino acid positions refers to the amino acid sequence of wild type PPV VP2.

[0068] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein described and claimed, wherein the numbering of the amino acid positions refers to the amino acid sequence as shown in SEQ ID NO:1.

[0069] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein described and claimed, wherein the PPV VP2 is a recombinant PPV VP2.

[0070] The term "recombinant" as used herein, in particular refers to a protein molecule which is expressed from a recombinant DNA molecule, such as a polypeptide which is produced by recombinant DNA techniques. An example of such techniques includes the case when DNA encoding the expressed protein (e.g. PPV VP2) is inserted into a suitable expression vector, preferably a baculovirus expression vector, which is in turn used to transfect, or in case of a baculovirus expression vector to infect, a host cell to produce the protein or polypeptide encoded by the DNA. The term "recombinant PPV VP2", as used herein, thus, in particular refers to a protein molecule which is expressed from a recombinant DNA molecule.

[0071] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein described and claimed, wherein the PPV VP2 is a recombinant baculovirus expressed PPV VP2.

[0072] The term "baculovirus" is well known to the person skilled in the art. As used herein "baculovirus" in particular means a system for producing a desired protein in an insect cell using a recombinant baculovirus vector designed to express said protein. A baculovirus expression system generally comprises all elements necessary to achieve recombinant protein expression in insect cells, and typically involves the engineering of a baculovirus vector to express a desired protein, the introduction of the engineered baculovirus vector into insect cells, the culturing of the insect cells containing the engineered baculovirus vector in a suitable growth medium such that the desired

protein is expressed, and the recovery of the protein. Typically, engineering a baculovirus vector involves the construction and isolation of recombinant baculoviruses in which the coding sequence for a chosen gene is inserted behind the promoter for a nonessential viral gene, wherein most of the presently used baculovirus expression systems are based on the sequence of *Autographa californica* nuclear polyhedrosis virus (AcMNPV) ((Virology 202 (2), 586-605 (1994), NCBI Accession No.: NC_001623). Baculovirus expression systems are well known in the art and have been described, for example, in "Baculovirus Expression Vectors: A Laboratory Manual" by David R. O'Reilly, Lois Miller, Verne Luckow, pub. by Oxford Univ. Press (1994), "The Baculovirus Expression System: A Laboratory Guide" by Linda A. King, R. D. Possee, published by Chapman & Hall (1992). An exemplary non-limiting example of a baculovirus system for producing a recombinant protein is e.g. described in WO 2006/072065 A2.

[0073] Preferred baculovirus vectors include baculovirus such as BaculoGold (BD Biosciences Pharmingen, San Diego, Calif.) or DiamondBac (Sigma Aldrich), in particular provided that the production cells are insect cells. Although the baculovirus expression system is preferred, it is understood by those of skill in the art that other expression systems will work for purposes of the present invention, namely the expression of PPV VP2 into the supernatant of a cell culture. Such other expression systems may require the use of a signal sequence in order to cause PPV VP2 expression into the media.

[0074] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PPV VP2 comprises or consists of an amino acid sequence having at least 90% sequence identity with the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NO:5 to 16.

[0075] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PPV VP2 comprises or consists of an amino acid sequence having at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.1%, at least 99.2%, at least 99.3%, at least 99.4%, at least 99.5%, at least 99.6%, at least 99.7%, at least 99.8%, or at least 99.9% sequence identity with the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NO:5 to 16.

[0076] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PPV VP2 comprises or consists of the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 or SEQ ID NO:5 to 16 or comprises or consists of any fragment having at least 210, at least 250 or at least 300 contiguous amino acid residues from SEQ ID NO:1, SEQ ID NO:2 or SEQ ID NO:5 to 16.

[0077] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PPV VP2 comprises or consists of the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 or SEQ ID NO:5 to 16.

5 [0078] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PPV VP2 is encoded by a nucleotide sequence encoding an amino acid sequence having at least 90% sequence identity with the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NO:5 to 16.

10 [0079] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PPV VP2 is encoded by a nucleotide sequence encoding an amino acid sequence having at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.1%, at least 99.2%, at least 99.3%, at least 99.4%, at least 99.5%, at least 99.6%, at least 99.7%, at least 99.8%, or at least 99.9% sequence identity with the amino acid sequence of
15 SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NO:5 to 16.

[0080] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PPV VP2 is encoded by a nucleotide sequence encoding an amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 or SEQ ID NO:5 to 16.

20 [0081] SEQ ID NO:4 is a codon-optimized PPV 27a VP2 nucleotide sequence which was further modified to possess two ClaI restriction enzyme sites (amino acid position 25 is an isoleucine residue, amino acid position 36 is a serine residue, amino acid position 37 is an isoleucine residue) so as to flank the VP2 coding region comprised of Glycine repeats. The ClaI sites were introduced in a manner so as to not disrupt the VP2 coding region. SEQ ID NO:2 is the protein sequence
25 corresponding to SEQ ID NO:4. SEQ ID NO:3 is a codon-optimized PPV 27a VP2 nucleotide sequence (without ClaI restriction enzyme sites). SEQ ID NO:1 is the protein sequence corresponding to SEQ ID NO:3.

[0082] The terms “nucleic acid” or “nucleic acid sequence” or “nucleotide sequence” or “polynucleotide” are used interchangeably herein and refer to polynucleotides including DNA
30 molecules, RNA molecules, cDNA molecules or derivatives. The term encompasses single as well as double stranded polynucleotides. The nucleic acid of the present invention encompasses isolated polynucleotides (i.e. isolated from its natural context) and genetically modified forms. Moreover, comprised are also chemically modified polynucleotides including naturally occurring modified

polynucleotides such as glycosylated or methylated polynucleotides or artificial modified one such as biotinylated polynucleotides. Further, the terms "nucleic acid" and "polynucleotide" are interchangeable and refer to any nucleic acid. The terms "nucleic acid" and "polynucleotide" also specifically include nucleic acids composed of bases other than the five biologically occurring bases (adenine, guanine, thymine, cytosine and uracil).

[0083] The term "identity" or "sequence identity" is known in the art and refers to a relationship between two or more polypeptide sequences or two or more polynucleotide sequences, namely a reference sequence and a given sequence to be compared with the reference sequence. Sequence identity is determined by comparing the given sequence to the reference sequence after the sequences have been optimally aligned to produce the highest degree of sequence similarity, as determined by the match between strings of such sequences. Upon such alignment, sequence identity is ascertained on a position-by-position basis, e.g., the sequences are "identical" at a particular position if at that position, the nucleotides or amino acid residues are identical. The total number of such position identities is then divided by the total number of nucleotides or residues in the reference sequence to give % sequence identity. Sequence identity can be readily calculated by known methods, including but not limited to, those described in Computational Molecular Biology, Lesk, A. N., ed., Oxford University Press, New York (1988), Biocomputing: Informatics and Genome Projects, Smith, D.W., ed., Academic Press, New York (1993); Computer Analysis of Sequence Data, Part I, Griffin, A.M., and Griffin, H. G., eds., Humana Press, New Jersey (1994); Sequence Analysis in Molecular Biology, von Heinge, G., Academic Press (1987); Sequence Analysis Primer, Gribskov, M. and Devereux, J., eds., M. Stockton Press, New York (1991); and Carillo, H., and Lipman, D., SIAM J. Applied Math., 48: 1073 (1988), the teachings of which are incorporated herein by reference. Preferred methods to determine the sequence identity are designed to give the largest match between the sequences tested. Methods to determine sequence identity are codified in publicly available computer programs which determine sequence identity between given sequences. Examples of such programs include, but are not limited to, the GCG program package (Devereux, J., et al., Nucleic Acids Research, 12(1):387 (1984)), BLASTP, BLASTN and FASTA (Altschul, S. F. et al., J. Molec. Biol., 215:403-410 (1990)). The BLASTX program is publicly available from NCBI and other sources (BLAST Manual, Altschul, S. et al., NCVI NLM NIH Bethesda, MD 20894, Altschul, S. F. et al., J. Molec. Biol., 215:403-410 (1990), the teachings of which are incorporated herein by reference). These programs optimally align sequences using default gap weights in order to produce the highest level of sequence identity between the given and reference sequences. As an illustration, by a polynucleotide having a nucleotide sequence having at least, for example, 85%, preferably 90%, even more preferably 95% "sequence identity" to a reference nucleotide sequence, it is intended that the nucleotide sequence of the given polynucleotide is identical to the reference sequence except that the given polynucleotide sequence may include up to 15, preferably up to 10, even more preferably up to

5 point mutations per each 100 nucleotides of the reference nucleotide sequence. In other words, in a polynucleotide having a nucleotide sequence having at least 85%, preferably 90%, even more preferably 95% identity relative to the reference nucleotide sequence, up to 15%, preferably 10%, even more preferably 5% of the nucleotides in the reference sequence may be deleted or substituted
5 with another nucleotide, or a number of nucleotides up to 15%, preferably 10%, even more preferably 5% of the total nucleotides in the reference sequence may be inserted into the reference sequence. These mutations of the reference sequence may occur at the 5'- or 3'-terminal positions of the reference nucleotide sequence or anywhere between those terminal positions, interspersed either individually among nucleotides in the reference sequence or in one or more contiguous groups within
10 the reference sequence. Analogously, by a polypeptide having a given amino acid sequence having at least, for example, 85%, preferably 90%, even more preferably 95% sequence identity to a reference amino acid sequence, it is intended that the given amino acid sequence of the polypeptide is identical to the reference sequence except that the given polypeptide sequence may include up to 15, preferably up to 10, even more preferably up to 5 amino acid alterations per each 100 amino acids of the
15 reference amino acid sequence. In other words, to obtain a given polypeptide sequence having at least 85%, preferably 90%, even more preferably 95% sequence identity with a reference amino acid sequence, up to 15%, preferably up to 10%, even more preferably up to 5% of the amino acid residues in the reference sequence may be deleted or substituted with another amino acid, or a number of amino acids up to 15%, preferably up to 10%, even more preferably up to 5% of the total number of
20 amino acid residues in the reference sequence may be inserted into the reference sequence. These alterations of the reference sequence may occur at the amino- or the carboxy-terminal positions of the reference amino acid sequence or anywhere between those terminal positions, interspersed either individually among residues in the reference sequence or in the one or more contiguous groups within the reference sequence. Preferably, residue positions which are not identical differ by conservative
25 amino acid substitutions. However, conservative substitutions are not included as a match when determining sequence identity.

[0084] The terms "identity", "sequence identity" and "percent identity" are used interchangeably herein. For the purpose of this invention, it is defined here that in order to determine the percent identity of two amino acid sequences or two nucleic acid sequences, the sequences are
30 aligned for optimal comparison purposes (e.g., gaps can be introduced in the sequence of a first amino acid or nucleic acid for optimal alignment with a second amino or nucleic acid sequence). The amino acid or nucleotide residues at corresponding amino acid or nucleotide positions are then compared. When a position in the first sequence is occupied by the same amino acid or nucleotide residue as the corresponding position in the second sequence, then the molecules are identical at that position. The
35 percent identity between the two sequences is a function of the number of identical positions shared

by the sequences (i.e., % identity = number of identical positions/total number of positions (i.e. overlapping positions) x 100). Preferably, the two sequences are the same length.

[0085] A sequence comparison may be carried out over the entire lengths of the two sequences being compared or over fragment of the two sequences. Typically, the comparison will be carried out over the full length of the two sequences being compared. However, sequence identity may be carried out over a region of, for example, twenty, fifty, one hundred or more contiguous amino acid residues.

[0086] The skilled person will be aware of the fact that several different computer programs are available to determine the homology between two sequences. For instance, a comparison of sequences and determination of percent identity between two sequences can be accomplished using a mathematical algorithm. In a preferred embodiment, the percent identity between two amino acid or nucleic acid sequences is determined using the Needleman and Wunsch (J. Mol. Biol. (48): 444-453 (1970)) algorithm which has been incorporated into the GAP program in the Accelrys GCG software package (available at <http://www.accelrys.com/products/gcg/>), using either a Blosum 62 matrix or a PAM250 matrix, and a gap weight of 16, 14, 12, 10, 8, 6, or 4 and a length weight of 1, 2, 3, 4, 5, or 6. The skilled person will appreciate that all these different parameters will yield slightly different results but that the overall percentage identity of two sequences is not significantly altered when using different algorithms.

[0087] The protein sequences or nucleic acid sequences of the present invention can further be used as a "query sequence" to perform a search against public databases to, for example, to identify other family members or related sequences. Such searches can be performed using the BLASTN and BLASTP programs (version 2.0) of Altschul, et al. (1990) J. Mol. Biol. 215:403-10. BLAST protein searches can be performed with the BLASTP program, score=50, wordlength=3 to obtain amino acid sequences homologous to protein molecules of the invention. To obtain gapped alignments for comparison purposes, Gapped BLAST can be utilized as described in Altschul et al. (1997) Nucleic Acids Res. 25(17): 3389-3402. When utilizing BLAST and Gapped BLAST programs, the default parameters of the respective programs (e.g., BLASTP and BLASTN) can be used. See the homepage of the National Center for Biotechnology Information at <http://www.ncbi.nlm.nih.gov/>.

[0088] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PRRS virus is selected from the group consisting of: PRRS virus genotype 1, PRRS virus genotype 2, PRRS virus genotype 1 comprising a genome encoded by a nucleotide sequence having at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99,1%, at least 99,2%, at least 99,3%, at least 99,4%, at least 99,5%, at least 99,6%, at least 99,7%, at least 99,8%, at least 99,9%, or 100% identity with the nucleic acid sequence of SEQ

ID NO:17 (Lelystad wild-type sequence), PRRS virus genotype 2 comprising a genome encoded by a nucleotide sequence having at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99,1%, at least 99,2%, at least 99,3%, at least 99,4%, at least 99,5%, at least 99,6%, at least 99,7%, at least 99,8%, at least 99,9%, or 100% identity with the nucleic acid sequence of SEQ ID NO:18 (VR2332 wild-type sequence).

[0089] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the PRRS virus is selected from the group consisting of: live attenuated/modified live PRRS virus, live attenuated/modified live PRRS virus type 1 genotype (e.g. Porcilis PRRS, Unistrain PRRS, Amervac PRRS, etc.), live attenuated/modified live PRRS virus type 2 genotype (e.g. Ingelvac® PRRS MLV, Foster PRRS, etc.), live attenuated/modified live PRRS virus strain 94881 [(genotype 1), ReproCyc® PRRS EU], killed/inactivated PRRS virus, killed/inactivated PRRS virus type 1 genotype (e.g. Progressis), killed/inactivated PRRS virus type 2 genotype, Lelystad virus strain (CDI-NL-2.91, Institut Pasteur, Paris, France, deposit number I-1102), PRRS virus subunit(s), or other strains such as those deposited under the Accession Numbers ECACC 04102703, ECACC 04102702, ECACC 04102704, CNCM Accession No. I-1140, CNCM Accession No I-1387, CNCM Accession No I-1388, ATCC VR 2332, VR 2385, VR 2386, VR 2429, VR 2474, and VR 2402; CNCM I-1102, CNCM I-1140, CNCM I-1387, CNCM I-1388, or ECACC V93070108, North American PRRS virus pT7P129A (ATCC Accession No. 203488), ATCC deposit VR-2332, ATCC deposit VR-2368; ATCC VR-2495; ATCC VR 2385, ATCC VR 2386, ATCC VR 2429, ATCC VR 2474, and ATCC VR 2402.

[0090] The terms "immunogenic composition" or "combination vaccine" or "combination" refer to a composition that comprises at least one antigen, in case of combination vaccine" or "combination" at least two antigens, which elicit(s) an immunological response in the host to which the "immunogenic composition" or "combination vaccine" or "combination" is administered. Such immunological response may be a cellular and/ or antibody-mediated immune response to the "immunogenic composition" or "combination vaccine" or "combination" of the invention. Preferably, the "immunogenic composition" or "combination vaccine" or "combination" induces an immune response and, more preferably, confers protective immunity against one or more of the clinical signs of a PPV and/or PRRSV infection. The host is also described as "subject". Preferably, any of the hosts or subjects described or mentioned herein are swine.

[0091] Usually, an "immunological response" includes but is not limited to one or more of the following effects: the production or activation of antibodies, B cells, helper T cells, suppressor T cells, and/or cytotoxic T cells and/or gamma-delta T cells, directed specifically to an antigen or antigens

included in the "immunogenic composition" or "combination vaccine" or "combination" of the invention. Preferably, the host will display either a protective immunological response or a therapeutically response.

[0092] A "protective immunological response" or "protective immunity" will be demonstrated by either a reduction or lack of clinical signs normally displayed by an infected host, a quicker recovery time and/or a lowered duration of infectivity or lowered pathogen titer in the tissues or body fluids or excretions of the infected host.

[0093] In case where the host displays a protective immunological response such that resistance to new infection will be enhanced and/or the clinical severity of the disease reduced, the "immunogenic composition" or "combination" is described as a "vaccine".

[0094] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination is formulated for a single-dose administration.

[0095] The volume for the single-dose administration has been defined elsewhere herein.

[0096] The immunogenic composition or combination vaccine or combination as herein disclosed and claimed is, preferably, administered topically or systemically. Suitable routes of administration conventionally used are oral or parenteral administration, such as intranasal, intravenous, intramuscular, intraperitoneal, subcutaneous, as well as inhalation. However, depending on the nature and mode of action of a compound, the immunogenic composition or combination vaccine or combination as herein disclosed and claimed may be administered by other routes as well. Most preferred the immunogenic composition or combination vaccine or combination as herein disclosed and claimed is administered intramuscularly.

[0097] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination is administered intramuscularly.

[0098] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination is safe for gilts and/or sows during pregnancy and lactation.

[0099] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic

composition or combination vaccine or combination is safe for gilts and/or sows from 30 days of gestation, preferably from 40 days of gestation.

[00100] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination further comprises at least one pharmaceutically acceptable carrier.

[00101] The term "pharmaceutical-acceptable carrier" includes any and all solvents, dispersion media, coatings, stabilizing agents, diluents, preservatives, antibacterial and antifungal agents, isotonic agents, adsorption delaying agents, adjuvants, immune stimulants, and combinations thereof.

[00102] "Diluents" can include water, saline, dextrose, ethanol, glycerol, phosphate buffered saline and the like. Isotonic agents can include sodium chloride, dextrose, mannitol, sorbitol, and lactose, among others. Stabilizers include albumin and alkali salts of ethylenediaminetetracetic acid, among others.

[00103] In one aspect of the present invention the pharmaceutically acceptable carrier is a carbomer.

[00104] Preferably, the immunogenic composition can further include one or more other immunomodulatory agents such as, e.g. interleukins, interferons, or other cytokines. The amounts and concentrations of adjuvants and additives useful in the context of the present invention can readily be determined by the skilled artisan.

[00105] In some aspects, the immunogenic composition of the present invention contains an adjuvant. "Adjuvants" as used herein, can include aluminum hydroxide and aluminum phosphate, saponins *e.g.*, Quil A, QS-21 (Cambridge Biotech Inc., Cambridge MA), GPI-0100 (Galenica Pharmaceuticals, Inc., Birmingham, AL), water-in-oil emulsion, oil-in-water emulsion, water-in-oil-in-water emulsion. The emulsion can be based in particular on light liquid paraffin oil (European Pharmacopea type); isoprenoid oil such as squalane or squalene; oil resulting from the oligomerization of alkenes, in particular of isobutene or decene; esters of acids or of alcohols containing a linear alkyl group, more particularly plant oils, ethyl oleate, propylene glycol di-(caprylate/caprates), glyceryl tri-(caprylate/caprates) or propylene glycol dioleate; esters of branched fatty acids or alcohols, in particular isostearic acid esters. The oil is used in combination with emulsifiers to form the emulsion. The emulsifiers are preferably nonionic surfactants, in particular esters of sorbitan, of mannide (*e.g.* anhydromannitol oleate), of glycol, of polyglycerol, of propylene glycol and of oleic, isostearic, ricinoleic or hydroxystearic acid, which are optionally ethoxylated, and polyoxypropylene-polyoxyethylene copolymer blocks, in particular the Pluronic products, especially

L121. See Hunter *et al.*, The Theory and Practical Application of Adjuvants (Ed. Stewart-Tull, D. E. S.), John Wiley and Sons, NY, pp51-94 (1995) and Todd *et al.*, Vaccine 15:564-570 (1997). Exemplary adjuvants are the SPT emulsion described on page 147 of "Vaccine Design, The Subunit and Adjuvant Approach" edited by M. Powell and M. Newman, Plenum Press, 1995, and the
5 emulsion MF59 described on page 183 of this same book.

[00106] A further instance of an adjuvant is a compound chosen from the polymers of acrylic or methacrylic acid and the copolymers of maleic anhydride and alkenyl derivative. Advantageous adjuvant compounds are the polymers of acrylic or methacrylic acid which are cross-linked, especially with polyalkenyl ethers of sugars or polyalcohols. These compounds are known by the term
10 carbomer (Phameuropa Vol. 8, No. 2, June 1996). Persons skilled in the art can also refer to U.S. Patent No. 2,909,462 which describes such acrylic polymers cross-linked with a polyhydroxylated compound having at least 3 hydroxyl groups, preferably not more than 8, the hydrogen atoms of at least three hydroxyls being replaced by unsaturated aliphatic radicals having at least 2 carbon atoms. The preferred radicals are those containing from 2 to 4 carbon atoms, *e.g.* vinyls, allyls and other
15 ethylenically unsaturated groups. The unsaturated radicals may themselves contain other substituents, such as methyl. The products sold under the name Carbopol; (BF Goodrich, Ohio, USA) are particularly appropriate. They are cross-linked with an allyl sucrose or with allyl pentaerythritol. Among them, there may be mentioned Carbopol 974P, 934P and 971P. Most preferred is the use of Carbopol 971P. Among the copolymers of maleic anhydride and alkenyl derivative, are the
20 copolymers EMA (Monsanto), which are copolymers of maleic anhydride and ethylene. The dissolution of these polymers in water leads to an acid solution that will be neutralized, preferably to physiological pH, in order to give the adjuvant solution into which the immunogenic, immunological or vaccine composition itself will be incorporated.

[00107] Further suitable adjuvants include, but are not limited to, the RIBI adjuvant system
25 (Ribi Inc.), Block co-polymer (CytRx, Atlanta GA), SAF-M (Chiron, Emeryville CA), monophosphoryl lipid A, Avridine lipid-amine adjuvant, heat-labile enterotoxin from *E. coli* (recombinant or otherwise), cholera toxin, IMS 1314 or muramyl dipeptide, or naturally occurring or recombinant cytokines or analogs thereof or stimulants of endogenous cytokine release, among many others.

[00108] It is expected that an adjuvant can be added in an amount of about 100 µg to about
30 10 mg per dose, preferably in an amount of about 100 µg to about 10 mg per dose, more preferably in an amount of about 500 µg to about 5 mg per dose, even more preferably in an amount of about 750 µg to about 2.5 mg per dose, and most preferably in an amount of about 1 mg per dose. Alternatively, the adjuvant may be at a concentration of about 0.01% to 50%, preferably at a
35 concentration of about 2% to 30%, more preferably at a concentration of about 5% to 25%, still more

preferably at a concentration of about 7% to 22%, and most preferably at a concentration of 10% to 20% by volume of the final product.

[00109] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the at least one pharmaceutically acceptable carrier is a carbomer.

[00110] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination comprises 0.1 µg to 50 µg of the PPV VP2 antigen, preferably 0.5 µg to 10 µg of the PPV VP2 antigen, more preferably 1.0 µg to 10 µg of the PPV VP2 antigen, and/or 3.9 to 7.0 log₁₀TCID₅₀ of the PRRS virus.

[00111] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed comprises between about 0.1 µg and 50 µg of the PPV VP2 antigen. Preferably, the immunogenic composition comprises between about 0.2 µg and 40 µg, more preferably between about 0.3 µg and 30 µg, more preferably between about 0.4 µg and 20 µg and even more preferably between about 0.5 µg and 10 µg and even more preferably between about 1.0 µg and 10 µg with an amount of 0.5 µg, 0.75 µg, 1 µg, 1.25 µg, 1.5 µg, 2 µg, 2.5 µg, 3 µg, 3.5 µg, 4 µg, 4.5 µg, 5 µg, 5.5 µg, 6 µg, 6.5 µg, 7 µg, 7.5 µg, 8 µg, 8.5 µg, 9 µg, 9.5 µg or 10 µg of the PPV VP2 antigen most preferred.

[00112] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed comprises between about 3.9 to 7.0 log₁₀TCID₅₀ of the PRRS virus.

[00113] In another aspect, the present invention concerns an immunogenic composition or combination as herein disclosed and claimed, wherein the immunogenic composition or combination is a vaccine.

[00114] The term “vaccine” already has been described elsewhere herein. However, in case where the host displays a protective immunological response such that resistance to new infection will be enhanced and/or the clinical severity of the disease reduced, the immunogenic composition or combination is described as a “vaccine.”

[00115] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed protects against a homologous and/or a heterologous challenge. Advantageously, the experimental data provided by the present invention disclose that the immunogenic composition or combination vaccine or combination of the

present invention has a broad protection spectrum as it protects against heterologous North American and/or heterologous European challenge strains.

[00116] The terms “protects” and “prophylaxis” and “preventing” are used interchangeably in this application. These terms have been defined elsewhere.

5 [00117] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed protects against a challenge with North American and/or European isolates.

[00118] The term “North American and/or European isolates” is well known to the person skilled in the art. The term “North American and/or European isolates” encompasses all isolates
10 which have been or will be isolated in North America and Europe.

[00119] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed is cross protective against North American and/or European isolates.

[00120] In another aspect, the present invention concerns an immunogenic composition or
15 combination vaccine or combination as herein disclosed and claimed is effective in the treatment and/or prophylaxis of clinical signs caused by a PPV and/or PRRSV infection in a subject of need. The terms “treatment and/or prophylaxis”, “clinical signs” and “of need” have been defined elsewhere.

[00121] In another aspect, the present invention concerns an immunogenic composition or
20 combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination protects against a homologous and/or a heterologous challenge with PPV and/or a homologous and/or a heterologous challenge with PRRS virus.

[00122] In another aspect, the present invention concerns an immunogenic composition or
25 combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination protects against a challenge with North American and/or European isolates of PPV and/or against a challenge with North American and/or European isolates of PRRS virus.

[00123] In another aspect, the present invention concerns an immunogenic composition or
30 combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination is cross-protective against North American

and/or European isolates of PPV and/or is cross-protective against North American and/or European isolates of PRRS virus.

[00124] In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the immunogenic composition or combination vaccine or combination is effective in the treatment and/or prophylaxis of clinical signs caused by a PPV infection and/or a PRRS virus infection in a subject of need.

[00125] Further, the present invention provides a virus like particle comprising the PPV VP2 as described and claimed herein.

[00126] The term “virus like particle” (VLP) encompasses a non-replicating, empty viral shell from a virus. VLPs are generally composed of one or more viral proteins, such as, but not limited to those proteins referred to as capsid, coat, shell, surface and/or envelope proteins, or particle-forming polypeptides derived from these proteins. VLPs can form spontaneously upon recombinant expression of the protein in an appropriate expression system. The presence of VLPs following recombinant expression of viral proteins can be detected using conventional techniques known in the art, such as by electron microscopy, X-ray crystallography, and the like. See, e.g., Baker et al., Biophys. J. (1991) 60: 1445-1456; Hagensee et al., J. Virol. (1994) 68: 4503-4505. For example, cryoelectron microscopy can be performed on vitrified aqueous samples of the VLP preparation in question, and images recorded under appropriate exposure conditions.

[00127] The term “virus like particle” (VLP) also encompasses VLPs which are composed of a plurality of PPV VP2.

[00128] In another aspect of the present invention the virus like particle is composed of a plurality of the PPV VP2 as described and claimed herein.

[00129] Further, the present invention provides a cell comprising the polynucleotide or the vector as described herein. Preferably, the vector is a baculovirus.

[00130] The term “cell” is well known to the person skilled in the art. The term “cell” encompasses eukaryotic cell such as an animal cell, protist cell, plant cell, or fungal cell. Preferably the eukaryotic cell is a mammalian cell such as CHO, BHK or COS, or a fungal cell such as *Saccharomyces cerevisiae*, or an insect cell such as Sf9.

[00131] In another aspect of the present invention the cell is an insect cell.

[00132] "Insect cell" as used herein means a cell or cell culture derived from an insect species. Of particular interest with respect to the present invention are insect cells derived from the species *Spodoptera frugiperda* and *Trichoplusia ni*.

[00133] Preferably, the insect cell, as mentioned herein, is a *Spodoptera Frugiperda* (Sf) cell or a cell from a cell line derived from *Spodoptera Frugiperda*, and is more preferably selected from the group consisting of Sf9 cell and Sf+ cell. Respectively, the insect cells, as mentioned herein, are preferably *Spodoptera Frugiperda* (Sf) cells or cells from a cell line derived from *Spodoptera Frugiperda*, and are more preferably selected from the group consisting of Sf9 cells and Sf+ cells.

[00134] In another aspect of the present invention the insect cell is selected from the group consisting of Sf9 cells and Sf+ cells.

[00135] Further, the present invention provides a method of producing the PPV VP2 as described and claimed herein, comprising transfecting a cell with the vector as described herein.

[00136] The term "vector" is well known to the person skilled in the art. The term "vector" as it is known in the art refers to a polynucleotide construct, typically a plasmid or a virus, used to transmit genetic material to a host cell. Vectors can be, for example, viruses, plasmids, cosmids, or phage. A vector as used herein can be composed of either DNA or RNA. In some embodiments, a vector is composed of DNA.

[00137] An "expression vector" is a vector that is capable of directing the expression of a protein encoded by one or more genes carried by the vector when it is present in the appropriate environment. Vectors are preferably capable of autonomous replication. Typically, an expression vector comprises a transcription promoter, a gene, and a transcription terminator. Gene expression is usually placed under the control of a promoter, and a gene is said to be "operably linked to" the promoter.

[00138] As used herein, the term "operably linked" is used to describe the connection between regulatory elements and a gene or its coding region. Typically, gene expression is placed under the control of one or more regulatory elements, for example, without limitation, constitutive or inducible promoters, tissue-specific regulatory elements, and enhancers. A gene or coding region is said to be "operably linked to" or "operatively linked to" or "operably associated with" the regulatory elements, meaning that the gene or coding region is controlled or influenced by the regulatory element. For instance, a promoter is operably linked to a coding sequence if the promoter effects transcription or expression of the coding sequence.

[00139] Vectors and methods for making and/or using vectors (or recombinants) for expression can be by or analogous to the methods disclosed in: U.S. Pat. Nos. 4,603,112, 4,769,330, 5,174,993, 5,505,941, 5,338,683, 5,494,807, 4,722,848, 5,942,235, 5,364,773, 5,762,938, 5,770,212, 5,942,235, 382,425, PCT publications WO 94/16716, WO 96/39491, WO 95/30018; Paoletti, "Applications of
5 pox virus vectors to vaccination: An update, "PNAS USA 93: 11349-11353, October 1996; Moss, "Genetically engineered poxviruses for recombinant gene expression, vaccination, and safety," PNAS USA 93: 11341-11348, October 1996; Smith et al., U.S. Pat. No. 4,745,051(recombinant baculovirus); Richardson, C. D. (Editor), Methods in Molecular Biology 39, "Baculovirus Expression Protocols" (1995 Humana Press Inc.); Smith et al., "Production of Human Beta Interferon in Insect
10 Cells Infected with a Baculovirus Expression Vector", Molecular and Cellular Biology, December, 1983, Vol. 3, No. 12, p. 2156-2165; Pennock et al., "Strong and Regulated Expression of Escherichia coli B-Galactosidase in Infect Cells with a Baculovirus vector, "Molecular and Cellular Biology March 1984, Vol. 4, No. 3, p. 406; EPA0 370 573; U.S. application No. 920,197, filed Oct. 16, 1986; EP Patent publication No. 265785; U.S. Pat. No. 4,769,331 (recombinant herpesvirus); Roizman,
15 "The function of herpes simplex virus genes: A primer for genetic engineering of novel vectors," PNAS USA 93:11307-11312, October 1996; Andreansky et al., "The application of genetically engineered herpes simplex viruses to the treatment of experimental brain tumors," PNAS USA 93: 11313-11318, October 1996; Robertson et al., "Epstein-Barr virus vectors for gene delivery to B lymphocytes", PNAS USA 93: 11334-11340, October 1996; Frolov et al., "Alphavirus-based
20 expression vectors: Strategies and applications," PNAS USA 93: 11371-11377, October 1996; Kitson et al., J. Virol. 65, 3068-3075, 1991; U.S. Pat. Nos. 5,591,439, 5,552,143; WO 98/00166; allowed U.S. application Ser. Nos. 08/675,556, and 08/675,566 both filed Jul. 3, 1996 (recombinant adenovirus); Grunhaus et al., 1992, "Adenovirus as cloning vectors," Seminars in Virology (Vol. 3) p. 237-52, 1993; Ballay et al. EMBO Journal, vol. 4, p. 3861-65, Graham, Tibtech 8, 85-87, April, 1990;
25 Prevec et al., J. Gen Virol. 70, 42434; PCT WO 91/11525; Felgner et al. (1994), J. Biol. Chem. 269, 2550-2561, Science, 259: 1745-49, 1993; and McClements et al., "Immunization with DNA vaccines encoding glycoprotein D or glycoprotein B, alone or in combination, induces protective immunity in animal models of herpes simplex virus-2 disease", PNAS USA 93: 11414-11420, October 1996; and U.S. Pat. Nos. 5,591,639, 5,589,466, and 5,580,859, as well as WO 90/11092, WO 93/19183, WO
30 94/21797, WO 95/11307, WO 95/20660; Tang et al., Nature, and Furth et al., Analytical Biochemistry, relating to DNA expression vectors, inter alia. See also WO 98/33510; Ju et al., Diabetologia, 41: 736-739, 1998 (lentiviral expression system); Sanford et al., U.S. Pat. No. 4,945,050; Fischbach et al. (Intracel); WO 90/01543; Robinson et al., Seminars in Immunology vol. 9, pp. 271-283 (1997), (DNA vector systems); Szoka et al., U.S. patent No. 4,394,448 (method of
35 inserting DNA into living cells); McCormick et al., U.S. Pat. No. 5,677,178 (use of cytopathic viruses); and U.S. Pat. No. 5,928,913 (vectors for gene delivery); as well as other documents cited herein.

[00140] The term "regulatory element" and "expression control element" are used interchangeably and refer to nucleic acid molecules that can influence the expression of an operably linked coding sequence in a particular host organism. These terms are used broadly to and cover all elements that promote or regulate transcription, including promoters, core elements required for basic interaction of RNA polymerase and transcription factors, upstream elements, enhancers, and response elements. Exemplary regulatory elements in prokaryotes include promoters, operator sequences and a ribosome binding sites. Regulatory elements that are used in eukaryotic cells can include, without limitation, transcriptional and translational control sequences, such as promoters, enhancers, splicing signals, polyadenylation signals, terminators, protein degradation signals, internal ribosome-entry element (IRES), 2A sequences, and the like, that provide for and/or regulate expression of a coding sequence and/or production of an encoded polypeptide in a host cell.

[00141] As used herein, the term "promoter" is a nucleotide sequence that permits binding of RNA polymerase and directs the transcription of a gene. Typically, a promoter is located in the 5' non-coding region of a gene, proximal to the transcriptional start site of the gene. Sequence elements within promoters that function in the initiation of transcription are often characterized by consensus nucleotide sequences. Examples of promoters include, but are not limited to, promoters from bacteria, yeast, plants, viruses, and mammals (including humans). A promoter can be inducible, repressible, and/or constitutive. Inducible promoters initiate increased levels of transcription from DNA under their control in response to some change in culture conditions, such as a change in temperature.

[00142] As used herein, the term "enhancer" refers to a type of regulatory element that can increase the efficiency of transcription, regardless of the distance or orientation of the enhancer relative to the start site of transcription.

[00143] Generation of a viral vector can be accomplished using any suitable genetic engineering techniques well known in the art, including, without limitation, the standard techniques of restriction endonuclease digestion, ligation, transformation, plasmid purification, and DNA sequencing, for example as described in Sambrook et al. (Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, N.Y. (1989)).

[00144] Further, the present invention provides a method of producing the PPV VP2 as described herein, comprising infecting a cell, preferably an insect cell, with the baculovirus as described herein.

[00145] The compositions may, if desired, be presented in a pack or dispenser device which may contain one or more unit dosage forms containing the active ingredient. The pack may for example comprise metal or plastic foil, such as a blister pack. The pack or dispenser device may be

accompanied by instructions for administration preferably for administration to animals, especially swine. Associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, which notice reflects approval by the agency of manufacture, use or sale for human administration.

5 **[00146]** In another aspect, the present invention concerns an immunogenic composition or combination vaccine or combination as herein disclosed and claimed, wherein the at least one porcine parvovirus (PPV) antigen and the at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen are contained together in one single container or are spatially separated from each other, preferably are contained in two or more separate containers.

10 **[00147]** In another aspect, the present invention concerns a kit comprising the immunogenic composition or combination vaccine or combination as herein disclosed and claimed.

[00148] In another aspect, the present invention concerns a kit as herein disclosed and claimed, wherein the at least one porcine parvo virus (PPV) antigen and the at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen are contained separately from each other in two or
15 more separate containers, preferably both independently from each other either in lyophilized or in frozen form, and wherein the kit further comprises an instruction manual for mixing the spatially separated at least one PPV antigen and at least one PRRS virus antigen, wherein preferably such instruction manual contains directions to combine the contents of the container(s) containing the at least one PPV antigen with the contents of the container(s) containing the at least one PRRS virus
20 antigen, wherein more preferably such instruction manual contains directions that the at least one porcine parvovirus (PPV) antigen and the at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen are to be administered to the subject simultaneously, more preferably separately simultaneously at the same or different administration sites, sequentially (in any order), and/or in a chronologically staggered fashion.

25 **[00149]** In another aspect, the present invention concerns a kit as herein disclosed and claimed, wherein the kit further comprises directions for the treatment and/or prophylaxis of diseases in swine and/or further comprises directions for the treatment and/or prophylaxis of PPV infections and/or PRRS virus infections, preferably such kit further comprises directions for the associated use of the PPV component (preferably as separated kit component) and the PRRSV component (preferably as
30 separated kit component) of the immunogenic composition or combination vaccine or combination as herein disclosed and claimed and contained in such kit.

[00150] The term “associated use” in the scope of the present invention relates to the use of the two vaccines or vaccine components PRRSV and PPV (each independently from each other also

herein referred to as “separated kit component”) by mixing the two vaccines before the administration at one injection site or the administration of the two vaccines at the same time but at different administration sites. Preferably, such two vaccines are administered simultaneously, more preferably separately simultaneously at the same or different administration sites, sequentially (in any order),
5 and/or in a chronologically staggered fashion.

[00151] In another aspect of the present invention the PPV and/or PRRSV of the present invention has been inactivated resulting in whole inactivated virus with a viral protein 2 (VP2) as described herein.

[00152] Any conventional inactivation method can be used for purposes of the present
10 invention. Thus, inactivation can be performed by chemical and/or physical treatments which are known to the person skilled in the art. Preferred inactivation methods include the addition of cyclized binary ethylenimine (BEI) including the addition of a solution of 2-bromoethylethylamine hydrobromide (BEA), which has been cyclized to binary ethylenimine (BEI). Preferred further chemical inactivation agents comprise but are not limited to Triton X-100, Sodium deoxycholate,
15 Cetyltrimethylammonium bromide, β -Propiolactone, Thimerosal, Phenol and Formaldehyde (Formalin). However, the inactivation may also comprise a neutralization step. Preferred neutralization agents include but are not limited to sodium thiosulfate, sodium bisulfite and the like.

[00153] Preferred formalin inactivation conditions include formalin concentration between from about 0,02% (v/v) – 2,0% (v/v), more preferably from about 0,1% (v/v) – 1,0% (v/v), still more
20 preferably from about 0,15% (v/v) – 0,8% (v/v), even more preferably from about 0,16% (v/v) – 0,6% (v/v), and most preferably about 0,2% (v/v) – 0,4% (v/v). Incubation time depends on the resistance of the PPV and/or PRRSV. In general, the inactivation process is performed until no growth of the PPV and/or PRRSV can be detected in a suitable cultivation system.

[00154] Preferably, the inactivated PPV and/or PRRSV of the present invention is formalin
25 inactivated, preferably using the concentrations as described hereinabove.

[00155] Preferably, the inactivated PPV and/or PRRSV of the present invention is cyclized binary ethylenimine (BEI) inactivated, including the addition of a solution of 2-bromoethylethylamine hydrobromide (BEA), which has been cyclized to binary ethylenimine (BEI).

[00156] The inactivated PPV and/or PRRSV of the invention may be incorporated into
30 liposomes using known technology such as that described in Nature, 1974, 252, 252-254 or Journal of Immunology, 1978, 120, 1109-1113. In another embodiment of the invention, the inactivated PPV of the invention may be conjugated to suitable biological compounds such as polysaccharides, peptides, proteins, or the like, or a combination thereof.

[00157] The term "immunizing" relates to an active immunization by the administration of an immunogenic composition to a subject to be immunized, thereby causing an immunological response against the antigen included in such immunogenic composition.

[00158] Preferably, immunization results in lessening of the incidence of the particular PPV and/or PRRSV infection in a herd or in the reduction in the severity of clinical signs caused by or associated with the particular PPV and/or PRRSV infection.

[00159] Further, the immunization of a subject in need with the immunogenic compositions as provided herewith, results in preventing infection of a subject by PPV and/or PRRSV infection. Even more preferably, immunization results in an effective, long-lasting, immunological-response against PPV and/or PRRSV infection. It will be understood that the said period of time will last more than 1 month, preferably more than 2 months, preferably more than 3 months, more preferably more than 4 months, more preferably more than 5 months, more preferably more than 6 months. It is to be understood that immunization may not be effective in all subjects immunized. However, the term requires that a significant portion of subjects of a herd are effectively immunized.

[00160] Preferably, a herd of subjects is envisaged in this context which normally, i.e. without immunization, would develop clinical signs caused by or associated with a PPV and/or PRRSV infection. Whether the subjects of a herd are effectively immunized can be determined without further ado by the person skilled in the art. Preferably, the immunization shall be effective if clinical signs in at least 33%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, still more preferably in at least 95% and most preferably in 100% of the subjects of a given herd are lessened in incidence or severity by at least 10%, more preferably by at least 20%, still more preferably by at least 30%, even more preferably by at least 40%, still more preferably by at least 50%, even more preferably by at least 60%, still more preferably by at least 70%, even more preferably by at least 80%, still more preferably by at least 90%, still more preferably by at least 95% and most preferably by 100% in comparison to subjects that are either not immunized or immunized with an immunogenic composition that was available prior to the present invention but subsequently infected by the particular PPV.

[00161] In another aspect, the present invention concerns the use of the immunogenic composition or combination vaccine or combination or the kit as herein described and claimed for the preparation of a medicament, preferably of a vaccine.

[00162] In another aspect, the present invention concerns the use of the immunogenic composition or combination vaccine or combination or the kit as herein described and claimed for the treatment and/or prevention of an infection with PPV and/or PRRS virus, the reduction, prevention or

treatment of clinical signs caused by an infection with PPV and/or PRRS virus, or for the treatment and/or prevention of a disease caused by an infection with PPV and/or PRRS virus.

[00163] In another aspect, the present invention concerns a method of immunizing a subject comprising administering to such subject an immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed.

[00164] In another aspect, the present invention concerns a method of treating and/or preventing clinical signs caused by a PPV infection and/or a PRRS virus infection, preferably Porcine Reproductive and Respiratory Syndrome, preferably in swine, in a subject of need, the method comprising administering to the subject a therapeutically effective amount of an immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed.

[00165] In another aspect, the present invention concerns a method of reducing the reproductive failure in a subject in comparison to a subject of a non-immunized control group of the same species, the method comprising administering to the subject a therapeutically effective amount of an immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed.

[00166] In another aspect, the present invention concerns a method of reducing embryonic and fetal death in a subject in comparison to a subject of a non-immunized control group of the same species, the method comprising administering to the subject a therapeutically effective amount of an immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed.

[00167] In another aspect, the present invention concerns a method for active immunization of breeding pigs (sows and gilts) for protection of embryos and fetuses against porcine parvovirus infection, the method comprising administering to such pigs (sows and gilts) a therapeutically effective amount of an immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed.

[00168] In another aspect, the present invention concerns the methods as herein described and claimed, wherein said subject is selected from the group consisting of swine, cattle, cat and dog, preferably swine, more preferably sow and/or gilt.

[00169] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is administered once or at two or more doses.

[00170] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is administered intramuscularly.

5 [00171] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is administered to gilts and/or sows, preferably to gilts and/or sows being at least 3 weeks of age, more preferably to gilts and/or sows before pregnancy, even more preferably to sows during pregnancy and lactation.

10 [00172] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is safe for gilts and/or sows during pregnancy and lactation and gilts before pregnancy.

15 [00173] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is safe for sows and/or gilts from 30 days of gestation, preferably from 40 days of gestation.

20 [00174] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) comprises 0.1 µg to 50 µg of the PPV VP2 antigen, preferably 0.5 µg to 10 µg of the PPV VP2 antigen, more preferably 1.0 µg to 10 µg of the PPV VP2 antigen and/or 3.9 to 7.0 log₁₀TCID₅₀ of the PRRS virus.

25 [00175] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) protects against a homologous and/or a heterologous challenge with PPV and/or a homologous and/or a heterologous challenge with PRRS virus.

[00176] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) protects against a challenge with North American and/or European isolates of PPV and/or against a challenge with North American and/or European isolates of PRRS virus.

30 [00177] In another aspect, the present invention concerns the methods as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated

kit components) is cross-protective against North American and/or European isolates of PPV and/or is cross-protective against North American and/or European isolates of PRRS virus.

[00178] In another aspect, the present invention concerns the methods as herein described and claimed, wherein said method results in an improvement of at least one efficacy parameter selected from the group consisting of: reduced transient leukopenia and reproductive failure characterized by embryonic and/or fetal infection and death, or combinations thereof, in comparison to a subject of a non-immunized control group of the same species.

[00179] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for use in a method of immunizing a subject comprising administering said immunogenic composition or combination vaccine or combination to such subject (or separated kit components).

[00180] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for use in a method of treating and/or preventing clinical signs caused by a PPV infection and/or a PRRS virus infection, preferably Porcine Reproductive and Respiratory Syndrome, preferably in swine, in a subject of need, the method comprising administering to the subject a therapeutically effective amount of said immunogenic composition or combination vaccine or combination (or separated kit components).

[00181] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for use in a method of reducing the reproductive failure in a subject in comparison to a subject of a non-immunized control group of the same species, the method comprising administering to the subject a therapeutically effective amount of said immunogenic composition or combination vaccine or combination (or separated kit components).

[00182] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for use in a method of reducing embryonic and fetal death in a subject in comparison to a subject of a non-immunized control group of the same species, the method comprising administering to the subject a therapeutically effective amount of said immunogenic composition or combination vaccine or combination (or separated kit components).

[00183] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for use in a method for active immunization of breeding pigs (sows and gilts) for protection of

embryos and fetuses against porcine parvovirus infection, the method comprising administering to such pigs (sows and gilts) said immunogenic composition or combination vaccine or combination (or separated kit components).

[00184] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein said subject is selected from the group consisting of swine, cattle, cat and dog, preferably swine, more preferably sow and/or gilt.

[00185] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is administered once or at two or more doses.

[00186] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is administered intramuscularly.

[00187] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is administered to gilts and/or sows, preferably to sows being at least 3 weeks of age, more preferably to sows before pregnancy, even more preferably to sows during pregnancy and lactation.

[00188] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is safe for gilts and/or sows during pregnancy and lactation.

[00189] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is safe for gilts and/or sows from 30 days of gestation, preferably from 40 days of gestation.

[00190] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) comprises 0.1 µg to 50 µg of the PPV VP2 antigen, preferably 0.5 µg to 10 µg of the PPV VP2 antigen, more preferably 1.0 µg to 10 µg of the PPV VP2 antigen, and/or 3.9 to 7.0 log₁₀TCID₅₀ of the PRRS virus.

[00191] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) protects against a homologous and/or a heterologous challenge with PPV and/or protects against a homologous and/or a heterologous challenge with PRRS virus.

[00192] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) protects against a challenge with North American and/or European isolates of PPV and/or protects against a challenge with North American and/or European isolates of PRRS virus.

[00193] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein the immunogenic composition or combination vaccine or combination (or separated kit components) is cross-protective against North American and/or European isolates of PPV and/or is cross-protective against North American and/or European isolates of PRRS virus.

[00194] In another aspect, the present invention concerns the immunogenic composition or combination vaccine or combination (or separated kit components) as herein described and claimed for the use as herein described and claimed, wherein said method results in an improvement of at least one efficacy parameter selected from the group consisting of: reduced transient leukopenia and reproductive failure characterized by embryonic and/or fetal infection and death, or combinations thereof, in comparison to a subject of a non-immunized control group of the same species.

[00195] The term “treatment and/or prophylaxis” refers to the lessening of the incidence of the particular PPV and/or PRRSV infection in a herd or the reduction in the severity of clinical signs caused by or associated with the particular PPV and/or PRRSV infection. Thus, the term “treatment

and/or prophylaxis” also refers to the reduction of the number of animals in a herd that become infected with the particular PPV and/or PRRSV (= lessening of the incidence of the particular PPV and/or PRRSV infection) or to the reduction of the severity of clinical signs normally associated with or caused by a PPV and/or PRRSV infection in a group of animals which animals have received an effective amount of the immunogenic composition or combination vaccine or combination as provided herein in comparison to a group of animals which animals have not received such the immunogenic composition or combination vaccine or combination.

[00196] The “treatment and/or prophylaxis” generally involves the administration of an effective amount of the immunogenic composition or combination vaccine or combination of the present invention to a subject or herd of subjects in need of or that could benefit from such a treatment/prophylaxis. The term “treatment” refers to the administration of the effective amount of the immunogenic composition or combination vaccine or combination once the subject or at least some animals of the herd is/are already infected with such PPV and/or PRRSV and wherein such animals already show some clinical signs caused by or associated with such PPV and/or PRRSV infection. The term “prophylaxis” refers to the administration of a subject prior to any infection of such subject with PPV and/or PRRSV or at least where such animal or none of the animals in a group of animals do not show any clinical signs caused by or associated with the infection by such PPV and/or PRRSV. The terms “prophylaxis” and “preventing” are used interchangeably in this application.

[00197] The term “an effective amount” as used herein means, but is not limited to an amount of antigen, that elicits or is able to elicit an immune response in a subject. Such effective amount is able to lessen the incidence of the particular PPV and/or PRRSV infection in a herd or to reduce the severity of clinical signs of the particular PPV and/or PRRSV infection.

[00198] Preferably, clinical signs are lessened in incidence or severity by at least 10%, more preferably by at least 20%, still more preferably by at least 30%, even more preferably by at least 40%, still more preferably by at least 50%, even more preferably by at least 60%, still more preferably by at least 70%, even more preferably by at least 80%, still more preferably by at least 90%, still more preferably by at least 95% and most preferably by 100% in comparison to subjects that are either not treated or treated with an immunogenic composition or combination vaccine or combination that was available prior to the present invention but subsequently infected by the particular PPV and/or PRRSV.

[00199] The term “clinical signs” as used herein refers to signs of infection of a subject from PPV and/or PRRSV. The clinical signs of infection depend on the pathogen selected. Examples for such clinical signs include but are not limited to reduced transient leukopenia and reproductive failure characterized by embryonic and/or fetal infection and death, or combinations thereof. Examples for

clinical signs that are directly observable include reduced litter size, increased mummification of the embryo or fetus per litter, autolysation of the embryo or fetus, reduced size of the embryo or fetus, reduced weight of the embryo or fetus and the alike or combinations thereof. Further examples of such clinical signs include but are not limited to increased viremia, increased viral load within the targeted tissues and blood, increased transmission/shed spread of PPV to pen mates and the alike or combinations thereof.

[00200] Preferably, the clinical signs lessened in incidence or severity in a treated subject compared to subjects that are either not treated or treated with an immunogenic composition that was available prior to the present invention but subsequently infected by the particular PPV and/or PRRSV refer to a transient leukopenia and reproductive failure characterized by embryonic and/or fetal infection and death, or combinations thereof.

[00201] The term “in need” or “of need”, as used herein means that the administration/treatment is associated with the boosting or improvement in health or clinical signs or any other positive medicinal effect on health of the animals (including its embryos or fetuses) which receive the immunogenic composition in accordance with the present invention.

[00202] The term “reducing” or “reduced” or “reduction” or lower” are used interchangeably in this application. The term “reduction” means, that the clinical sign is reduced by at least 10%, more preferably by at least 20%, still more preferably by at least 30%, even more preferably by at least 40%, still more preferably by at least 50%, even more preferably by at least 60%, still more preferably by at least 70%, even more preferably by at least 80%, even more preferably by at least 90%, still more preferably by at least 95% most preferably by 100% in comparison to subjects that are not treated (not immunized) but subsequently infected by the particular PPV and/or PRRSV.

[00203] In one aspect of the present invention the immunogenic composition or combination vaccine or combination (or separated kit components) as described and claimed herein is administered once. It is understood, that a single-dose is administered only once.

[00204] The dose volume per subject depends on the route of vaccination and the age of the subject. Preferably, the single-dose has a total volume between about 0.2 ml and 2.5 ml, more preferably between about 0.2 ml and 2.0 ml, even more preferably between about 0.2 ml and 1.75 ml, still more preferably between about 0.2 ml and 1.5 ml, even more preferably between about 0.4 ml and 1.25 ml, even more preferably between about 0.4 ml and 1.0 ml with a single 0.5 ml dose or 1.0 ml dose being the most preferred. Most preferred the single-dose has a total volume of 0.5 ml, 1 ml, 1.5 ml or 2 ml.

[00205] In one aspect of the present invention the immunogenic composition or combination vaccine or combination (or separated kit components) as described and claimed herein is administered at two or more doses.

[00206] However, the immunogenic composition or combination vaccine or combination can be administered at two or more doses, with a first dose being administered prior to the administration of a second (booster) dose. Preferably, the second dose is administered at least 15 days after the first dose. More preferably, the second dose is administered between 15 days and 40 days after the first dose. Even more preferably, the second dose is administered at least 17 days after the first dose. Still more preferably, the second dose is administered between 17 days and 30 days after the first dose. Even more preferably, the second dose is administered at least 19 days after the first dose. Still more preferably, the second dose is administered between 19 days and 25 days after the first dose. Most preferably the second dose is administered at least 21 days after the first dose. Even more preferably, the second dose is administered at about 21 days after the first dose or at 21 days after the first dose. In a preferred aspect of the two-time administration regimen, both the first and second doses of the immunogenic composition are administered in the same amount. Preferably, each dose is in the preferred amounts specified above, with a dose of 1 ml or 2 ml for the first and second dose being most preferred. In addition to the first and second dose regimen, an alternate embodiment comprises further subsequent doses. For example, a third, fourth, or fifth dose could be administered in these aspects. Preferably, subsequent third, fourth, and fifth dose regimens are administered in the same amount as the first dose, with the time frame between the doses being consistent with the timing between the first and second doses mentioned above. The above administration regimens are preferably applied for gilts only. Sows are preferably only administered the immunogenic composition or combination vaccine or combination as a single administration/single shot.

[00207] In one aspect of the present invention the subject is selected from the group consisting of swine, cattle, cat and dog.

[00208] Preferably, the subject is swine. It has to be understood that swine comprises female and male animals. Semen may contain PPV and, for that reason female and male breeding animals are encompassed by the wording "swine". Thus, the wording "swine" comprises male animals such as boars as well as female animals such as gilts and sows.

[00209] The term "gilt", as used herein, refers to a porcine, preferably a pig, before and during first gestation/pregnancy. In contrast, the term "sow", as used herein, refers to a porcine, preferably a pig, after first farrowing, – as a positive result of its first gestation/pregnancy.

[00210] The dose volume per subject depends on the route of vaccination and the age of the subject. Preferably, the total volume is between about 0.2 ml and 5 ml, more preferably between about 0.5 ml and 3.0 ml, even more preferably between about 1.0 ml and 2.5 ml, even more preferably between about 1.0 ml and 2.0 ml. Most preferred the volume is 1 ml, 1.5 ml, 2 ml or 2.5 ml per dose.

5 [00211] The immunogenic composition or combination vaccine or combination (or separated kit components) is, preferably, administered topically or systemically. Suitable routes of administration conventionally used are oral or parenteral administration, such as intranasal, intravenous, intradermal, transdermal, intramuscular, intraperitoneal, subcutaneous, as well as inhalation. However, depending on the nature and mode of action of a compound, the immunogenic composition may be administered
10 by other routes as well. For example, such other routes include intracutaneously, intravenously, intravascularly, intraarterially, intraperitoneally, intrathecally, intratracheally, intracutaneously, intracardially, intralobally, intralobarly, intramedullary, intrapulmonarily, intrarectally, and intravaginally. However, more preferred the immunogenic composition or combination vaccine or combination is administered subcutaneously or intramuscularly. Most preferred the immunogenic
15 composition or combination vaccine or combination is administered intramuscular.

[00212] The following clauses are described herein:

[00213] 1. An immunogenic composition or a combination vaccine or a combination comprising

(a) at least one porcine parvo virus (PPV) antigen, wherein the at least one PPV antigen is any antigen contained in PPV, and

20 (b) at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen, wherein the at least one PRRS virus antigen is any antigen contained in PRRS virus.

[00214] 2. The immunogenic composition or combination vaccine or combination according to clause 1, wherein the PPV is selected from the group consisting of: live attenuated/modified live PPV virus, killed/inactivated PPV virus (e.g. Porcine Parvo), killed/inactivated PPV strain 014, German
25 field isolates of Porcine parvovirus PPV-27a and PPV-143a and Porcine parvovirus vaccine viruses PPV-NADL-2 and PPV-IDT (MSV).

[00215] 3. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 2, wherein the at least one PPV antigen is one or more PPV subunit(s).

[00216] 4. The immunogenic composition or combination vaccine or combination according to
30 any one of clauses 1 to 3, wherein the at least one PPV subunit(s) is PPV viral protein 2 (VP2).

[00217] 5. The immunogenic composition or combination vaccine or combination according to clause 4, wherein the PPV VP2 is the only PPV antigen.

[00218] 6. The immunogenic composition or combination vaccine or combination according to any one of clauses 4 to 5, wherein the PPV VP2 has

- 5
- at amino acid position 228 a glutamic acid residue or a glutamate residue, and/or
 - at amino acid position 414 a serine residue, and/or
 - at amino acid position 419 a glutamine residue, and/or
 - at amino acid position 436 a threonine residue,

10 wherein the numbering of the amino acid positions refers to the amino acid sequence of wild type PPV VP2.

[00219] 7. The immunogenic composition or combination vaccine or combination according to clause 6, wherein the PPV VP2 further has

- 15
- at amino acid position 25 an isoleucine residue, and/or
 - at amino acid position 36 a serine residue, and/or
 - at amino acid position 37 an isoleucine residue.

[00220] 8. The immunogenic composition or combination vaccine or combination according to any one of clauses 6 to 7, wherein the numbering of the amino acid positions refers to the amino acid sequence as shown in SEQ ID NO:1.

20 [00221] 9. The immunogenic composition or combination vaccine or combination according to any one of clauses 4 to 8, wherein the PPV VP2 is a recombinant PPV VP2.

[00222] 10. The immunogenic composition or combination vaccine or combination according to clause 9, wherein the PPV VP2 is a recombinant baculovirus expressed PPV VP2.

25 [00223] 11. The immunogenic composition or combination vaccine or combination according to any one of clauses 4 to 10, wherein the PPV VP2 comprises or consists of an amino acid sequence having at least 90% sequence identity with the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NO:5 to 16.

30 [00224] 12. The immunogenic composition or combination vaccine or combination according to clause 11, wherein the PPV VP2 comprises or consists of an amino acid sequence having at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.1%, at least 99.2%, at least 99.3%, at least 99.4%, at least

99.5%, at least 99.6%, at least 99.7%, at least 99.8%, or at least 99.9% sequence identity with the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NO:5 to 16.

[00225] 13. The immunogenic composition or combination vaccine or combination according to clause 12, wherein the PPV VP2 comprises or consists of the amino acid sequence of
 5 SEQ ID NO:1, SEQ ID NO:2 or SEQ ID NO:5 to 16 or comprises or consists of any fragment having at least 210, at least 250 or at least 300 contiguous amino acid residues from SEQ ID NO:1, SEQ ID NO:2 or SEQ ID NO:5 to 16.

[00226] 14. The immunogenic composition or combination vaccine or combination according to clause 13, wherein the PPV VP2 comprises or consists of the amino acid sequence of
 10 SEQ ID NO:1, SEQ ID NO:2 or SEQ ID NO:5 to 16.

[00227] 15. The immunogenic composition or combination vaccine or combination according to any one of clauses 4 to 14, wherein the PPV VP2 is encoded by a nucleotide sequence encoding an amino acid sequence having at least 90% sequence identity with the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NO:5 to 16.

[00228] 16. The immunogenic composition or combination vaccine or combination according to clause 15, wherein the PPV VP2 is encoded by a nucleotide sequence encoding an amino acid sequence having at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.1%, at least 99.2%, at least 99.3%, at least 99.4%, at least 99.5%, at least 99.6%, at least 99.7%, at least 99.8%, or at least 99.9% sequence
 20 identity with the amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NO:5 to 16.

[00229] 17. The immunogenic composition or combination vaccine or combination according to clause 16, wherein the PPV VP2 is encoded by a nucleotide sequence encoding an amino acid sequence of SEQ ID NO:1, SEQ ID NO:2 or SEQ ID NO:5 to 16.

[00230] 18. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 16, wherein the PRRS virus is selected from the group consisting of: PRRS virus genotype 1, PRRS virus genotype 2, PRRS virus genotype 1 comprising a genome encoded by a nucleotide sequence having at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.1%, at least 99.2%, at least 99.3%, at least 99.4%, at least 99.5%, at least 99.6%, at least 99.7%, at least 99.8%, at
 25 least 99.9%, or 100% identity with the nucleic acid sequence of SEQ ID NO:17 (Lelystad wild-type sequence), PRRS virus genotype 2 comprising a genome encoded by a nucleotide sequence having at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99.1%, at least 99.2%, at least 99.3%, at least 99.4%, at least
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99,5%, at least 99,6%, at least 99,7%, at least 99,8%, at least 99,9%, or 100% identity with the nucleic acid sequence of SEQ ID NO:18 (VR2332 wild-type sequence).

[00231] 19. The immunogenic composition or combination vaccine or combination according to clause 18, wherein the PRRS virus is selected from the group consisting of: live
5 attenuated/modified live PRRS virus, live attenuated/modified live PRRS virus type 1 genotype (e.g. Porcilis PRRS, Unistrain PRRS, Amervac PRRS), live attenuated/modified live PRRS virus type 2 genotype (e.g. Ingelvac® PRRS MLV, Foster PRRS), live attenuated/modified live PRRS virus strain 94881 [(genotype 1), ReproCyc® PRRS EU], killed/inactivated PRRS virus, killed/inactivated PRRS virus type 1 genotype (e.g. Progressis), killed/inactivated PRRS virus type 2 genotype, Lelystad
10 virus strain (CDI-NL-2.91, Institut Pasteur, Paris, France, deposit number I-1102), PRRS virus subunit(s), or other strains such as those deposited under the Accession Numbers ECACC 04102703, ECACC 04102702, ECACC 04102704, CNCM Accession No. I-1140, CNCM Accession No I-1387, CNCM Accession No I-1388, ATCC VR 2332, VR 2385, VR 2386, VR 2429, VR 2474, and VR 2402; CNCM I-1102, CNCM I-1140, CNCM I-1387, CNCM I-1388, or ECACC V93070108, North
15 American PRRS virus pT7P129A (ATCC Accession No. 203488), ATCC deposit VR-2332, ATCC deposit VR-2368; ATCC VR-2495; ATCC VR 2385, ATCC VR 2386, ATCC VR 2429, ATCC VR 2474, and ATCC VR 2402.

[00232] 20. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 19, wherein the at least one PPV antigen is one or more PPV
20 subunit(s), preferably wherein the at least one PPV antigen is PPV viral protein 2 (VP2), wherein more preferably the PPV VP2 is the only PPV antigen, and wherein the at least one PRRS virus antigen is live attenuated/modified live PRRS virus, preferably live attenuated/modified live PRRS virus type 1 genotype (e.g. Porcilis PRRS, Unistrain PRRS, Amervac PRRS), more preferably live attenuated/modified live PRRS virus strain 94881 [(genotype 1), ReproCyc® PRRS EU] and live
25 attenuated/modified live PRRS virus type 2 genotype (e.g. Ingelvac® PRRS MLV, Foster PRRS).

[00233] 21. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 20, wherein the immunogenic composition or combination vaccine or combination is formulated for a single-dose administration or a two-dose administration.

[00234] 22. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 21, wherein the immunogenic composition or combination
30 vaccine or combination is administered intramuscularly.

[00235] 23. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 22, wherein the immunogenic composition or combination vaccine or combination is safe for gilts and/or sows during pregnancy and lactation.

[00236] 24. The immunogenic composition or combination vaccine or combination of according to clause 23, wherein the immunogenic composition or combination vaccine or combination is safe for gilts and/or sows from 30 days of gestation, preferably from 40 days of gestation.

[00237] 25. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 24, wherein the immunogenic composition or combination vaccine or combination further comprises at least one pharmaceutically acceptable carrier.

[00238] 26. The immunogenic composition or combination vaccine or combination according to clause 25, wherein the at least one pharmaceutically acceptable carrier is a carbomer.

[00239] 27. The immunogenic composition or combination vaccine or combination according to any one of clauses 4 to 26, wherein the immunogenic composition or combination vaccine or combination comprises 0.1 µg to 50 µg of the PPV VP2 antigen, preferably 0.5 µg to 10 µg of the PPV VP2 antigen, more preferably 1.0 µg to 10 µg of the PPV VP2 antigen, and/or 3.9 to 7.0 log₁₀TCID₅₀ of the PRRS virus.

[00240] 28. The immunogenic composition or combination according to any one of clauses 1 to 27, wherein the immunogenic composition or combination is a vaccine.

[00241] 29. The immunogenic composition or combination vaccine or combination of according to any one of clauses 1 to 28, wherein the immunogenic composition or combination vaccine or combination protects against a homologous and/or a heterologous challenge with PPV and/or a homologous and/or a heterologous challenge with PRRS virus.

[00242] 30. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 29, wherein the immunogenic composition or combination vaccine or combination protects against a challenge with North American and/or European isolates of PPV and/or against a challenge with North American and/or European isolates of PRRS virus.

[00243] 31. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 30, wherein the immunogenic composition or combination vaccine or combination is cross-protective against North American and/or European isolates of PPV and/or is cross-protective against North American and/or European isolates of PRRS virus.

[00244] 32. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 31, wherein the immunogenic composition or combination vaccine or combination is effective in the treatment and/or prophylaxis of clinical signs caused by a PPV infection and/or a PRRS virus infection in a subject of need.

5 [00245] 33. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 31, wherein the at least one porcine parvovirus (PPV) antigen and the at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen are contained together in one single container or are spatially separated from each other, preferably are contained in two or more separate containers.

10 [00246] 34. A kit comprising the immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33.

[00247] 35. The kit according to clause 34, wherein the at least one porcine parvo virus (PPV) antigen and the at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen are contained separately from each other in two or more separate containers, preferably both
15 independently from each other either in lyophilized or in frozen form, and wherein the kit further comprises an instruction manual for mixing the spatially separated at least one PPV antigen and at least one PRRS virus antigen, wherein preferably such instruction manual contains directions to combine the contents of the container(s) containing the at least one PPV antigen with the contents of the container(s) containing the at least one PRRS virus antigen, wherein more preferably the liquid
20 contents of the container(s) containing the at least one PPV antigen are used as a diluent for the lyophilized contents of the container(s) containing the at least one PRRS virus antigen.

[00248] 36. The kit according to any one of clauses 34 to 35, wherein the kit further comprises directions for the treatment and/or prophylaxis of diseases in swine and/or further comprises directions for the treatment and/or prophylaxis of PPV infections and/or PRRS virus
25 infections, preferably such kit further comprises directions for the associated use of the PPV component and the PRRSV component of the immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33.

[00249] 37. Use of the immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33 or the kit according to any one of clauses 34 to 36 for the
30 preparation of a medicament, preferably of a vaccine.

[00250] 38. The use according to clause 37 for the preparation of a medicament for the treatment and/or prevention of an infection with PPV and/or PRRS virus, the reduction, prevention or

treatment of clinical signs caused by an infection with PPV and/or PRRS virus, or for the treatment and/or prevention of a disease caused by an infection with PPV and/or PRRS virus.

[00251] 39. A method of immunizing a subject comprising administering to such subject an immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33.

[00252] 40. A method of treating and/or preventing clinical signs caused by a PPV infection and/or a PRRS virus infection, preferably Porcine Reproductive and Respiratory Syndrome, preferably in swine, in a subject of need, the method comprising administering to the subject a therapeutically effective amount of an immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33.

[00253] 41. A method of reducing the reproductive failure in a subject in comparison to a subject of a non-immunized control group of the same species, the method comprising administering to the subject a therapeutically effective amount of an immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33.

[00254] 42. A method of reducing embryonic and fetal death in a subject in comparison to a subject of a non-immunized control group of the same species, the method comprising administering to the subject a therapeutically effective amount of an immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33.

[00255] 43. The method according to any one of clauses 39 to 42, wherein said subject is selected from the group consisting of swine, cattle, cat and dog, preferably swine, more preferably sow and/or gilt.

[00256] 44. The method according to any one of clauses 39 to 43, wherein the immunogenic composition or combination vaccine or combination is administered once or at two or more doses.

[00257] 45. The method according to any one of clauses 39 to 44, wherein the immunogenic composition or combination vaccine or combination is administered intramuscularly.

[00258] 46. The method according to any one of clauses 39 to 45, wherein the immunogenic composition or combination vaccine or combination is administered to gilts and/or sows, preferably to sows being at least 3 weeks of age, more preferably to sows before pregnancy, even more preferably to sows during pregnancy and lactation.

[00259] 47. The method according to any one of clauses 39 to 46, wherein the immunogenic composition or combination vaccine or combination is safe for gilts and/or sows during pregnancy and lactation.

[00260] 48. The method according to any one of clauses 39 to 47, wherein the immunogenic composition or combination vaccine or combination is safe for sows and/or gilts from 30 days of gestation, preferably from 40 days of gestation.

[00261] 49. The method according to any one of clauses 39 to 48, wherein the immunogenic composition or combination vaccine or combination comprises 0.1 µg to 50 µg of the PPV VP2 antigen, preferably 0.5 µg to 10 µg of the PPV VP2 antigen, more preferably 1.0 µg to 10 µg of the PPV VP2 antigen, and/or 3.9 to 7.0 log₁₀ TCID₅₀ of the PRRS virus.

[00262] 50. The method according to any one of clauses 39 to 49, wherein the immunogenic composition or combination vaccine or combination protects against a homologous and/or a heterologous challenge with PPV and/or a homologous and/or a heterologous challenge with PRRS virus.

[00263] 51. The method according to any one of clauses 39 to 50, wherein the immunogenic composition or combination vaccine or combination protects against a challenge with North American and/or European isolates of PPV and/or against a challenge with North American and/or European isolates of PRRS virus.

[00264] 52. The method according to any one of clauses 39 to 51, wherein the immunogenic composition or combination vaccine or combination is cross-protective against North American and/or European isolates of PPV and/or is cross-protective against North American and/or European isolates of PRRS virus.

[00265] 53. The method according to any one of clauses 39 to 52, wherein said method results in an improvement of at least one efficacy parameter selected from the group consisting of: reduced transient leukopenia and reproductive failure characterized by embryonic and/or fetal infection and death, or combinations thereof, in comparison to a subject of a non-immunized control group of the same species.

[00266] 54. The method according to any one of clauses 39 to 53, wherein the at least one porcine parvovirus (PPV) antigen and the at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen are administered to the subject simultaneously, preferably separately simultaneously at the same or different administration sites, sequentially (in any order), and/or in a chronologically staggered fashion.

[00267] 55. The method according to any one of clauses 39 to 54 for active immunization of breeding pigs (sows and gilts) for protection of embryos and fetuses against porcine parvovirus infection comprising administering to such pigs (sows and gilts) an immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33.

5 [00268] 56. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33 for use in a method of immunizing a subject comprising administering said immunogenic composition or combination vaccine or combination to such subject.

[00269] 57. The immunogenic composition or combination vaccine or combination according to any one of clauses 1 to 33 for use in a method of treating and/or preventing clinical signs
10 caused by a PPV infection and/or a PRRS virus infection, preferably Porcine Reproductive and Respiratory Syndrome, preferably in swine, in a subject of need, the method comprising administering to the subject a therapeutically effective amount of said immunogenic composition or combination vaccine or combination.

[00270] 58. The immunogenic composition or combination vaccine or combination
15 according to any one of clauses 1 to 33 for use in a method of reducing the reproductive failure in a subject in comparison to a subject of a non-immunized control group of the same species, the method comprising administering to the subject a therapeutically effective amount of said immunogenic composition or combination vaccine or combination.

[00271] 59. The immunogenic composition or combination vaccine or combination
20 according to any one of clauses 1 to 33 for use in a method of reducing embryonic and fetal death in a subject, in comparison to a subject of a non-immunized control group of the same species, the method comprising administering to the subject a therapeutically effective amount of said immunogenic composition or combination vaccine or combination.

[00272] 60. The immunogenic composition or combination vaccine or combination
25 according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 59, wherein said subject is selected from the group consisting of swine, cattle, cat and dog, preferably swine, more preferably sow and/or gilt.

[00273] 61. The immunogenic composition or combination vaccine or combination
30 according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 60, wherein the immunogenic composition or combination vaccine or combination is administered once or at two or more doses.

[00274] 62. The immunogenic composition or combination vaccine or combination according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 61, wherein the immunogenic composition or combination vaccine or combination is administered intramuscularly.

5 [00275] 63. The immunogenic composition or combination vaccine or combination according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 62, wherein the immunogenic composition or combination vaccine or combination is administered to gilts and/or sows, preferably to sows being at least 3 weeks of age, more preferably to sows before pregnancy, even more preferably to sows during pregnancy and lactation.

10 [00276] 64. The immunogenic composition or combination vaccine or combination according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 63, wherein the immunogenic composition or combination vaccine or combination is safe for gilts and/or sows during pregnancy and lactation.

[00277] 65. The immunogenic composition or combination vaccine or combination
15 according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 64, wherein the immunogenic composition or combination vaccine or combination is safe for gilts and/or sows from 30 days of gestation, preferably from 40 days of gestation.

[00278] 66. The immunogenic composition or combination vaccine or combination
20 according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 65, wherein the immunogenic composition or combination vaccine or combination comprises 0.1 µg to 50 µg of the PPV VP2 antigen, preferably 0.5 µg to 10 µg of the PPV VP2 antigen, more preferably 1.0 µg to 10 µg of the PPV VP2 antigen, and/or 3.9 to 7.0 log₁₀TCID₅₀ of the PRRS virus.

[00279] 67. The immunogenic composition or combination vaccine or combination
25 according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 66, wherein the immunogenic composition or combination vaccine or combination protects against a homologous and/or a heterologous challenge with PPV and/or protects against a homologous and/or a heterologous challenge with PRRS virus.

[00280] 68. The immunogenic composition or combination vaccine or combination
30 according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 67, wherein the immunogenic composition or combination vaccine or combination protects against a challenge with North American and/or European isolates of PPV and/or protects against a challenge with North American and/or European isolates of PRRS virus.

[00281] 69. The immunogenic composition or combination vaccine or combination according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 68, wherein the immunogenic composition or combination vaccine or combination is cross-protective against North American and/or European isolates of PPV and/or is cross-protective against North American and/or European isolates of PRRS virus.

[00282] 70. The immunogenic composition or combination vaccine or combination according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 69, wherein said method results in an improvement of at least one efficacy parameter selected from the group consisting of: transient leukopenia and reproductive failure characterized by embryonic and/or fetal infection and death, or combinations thereof, in comparison to a subject of a non-immunized control group of the same species.

[00283] 71. The immunogenic composition or combination vaccine or combination according to of any one of clauses 1 to 33 for the use according to any one of clauses 56 to 70, wherein the at least one porcine parvovirus (PPV) antigen and the at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen are administered to the subject simultaneously, preferably separately simultaneously at the same or different administration sites, sequentially (in any order), and/or in a chronologically staggered fashion.

[00284] 72. The immunogenic composition or combination vaccine or combination according to of any one of clauses 1 to 33 for use in a method for active immunization of breeding pigs (sows and gilts) for protection of embryos and fetuses against porcine parvovirus infection comprising administering said immunogenic composition or combination vaccine or combination to such pigs (sows and gilts).

[00285] **Second consideration of the present invention**

[00286] In one aspect, the present invention concerns a method of producing an immunogenic composition comprising a recombinant protein, wherein the method comprises the steps in the following order:

- (i) providing/obtaining a mixture comprising
 - a first liquid,
 - recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein, and
 - a vector comprising a nucleic acid sequence encoding said recombinant protein;
- (ii) adding a second liquid to the mixture of step (i), wherein the second liquid is different from the first liquid;

- (iii) washing, and optionally finally concentrating, the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein in the mixture by further adding additional second liquid to the mixture resulting from step (ii) and removing a portion of the first and/or second liquid from such combined mixture;
- (iv) inactivating the vector by adding an inactivating agent to the mixture resulting from step (iii);
- (v) neutralizing the inactivating agent by adding a neutralizing agent to the mixture resulting from step (iv).

[00287] For purposes of the present invention, a “first liquid” refers to liquid, aqueous, or fluid media typically used in combination with cells, antigens, immunogenic compositions, vaccines, and the like. Preferably, the first liquid comprises media from an antigenic composition; more preferably, the first liquid comprises or preferably consists of cell culture media used for the production of recombinant proteins in cultivated host cells. Said cultivated host cells can be bacteria, yeasts, insect cells, animal cells, and mammalian cells, with insect and mammalian cells being particularly preferred. Thus, the first liquid may comprise or consist of media for the cultivation of bacteria, yeast, insect cells, animal cells or mammalian cells. Preferably, the cell media is serum free cell media, and most preferably the culture media is Excell 420 serum free media, when insect cells are used.

[00288] A “second liquid”, for purposes of the present invention, refers to any liquid normally used in combination with cells, antigen, immunogenic compositions, vaccines, and the like, which is different from the first liquid. Preferably, the second liquid is an aqueous solution, even more preferably a pharmaceutically acceptable solution, and even more preferably a buffer, such as a saline or phosphate buffer and the like. Most preferably, the second liquid is characterized by not being virucidal to any live virus or live bacteria, when the live virus or live bacteria is cultivated in or stored in such a liquid.

[00289] “Portion”, for purposes of the present invention, refers to any amount which does not encompass the entire amount. For example, a portion of liquid would be anything less than 100% of the volume of the liquid, such as 90% of the liquid, 80% of the liquid, 70% of the liquid, and all amounts between more than 0% and less than 100%.

[00290] “Recombinant protein”, for purposes of the present invention, refers to any recombinant protein, preferably to a PPV VP2 protein, more preferably comprising or consisting of a sequence having at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99,1%, at least 99,2%, at least 99,3%, at least 99,4%, at least 99,5%, at least 99,6%, at least 99,7%, at

least 99,8%, at least 99,9%, or 100% sequence identity with the sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NOS 5 to 16.

[00291] "Quaternary structures" as well as "quaternary structures composed of a plurality of said recombinant protein", for purposes of the present invention, refers to a three-dimensional arrangement of a plurality of said recombinant protein, such as virus-like particles and/or homotrimers.

[00292] "Vector" as well as "vector comprising a nucleic acid sequence encoding said recombinant protein", for purposes of the present invention, refers to suitable expression vector, preferably a baculovirus expression vector, which is in turn used to transfect, or in case of a baculovirus expression vector to infect, a host cell to produce the protein or polypeptide encoded by the DNA.

[00293] Vectors and methods for making and/or using vectors (or recombinants) for expression can be by or analogous to the methods disclosed in: U.S. Pat. Nos. 4,603,112, 4,769,330, 5,174,993, 5,505,941, 5,338,683, 5,494,807, 4,722,848, 5,942,235, 5,364,773, 5,762,938, 5,770,212, 5,942,235, 382,425, PCT publications WO 94/16716, WO 96/39491, WO 95/30018; Paoletti, "Applications of pox virus vectors to vaccination: An update," PNAS USA 93: 11349-11353, October 1996; Moss, "Genetically engineered poxviruses for recombinant gene expression, vaccination, and safety," PNAS USA 93: 11341-11348, October 1996; Smith et al., U.S. Pat. No. 4,745,051(recombinant baculovirus); Richardson, C. D. (Editor), Methods in Molecular Biology 39, "Baculovirus Expression Protocols" (1995 Humana Press Inc.); Smith et al., "Production of Human Beta Interferon in Insect Cells Infected with a Baculovirus Expression Vector", Molecular and Cellular Biology, December, 1983, Vol. 3, No. 12, p. 2156-2165; Pennock et al., "Strong and Regulated Expression of Escherichia coli B-Galactosidase in Infect Cells with a Baculovirus vector, "Molecular and Cellular Biology March 1984, Vol. 4, No. 3, p. 406; EPA0 370 573; U.S. application No. 920,197, filed Oct. 16, 1986; EP Patent publication No. 265785; U.S. Pat. No. 4,769,331 (recombinant herpesvirus); Roizman, "The function of herpes simplex virus genes: A primer for genetic engineering of novel vectors," PNAS USA 93:11307-11312, October 1996; Andreansky et al., "The application of genetically engineered herpes simplex viruses to the treatment of experimental brain tumors," PNAS USA 93: 11313-11318, October 1996; Robertson et al., "Epstein-Barr virus vectors for gene delivery to B lymphocytes", PNAS USA 93: 11334-11340, October 1996; Frolov et al., "Alphavirus-based expression vectors: Strategies and applications," PNAS USA 93: 11371-11377, October 1996; Kitson et al., J. Virol. 65, 3068-3075, 1991; U.S. Pat. Nos. 5,591,439, 5,552,143; WO 98/00166; allowed U.S. application Ser. Nos. 08/675,556, and 08/675,566 both filed Jul. 3, 1996 (recombinant adenovirus); Grunhaus et al., 1992, "Adenovirus as cloning vectors," Seminars in Virology (Vol. 3) p. 237-52, 1993; Ballay et al. EMBO Journal, vol. 4, p. 3861-65, Graham, Tibtech 8, 85-87, April, 1990;

Prevec et al., J. Gen Virol. 70, 42434; PCT WO 91/11525; Felgner et al. (1994), J. Biol. Chem. 269, 2550-2561, Science, 259: 1745-49, 1993; and McClements et al., "Immunization with DNA vaccines encoding glycoprotein D or glycoprotein B, alone or in combination, induces protective immunity in animal models of herpes simplex virus-2 disease", PNAS USA 93: 11414-11420, October 1996; and
 5 U.S. Pat. Nos. 5,591,639, 5,589,466, and 5,580,859, as well as WO 90/11092, WO93/19183, WO94/21797, WO95/11307, WO95/20660; Tang et al., Nature, and Furth et al., Analytical Biochemistry, relating to DNA expression vectors, inter alia. See also WO 98/33510; Ju et al., Diabetologia, 41: 736-739, 1998 (lentiviral expression system); Sanford et al., U.S. Pat. No. 4,945,050; Fischbach et al. (Intracel); WO 90/01543; Robinson et al., Seminars in Immunology vol. 9,
 10 pp. 271-283 (1997), (DNA vector systems); Szoka et al., U.S. patent No. 4,394,448 (method of inserting DNA into living cells); McCormick et al., U.S. Pat. No. 5,677,178 (use of cytopathic viruses); and U.S. Pat. No. 5,928,913 (vectors for gene delivery); as well as other documents cited herein.

[00294] Preferred cells are those susceptible for infection with an appropriate recombinant viral vector, containing a recombinant protein DNA and expressing the recombinant protein. Preferably the
 15 cells are insect cells, and more preferably, they include the insect cells sold under the trademark SF+ insect cells (Protein Sciences Corporation, Meriden, CT). Preferred cell cultures have a cell count between about $0.3 - 2.0 \times 10^6$ cells/mL, more preferably from about $0.35 - 1.9 \times 10^6$ cells/mL, still more preferably from about $0.4 - 1.8 \times 10^6$ cells/mL, even more preferably from about $0.45 - 1.7 \times 10^6$
 20 cells/mL, and most preferably from about $0.5 - 1.5 \times 10^6$ cells/mL.

[00295] Preferred viral vectors include baculovirus such as BaculoGold (BD Biosciences Pharmingen, San Diego, CA), in particular provided that the production cells are insect cells. Although the baculovirus expression system is preferred, it is understood by those of skill in the art that other expression systems, including those described above will work for purposes of the present
 25 invention, namely the expression of recombinant protein.

[00296] Appropriate growth media will also be determinable by those of skill in the art with a preferred growth media being serum-free insect cell media such as Excell 420 (JRH Biosciences, Inc., Lenexa, KS) and the like.

[00297] The recombinant viral vector containing the recombinant protein DNA sequences has a
 30 preferred multiplicity of infection (MOI) of between about 0.03 - 1.5, more preferably from about 0.05 - 1.3, still more preferably from about 0.09 - 1.1, and most preferably from about 0.1 - 1.0, when used for the infection of the susceptible cells. Preferably the MOIs mentioned above relates to one mL of cell culture fluid. Preferably, the method described herein comprises the infection of $0.35 - 1.9 \times 10^6$ cells/mL, still more preferably of about $0.4 - 1.8 \times 10^6$ cells/mL, even more preferably of about

0.45 - 1.7 x 10⁶ cells/mL, and most preferably of about 0.5 - 1.5 x 10⁶ cells/mL with a recombinant viral vector containing a recombinant protein DNA and expressing the recombinant protein having a MOI (multiplicity of infection) of between about 0.03 - 1.5, more preferably from about 0.05 - 1.3, still more preferably from about 0.09 - 1.1, and most preferably from about 0.1 - 1.0.

5 [00298] The portion of the first liquid can be removed from the combined mixture of step (iii) comprising the recombinant protein by a filtration step utilizing a filter. However, any other method known to a person skilled in the art can be used to remove the portion of any liquid, including the first and, whenever applicable, a portion of the second liquid from the combined mixture of step (iii). Such method for instance includes but is not limited to centrifugation and/or chromatography. However,
10 filtration is most preferred. A preferred filtration method to remove the said portion of the first liquid, or any other liquid, whenever applicable, comprises ultra- and/or diafiltration. Ultra- and diafiltration are standard methods known to a person skilled in the art, described for example in detail in *Protein Purification Methods - A Practical Approach* – editors: E.L.V. Harris and S. Angel, Oxford University Press 1995 (the contents and teachings of which are hereby incorporated by reference). In
15 particular, in Chapter 3 of that textbook, several methods and types of equipment are described, all of which can be used by an ordinary person skilled in the art in an exemplary manner for the purpose of the present invention.

[00299] “Inactivating agent”, for purposes of the present invention, refers to any agent that can be used in any conventional inactivation method. Inactivation can be performed by chemical and/or
20 physical treatments which are known to the person skilled in the art. Preferred inactivating agents include cyclized binary ethylenimine (BEI) including a solution of 2-bromoethylenamine hydrobromide (BEA), which has been cyclized to binary ethylenimine (BEI). Preferred further chemical inactivation agents comprise but are not limited to Triton X-100, Sodium deoxycholate, Cetyltrimethylammonium bromide, β-Propiolactone, Thimerosal, Phenol and Formaldehyde
25 (Formalin).

[00300] “Neutralizing agent”, for purposes of the present invention, refers to any agent capable of neutralizing the inactivating agents as herein described such that the inactivating agent is no longer capable of inactivating the vector. The agent that neutralizes the inactivating agent is preferably sodium thiosulfate, sodium bisulfite and the like.

30 [00301] In another aspect, the present invention concerns a method as herein described and claimed, wherein the mixture of step (i) is obtainable by a procedure comprising the steps of

- (a) permitting infection of susceptible cells in culture with a vector comprising a nucleic acid sequence encoding said recombinant protein and/or quaternary structures composed of a

plurality of said recombinant protein, wherein said recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein is expressed by said vector,

- (b) thereafter recovering the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein from the cell culture, wherein preferably cell debris is separated from the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein via a separation step, preferably including a micro filtration through at least one filter, more preferably two filters, wherein the at least one filter preferably has a pore size larger than the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein, in particular has a pore size of about 0.1 μm to about 4 μm .

[00302] In another aspect, the present invention concerns a method as herein described and claimed, wherein the cell culture in step (a) is maintained at $27\pm 2^\circ\text{C}$, preferably while the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein is expressed by said vector, and/or wherein the recovering in step (b) occurs 6 to 8 days, preferably 8 days, after inoculation of the cells with the vector.

[00303] In another aspect, the present invention concerns a method as herein described and claimed, wherein the separation step includes or consists of:

- a micro filtration through at least one filter having a pore size of about 2 μm to about 4 μm , and/or
- a micro filtration through at least one filter having a pore size of about 0.1 μm to about 0.8 μm .

[00304] In another aspect, the present invention concerns a method as herein described and claimed, wherein said first liquid comprises a portion of cell culture medium or consists of cell culture medium, and wherein the cell culture medium preferably is insect cell culture medium.

[00305] In another aspect, the present invention concerns a method as herein described and claimed, wherein said recombinant protein is selected from the group consisting of:

- a PPV VP2 protein preferably comprising or consisting of a sequence having at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99,1%, at least 99,2%, at least 99,3%, at least 99,4%, at least 99,5%, at least 99,6%, at least 99,7%, at least 99,8%, at least 99,9%, or 100% sequence identity with the sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NOS: 5 to 16.

[00306] In another aspect, the present invention concerns a method as herein described and claimed, wherein said quaternary structures composed of a plurality of said recombinant protein are virus-like particles or wherein said quaternary structures composed of a plurality of said recombinant protein are homotrimers.

[00307] In another aspect, the present invention concerns a method as herein described and claimed, wherein the vector is a recombinant virus, preferably baculovirus, and/or wherein the nucleic acid sequence is a DNA sequence.

[00308] In another aspect, the present invention concerns a method as herein described and claimed, wherein the vector comprising a nucleic acid encoding said recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein is a recombinant baculovirus, wherein said baculovirus comprises a DNA sequence encoding said recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein.

[00309] In another aspect, the present invention concerns a method as herein described and claimed, wherein in step (iii) said recombinant protein and/or said quaternary structures composed of a plurality of said recombinant protein is washed with at least 2x, preferably from 2x to 3x, of second liquid, and optionally finally concentrated, in comparison to the original volume of said recombinant protein and/or said quaternary structures composed of a plurality of said recombinant protein in the mixture of step (i). More preferably, in step (iii) such washing step(s), i.e. the process of diafiltration, is performed at a temperature of lower than 37° C., more preferably at a temperature of lower than 30° C, even more preferably at a temperature of lower than 20° C, even more preferably at a temperature of lower than 10° C, such as for instance at a temperature between 4° C and 29° C, for instance 27° C or 4° C. Thereby, the degree of precipitation (aggregation) is significantly reduced.

[00310] In another aspect, the present invention concerns a method as herein described and claimed, wherein in step (iii) the portion of the first and/or second liquid is removed from the mixture by filtration, wherein preferably a filter or a hollow filter is utilized comprising a semi-permeable membrane having an average pore size that is smaller than said recombinant protein and/or said quaternary structures composed of a plurality of said recombinant protein and/or prevents passage of the majority of, preferably substantially all, proteins of 20 kDa to 500 kDa, in size through the semi-permeable membrane.

[00311] The filter can be any conventional filter in the art. Preferably, said filter includes a semi-permeable membrane. In a further preferred form, the said semi-permeable membrane has an average pore size that is smaller than the recombinant protein to thereby prevent passage of at least

90% of said recombinant protein through said semi-permeable membrane pores and withhold the recombinant protein by means of the filter.

[00312] In a further aspect, the said filter has an average pore size which prevents passage of at least 90% of proteins of 20 kDa to 500 kDa in size, more preferably, the said filter has an average

5 pore size which prevents passage of at least 90% of proteins of 50 kDa to 400 kDa in size, and most preferably, the said filter has an average pore size which prevents passage of at least 90% of proteins of 75 kDa to 300 kDa in size. This pore size is preferred, when the recombinant protein is produced as whole virus or as virus like particles. In a still further aspect, the said semi-permeable membrane includes a material selected from the group consisting of polysulfone, polyethersulfone, and
10 regenerated cellulose. However, any other material that allows removing of a portion of the first liquid and in case of a multiple process step, removing of a mixture of the first and the second liquid from the recombinant protein can be used. Said filter can be selected from the group consisting of a hollow fiber membrane ultrafiltration cartridge, flat sheets, or a cassette, with a hollow fiber membrane ultrafiltration cartridge being particularly preferred.

15 [00313] A preferred second liquid to be used in any of the methods described is a buffer, preferably a physiologically acceptable buffer with saline being particularly preferred.

[00314] In another aspect, the present invention concerns a method as herein described and claimed, wherein the second liquid is a buffer solution, preferably wash phosphate buffered saline (WPBS).

20 [00315] The concentrating step and the liquid addition step of the method as described herein can be performed substantially simultaneously or alternatively, the concentrating step and the liquid addition step are performed sequentially.

[00316] When the concentrating step and liquid addition step are performed sequentially, the order of the steps does not matter. For example, in a further aspect, the liquid addition step occurs
25 prior to said concentrating step and in an alternative aspect, the concentrating step occurs prior to said liquid addition step. The liquid addition step and the concentrating step, regardless of the order in which they are performed, can be performed multiple times. For example, each of these respective steps can be performed at least two, at least three, at least four, at least five, at least 10, up to as many times as desired. In one aspect, the concentrating step and the liquid addition step are each performed
30 at least two times. In another aspect, the concentrating step and the liquid addition step are each performed at least three times.

[00317] The concentration step of the methods provided herein can be performed such that the recombinant protein is concentrated from 3X to 50X in comparison to the volume of said first liquid.

More preferably, said concentrating step can be done such that the recombinant protein is concentrated 4X to 20X in comparison to the volume of said first liquid. Most preferably, said concentration step can be done such that the recombinant protein is concentrated from 7X to 10X in comparison to the volume of the first liquid.

5 [00318] In another aspect, the present invention concerns a method as herein described and claimed, wherein the volume of the second liquid added in step (ii) is about the volume of the first and/or second liquid removed in step (iii). In other words, no concentration step is performed and/or required.

[00319] In the event, viral vectors such as a recombinant poxvirus, adenovirus or baculovirus is
10 used to produce the recombinant protein it is recommended to inactivate the viral nucleic acid by an appropriate inactivation treatment. Such inactivation may occur anytime during the purification of the recombinant protein. Thus, inactivation may occur immediately after the harvest of the cell culture fluid comprising the recombinant protein or after the micro-filtration of the recombinant protein, if micro-filtration is done, prior or after the purification step, for instance, prior to or after the gel
15 filtration, and prior to or after the anion exchange chromatography, if this is done.

[00320] Any conventional inactivation method can be used for purposes of the present invention. Thus, inactivation can be performed by chemical and/or physical treatments. In preferred forms, the volume of harvest fluids is determined and the temperature is brought to between about 32°C - 42°C, more preferably between about 34°C - 40°C, and most preferably between about 35°C -
20 39°C. Preferred inactivation methods include the addition cyclized binary ethylenimine (BEI), preferably in a concentration of about 1 mM to about 20 mM, preferably of about 2 mM to about 10 mM, still more preferably of about 2 mM to about 8 mM, still more preferably of about 3 mM to about 7 mM, most preferably of about 5 mM. For example the inactivation includes the addition of a solution of 2-bromoethylethylamine hydrobromide (BEA), preferably of about 0.4 M, which has been
25 cyclized to 0.2 M binary ethylenimine (BEI) in 0.3 N NaOH, to the fluids to give a final concentration of about 5 mM BEI. Preferably, the fluids are then stirred continuously for 2 - 96 hours and the inactivated harvest fluids can be stored frozen at - 40°C or below or between about 1°C - 7°C. After inactivation is completed a sodium thiosulfate solution, preferably at 1.0M is added to neutralize any residual BEI. Preferably, the sodium thiosulfate is added in equivalent amount as compared to the BEI
30 added prior to for inactivation. For example, in the event BEI is added to a final concentration of 5mM, a 1.0M sodium thiosulfate solution is added to give a final minimum concentration of 5 mM to neutralize any residual BEI.

[00321] In another aspect, the present invention concerns a method as herein described and claimed, wherein the inactivating agent is an aziridine compound, preferably binary ethylenimine (BEI), and/or wherein the inactivating agent is added in a molar excess in relation to the vector.

5 [00322] In another aspect, the present invention concerns a method as herein described and claimed, wherein the neutralizing agent is sodium thiosulfate and/or wherein the neutralizing agent is added in a molar excess in relation to the inactivating agent.

[00323] In another aspect, the present invention concerns a method as herein described and claimed, wherein said method further comprises the step of admixing the mixture remaining after step (v) with a further component selected from the group consisting of pharmaceutically acceptable
10 carriers, adjuvants, diluents, excipients, and combinations thereof.

[00324] In another aspect, the present invention concerns a method as herein described and claimed, wherein the virucidal activity of the mixture resulting from said method is reduced by at least 10% as compared to the mixture that has not undergone said method, and/or wherein the immunogenic composition produced by said method causes a loss of less than 1 log TCID₅₀ per mL of
15 a live virus, when the live virus is mixed with the immunogenic composition for two or more hours.

[00325] In another aspect, the present invention concerns a method as herein described and claimed, wherein the live virus is Porcine Reproductive and Respiratory Syndrome (PRRS) virus.

[00326] In another aspect, the present invention concerns a method as herein described and claimed, wherein the method further comprises the step (vi) of harvesting the recombinant protein and/or the quaternary structures composed of a plurality of said recombinant protein remaining after
20 step (v), and in particular further comprising the step of purifying the harvest comprising the recombinant protein and/or the quaternary structures composed of a plurality of said recombinant protein, by chromatographic procedure, preferably size exclusion chromatography.

[00327] In another aspect, the present invention concerns a method as herein described and
25 claimed, wherein the method further comprises the step of combining the (purified) harvested recombinant protein and/or the quaternary structures composed of a plurality of said recombinant protein with at least one additional antigen.

[00328] In another aspect, the present invention concerns a method as herein described and
30 claimed, wherein the at least one additional antigen is Porcine Reproductive and Respiratory Syndrome (PRRS) virus.

[00329] In a further aspect, the method further comprises the step of harvesting the recombinant protein obtained after at least a portion of said first liquid is removed from said recombinant protein.

[00330] As used herein, "harvesting" or "harvest" refers to collecting or recovering the recombinant protein. Any conventional method known in the art can be used to recover the recombinant protein either when a recombinant protein is being produced for use with the methods and compositions of the present invention, or when the recombinant protein is undergoing the methods described herein. In a particularly preferred manner of harvesting, the portion of said first liquid is removed from said recombinant protein via a filtration step and the recombinant protein is recovered or harvested from the filter retard. In a more preferred form, the recombinant protein is harvested or collected, or recovered from the retard of a semi-permeable membrane having the pore size described herein.

[00331] The recombinant protein remaining after having undergone the methods provided herein, preferably after having been harvested from the filter retard, is admixed with a further component selected from the group consisting of pharmaceutically acceptable carriers, adjuvants, diluents, excipients, and combinations thereof. Preferably, said further component is an adjuvant, even more preferably said adjuvant is a polymer of acrylic or methacrylic acid, and still more preferably said adjuvant is Carbomer.

[00332] In a further aspect of the present application, the method described above further comprises the steps admixing the recombinant protein obtained after the inactivating and neutralizing steps with a further component selected from the group consisting of pharmaceutically acceptable carriers, adjuvants, diluents, excipients, and combinations thereof. Prior to the mixing of the purified recombinant protein with an adjuvant, it is also recommended to dialyze the purified recombinant protein against phosphate buffered saline, pH 7.4 or any other physiological buffer.

[00333] As used herein, "a pharmaceutical-acceptable carrier" and a "veterinary acceptable carrier" includes any and all solvents, dispersion media, coatings, stabilizing agents, diluents, preservatives, antibacterial and antifungal agents, isotonic agents, adsorption delaying agents, and the like.

[00334] "Adjuvants" as used herein, can include aluminum hydroxide and aluminum phosphate, saponins e.g., Quil A, QS-21 (Cambridge Biotech Inc., Cambridge MA), GPI-0100 (Galenica Pharmaceuticals, Inc., Birmingham, AL), water-in-oil emulsion, oil-in-water emulsion, water-in-oil-in-water emulsion. The emulsion can be based in particular on light liquid paraffin oil (European Pharmacopea type); isoprenoid oil such as squalane or squalene; oil resulting from the oligomerization of alkenes, in particular of isobutene or decene; esters of acids or of alcohols containing a linear alkyl

group, more particularly plant oils, ethyl oleate, propylene glycol di-(caprylate/caprates), glyceryl tri-(caprylate/caprates) or propylene glycol dioleate; esters of branched fatty acids or alcohols, in particular isostearic acid esters. The oil is used in combination with emulsifiers to form the emulsion. The emulsifiers are preferably nonionic surfactants, in particular esters of sorbitan, of mannide (e.g. anhydromannitol oleate), of glycol, of polyglycerol, of propylene glycol and of oleic, isostearic, ricinoleic or hydroxystearic acid, which are optionally ethoxylated, and polyoxypropylene-polyoxyethylene copolymer blocks, in particular the Pluronic products, especially L121. See Hunter et al., *The Theory and Practical Application of Adjuvants* (Ed. Stewart-Tull, D. E. S.). John Wiley and Sons, NY, pp51-94 (1995) and Todd et al., *Vaccine* 15:564-570 (1997). For example, it is possible to use the SPT emulsion described on page 147 of "Vaccine Design, The Subunit and Adjuvant Approach" edited by M. Powell and M. Newman, Plenum Press, 1995, and the emulsion MF59 described on page 183 of this same book. Further suitable adjuvants include, but are not limited to, the RIBI adjuvant system (Ribi Inc.), Block co-polymer (CytRx, Atlanta GA), SAF-M (Chiron, Emeryville CA), monophosphoryl lipid A, Avridine lipid-amine adjuvant, heat-labile enterotoxin from *E. coli* (recombinant or otherwise), cholera toxin, IMS 1314 or muramyl dipeptide among many others. Among the copolymers of maleic anhydride and alkenyl derivative, the copolymers EMA (Monsanto), which are copolymers of maleic anhydride and ethylene, are included. The dissolution of these polymers in water leads to an acid solution that will be neutralized, preferably to physiological pH, in order to give the adjuvant solution into which the immunogenic, immunological or vaccine composition itself will be incorporated.

[00335] A further instance of an adjuvant is a compound chosen from the polymers of acrylic or methacrylic acid and the copolymers of maleic anhydride and alkenyl derivative. Advantageous adjuvant compounds are the polymers of acrylic or methacrylic acid which are cross-linked, especially with polyalkenyl ethers of sugars or polyalcohols. These compounds are known by the term carbomer (Pharmeuropa Vol. 8, No. 2, June 1996). Persons skilled in the art can also refer to U.S. Patent No. 2,909,462 which describes such acrylic polymers cross-linked with a polyhydroxylated compound having at least 3 hydroxyl groups, preferably not more than 8, the hydrogen atoms of at least three hydroxyls being replaced by unsaturated aliphatic radicals having at least 2 carbon atoms. The preferred radicals are those containing from 2 to 4 carbon atoms, e.g. vinyls, allyls and other ethylenically unsaturated groups. The unsaturated radicals may themselves contain other substituents, such as methyl. The products sold under the name Carbopol; (BF Goodrich, Ohio, USA) are particularly appropriate. They are cross-linked with an allyl sucrose or with allyl pentaerythritol. Among them, there may be mentioned Carbopol 974P, 934P and 971P. Most preferred is the use of Carbopol 971P.

[00336] “Diluents” can include water, saline, dextrose, ethanol, glycerol, and the like. Isotonic agents can include sodium chloride, dextrose, mannitol, sorbitol, and lactose, among others. Stabilizers include albumin and alkali salts of ethylenediaminetetraacetic acid, among others.

[00337] A “preservative” as used herein refers to an anti-microbiological active agent, such as for example Gentamycin, Merthiolate, and the like. In particular adding of a preservative is most preferred for the preparation of a multi-dose composition. Those anti-microbiological active agents are added in concentrations effective to prevent the composition of interest for any microbiological contamination or for inhibition of any microbiological growth within the composition of interest.

[00338] Further purification of the recombinant protein can be achieved with chromatography procedures, preferably a two-step chromatography procedure. If the recombinant protein is assembled to virus like particles (VLP), one step, preferably the first step, is preferably a size exclusion (gel filtration) chromatography, which can be done, for instance, by using a Sephacryl S300 matrix. In lab scale use of HiPrep 26/60 Sephacryl S300HR columns are most preferred. However, any other size exclusion chromatography matrices known to a person skilled in the art can be used, which allow the separation of the recombinant protein VLPs from the culture filtrate or supernatant. Suitable matrices are described, for instance, in E.L.V. Harris and S. Angel (eds.), Protein purification methods – a practical approach, IRL Press Oxford 1995). The gel filtration chromatography can be conducted, for instance, by loading the column with the crude preparation comprising the recombinant protein with a flow-rate of 1.0 ml/min and eluting the column with 1.5 column volume of a buffer comprising 20 mM Tris, pH 6.5, 5 mM DTT. However, the recombinant protein can also be purified by using affinity chromatography, for instance, via selective binding to an immobilized recombinant protein specific antibody, or any other method known to a person skilled in the art.

[00339] In order to obtain a higher purity grade a second chromatography step can be done, which however is different from the first one. For instance if the first purification step / chromatography step is size exclusion (gel filtration) the second should be different from that e.g. an affinity chromatography, ion exchange chromatography, etc. Preferably, if the first step to purify recombinant protein is a size exclusion (gel filtration) chromatography, the second step can be ion-exchange chromatography, preferably anion-exchange chromatography (AIEX). A preferred anion-exchange chromatography matrix for the purification of recombinant protein is Q Sepharose. In a small scale of about 50 ml, use of 5 ml HiTrap Q Sepharose HP columns are most preferred.

[00340] The present application does not only provide methods of producing recombinant protein containing immunogenic composition, it also relates to a recombinant protein containing immunogenic composition.

[00341] In another aspect, the present invention concerns an immunogenic composition obtainable by a method as herein described and claimed.

[00342] In a further aspect, the virucidal activity of the recombinant protein containing immunogenic composition produced by the methods herein is reduced by at least 10% as compared to a recombinant protein containing immunogenic composition that has not undergone said production method. More preferably, the virucidal activity of the recombinant protein containing immunogenic composition is reduced by at least 50% as compared to a recombinant protein containing immunogenic composition that has not undergone said production method. Still more preferably, the virucidal activity of the recombinant protein containing immunogenic composition is reduced by at least 70% as compared to a recombinant protein containing immunogenic composition that has not undergone said production method. Even still more preferably, the virucidal activity of the recombinant protein containing immunogenic composition is reduced by at least 90% as compared to a recombinant protein containing immunogenic composition that has not undergone said production method.

[00343] For the purpose of the current invention the term “virucidal activity” means, that a liquid, fluid, solution, composition or the like inactivates or kills live viruses or live bacteria to a certain extent, when said liquid, fluid, solution, composition or the like is mixed with such live viruses or live bacteria. Thus, a reduction of the virucidal activity of a liquid, fluid, solution, composition or the like by at least 10% means, that the survival rate of live viruses or live bacteria is 90% higher in a liquid, fluid, solution, composition or the like that has undergone any of the production methods described herein, as compared to a liquid, fluid, solution, composition or the like, that has not undergone any of such production methods.

[00344] The recombinant protein immunogenic composition produced by the method described herein causes a loss of less than 1 log TCID₅₀ of a live virus or less than 1 log CFU per ml of a live bacterium, when the live virus or live bacterium is mixed with the recombinant protein immunogenic composition and incubated for 2 or more hours, preferably for more than 4 hours, even more preferably for more than 12 hours, even more preferably for more than 24 hours, even more preferably for more than 2 days, even more preferably for more than 4 days, even more preferably for more than 7 days, even more preferably for more than 2 weeks, even more preferably for more than 4 weeks, even more preferably for more than 2 months, even more preferably for more than 3 months, even more preferably for more than 4 months, even more preferably for more than 6 months, even more preferably for more than 9 months, even more preferably for more than 12 months, even more preferably for more than 18 months, most preferably for more than 2 years. More preferably, recombinant protein immunogenic composition produced by the method described herein causes a loss of less than 0.9 log TCID₅₀ per ml of a live virus or less than 0.9 log CFU per ml of a live

bacterium, when the live virus or live bacterium is mixed and incubated with the recombinant protein immunogenic composition for 2 or more hours, preferably for more than 4 hours, even more preferably for more than 12 hours, even more preferably for more than 24 hours, even more preferably for more than 2 days, even more preferably for more than 4 days, even more preferably for more than 7 days, even more preferably for more than 2 weeks, even more preferably for more than 4 weeks, even more preferably for more than 2 months, even more preferably for more than 3 months, even more preferably for more than 4 months, even more preferably for more than 6 months, even more preferably for more than 9 months, even more preferably for more than 12 months, even more preferably for more than 18 months, most preferably for more than 2 years. Even more preferably, the recombinant protein immunogenic composition produced by the method described herein causes a loss of less than 0.7 log TCID₅₀ per ml of a live virus or less than 0.7 log CFU per ml of a live bacterium, when the live virus or live bacterium is mixed and incubated with the recombinant protein immunogenic composition for 2 or more hours, preferably for more than 4 hours, even more preferably for more than 12 hours, even more preferably for more than 24 hours, even more preferably for more than 2 days, even more preferably for more than 4 days, even more preferably for more than 7 days, even more preferably for more than 2 weeks, even more preferably for more than 4 weeks, even more preferably for more than 2 months, even more preferably for more than 3 months, even more preferably for more than 4 months, even more preferably for more than 6 months, even more preferably for more than 9 months, even more preferably for more than 12 months, even more preferably for more than 18 months, most preferably for more than 2 years. Still more preferably, the recombinant protein immunogenic composition produced by steps by the method described herein causes a loss of less than 0.5 log TCID₅₀ per ml of a live virus or less than 0.5 log CFU per ml of a live bacterium, when the live virus or live bacterium is mixed and incubated with the recombinant protein immunogenic composition for 2 or more hours, preferably for more than 4 hours, even more preferably for more than 12 hours, even more preferably for more than 24 hours, even more preferably for more than 2 days, even more preferably for more than 4 days, even more preferably for more than 7 days, even more preferably for more than 2 weeks, even more preferably for more than 4 weeks, even more preferably for more than 2 months, even more preferably for more than 3 months, even more preferably for more than 4 months, even more preferably for more than 6 months, even more preferably for more than 9 months, even more preferably for more than 12 months, even more preferably for more than 18 months, most preferably for more than 2 years. Even more preferably, the recombinant protein immunogenic composition produced by the method described herein causes a loss of less than 0.3 log TCID₅₀ per ml of a live virus or less than 0.3 log CFU per ml of a live bacterium, when the live virus or live bacterium is mixed and incubated with the recombinant protein immunogenic composition for 2 or more hours, preferably for more than 4 hours, even more preferably for more than 12 hours, even more preferably for more than 24 hours, even more preferably for more than 2 days, even more preferably for more than 4 days, even more preferably for

more than 7 days, even more preferably for more than 2 weeks, even more preferably for more than 4 weeks, even more preferably for more than 2 months, even more preferably for more than 3 months, even more preferably for more than 4 months, even more preferably for more than 6 months, even more preferably for more than 9 months, even more preferably for more than 12 months, even more preferably for more than 18 months, most preferably for more than 2 years. The TCID₅₀ per ml can be estimated by a standard in vitro titration assay which allows the estimation of the amount of a live virus. The CFU per ml can be determined also by a standard in vitro titration assay which allows the estimation of the amount of a live bacterium. The term “per ml” preferably refers to 1 ml of a fluid. Such purified recombinant protein does not only show reduced virucidal activity, as defined herein, it also shows an increased immunogenicity as compared to a non-purified recombinant protein as defined herein, preferably such recombinant protein increases the cellular and/or antibody mediated immune response by at least 10%, preferably by at least 20%, more preferably by at least 30%, even more preferably by at least 40%, even more preferably by at least 50%, even more preferably by at least 75%, most preferably by at least 100% as compared to the cellular and/or antibody mediated immune response elicited by a reference immunogenic composition comprising a non-purified recombinant protein.

[00345] The immunogenic compositions comprising the purified recombinant protein, preferably those obtainable by the methods described herein are characterized by an increased immunogenicity as compared to an immunogenic composition not comprising such a purified recombinant protein.

[00346] In addition, the terms “increased immunogenicity or improved immunogenicity” as used herein, mean that the immune response caused by an immunogenic composition comprising an antigen of interest is increased as compared to a reference immunogenic composition comprising a different antigen or different purity grade of the antigen, whether this immune response is a cellular mediated and/or antibody mediated immune response. According to a preferred embodiment, the term increased immunogenicity or improved immunogenicity means, that the antibody mediated immune response elicited by an immunogenic composition comprising the antigen of interest is increased as compared to a reference immunogenic composition comprising a different antigen or a different purity grade of the antigen. In this regard antibody mediated immune response means, that the production of antibodies, which are specific to the antigen of interest is increased as compared to the antibody production elicited by a reference immunogenic composition comprising a different antigen or a different purity grade of the antigen.

[00347] The term “increased” means, that the cellular and/or antibody mediated immune response is increased by at least 10%, preferably by at least 20%, more preferably by at least 30%, even more preferably by at least 40%, even more preferably by at least 50%, even more preferably by

at least 75%, most preferably by at least 100% as compared to the cellular and/or antibody mediated immune response elicited by a reference immunogenic composition comprising a recombinant protein or a different purity grade of the recombinant protein.

[00348] It is in the general knowledge of a person skilled in the art how to measure the cellular and/or antibody mediated immune response. In particular, it is clear to such person skilled in the art either to compare the cellular mediated immune response of the immunogenic composition of interest with cellular mediated immune response of the reference, or the antibody mediated immune response of the immunogenic composition of interest with that of the reference composition, but neither the cellular mediated immune response of a immunogenic composition of interest with the antibody mediated immune response of the reference or *vice versa*. Moreover, the cellular mediated immune response can be measured, for instance, by measuring the activation of cytotoxic T-cells by an immunogenic composition/antigen of interest. The antibody mediated immune response can be measured, for instance, by measuring the amount of antigen specific antibodies, generated in cause of the administration of the immunogenic composition comprising such antigen to an animal. The cellular and/or antibody mediated immune response can be measured, for instance, by using a mouse model. According to the current invention, the mouse model is used as the reference method.

[00349] The term “immunogenic composition” means, but is not limited to, a composition of matter that comprises at least one antigen which elicits a cellular and/ or antibody-mediated immune response in a host against the antigen of interest. Usually, an “immune response” includes but is not limited to one or more of the following effects: the production or activation of antibodies, B cells, helper T cells, suppressor T cells, and/or cytotoxic T cells and/or gamma-delta T cells, directed specifically to an antigen or antigens included in the composition or vaccine of interest. Preferably, the host will display either a therapeutic or protective immune response such that resistance to new infection will be enhanced and/or the clinical severity of the disease reduced. In such a case the immunogenic composition is a “vaccine”. Such protection will be demonstrated by either a reduction or lack of symptoms normally displayed by an infected host, a quicker recovery time and/or a lowered viral titer in the infected host.

[00350] In another aspect, the present invention concerns an immunogenic composition as herein described and claimed, wherein the immunogenic composition further comprises an attenuated live virus, preferably an attenuated Porcine Reproductive and Respiratory Syndrome (PRRS) virus, or an attenuated live bacterium.

[00351] “Live” virus or bacterium, for purposes of the present invention, refers to a virus or bacterium that is capable of replicating in a host. A preferred live virus and a preferred live bacterium of the present invention are the PRRS virus and the *Mycoplasma hyopneumonia* bacterium,

respectively. However, the term live virus or live bacterium is not limited to PRRS and *Mycoplasma hyopneumoniae*, respectively.

[00352] In another aspect, the present invention concerns an immunogenic composition as herein described and claimed, wherein the attenuated live virus is Porcine Reproductive and

5 Respiratory Syndrome (PRRS) virus.

[00353] In another aspect, the present invention concerns an immunogenic composition as herein described and claimed, wherein the immunogenic composition induces a protective immune response against a pathogen, preferably a pathogen comprising a recombinant protein as herein described and claimed, after the administration of one dose of the immunogenic composition.

10 [00354] In another aspect, the present invention concerns an immunogenic composition as herein described and claimed, wherein the immunogenic composition induces a protective immune response against PRRS virus after the administration of one dose of the immunogenic composition.

[00355] The recombinant protein immunogenic composition obtained according to the method described above, or the recombinant protein used in step i) of the method described above, can be
 15 combined with at least one additional antigen, preferably a viral or bacterial antigen, and even more preferably, a viral or bacterial antigen from at least one other disease-causing organism in swine. The additional antigen can be any one of those disclosed in the international patent application WO2007/094893 (the contents and teachings of which are hereby incorporated by reference). Briefly, the additional antigens can be antigens of any other disease-causing organisms of swine. Preferably
 20 the “another disease-causing organisms” of swine are selected from the group consisting of: Actinobacillus pleuropneumonia (1); Adenovirus (2); Alphavirus such as Eastern equine encephalomyelitis viruses (3); Bordetella bronchiseptica (4); Brachyspira spp. (5), preferably B. hyodysenteriae (6); B. piosicoli (7), Brucella suis, preferably biovars 1, 2, and 3 (8); Classical swine fever virus (9); Clostridium spp. (10), preferably Cl. difficile (11), Cl. perfringens types A, B, and C
 25 (12), Cl. novyi (13), Cl. septicum (14), Cl. tetani (15); Coronavirus (16), preferably Porcine Respiratory Corona virus (17); Eperythrozoonosis suis (18); Erysipelothrix rhusiopathiae (19) Escherichia coli (20); Haemophilus parasuis, preferably subtypes 1, 7 and 14 (21) Hemagglutinating encephalomyelitis virus (22); Japanese Encephalitis Virus (23); Lawsonia intracellularis (24) Leptospira spp. (25), preferably Leptospira australis (26); Leptospira canicola (27); Leptospira
 30 grippotyphosa (28); Leptospira icterohaemorrhagiae (29); and Leptospira interrogans (30); Leptospira pomona (31); Leptospira tarassovi (32); Mycobacterium spp. (33) preferably M. avium (34), M. intracellulare (35) and M. bovis (36); Mycoplasma hyopneumoniae (37); Pasteurella multocida (38); Porcine cytomegalovirus (39); Porcine Parvovirus (40); Porcine Reproductive and Respiratory Syndrome Virus (41); Pseudorabies virus (42); Rotavirus (43); Salmonella spp. (44),

preferably *S. typhimurium* (45) and *S. choleraesuis* (46); *Staph. hyicus* (47); *Staphylococcus* spp. (48) preferably *Streptococcus* spp. (49), preferably *Strep. suis* (50); Swine herpes virus (51); Swine Influenza Virus (52); Swine pox virus (53); Swine pox virus (54); Vesicular stomatitis virus (55); Virus of vesicular exanthema of swine (56); *Leptospira Hardjo* (57); and/or *Mycoplasma hyosynoviae* (58).

[00356] In another aspect, the present invention concerns a kit comprising a container containing the immunogenic composition as herein described and claimed.

[00357] In another aspect, the present invention concerns a kit as herein described and claimed further comprising at least one additional container containing at least one additional antigen selected from the group consisting of attenuated live virus, preferably attenuated PRRS virus, and attenuated live bacterium.

[00358] In another aspect, the present invention concerns an immunogenic composition as herein described and claimed for use as a medicament, preferably as a vaccine.

[00359] In another aspect, the present invention concerns an immunogenic composition as herein described and claimed and/or the kit as herein described and claimed, for use in a method of reducing one or more clinical symptoms of a pathogen infection in an animal as compared to an animal not receiving said immunogenic composition.

[00360] The term “reduction in the incidence of or severity of clinical signs” shall mean that any of such signs are reduced in incidence or severity in animals receiving an administration of the vaccine in comparison with a “control group” of animals when both have been infected with or challenged by the pathogen from which the immunological active component(s) in the vaccine are derived and wherein the control group has not received an administration of the vaccine or immunogenic composition. In this context, the term “decrease” or “reduction” means a reduction of at least 10%, preferably 25%, even more preferably 50%, most preferably of more than 100% in the vaccinated group as compared to the control group not vaccinated.

[00361] As used herein, “clinical symptoms” or “clinical signs” shall refer to signs of infection from pathogens that are directly observable from a live animal such as symptoms. Representative examples will depend on the pathogen selected but can include things such as nasal discharge, lethargy, coughing, elevated fever, weight gain or loss, dehydration, diarrhea, swelling, lameness, and the like.

[00362] As used herein, a “protective immune response” refers to a reduced incidence of or reduced severity of clinical, pathological, or histopathological signs or symptoms of infection from a pathogen of interest up to and including the complete prevention of such signs or symptoms.

[00363] The term “pathological signs” shall refer to signs of infection that are observable at the
5 microscopic or molecular level, through biochemical testing, or with the naked eye upon necropsy.

[00364] The term “histopathological signs” signs shall refer to signs of tissue changes resulting from infection.

[00365] The terms, “clinical symptoms” or “clinical signs” are defined above.

[00366] The following clauses are described herein:

10 [00367] 1.A method of producing an immunogenic composition comprising a recombinant protein, wherein the method comprises the steps in the following order:

- (i) providing/obtaining a mixture comprising
 - a first liquid,
 - recombinant protein and/or quaternary structures composed of a plurality of said
15 recombinant protein, and
 - a vector comprising a nucleic acid sequence encoding said recombinant protein;
- (ii) adding a second liquid to the mixture of step (i), wherein the second liquid is different from the first liquid;
- (iii) washing, and optionally finally concentrating, the recombinant protein and/or quaternary
20 structures composed of a plurality of said recombinant protein in the mixture by further adding additional second liquid to the mixture resulting from step (ii) and removing a portion of the first and/or second liquid from such combined mixture;
- (iv) inactivating the vector by adding an inactivating agent to the mixture resulting from step (iii);
- 25 (v) neutralizing the inactivating agent by adding a neutralizing agent to the mixture resulting from step (iv).

[00368] 2.The method of clause 1, wherein the mixture of step (i) is obtainable by a procedure comprising the steps of

- (a) permitting infection of susceptible cells in culture with a vector comprising a nucleic acid
30 sequence encoding said recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein, wherein said recombinant protein and/or

quaternary structures composed of a plurality of said recombinant protein is expressed by said vector,

- (b) thereafter recovering the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein from the cell culture, wherein preferably cell debris is separated from the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein via a separation step, preferably including a micro filtration through at least one filter, preferably two filters, wherein the at least one filter preferably has a pore size larger than the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein, in particular has a pore size of about 0.1 μm to about 4 μm .

[00369] 3.The method of clause 2, wherein the cell culture in step (a) is maintained at $27\pm 2^\circ\text{C}$, preferably while the recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein is expressed by said vector, and/or wherein the recovering in step (b) occurs 6 to 8 days, preferably 8 days, after inoculation of the cells with the vector.

[00370] 4.The method of clauses 2 or 3, wherein the separation step includes or consists of:

- a micro filtration through at least one filter having a pore size of about 2 μm to about 4 μm , and/or
- a micro filtration through at least one filter having a pore size of about 0.1 μm to about 0.8 μm .

[00371] 5.The method of any one of clauses 1 to 4, wherein said first liquid comprises a portion of cell culture medium or consists of cell culture medium, and wherein the cell culture medium preferably is insect cell culture medium.

[00372] 6.The method of any one of clauses 1 to 5, wherein said recombinant protein is selected from the group consisting of:

- a PPV VP2 protein preferably comprising or consisting of a sequence having at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, at least 99,1%, at least 99,2%, at least 99,3%, at least 99,4%, at least 99,5%, at least 99,6%, at least 99,7%, at least 99,8%, at least 99,9%, or 100% sequence identity with the sequence of SEQ ID NO:1, SEQ ID NO:2 and/or SEQ ID NOS 5 to 16.

[00373] 7. The method of any one of clauses 1 to 6, wherein said quaternary structures composed of a plurality of said recombinant protein are virus-like particles or wherein said quaternary structures composed of a plurality of said recombinant protein are homotrimers.

[00374] 8. The method of any one of clauses 1 to 7, wherein the vector is a recombinant virus, preferably baculovirus, and/or wherein the nucleic acid sequence is a DNA sequence.

[00375] 9. The method of any one of clauses 1 to 8, wherein the vector comprising a nucleic acid encoding said recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein is a recombinant baculovirus, wherein said baculovirus comprises a DNA sequence encoding said recombinant protein and/or quaternary structures composed of a plurality of said recombinant protein.

[00376] 10. The method of any one of clauses 1 to 9, wherein in step (iii) said recombinant protein and/or said quaternary structures composed of a plurality of said recombinant protein is washed with at least 2x, preferably from 2x to 3x, of second liquid, and optionally finally concentrated, in comparison to the original volume of said recombinant protein and/or said quaternary structures composed of a plurality of said recombinant protein in the mixture of step (i).

[00377] 11. The method of any one of clauses 1 to 10, wherein in step (iii) such washing step(s), i.e. the process of diafiltration, is performed at a temperature of lower than 37° C., more preferably at a temperature of lower than 30° C, even more preferably at a temperature of lower than 20° C, even more preferably at a temperature of lower than 10° C, such as for instance at a temperature between 4° C and 29° C, for instance 27° C or 4° C.

[00378] 12. The method of any one of clauses 1 to 11, wherein in step (iii) the portion of the first and/or second liquid is removed from the mixture by filtration, wherein preferably a filter or a hollow filter is utilized comprising a semi-permeable membrane having an average pore size that is smaller than said recombinant protein and/or said quaternary structures composed of a plurality of said recombinant protein and/or prevents passage of the majority of, preferably substantially all, proteins of 20 kDa to 500 kDa, in size through the semi-permeable membrane.

[00379] 13. The method of any one of clauses 1 to 12, wherein the second liquid is a buffer solution, preferably wash phosphate buffered saline (WPBS).

[00380] 14. The method of any one of clauses 1 to 13, wherein the volume of the second liquid added in step (ii) is about the volume of the first and/or second liquid removed in step (iii), i.e. no concentration step is performed and/or required.

[00381] 15. The method of any one of clauses 1 to 14, wherein the inactivating agent is an aziridine compound, preferably binary ethylenimine (BEI), and/or wherein the inactivating agent is added in a molar excess in relation to the vector.

[00382] 16. The method of any one of clauses 1 to 15, wherein the neutralizing agent is sodium thiosulfate and/or wherein the neutralizing agent is added in a molar excess in relation to the inactivating agent.

[00383] 17. The method of any one of clauses 1 to 16, wherein said method further comprises the step of admixing the mixture remaining after step (v) with a further component selected from the group consisting of pharmaceutically acceptable carriers, adjuvants, diluents, excipients, and combinations thereof.

[00384] 18. The method according to any one of clauses 1 to 17, wherein the virucidal activity of the mixture resulting from said method is reduced by at least 10% as compared to the mixture that has not undergone said method, and/or wherein the immunogenic composition produced by said method causes a loss of less than 1 log TCID₅₀ per mL of a live virus, when the live virus is mixed with the immunogenic composition for two or more hours.

[00385] 19. The method according to clause 18, wherein the live virus is Porcine Reproductive and Respiratory Syndrome (PRRS) virus.

[00386] 20. The method according to any one of clauses 1 to 19, wherein the method further comprises the step (vi) of harvesting the recombinant protein and/or the quaternary structures composed of a plurality of said recombinant protein remaining after step (v), and in particular further comprising the step of purifying the harvest comprising the recombinant protein and/or the quaternary structures composed of a plurality of said recombinant protein, by chromatographic procedure, preferably size exclusion chromatography.

[00387] 21. The method according to any one of clauses 1 to 20, wherein the method further comprises the step of combining the (purified) harvested recombinant protein and/or the quaternary structures composed of a plurality of said recombinant protein with at least one additional antigen.

- [00388] 22. The method according to clause 21, wherein the at least one additional antigen is Porcine Reproductive and Respiratory Syndrome (PRRS) virus.
- [00389] 23. An immunogenic composition obtainable by a method according to any one of clauses 1 to 22.
- 5 [00390] 24. The immunogenic composition according to clause 23, wherein the immunogenic composition further comprises an attenuated live virus, preferably an attenuated Porcine Reproductive and Respiratory Syndrome (PRRS) virus, or an attenuated live bacterium.
- [00391] 25. The immunogenic composition according to clause 23 or 24, wherein the attenuated live virus is Porcine Reproductive and Respiratory Syndrome (PRRS) virus.
- 10 [00392] 26. The immunogenic composition according to any one of clauses 23 to 25, wherein the immunogenic composition induces a protective immune response against a pathogen, preferably a pathogen comprising a recombinant protein according to clause 6, after the administration of one dose of the immunogenic composition.
- [00393] 27. The immunogenic composition according to any one of clauses 23 to 26,
15 wherein the immunogenic composition induces a protective immune response against PRRS virus after the administration of one dose of the immunogenic composition.
- [00394] 28. Kit comprising a container containing the immunogenic composition according to any one of clauses 23 to 27.
- [00395] 29. The kit according to clause 28 further comprising at least one additional
20 container containing at least one additional antigen selected from the group consisting of attenuated live virus, preferably attenuated PRRS virus, and attenuated live bacterium.
- [00396] 30. The immunogenic composition according to any one of clauses 23 to 29 for use as a medicament, preferably as a vaccine.
- [00397] 31. The immunogenic composition according to any one of clauses 23 to 29
25 and/or the kit according to any one of clauses 28 or 29, for use in a method of reducing one or more clinical symptoms of a pathogen infection in an animal as compared to an animal not receiving said immunogenic composition.

EXAMPLES

[00398] The following examples are set forth below to illustrate specific embodiments of the present invention. These examples are merely illustrative and are understood not to limit the scope or the underlying principles of the present invention.

5

EXAMPLE 1:

Production of porcine parvovirus (PPV) 27a VP2 – Upstream processing

[00399] The PPV 27a VP2 is produced in baculovirus-infected SF+ cells, and is BEI-inactivated in a process somewhat similar to that of PCV2 ORF2 (WO 2006/072065; Examples 1 to 3). However, the PPV 27a VP2 uses a different baculovirus backbone designated as “DiamondBac” (Sigma
10 Aldrich, D6192) (instead of the older BaculoGold backbone used for PCV2 ORF2).

[00400] Porcine parvovirus (PPV) 27a VP2 nucleotide sequence is obtained from Genbank Accession AY684871.1. The PPV 27a VP2 coding region was reverse-translated and codon-optimized for Drosophila using the SciTools® Web Tools software provided by Integrated DNA Technologies. The codon-optimized PPV 27a VP2 gene was further modified to insert two ClaI
15 restriction enzyme sites into the VP2 coding region, along with the addition of BamHI and NotI restriction enzyme sites to the 5'- and 3'-ends, respectively. The ClaI sites are inserted in a manner so as to not disrupt the VP2 coding region. The insertion of the ClaI sites introduces three minor amino acid changes in the predicted 27a VP2 amino acid sequence. The amino acid changes resulting from the ClaI insertions are at position 25 (Glycine ⇒ Isoleucine), 36 (Alanine ⇒ Serine), and 37 (Glycine
20 ⇒ Isoleucine). The codon-optimized PPV 27a-ClaI VP2 gene was chemically synthesized and subsequently cloned into the standard cloning plasmid, pUC57, at Integrated DNA Technologies (PPV27a-ClaI 38320377). The PPV 27a-ClaI gene was then excised from the Integrated DNA Technologies-provided pUC57 plasmid by digestion with BamHI and NotI restriction enzymes, and the PPV 27a-ClaI gene was subcloned into the respective enzyme sites of the baculovirus transfer
25 vector pVL1393 (BD Pharmingen, 21486P). The pVL1393 plasmid containing the PPV 27a-ClaI gene was amplified in DH5α *E. coli* (Invitrogen™ MAX Efficiency™) and subsequently extracted and purified using a commercial plasmid purification kit (QIAprep Spin Miniprep kit, Qiagen). The purified pVL1393 plasmid containing the PPV 27a-ClaI gene and the linearized baculovirus DiamondBac® backbone were co-transfected into Sf9 insect cells using Escort™ Transfection
30 Reagent (Sigma Aldrich, E9770) to generate recombinant baculovirus. Limiting dilution was performed to obtain a purified recombinant baculovirus stock containing the PPV 27a-ClaI VP2 gene under control of the polyhedrin promoter. The baculovirus expression vector system (BEVS) is utilized to allow suspension insect cell culture (SF+) to produce recombinant antigen comprised of

PPV 27a VP2 protein. For this product, the infected SF+ cell culture is run in batch mode for approximately seven days and is then processed to remove cell debris and media components.

EXAMPLE 2:

Production of porcine parvovirus (PPV) 27a VP2 – Downstream processing

5 [00401] Two consecutive steps are followed to comprise the downstream processing. The removal of cell debris occurs in the process known as “clarification”, while the removal of media components is achieved through two volumes of wash phosphate buffered saline (WPBS), called “diafiltration”.

[00402] PPV 27a VP2 Baculovirus-vector is produced in bioreactors. The medium is added pre
10 sterilized or sterile-filtered into the bioreactor. The medium is added with SF+ cells originating from expansion cultures. The cells are simultaneously inoculated (concurrent infection) upon planting with PPV 27a VP2 Baculovirus seed. Throughout the virus propagation temperature is maintained at $27\pm 2^{\circ}\text{C}$ and pH is monitored. Dissolved Oxygen (DO) is controlled by sparging cleaned-compressed air, and oxygen (O_2). The harvest window occurs between 6 to 8 days after virus infection and the
15 harvest criterion of $\leq 20\%$ Cell Viability is achieved. At harvest, PPV 27a VP2 antigen fluids are clarified using two sets of filters, a pre-filter of 2.0-4.0 μm pore size and a final filter of 0.1-0.8 μm pore size. The filtered harvest fluids are collected in a tank.

[00403] Clarified PPV 27a VP2 antigen fluids are then “diafiltered” with $\geq$ two volumes (2x-2.5X) WPBS [using a 300,000-500,000 kilo Dalton (kDa) nominal molecular weight cut-off (NMWC)
20 hollow fiber filter] at a temperature between 4°C and 29°C . After diafiltration, the PPV 27a VP2 antigen temperature is increased to $37\pm 2^{\circ}\text{C}$. for inactivation by addition of binary ethylenimine (BEI) to a final concentration of 5mM. The antigen is incubated at $37\pm 2^{\circ}\text{C}$. and mixed for 72-96 hours. Residual BEI is neutralized with sodium molar excess of thiosulfate solution for at least 30 minutes. The PPV 27a VP2 antigen fluids are transferred to bags for storage at $4\pm 3^{\circ}\text{C}$. until vaccine blending.

25 [00404] The data below in Tables 1A and 1B show that PPV 27a VP2 vaccine is non-virucidal to ReproCyc[®] PRRS EU vaccine and Ingelvac[®] PRRS MLV vaccine, respectively, when mixed together for up to 8 hours (one working day).

[00405] **Table 1A:** Two (2) serials of ReproCyc PRRS EU[®], batch numbers 3910003A (10 dose) and 3910004A (50 dose), were stored at $5^{\circ}\text{C} \pm 3^{\circ}\text{C}$ in the packaging materials until being used
30 for the study. Two (2) serials of PPV 27a VP2, batch numbers 7600016A (10dose) and 7600018B (50dose), were used as diluent for the Ingelvac ReproCyc[®] PRRS EU batches 3910003A (10 dose) and 3910004A (50 dose), respectively. These two batches were stored at $5^{\circ}\text{C} \pm 3^{\circ}\text{C}$ in the packaging

materials until being used for the study. ReproCyc® PRRS EU vaccine, after reconstitution (either in the Carbopol-containing diluent in group 1 or the liquid vaccine PPV 27a VP2 in group 2), was stored at room temperature (15-25 °C) for a maximum period of 8 hours and tested for titer at zero, two, four and 8 hours. Group 1 results of the virus titration (Log10 TCID50/2mL dose) in Table 1A below at T0, T2, T4 and T8 demonstrated the stability of the virus up to 8h. Group 2 results of the virus titration (Log10 TCID50/2mL dose) on the associated product at T0, T2, T4 and T8 demonstrated that PPV 27a VP2 vaccine does not have virucidal activity against ReproCyc® PRRS EU up to 8h.

Table 1A

Group	Active substance	Serial number	Objective	Testing (Hrs) Log10 TCID50/2mL dose			
				0	2	4	8
1	ReproCyc® PRRS EU + Carbopol diluent	3910003A + 8080019A	Control ReproCyc® PRRS EU	5.8	5.9	5.9	5.9
		3910004A + 8080019A		6.0	6.0	5.9	6.0
2	PPV 27a VP2 + ReproCyc® PRRS EU	3910003A + 7600016A	Determination of in-use stability for the associated use claim	5.8	5.9	5.8	5.8
		3910004A + 7600018B		6.0	6.1	6.0	5.9

[00406] Table 1B: Two (2) serials of Ingelvac PRRS MLV, batch numbers 2451189A (10 dose) and 2451188A (50 dose), were stored at 5°C ± 3°C in the packaging materials until being used for the study. Two (2) serials of PPV 27a VP2, batch numbers 7600016A (10dose) and 7600018B (50dose), were used as diluent for the Ingelvac® PRRS MLV batches 2451189A (10 dose) and 2451188A (50 dose), respectively. These two batches were stored at 5°C ± 3°C in the packaging materials until being used for the study. Ingelvac® PRRS MLV vaccine, after reconstitution (either in the Carbopol-containing diluent in group 1 or the liquid vaccine PPV 27a VP2 in group 2), was stored at room temperature (15-25 °C) for a maximum period of 8 hours and tested for titer (TCID50 per 2mL dose) at zero, two, four and 8 hours. Group 1 results of the virus titration (Log10 TCID50/2mL dose) in Table 1B below at T0, T2, T4 and T8 demonstrated the stability of the virus up to 8h. Group 2 results of the virus titration (Log10 TCID50/2mL dose) on the associated product at T0, T2, T4 and T8 demonstrated that PPV 27a VP2 vaccine does not have virucidal activity against Ingelvac® PRRS MLV up to 8h.

Table 1B

Group	Active substance	Serial number	Objective	Testing (Hrs) Log10 TCID50/2mL dose			
				0	2	4	8
1	Ingelvac® PRRS MLV + Carbopol diluent	2451189A + 8080019A	Control Ingelvac® PRRS MLV	6.0	6.1	6.2	6.3
		2451188A + 8080019A		6.3	6.3	6.3	6.4
2	PPV 27a VP2 + Ingelvac® PRRS MLV	2451189A + 7600016A	Determination of in-use stability for the associated use claim	6.0	6.0	6.1	6.0
		2451188A + 7600018B		6.4	6.3	6.5	6.5

EXAMPLE 3:

PRRSV-EU vaccine effectiveness when PRRSV-EU vaccine is mixed with PPV VP2 vaccine

- 5 **[00407]** Thirty six (36) non-pregnant, breeding-age gilts were randomized to three treatment groups, each group comprising twelve gilts. Group T01 received control product of WPBS (wash phosphate buffered saline) (**control**) on days 0 and 21 (D0, D21). Group T02 received ReproCyc® PRRS EU (PRRS Strain 94881), 3.9 log₁₀ TCID₅₀ per dose, and Porcine Parvovirus vaccine, PPV-27a VP2, 10 µg per dose (**mixed**) on D0 and PPV-27a VP2, 10 µg per dose, only on D21. The
- 10 ReproCyc® PRRS EU as a lyophilized cake was reconstituted with the liquid PPV-27a VP2. Group T03 received ReproCyc® PRRS EU (**alone**) on D0. Treatments were formulated so that gilts received ReproCyc® PRRS EU at the minimum immunizing dose and PPV-27a VP2 at the maximum relative potency. Gilts were challenged with 5.5 log₁₀TCID₅₀ / 6 mL total dose (2 mL intramuscularly and 2 mL per nostril) heterologous PRRSV EU isolate 190136 four weeks after initial vaccination (D28),
- 15 and serum samples were collected on the following days: D31, D35, D38, D42 and D49. PRRSV viraemia was tested by quantitative PCR (qPCR) [Sandra Revilla-Fernández et al., Journal of Virological Methods 126 (2005) 21–30]. The challenge virus European PRRS virus isolate 190136 was originally obtained from lung tissue of a newborn piglet from a farm showing typical reproductive signs of PRRSV (abortions in sows and weakness in new born piglets) during an
- 20 outbreak in Lower Saxony, Germany, in April 2004. The attending veterinarians submitted the lung

samples to BioScreen (sample arrived on 21 April, 2004) for diagnostic testing. The challenge virus was propagated in AK-MA104 cells and passed twice prior to the challenge.

[00408] Post-challenge, both groups (mixed and alone) were shown to be efficacious against virulent PRRSV with quantitative viral load areas under the curve (AUC) for D28 to D49 of 24.36 GE/mL (GE = genomic equivalents) for mixed ($p=0.0002$) and 32.54 GE/mL for alone ($p=0.0045$) compared to 50.85 GE/mL in the control. This represents an approximate 50% reduction in systemically circulating virus in the pigs over time for the mixed group and an approximate 40% reduction for the ReproCyc® PRRS EU alone group (figure 1) demonstrating the substantial protective effect of the mixed and alone groups. Additionally, quantitative mean PRRSV qPCR analysis demonstrated significant reductions in PRRSV viral load in for mixed on D35 ($p<0.0001$) and on D38 ($p=0.0052$) and in alone for D35 ($p<0.0001$) compared to the control demonstrating the substantial protective effect of the mixed and alone groups. qPCR analysis showed significant reductions in proportion of positive gilts on D35 for mixed ($p=0.0013$) and alone ($p=0.0046$) and on D38 for mixed ($p=0.0137$) compared to the control. While not statistically significant, a numerical trend toward reduction in mean viral load and proportion PRRSV qPCR positive was observed for mixed on D42 and D49. Similar trends were seen for alone with numerical reduction in mean viral load on D49 and proportion qPCR positive on D42 and D49.

[00409] The use of ReproCyc® PRRS EU vaccine alone or when mixed with PPV-27a VP2 vaccine was proven efficacious against a virulent PRRSV-EU challenge strain demonstrating a four-week onset of immunity. From the data in Figure 1 and Figure 2, it is apparent that mixing ReproCyc® PRRS EU vaccine with PPV-27a VP2 improved efficacy. The results show a lack of interference between PRRSV component and PPV component in the mixed group demonstrating the advantageous possibility of associated use through mixing.

EXAMPLE 4:

PPV VP2 vaccine effectiveness when PRRSV-EU vaccine is mixed with PPV VP2 vaccine

[00410] **Assessment of effectiveness of the combined vaccines:** The efficacy of the associated use of both vaccines [ReproCyc® PRRS EU (PRRS Strain 94881) and PPV-27a VP2] is evaluated against PPV experimental infections.

[00411] **Efficacy against an experimental challenge with PPV wild strain:** The efficacy of the combined vaccines against PPV is evaluated based on the PPV infection in fetus. The vaccine is considered efficacious if $\geq 80\%$ of fetuses in each treated group are seronegative for PPV.

[00412] Animal Care: Animals are in good health and nutritional status before a study is initiated. Prior to the inclusion and the randomization procedure a health examination is conducted. Non-medicated feed is used throughout the duration of the study. Feed rations are appropriate for the age, condition, and species of test animal according to facility standard operations procedure. Water is provided *ad libitum* throughout the study.

[00413] Assessment of the efficacy of the associated use of PPV and PRRSV vaccines after challenge with and heterologous PPV strain: On D0, conventional non-pregnant gilts of 5-6 months of age are randomized equitably to three treatment groups. Group T01 receives 2mL IM of control product (PBS-Carbopol diluent (Impran FLEX[®]) on days 0 and 21 (D0, D21). Group T02 receives 2mL IM of ReproCyc[®] PRRS EU (PRRS Strain 94881) and Porcine Parvovirus vaccine, PPV-27a VP2, on D0 and PPV-27a VP2 only on D21. As for Group T02, the ReproCyc[®] PRRS EU as a lyophilized cake was reconstituted with the PPV-27a VP2 vaccine solution. Group T03 receives 2mL IM Porcine Parvovirus vaccine, PPV-27a VP2, (1 µg /dose) on D0 and on D21. The gilts are observed daily for general health. The animals are challenged between day 39 and 42 of gestation with heterologous PPV strain 401/09 (198669) obtained from BioScreen (Münster, Germany) from the tissue of a mummified piglet on 15th June 2004 and sent to Leipzig University, Germany (challenge virus is thawed and diluted in DMEM (1x, Gibco, Ref#11966-025, Lot# 1632505) to a target dosage of 6.0 log₁₀ TCID₅₀/6-mL dose). Fetuses are harvested (standard procedure) at around day 90 of gestation and evaluated for the presence of PPV by PCR (Molitor TW et al., Journal of Virological Methods 1991, 32: 201-211) from their organ or tissue fluid samples as well as for their condition, size and weight. Treatments are formulated so that gilts receive ReproCyc[®] PRRS EU (PRRS Strain 94881) and Porcine Parvovirus vaccine, PPV-27a VP2, at the maximum ReproCyc[®] PRRS EU immunizing dose (10^{7.0} TCID₅₀/2-mL dose; geometric mean) and Porcine Parvovirus vaccine, PPV-27a VP2, at the minimum relative potency (1 µg /dose).

[00414] The study was valid according to Ph.Eur. Monograph 8.0 04/2013:0965 as the vaccine provided a protection of 95.7% (T03 group) and 94.3% (T02 group), while the T01 group (control) had 91.4% positive fetuses (see Table 2).

[00415] It is concluded that vaccination with the PPV vaccine alone or mixed with ReproCyc[®] PRRS EU is safe and efficacious when vaccination is completed three weeks before mating.

Table 2 – Percentage of positive fetuses per group

Group	N gilts	N fetuses	N pos fetuses	% PPV positives foetus per treatment ¹

T01	19	269	246	91.4
T02	14	176	10	5.7
T03	19	231	10	4.3

¹ Number of positive PPV fetus/ Number of fetus per group.

EXAMPLE 5:

5

PREPARATION OF SUBUNIT PPV VACCINE

[00416] The PPV VP2 antigen is selected to be expressed in baculovirus-infected insect cells based on the German PPV 27a isolate. Porcine parvovirus (PPV) 27a VP2 nucleotide sequence is obtained from Genbank Accession AY684871.1. The PPV 27a VP2 coding region is reverse-translated and codon-optimized for Drosophila (SEQ ID NO:4 and SEQ ID NO:3). The codon-optimized PPV 27a VP2 gene is chemically synthesized at Integrated DNA Technologies. The PPV 27a gene is then subcloned into the baculovirus transfer vector pVL1393, and co-transfected with the linearized baculovirus DiamondBac® backbone into Sf9 insect cells to generate recombinant baculovirus containing the PPV 27a VP2 gene under control of the polyhedrin promoter.

[00417] When expressed in Sf9 insect cells the PPV VP2 self-assembled into a non-enveloped VLP (data not shown).

[00418] The PPV VP2 antigen is adjuvanted with a carbomer (Carbopol).

EXAMPLE 6:

PROOF OF CONCEPT STUDY OF THE PPV VACCINE

[00419] In all animal studies the animals are in good health and nutritional status before the study is initiated. Prior to the randomization procedure a health examination is conducted. Non-medicated feed is used through the duration of the study. Feed rations are appropriate for the age, condition, and species of test animal according to facility standard operating procedure. Water is provided ad libitum throughout the study.

[00420] The objective of this vaccination-challenge study is to establish proof of concept dose determination efficacy for a pre-breeding subunit Porcine Parvovirus (PPV) vaccine (see Example 5). Gilts are vaccinated and bred prior to challenge with a live virulent PPV isolate (PPV 002346-5; a North American Strain) at approximately 40 days of gestation (dG). Fetuses are evaluated for PPV infection at approximately 90 dG.

[00421] The study design is described in Table 3.

Table 3: Study Design

Treatment		Vaccination	Insemination	Pregnancy Evaluation	Challenge	Necropsy
T1	Negative Control	2mL on D0 right neck IM & 2 mL on D21 left neck IM	D34 – D42	D71	6 mL on D80 (~40dG) PPV 002346-5 right neck IM and IN	D129/130 (~90dG)
T2	PPV 10 µg					
T3	Positive Control (whole cell inactivated PPV)					
NTX	None	Not applicable			Not applicable	D79 (39dG)

NTX = Non-Treated/Non-Challenged Control; IN = intranasal; IM = intramuscular; dG = days of gestation.

5 [00422] Sixty-seven gilts originated from a herd that previously tested negative for PPV with no prior history of reproductive disease or vaccination against PPV are used. Gilts are randomized into 6 treatment groups (T) of n=9 commingled into 3 pens receiving vaccination on D0 and boosted on D21: **T1** NC (negative control of water for injection), **T2** PPV 10µg, **T3** PC (positive control; whole, inactivated *porcine parvovirus (PPV)*, *Erysipelothrix rhusiopathiae*, *Leptospira canicola*,
10 *L. grippotyphosa*, *L. hardjo*, *L. icterohaemorrhagiae*, and *L. Pomona*; commercially available; used according to manufacturer's manual). Three non-treated control (**NTX**) gilts are included, one per pen. Post-vaccination, the gilts are synchronized (via administration of Matrix®; altrenogest, Intervet Schering-Plough Animal Health; per label for 14 consecutive days, D18 to D31) and then bred between D35 and D42. Fifty-four of the 67 gilts become pregnant. On D80 (approximately 40dG),
15 NTX gilts are necropsied, and the remaining gilts are inoculated with 6 mL of PPV strain PPV002346-5 (a North American Strain) at 4.25 log₁₀TCID₅₀ per dose (2 mL intramuscularly and 2mL per nostril intranasally). Gilts are bled weekly except during synchronization and breeding (D35 – D70). Serology is performed on sera from D0, D7, D14, D21, D28 and D73; serology and polymerase chain reaction (PCR) (as described in Jozwik et al. 2009; Journal of General Virology, 90,
20 2437-2441) for viremia is performed on sera from D80, D87, D94, D101, D108, D115, D122, and D128. Gilts are necropsied on D129 or D130 (approximately 90dG). At necropsy, each reproductive tract is removed, and the position of the fetus in the uterus, the fetal condition, size and weight are recorded. Samples of thoracic wash and lung from each fetus are collected. Thoracic wash samples are collected aseptically from each fetus. Briefly, 3 ml of sterile PBS are injected into the thoracic cavity with a sterile needle and syringe. Fluid is aspirated back into the syringe and injected into an
25 appropriate, sterile SST (serum separator tube) of suitable size. Thoracic washes are tested for the

presence of PPV by PCR and for the presence of PPV antibody by hemagglutination inhibition (HI). Lung tissue is stored frozen.

[00423] Gilt Viremia (PPV)

[00424] All gilts are negative for PPV viremia prior to challenge on D0, D73 (data not shown) and D80 (Table 4). All negative controls are viremic on D87, and 4/7 are viremic on D94.

[00425] Post-vaccination T3 gilts seroconvert following booster vaccination. T2 has a serological response to initial vaccination and stays seropositive after the booster vaccination. T1 control gilts remain serologically negative for PPV until challenge. Post-challenge, all negative control gilts are viremic on D87 (seven days after challenge). One T3 gilt is viremic on D87. All other gilts are not viremic at these time points (see Table 4).

[00426] NTX gilts remained seronegative and their fetuses were all PPV negative by PCR on thoracic wash samples.

Table 4: Frequency distribution of PPV-positive (PCR) gilts when challenged with PPV at 40 days of gestation (dG) on D80.

Treatment/Description		Day of Study (dG =days of gestation)							
		D80	D87	D94	D101	D108	D115	D122	D128
		dG40	dG 47	dG 54	dG 61	dG 68	dG 75	dG 82	dG 89
T1	Negative Control	0/7	7/7	4/7	0/7	0/7	0/7	0/7	0/7
T2	10µg PPV	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8
T3	Positive Control (whole cell inactivated PPV)	0/9	1/9	0/9	0/9	0/9	0/8	0/8	0/8
NTX	None	0/3	NA	NA	NA	NA	NA	NA	NA
NA = not applicable.									

[00427] Fetus Results

[00428] All of the NTX fetuses are considered normal on D80 necropsy (Table 5). At final necropsy on D129 and D130, 22.5% of T1 (Negative Control) fetuses are normal while 98.39% of fetuses in T3 and 97.62% of fetuses in T2 are normal. The average size and weight of T1 (Negative Control) fetuses is 11.5 cm and 168.8 g, respectively, while the average size and weight of fetuses in T2 is 17.5 cm and 590.1 g, respectively.

[00429] All T4 (NTX) fetuses are PPV negative determined by PCR on thoracic wash samples (see Table 3). PPV infection is confirmed in 67/80 T1 Negative Control fetuses (83.75%). Sixty-two

of the 67 Negative Control fetuses confirmed to be PPV infected are mummies. In contrast, PPV infection is confirmed only in 0.79% in T2 fetuses.

[00430] Based on the conclusion parameter for establishing efficacy as stated in the European Pharmacopoeia (monograph 01/2008:0965), all vaccines (including the Positive Control (whole cell inactivated PPV)) meet criteria for protection from infection (>80% fetuses negative for PPV).

Table 5: Litter details: number, size, weight and condition of fetuses and laboratory confirmation of PPV infection (PCR on thoracic wash samples).

Treatment	T1	T2	T3	T4
Description	NC	PPV 10µg	Positive Control (whole cell inactivated PPV)	NTX *
# of gilts	5	8	9	3
Total # fetuses	80	126	124	44
Avg. litter size	16.0	15.8	13.8	14.7
Fetal Condition:				
Mummies	62	3	2	0
Normal	18	123	122	44
% Normal	22.50	97.62	98.39	100.0
Average size (cm)	11.5	17.5	17.8	6.0
Average weight (g)	168.8	590.1	580.3	11.9
Laboratory Confirmation of PPV Infection:				
# PPV+ fetuses	67	1	3	0
% positive	83.75	0.79	2.42	0.0
% protected	16.25	99.21	97.58	
*NTX fetuses necropsied at 50 days of gestation NC = Negative Control				

[00431] Conclusion: The PPV vaccine of the present invention showed protection of fetuses after virulent heterologous PPV challenge. The study results show that the vaccine is safe when administered pre-breeding and efficacious in significantly reducing viremia, and transplacental infection in fetuses. Further, it has been shown that the vaccine protect against a heterologous North

American PPV challenge strain. Furthermore, it has been shown that the subunit PPV VP2 protein is as efficacious as the whole killed virus.

EXAMPLE 7:

ESTABLISHING THE MINIMUM IMMUNIZING DOSE OF THE PPV VACCINE – PROTECTION AGAINST HETEROLOGOUS US PPV STRAIN

[00432] The objective of this vaccination-challenge study is to establish the minimum immunizing dose (MID) for the Porcine Parvovirus (PPV) vaccine. Gilts are challenged with a live virulent PPV serotype 1 isolate (PPV 002346-5) at approximately 40 days of gestation (dG). A vaccine is considered efficacious if $\geq 80\%$ of fetuses in the vaccinated group are negative for PPV after challenge. Supportive parameters include fetus size, weight and condition, gilt viremia status post-challenge and gilt serological status.

[00433] Gilts (with no prior history of reproductive disease or vaccination against PPV) are randomized into treatment groups: T01 negative control (Product matched placebo (PMP)) and T02 = 1.0 μg PPV/2 mL dose). Non-treated/non-challenged (NTX) gilts are randomly assigned to pens as controls for general health status.

[00434] Gilts are given 2 mL of the appropriate treatment intramuscularly on D0 and D21. Post-vaccination, gilts are bred between D37 and D50, and then evaluated for pregnancy status on D74. On D81, gestating gilts are challenged with 6.77 $\log_{10}\text{TCID}_{50}$ /6 mL of PPV serotype 1 intramuscularly and intranasally. Gilts are bled weekly except during estrus synchronization and breeding (D36-D73). Hemagglutination Inhibition (HI) assays are performed on sera from D7, D14, D21, D28 and D35; HI and polymerase chain reaction (PCR) (see Example 6) for viremia are performed on sera from D-3, D74, D80, D88, D95, D102 and D127. Gilts are necropsied on D128 and D129 (approximately 90 dG). At necropsy, the reproductive tract of each sow is removed, and the position of each fetus in the uterus, the fetal condition, size and weight are recorded. Thoracic wash samples (see Example 6) are collected from each fetus and tested for the presence of PPV by PCR.

[00435] Gilt Viremia (PPV)

[00436] The vaccines are considered safe since animals show no abnormal body temperature 24 hours or 48 hours post-vaccination, no abnormal local reactions attributable to the vaccine and no clinical signs related to vaccination (data not shown).

[00437] All gilts are negative for PPV viremia prior to vaccination, prior to challenge on D74, and on D80. Thus, post-vaccination, no clinical signs related to vaccine administration are observed.

On D88, all ten T01 gilts are viremic, and all vaccinated gilts are negative. All other blood samples on D95, D102 and D127 are negative for PPV viremia for all treatment groups (Table 6).

Table 6: Frequency distribution of PPV-positive (PCR) gilts when challenged with PPV at ~40 days of gestation (dG) on D81.

Treatment/Description		Day of Study/Days of Gestation (dG)					
		D74	D80	D88	D95	D102	D127
		dG 32	dG 38	dG 46	dG 53	dG 60	dG 85
T01	Negative Control	0/12	0/12	10/10*	0/10	0/10	0/10
T02	PPV (1.0 µg/dose)	0/12	0/12	0/12	0/12	0/12	0/12

5 * 2 gilts have been diagnosed as not pregnant and, therefore, removed from the group

[00438] Fetus Results

[00439] At final necropsy on D128 and D129, 38% of T01 (Negative Control) fetuses are normal condition while 95% of fetuses in the vaccine group are normal condition. The average size and weight of T01 (Negative Control) fetuses is 14.4 cm and 245.9 g, respectively, while the average size and weight of fetuses from the vaccinated dams is 19.3 cm and 550 g, respectively (Table 7). Thus, the vaccine group meets the criteria for protection from infection with PPV as the conclusion parameter for PPV efficacy established by the Ph. Eur. 01/2008:0965 is >80% fetuses in a treatment group must be negative for PPV.

[00440] PPV infection is confirmed in 113/146 of Negative Control (T01) fetuses (77%). However, PPV infection in the vaccinated group (T02) is only 10%.

Table 7 Litter details: number, size, weight and condition of fetuses and laboratory confirmation of PPV infection (PCR on thoracic wash samples).

Treatment	T01	T02
Description	Negative Control	PPV 1µg
# of gilts	10	11
Total # fetuses	146	148
Avg. litter size	14.6	13.5
Fetal Condition:		
# Necrotic (%)	9 (6%)	0 (0%)
# Mummies (%)	82 (56%)	8 (5%)
# Normal (%)	55 (38%)	140 (95%)
Average size (cm)	14.4	19.3
Average weight (g)	245.9	550.0
Laboratory Confirmation of PPV Infection:		
# Thoracic wash positive fetuses (%)	113 (77%)	15 (10%)
% protected		90%
# = number, % = percent		

[00441] Conclusion: The PPV VP2 subunit vaccine of the present invention shows protection of fetuses after challenge with a virulent heterologous PPV. This study results reveal that the vaccine is safe and efficacious in preventing viremia in gilts and PPV infection in fetuses when using only 1 µg of PPV VP2 subunit vaccine. Further, it is shown that the vaccine protects against a heterologous North American challenge strain.

EXAMPLE 8:

ESTABLISHING THE MINIMUM IMMUNIZING DOSE OF THE PPV VACCINE – PROTECTION AGAINST HETEROLOGOUS EU PPV STRAIN

[00442] The objective of this study is to evaluate the onset of immunity of the Porcine Parvovirus Vaccine (PPV VP2, called PPV vaccine from here on). In addition, safety and efficacy is evaluated using a randomized, blinded, negative controlled vaccination - challenge study design.

[00443] Gilts are randomly assigned to three groups. In groups 1 and 2 gilts are vaccinated twice, with a three week interval (on D0 and D21). The second dose is given three weeks before mating. All treatments are administered by the intramuscular (IM) route in a 2 mL volume. Group 2 received the PPV vaccine, whereas group 1 is the placebo group which receives a sterile diluent as control product and group 3 served as strict control, without any treatment.

[00444] The gilts are estrus synchronized and three weeks after the second vaccination they are artificially inseminated. Animals that got pregnant are challenged on D84 between the 39th and 42nd day of gestation with a virulent, heterologous PPV strain.

[00445] On D132-135, at about the 90th day of gestation, the gilts are euthanized, necropsied and the fetuses were evaluated.

Table 8: Study Design

Group	1 st Treatment D0 (2 mL right side of neck IM)	2 nd Treatment D21 (2 mL left side of neck IM)	Challenge D84 6.0 Log ₁₀ TCID ₅₀ /6 mL) dose (~40dG) 2 mL right neck IM and 2 mL per nostril	Necrops y
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			intranasal	
1 (Negative Control)	Control Product	Control Product	PPV EU Strain 401/09 (198669)	D132 to D135
2	PPV (1µg/dose)	PPV (1µg/dose)	PPV EU Strain 401/09 (198669)	D132 to D135
3 (Strict Control)	-	-	No Challenge	D83

[00446] Evaluation of PPV viremia in gilts pre- and post- challenge by PCR:

[00447] All animals are negative for PPV by PCR at D-6 and D-1 before vaccination fulfilling the inclusion criteria. Post vaccination all animals in the strict control and control product group are negative for PPV antigen until challenge, therefore, a PPV infection before challenge can be excluded.

[00448] Viremia is investigated at 7 (D90), 14 (D97) and 21 (D104) days post challenge and at the day of necropsy. After challenge no viremia is detected in the vaccinated animals, viremia occurs only in the non-vaccinated control animals.

[00449] On D90, (7 days post challenge) already 95% of the non-vaccinated control animals are positive for PPV. On D97 still 60% of these animals have a positive result while on D104 all animals are tested negative for PPV. In contrast, in the vaccinated group all animals tested on day D90, D97 or D104 are negative for PPV.

Table 9: Number of animals with viremia after challenge

	7 days post challenge (D90)	14 days post challenge (D97)	21 days post challenge (D104)
Control	19/20 (95%)	12/20 (60%)	0/20
PPV	0/20	0/20	0/20

[00450] Fetus Results

[00451] The percentage of PPV infected fetus was of 91.4% in the Control group, but only 4.3% in the PPV group (see Table 10).

Table 10 Percentage of positive fetuses per group and litter size

Group	N gilts	N fetuses	N positive fetuses	% PPV positive (PCR)	N Average litter size	Min % positive fetuses	Max % positive fetuses
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				fetuses per treatment¹		per litter	per litter
Control	19	269	246	91.4	14.2	57	100
PPV	19	231	10	4.3	12.2	0	20

¹Number of positive PPV fetuses/Number of fetuses per group. N Total number

[00452] Evaluation of condition of fetuses

[00453] All fetuses are evaluated for their condition and allocated to three categories: normal, mummified and autolysed.

- 5 **[00454]** The majority of mummified and autolysed fetuses are found in the control group. Only 39.8% of fetuses in this group are of normal condition while in the vaccinated groups 97.4% (PPV group) of fetuses have a normal condition (see Table 11).

Table 11: Fetal condition

Group	Foetal condition			
	[% normal]	[% autolysed]	[% mummified]	[N (total)]
Control	39.8%	12.3%	48.0%	269
PPV	97.4%	0.9%	1.7%	231

- 10 **[00455] Conclusion:** The PPV vaccine of the present invention shows protection of fetuses after virulent heterologous PPV challenge indicating that the vaccine is safe and efficacious in preventing viremia and PPV infection in fetuses when using only 1 µg of vaccine. Further, it is shown that the vaccine also protects against a heterologous European challenge strain of PPV. Thus, the vaccine has a broad protection spectrum as the vaccine protects against heterologous North American as well as
- 15 heterologous European challenge strains.

- [00456]** All of the compositions and methods disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the compositions and methods of this invention have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the compositions and methods
- 20 and in the steps or in the sequence of steps of the method described herein without departing from the concept, spirit and scope of the invention. More specifically, it will be apparent that certain agents which are both chemically and physiologically related may be substituted for the agents described herein while the same or similar results would be achieved. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the spirit, scope and concept
- 25 of the invention as defined by the following claims.

EXAMPLE 9:

Porcine Parvovirus (PPV) Proof of Concept/Vaccine Dose Determination of PPV Subunit
Combination Vaccine with *Erysipelothrix rhusiopathiae* and/or Porcine Reproductive and Respiratory
Syndrome Virus in Breeding Age Gilts

[00457] The objective of this vaccination-challenge study is to provide data on the associated
5 use of Ingelvac® PRRSV MLV with an experimental subunit Porcine Parvovirus (PPV) combination
vaccine with *Erysipelothrix rhusiopathiae* (Ery) bacterin and was to establish proof of concept dose
determination of efficacy for a PPV combination vaccine with Ery bacterin in 5- to 6-month-old gilts.

[00458] Sixty-seven gilts originated from a herd previously tested negative for PPV with no
prior PPV history of disease or vaccination. Gilts were randomized into 6 treatment groups of n=9
10 commingled into 3 pens receiving vaccination on D0 and boosted on D21: **T1** Negative Control, **T2**
PPV 10µg, **T3** PPV 0.1 µg + Ery 10 logs, **T4** PPV 1.0 µg + Ery 10 logs, **T5** PPV 10 µg + Ery 10 logs,
T6 Positive Control (FarrowSure® GOLD). Three non-treated control (**NTX**) gilts were included, one
per pen. In addition, ten gilts were housed in a separate building receiving **T7** PPV 10 µg + Ery 10
logs used to rehydrate Ingelvac® PRRSV MLV to assess PPV efficacy when combined with the
15 commercially available Porcine Reproductive and Respiratory Syndrome (PRRS) vaccine. **T7 is the**
group of interest for this Example 9.

[00459] Gilts were vaccinated and mated; 54 of the 67 gilts became pregnant. At approximately
40 days of gestation (dG), NTX gilts were necropsied, and the remaining gilts were inoculated with 6
mL of PPV strain PPV002346-5 at 4.25 log₁₀TCID₅₀ per dose (2 mL intramuscularly and 2mL per
20 nostril intranasally. Gilts were bled weekly except during synchronization and breeding (D35 – D70),
and sera was tested as described in Table 12.

Table 12 Samples and Laboratory Testing, Gilts

Sample	Day of Sample Collection	Test Type	Test
Serum	Pre-screen	SIV Serology	HI
Serum	All: D0, D73. T7 only: D21, D80, D128	PRRSV Serology	ELISA
Serum	D0, D80, D87, D94, D101, D108, D115, D122, D128	PPV Gilt Serology	HI
Serum	D0, D7, D14, D21, D28, D73, D80, D94, D101, D108, D115, D122, D128	PPV Gilt Viremia	PCR

[00460] Gilts were necropsied on D129 or D130 (~ 90dG). At necropsy, each reproductive tract
25 was removed, and the position of the fetus in the uterus, the fetal condition, size and weight were
recorded. Samples of thoracic wash and lung from each fetus were collected. Thoracic washes were
tested for the presence of PPV by PCR and for the presence of PPV antibody by hemagglutination
inhibition (HI). Lung tissue was stored frozen.

[00461] T7 gilts had a serological response to vaccination and were not viremic post-challenge. At necropsy, 97.37% (111/114) of T7 fetuses were normal condition, and only one fetus tested positive for PPV. In contrast, all T1 gilts were seronegative during the vaccination phase and seroconverted and became viremic post-challenge. At necropsy, only 22.50% (18/80) of T1 fetuses were normal condition, and 83.75% (67/80) tested positive for PPV infection by PCR of thoracic wash fluid. In conclusion, the combination vaccine (PPV 10 µg + Ery) with Ingelvac PRRS MLV was efficacious in preventing viremia and PPV infection of fetuses at 40dG.

[00462] Study Design:

Table 13 - Study Design

Treatment		#	Vaccination	Insemination	Pregnancy Evaluation	Challenge	Necropsy
T1	Negative Control	9	2mL on D0 right neck IM & 2 mL on D21 (no PRRSV) left neck IM	D34 – D42	D71	6 mL on D80 (~40dG) PPV 002346-5 right neck IM and IN	D129/130 (~90dG)
T2	PPV 10 µg	9					
T3	PPV 0.1 µg + Ery	9					
T4	PPV 1.0 µg + Ery	9					
T5	PPV 10 µg + Ery	9					
T6	Farrow [®] Sure GOLD	9					
T7	PPV 10 µg + Ery + Ingelvac PRRS MLV	10					
NTX	None	3	Not applicable			Not applicable	D79 (39dG)

10 # = number; NTX = Non-Treated/Non-Challenged Control; IN = intranasal; IM = intramuscular; dG = days of gestation

[00463] Materials:

[00464] Control Product: The control product administered to the Negative Control (T1) animals was sterile diluent (lot #240) prepared using water for injection (WFI) from purified water at BIVI, St. Joseph MO, USA. The control product was supplied as a 100-mL fill volume presentation in plastic bottles. A 2-mL dose was applied in the right neck muscle on D0 with a 2-mL booster applied in the left neck muscle on D21.

[00465] Vaccine: The combination vaccine of interest for T7 was an experimental subunit PPV combination vaccine with Ery bacterin used as a diluent to rehydrate Ingelvac® PRRS MLV. Serial #311-171 was targeted at 10 µg/dose for PPV in combination with a 10 logs/dose of killed Ery bacterin provided by the Laboratory Scientist in plastic bottles containing 20 mL (10 doses). A single
5 bottle of Serial #311-171 was used to rehydrate a single bottle of a commercial serial of Ingelvac® PRRS MLV obtained by the Study Investigator, Serial #245-B53. A 2-mL dose was applied in the right neck muscle on D0 with a 2-mL booster applied in the left neck muscle on D21.

[00466] Challenge Material: The challenge material was prepared by the Laboratory Scientist, BIVI-R&D, Ames IA, prior to the challenge event. PPV strain 002346-5 was targeted at
10 $5 \log^{10} \text{TCID}_{50}$ per dose, 6 mL dose (assigned lot #354-021) and kept on ice during the challenge event. The challenge titers was determined by TCID_{50} assay on retained post-challenge material held at 4°C. The final titer of the challenge material was 3.47 logs/mL or 4.25 logs/6 mL dose. On D80, all gilts were inoculated with 2 mL of challenge material per each nostril in addition to 2 mL intramuscularly in the right neck.

15 [00467] Methods:

[00468] Necropsy and Fetal Evaluation: On D79, all NTX gilts were euthanized by intravenous barbiturate injection, and on D129 and D130, all remaining gilts were euthanized. For each necropsy, the reproductive tract was removed, and fetuses were delivered aseptically via caesarean. Fetuses were identified by a fetus ID composed of the gilt ID then a letter (R for “right horn” or L for left
20 horn) and then the number as the fetus is encountered from the uterine bifurcation. The fetal condition (normal or mummy), size and weight were recorded.

[00469] Fetal Sample Collection: To prevent cross-contamination of samples, all appropriate techniques were used to sterilize or clean work areas and utensils between handling each fetus and each sample both at necropsy and in the laboratory. Samples were labeled with the fetus ID, sample
25 type, study day and the collection date. At the earliest possible time on the day of collection, samples were transported on ice to the Laboratory Scientist. The Laboratory Scientist or designee processed each sample using proper techniques to prevent cross-contamination while aliquoting each sample into appropriately-sized and appropriately-labeled tubes. One aliquot was submitted to ISU-VDL. The presence of virus was measured on each sample by PCR. Remaining aliquots were stored at -70° C. at
30 BIVI-R&D – Ames.

[00470] Thoracic Wash Collection: As aseptically as possible, a thoracic wash was collected from each fetus by the Study Investigator. Briefly, 3 mL of sterile PBS was injected into the thoracic

cavity with a sterile needle and syringe. As much of the fluid as possible was aspirated back into the syringe and was then injected into an appropriate-sized SST.

[00471] Statistical Methods:

[00472] EXPERIMENTAL UNIT: The gilt was the experimental unit for T1-T6. In the case
5 where comparisons were made with T7, the room was the experimental unit with the understanding that the housing of T7 was separate from the other treatment groups.

[00473] Justification for number of animals: The European Pharmacopoeia required at least seven vaccinated gilts and five control gilts to be challenged (EPH 01/2008:0965). Nine or ten gilts were sourced for each treatment to account for gilts failing to conceive.

10 **[00474]** Randomization: Prior to the start of the study, the Statistician was supplied with gilt ID numbers and randomized gilts to pen and treatment completely at random. Three gilts were randomized to the NTX group, ten gilts were randomized to the T7 group and the remaining gilts were randomized equally to T1, T2, T3, T4, T5 and T6 groups. T1-6 gilts and NTX gilts were equally divided between three pens in Barn 1. T7 gilts were individually housed in pens in Barn 2.

15 **[00475]** Blinding Criteria: Throughout the study, any personnel involved in collecting data or performing laboratory assays was masked to the allocation of gilts to treatment groups T1, T2, T3, T4, T5 and T6. Since T7 and NTX gilts were housed separately and serum was tested for PRRSV antibody, personnel could not be blinded to these two groups. Treatments were administered by an individual not involved with data collection.

20 **[00476]** Data Management: Statistical analysis of data was conducted by the Statistician. All data was imported into SAS version 9.2 (Cary, USA/North Carolina, SAS Institute Inc.) for management and analyses.

[00477] Results:

[00478] Only comparisons for the Negative Control (T1) compared to the PPV 10 µg + Ery 10
25 logs used to rehydrate Ingelvac® PRRSV MLV group (T7) are presented in this study summary, and data for T1, T7 and NTX groups are presented.

[00479] Gilt Results: On D0, all gilts were serologically negative for PRRSV by ELISA. On D21, D80 and D128, all T7 gilts were seropositive for PRRSV. On D73, all T7 gilts were seropositive, and gilts in all other treatment groups were seronegative.

[00480] Geometric mean PPV HI titers for T7 became and stayed seropositive after the booster vaccination on D21 whereas geometric mean PPV HI titers for T1 and NTX treatments remained seronegative (<100) during the vaccination phase. After D80 when T1 and T7 gilts were challenged with PPV, both groups were seropositive.

- 5 **[00481]** All gilts were negative for PPV viremia prior to challenge on D0, D73 (data not shown) and D80 (0). All negative controls were viremic on D87, and 4/7 were viremic on D94.

Table 14 Frequency distribution of PPV-positive (PCR) gilts when challenged with PPV at 40 days of gestation (dG) on D80.

Treatment/Description		Day of Study (dG =days of gestation)							
		D80	D87	D94	D101	D108	D115	D122	D128
		dG40	dG 47	dG 54	dG 61	dG 68	dG 75	dG 82	dG 89
T1	Negative Control	0/7	7/7	4/7	0/7	0/7	0/7	0/7	0/7
T7	10µg PPV/Ery/PRRS	0/9	0/9	0/9	0/9	0/9	0/9	0/9	0/9
NTX	None	0/3	NA	NA	NA	NA	NA	NA	NA
NA = not applicable; Ery = 10 log <i>Erysipelothrix rhusiopathiae</i> bacterin; PRRS = Ingelvac® PRRS MLV									

- 10 **[00482]** Fetus Results: All of the NTX fetuses were considered normal on D80 necropsy ([00430]). At final necropsy on D129 and D130, 22.5% of T1 (Negative Control) fetuses were normal while 99.12% of fetuses in T7 were normal. The average size and weight of T1 (Negative Control) fetuses was 11.5 cm and 168.8 g, respectively, while the average size and weight of fetuses in T7 was 17.8 cm and 576.3 g, respectively.
- 15 **[00483]** All NTX fetuses were PPV negative determined by PCR on thoracic wash samples. PPV infection was confirmed in 67/80 T1 Negative Control fetuses (83.75%). Sixty-two of the 67 Negative Control fetuses confirmed to be PPV infected were mummies. The 18 normal-appearing fetuses were all from the same litter, and only five of these 18 fetuses were confirmed to be PPV positive. For T7, only one pig was infected for <1% infection rate.
- 20 **Table 15** Litter details: number, size, weight and condition of fetuses and laboratory confirmation of PPV infection (PCR on thoracic wash samples).

Treatment	T1	T7	NTX*
Description	Negative Control	PPV/Ery/PRRS	NTX*
Number of gilts	5	8	3
Total number fetuses	80	114	44
Average litter size	16.0	14.3	14.7
Fetal Condition:			

Mummies	62 (77.50%)	3 (0.63%)	0 (0.0%)
Normal	18 (22.50%)	111 (97.37%)	44 (100%)
Average size	11.5 cm	17.8 cm	6.0 cm
Average weight	168.8 g	576.3 g	11.9 g
Laboratory Confirmation of PPV infection (PCR results)			
PCR positive fetuses	67 (83.75%)	1 (0.88%)	0 (0.0%)
% protected	13 (16.25%)	113 (99.12%)	
*NTX fetuses necropsied at 50 days of gestation PPV/Ery/PRRS = 10 µg PPV + 10 log <i>Erysipelothrix rhusiopathiae</i> bacterin used to rehydrate Ingelvac® PRRS MLV			

[00484] DISCUSSION/CONCLUSION

[00485] NTX gilts remained seronegative, and their fetuses were all PPV negative by PCR on thoracic wash samples.

5 [00486] Gilts administered T7 (10 µg PPV+Ery+PRRSV) had a serological response to initial vaccination and stayed seropositive after the booster vaccination. No T7 gilts were viremic on the weekly sampling points post-challenge. At necropsy, 97.37% (111/114) of T7 fetuses were normal condition, and only one fetus tested positive for PPV infection by PCR of thoracic wash fluid. In contrast, gilts administered T1 (Negative Control) were seronegative during the vaccination phase, and post-challenge, all gilts seroconverted and became viremic. The average size and average weight of T1 fetuses were substantially less than T7 averages. At necropsy, only 22.50% (18/80) of T1 fetuses were normal condition, and 83.75% (67/80) tested positive for PPV infection by PCR of thoracic wash fluid.

15 [00487] In conclusion, the combination vaccine (PPV 10 µg + Ery) with PRRS MLV was efficacious in preventing viremia and PPV infection of fetuses at 40dG.

SEQUENCE LISTING

[00488] SEQ ID NO:4 is a codon-optimized PPV 27a VP2 nucleotide sequence which was further modified to have two ClaI restriction enzyme sites (amino acid position 25 is an isoleucine residue, amino acid position 36 is a serine residue, amino acid position 37 is an isoleucine residue) so as to flank the VP2 coding region comprised of Glycine repeats. However, the ClaI sites were introduced in a manner so as to not disrupt the VP2 coding region. SEQ ID NO:2 is the protein sequence corresponding to SEQ ID NO:4. SEQ ID NO:3 is a codon-optimized PPV 27a VP2 nucleotide sequence (without ClaI restriction enzyme sites). SEQ ID NO:1 is the protein sequence corresponding to SEQ ID NO:3. SEQ ID NO: 5 to 16 disclose further PPV VP2 protein sequences with (SEQ ID NO: 5 to 10) or without (SEQ ID NO: 11 to 16) ClaI sites. SEQ ID NO:17 corresponds

to PRRSV Lelystad wild-type sequence and SEQ ID NO:18 corresponds to PRRSV VR2332 wild-type sequence.

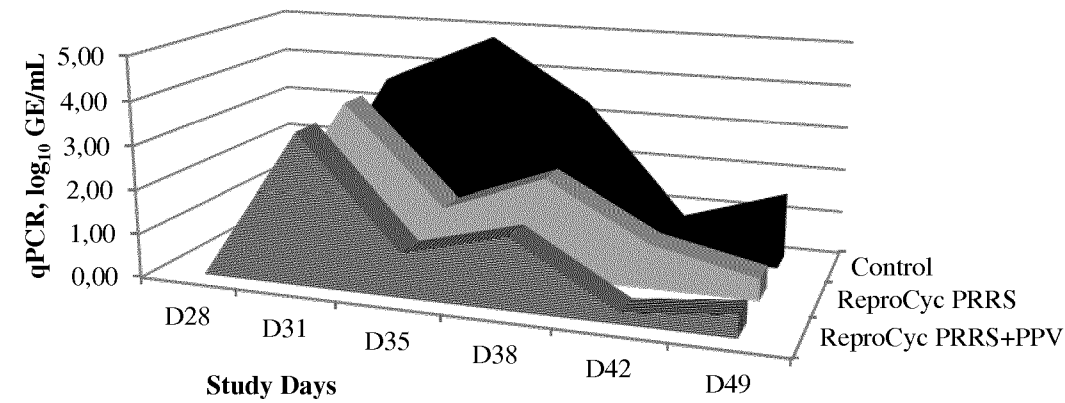
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A combination vaccine comprising:
 - a) at least one porcine parvo virus (PPV) antigen, wherein the at least one PPV antigen is one or more PPV subunit(s) and the at least one PPV subunit(s) is PPV viral protein 2 (VP2), wherein the PPV VP2 consists of an amino acid sequence having at least 99% sequence identity with the amino acid sequence of SEQ ID NO:2, and
 - b) at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen, wherein the at least one PRRS virus antigen is a live attenuated/modified live PRRS virus selected from the group consisting of live attenuated/modified live PRRS virus type 1 genotype, live attenuated/modified live PRRS virus type 2 genotype, live attenuated/modified live PRRS virus strain 94881 and PRRS virus strain ATCC deposit VR-2332.
2. The vaccine according to claim 1, wherein the PPV VP2 consists of an amino acid sequence having 100% sequence identity with the amino acid sequence of SEQ ID NO:2.
3. The vaccine according to claim 1 or 2, wherein the PPV VP2 is the only PPV antigen.
4. The vaccine according to any one of claims 1 to 3, wherein the vaccine is formulated for a single-dose administration or a two-dose administration.
5. The vaccine according to any one of claims 1 to 4, wherein vaccine further comprises at least one pharmaceutically acceptable carrier.
6. The vaccine according to claim 5, wherein the at least one pharmaceutically acceptable carrier is a carbomer.
7. The vaccine according to any one of claims 4 to 6, wherein the vaccine 0.1 µg to 50 µg of the PPV VP2 antigen, preferably 0.5 µg to 10 µg of the PPV VP2 antigen, more preferably 1.0 µg to 10 µg of the PPV VP2 antigen and/or 3.9 to 7.0 log₁₀TCID₅₀ of the PRRS virus.
8. The vaccine according to any one of claims 1 to 7, wherein the at least one porcine parvovirus (PPV) antigen and the at least one porcine reproductive and respiratory syndrome (PRRS) virus antigen are contained together in one single container.
9. The vaccine according to any one of claims 1 to 8, wherein the combination is produced by combining the contents of the container(s) containing the at least one PPV antigen with the

contents of the container(s) containing the at least one PRRS virus antigen, wherein more preferably the liquid contents of the container(s) containing the at least one PPV antigen are used as a diluent for the lyophilized contents of the container(s) containing the at least one PRRS virus antigen.

- 5 10. The vaccine according to any one of claims 1 to 9, wherein the at least one PPV antigen and at least one PRRS antigen are administered to the subject simultaneously.
11. The vaccine according to any one of claims 1 to 10, which is administered intramuscularly.
12. A kit when used for vaccination an animal against infection with PPV and/or PRRS virus, comprising the vaccine according to any one of claims 1 to 11.
- 0 13. A method of treatment and/or prevention of an infection with PPV and/or PRRS virus, the reduction, prevention or treatment of clinical signs caused by an infection with PPV and/or PRRS virus, or for the treatment and/or prevention of a disease caused by an infection with PPV and/or PRRS virus by administration to a swine of the combination vaccine according to any one of claims 1 to 11.
- 5 14. The method according to claim 13, wherein at least one PPV antigen and at least one PRRS antigen are administered to the subject simultaneously.

Figure 1



	D28	D31	D35	D38	D42	D49
ReproCyc PRRS+PPV	0,00	3,45	1,00	1,62	0,25	0,50
ReproCyc PRRS	0,00	3,61	1,36	2,25	1,00	0,50
Control	0,00	3,74	4,77	3,33	0,75	1,51

Figure 2

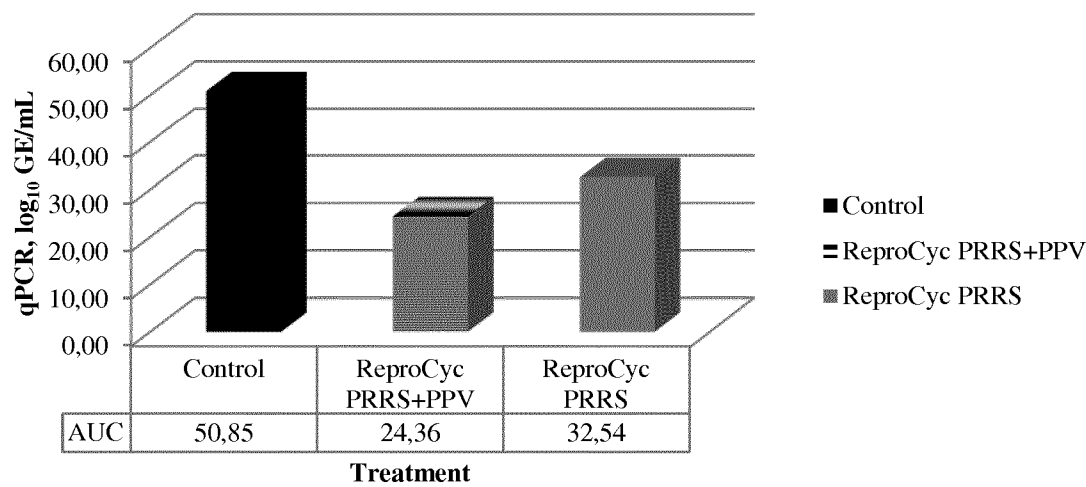
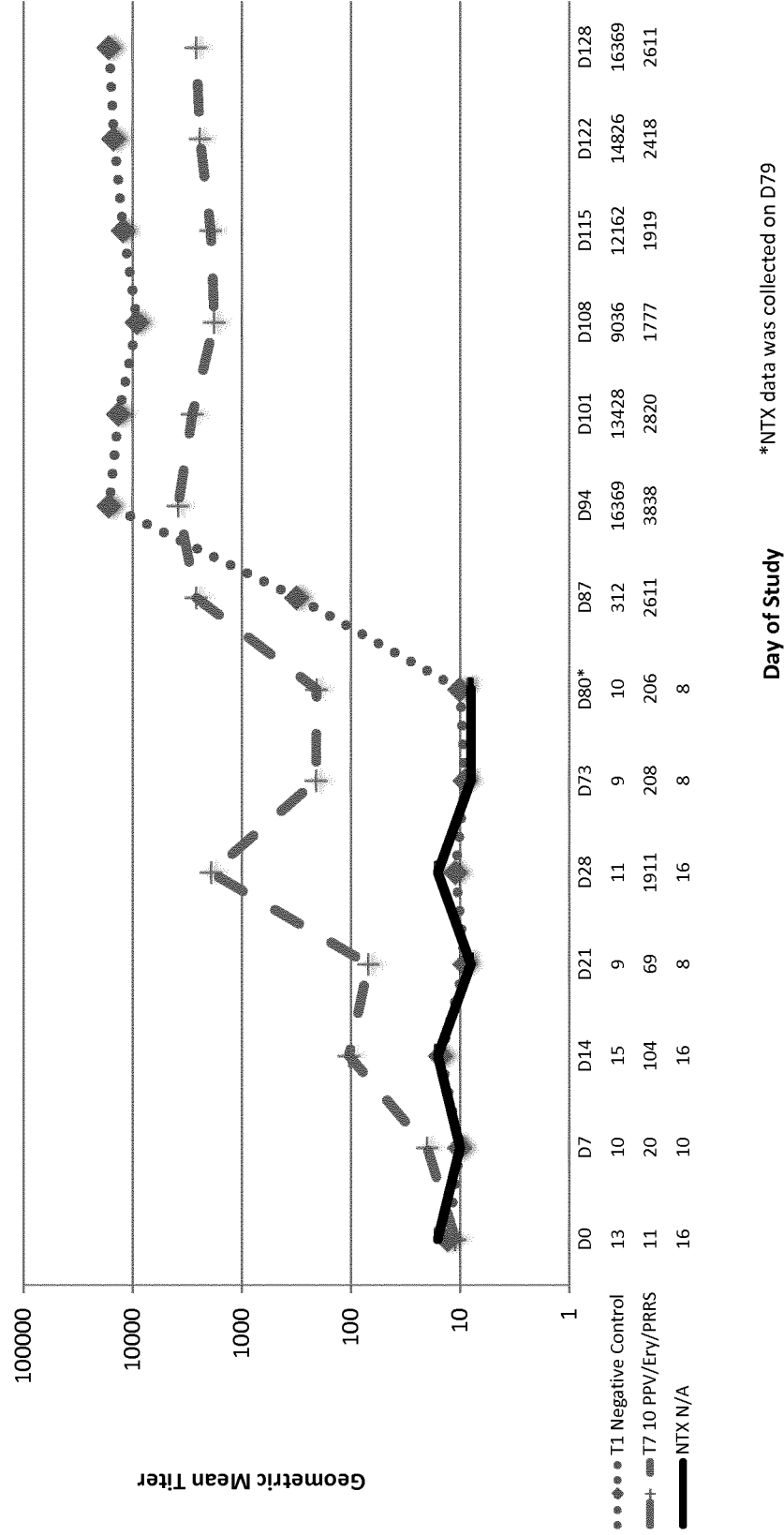


Figure 3



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Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
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His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
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Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
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Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
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Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu

130

135

140

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Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
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Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
 275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
 290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
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Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
 325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe

340

345

350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
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Pro Asn Gly Ala Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
 370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
 385 390 395 400

Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
 405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
 420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly
 435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
 450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
 465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
 485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
 500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
 515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
 530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn

545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

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<210> 2
<211> 579
<212> PRT
<213> Porcine parvovirus
<400> 2
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Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Ile Gly Gly Gly Gly Gly Gly Gly
20 25 30

Gly Arg Gly Ser Ile Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val	Gln	Asp	Asp	Ala	His	Thr	Gln	Met	Val	Thr	Pro	Trp	Ser	Leu	Ile
			100					105					110		

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
385 390 395 400

Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly
435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 3
<211> 1760
<212> DNA
<213> Porcine parvovirus

<400> 3
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ctgtcggcga ctggcaatga gagcggaggc ggaggcggcg gaggagggtg acgcggcgca 120
ggcggagtg gcgtttcgac cggaagcttc aataatcaaa ccgagtttca gtacctgggc 180
gagggttttg tgcggattac ggctcacgcg tcccgactga tacatctcaa tatgccggag 240
catgagacct acaagcgtat ccatgtcctg aactcggaat cgggcgtcgc cggtcagatg 300
gtccaagatg atgctcatat tcagatgggtg acaccctgga gcttgataga tgccaacgca 360
tggggcgtgt ggttcaaccc tgcggatttg cagctgataa gcaataacat gacagaaatc 420
aatttggtta gtttcgagca agagatatatt aatgtcgtgc tgaaaaccat cacagagagc 480
gccacgagcc ccccgacgaa gattttacaat aacgacctga cggcgtcctt gatggtcgcc 540
ttggacacaa ataacaccct cccgtacacc cccgcggccc cccgcagcga gaccctgggc 600
ttttatccct ggctgcccac caagccaacg cagtatcgct actacctgag ttgtacacga 660
aatttgaatc cgccgacata cactgggtcag tcggagcaga tcacggacag cattcaaacg 720
ggcctgcact ccgatatcat gttttacacg atagagaacg cagtacccat ccacctgctg 780
cgtacgggag atgagttctc gaccgggtatc tatcattttg acacaaaacc cttgaaattg 840
acgcacagtt ggcaaacc aa tcgctcgtg ggcttgcccc caaagttgtt gacggaaccc 900
accaccgagg gtgaccaaca cccaggcact ctccccgcag caaataaccg caagggctat 960
catcaaacga tcaacaatag ctataccgag gctaccgcca ttcggccagc acaggtggga 1020
tacaacacac cttacatgaa ctttgaatac tccaacggcg gcccgttcct gaccccgata 1080

eolf-othd-000002.txt

gttccgaccg ccgacactca gtacaacgat gacgagccga acggcgccat caggtttacc	1140
atgggctatc agcacggtca attgacaact tcgtcgcaag aactggaacg ctatacattc	1200
aaccctcaga gtaagtgtgg ccgggcaccc aaacaacagt tcaaccagca atccccactg	1260
aacctgcaga ataccaacaa tggcacgctg ctgccatccg atcccattgg aggaaagacc	1320
aacatgcatt tcatgaacac gctgaataca tacggaccac tgaccgccct gaacaatacc	1380
gcacccgtct tccctaattg ccagatctgg gataaagagc tggatacgga cctgaagccc	1440
cgactccacg tgactgcgcc ctttgtgtgc aaaaataacc caccgggaca gttgttcgtc	1500
aaaatagccc ccaacttgac cgacgacttc aatgcagaca gccctcagca gccgcgaatc	1560
atcacctatt cgaacttctg gtggaagggc acgctgactt tcacggctaa gatgcgctcg	1620
agcaatatgt ggaacccaat ccagcaacat accacaaccg ctgaaaatat tggcaattac	1680
atccctacga atataggcgg aataaagatg tttccggagt attcccagct cattccacgc	1740
aagctgtatt aagcggccgc	1760

<210> 4

<211> 1760

<212> DNA

<213> Porcine parvovirus

<400> 4

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ctgtcggcga ctggcaatga atcgatcggc ggaggcggcg gaggagggtgg acgcggatcg	120
atcggagtgg gcgtttcgac cggaagcttc aataatcaaa ccgagtttca gtacctgggc	180
gagggtttgg tgcggattac ggctcacgcg tcccgactga tacatctcaa tatgccggag	240
catgagacct acaagcgtat ccatgtcctg aactcggaat cgggcgtcgc cggtcagatg	300
gtccaagatg atgctcatac tcagatggtg acaccctgga gcttgataga tgccaacgca	360
tggggcgtgt ggttcaaccc tgcggattgg cagctgataa gcaataacat gacagaaatc	420
aatttggtta gtttcgagca agagatattt aatgtcgtgc tgaaaaccat cacagagagc	480
gccacgagcc ccccgacgaa gatttacaat aacgacctga cggcgtcctt gatggtcgcc	540
ttggacacaa ataacaccct cccgtacacc cccgcggccc cccgcagcga gaccctgggc	600
ttttatccct ggctgcccac caagccaacg cagtatcgct actacctgag ttgtacacga	660

eolf-othd-000002.txt

aatttgaatc cgccgacata cactgggtcag tcggagcaga tcacggacag cattcaaacg	720
ggcctgcact ccgatatcat gttttacacg atagagaacg cagtacccat ccacctgctg	780
cgtacgggag atgagttctc gaccggtatc tatcattttg acacaaaacc cttgaaattg	840
acgcacagtt ggcaaaccaa tcgctcgtg ggcttgcccc caaagttgtt gacggaaccc	900
accaccgagg gtgaccaaca cccaggcact ctccccgcag caaatacccg caagggctat	960
catcaaacga tcaacaatag ctataccgag gctaccgcca ttcggccagc acaggtggga	1020
tacaacacac cttacatgaa ctttgaatac tccaacggcg gcccgttcct gaccccgata	1080
gttccgaccg ccgacactca gtacaacgat gacgagccga acggcgccat caggtttacc	1140
atgggctatc agcacggtca attgacaact tcgtcgcaag aactggaacg ctatacatc	1200
aaccctcaga gtaagtgtgg ccgggcaccc aaacaacagt tcaaccagca atccccactg	1260
aacctgcaga ataccaaaa tggcacgctg ctgccatccg atcccattgg aggaaagacc	1320
aacatgcatt tcatgaacac gctgaataca tacggaccac tgaccgccct gaacaatacc	1380
gcacccgtct tccctaattg ccagatctgg gataaagagc tggatacgga cctgaagccc	1440
cgactccacg tgactgcgcc ctttgtgtgc aaaaataacc caccgggaca gttgttcgtc	1500
aaaatagccc ccaacttgac cgacgacttc aatgcagaca gccctcagca gccgcgaatc	1560
atcacctatt cgaacttctg gtggaagggc acgctgactt tcacggctaa gatgcgctcg	1620
agcaatatgt ggaaccfaat ccagcaacat accacaaccg ctgaaaatat tggcaattac	1680
atccctacga atataggcgg aataaagatg tttccggagt attcccagct cattccacgc	1740
aagctgtatt aagcggccgc	1760

<210> 5
 <211> 579
 <212> PRT
 <213> Porcine parvovirus

<400> 5

Met	Ser	Glu	Asn	Val	Glu	Gln	His	Asn	Pro	Ile	Asn	Ala	Gly	Thr	Glu
1				5					10					15	

Leu	Ser	Ala	Thr	Gly	Asn	Glu	Ser	Ile	Gly	Gly	Gly	Gly	Gly	Gly	Gly
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

20

25

30

Gly Arg Gly Ser Ile Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
 35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
 50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
 65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
 85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
 100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
 115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Ala
 130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
 145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
 165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
 180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
 195 200 205

Arg Tyr Tyr Leu Ser Cys Ile Arg Asn Leu Asn Pro Pro Thr Tyr Thr
 210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser

225 230 235 240
 Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
 245 250 255
 Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
 260 265 270
 Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
 275 280 285
 Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
 290 295 300
 Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Thr
 305 310 315 320
 Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
 325 330 335
 Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
 340 345 350
 Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
 355 360 365
 Pro Asn Gly Ala Ile Arg Phe Thr Met Asp Tyr Gln His Gly Gln Leu
 370 375 380
 Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
 385 390 395 400
 Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
 405 410 415
 Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
 420 425 430
 Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly

435

440

445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
 450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
 465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
 485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
 500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
 515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
 530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
 545 550 555 560

Ile Gly Gly Ile Arg Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
 565 570 575

Lys Leu Tyr

<210> 6

<211> 579

<212> PRT

<213> Porcine parvovirus

<400> 6

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
 1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Ile Gly Gly Gly Gly Gly Gly Gly
 20 25 30

Gly Arg Gly Ser Ile Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
385 390 395 400

Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly
435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 7

<211> 579

<212> PRT

<213> Porcine parvovirus

<400> 7

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Ile Gly Gly Gly Gly Gly Gly Gly
20 25 30

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Gly Arg Gly Ser Ile Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

eolf-othd-000002.txt

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Phe Ile Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Gly Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
370 375 380

Ile Thr Ser Ser Gln Glu Val Glu Arg Tyr Thr Phe Asn Pro Gln Arg
385 390 395 400

Lys Cys Gly Arg Gly Ala Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Ile Gln Asn Thr Asn Asn Gly Thr Ile Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Pro Asn Thr Tyr Gly
435 440 445

eolf-othd-000002.txt

Pro Leu Thr Ala Val Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 8

<211> 579

<212> PRT

<213> Porcine parvovirus

<400> 8

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Ile Gly Gly Gly Gly Gly Gly Gly
20 25 30

eolf-othd-000002.txt

Gly Arg Gly Ser Ile Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Ala
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu His Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Ile Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

eolf-othd-000002.txt

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Asp Tyr Gln His Gly His Leu
370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
385 390 395 400

Lys Cys Gly Arg Thr Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly
435 440 445

eolf-othd-000002.txt

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Lys Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 9
<211> 579
<212> PRT
<213> Porcine parvovirus

<400> 9

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Ile Gly Gly Gly Gly Gly Gly Gly
20 25 30

Gly Arg Gly Ser Ile Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn

35

40

45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
 50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
 65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
 85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
 100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
 115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
 130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
 145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
 165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
 180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
 195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
 210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
 225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu

245

250

255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
 260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
 275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
 290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
 305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
 325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
 340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
 355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
 370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
 385 390 395 400

Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
 405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
 420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Ser Thr Leu Asn Thr Tyr Gly
 435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln

450

455

460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
 465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
 485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
 500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
 515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
 530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
 545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
 565 570 575

Lys Leu Tyr

<210> 10

<211> 579

<212> PRT

<213> Porcine parvovirus

<400> 10

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
 1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Ile Gly Gly Gly Gly Gly Gly Gly
 20 25 30

Gly Arg Gly Ser Ile Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
 35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Thr
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
385 390 395 400

Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly
435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 11
<211> 579
<212> PRT
<213> Porcine parvovirus

<400> 11

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Gly Gly Gly Gly Gly Gly Gly Gly
20 25 30

Gly Arg Gly Ala Gly Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

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Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Ala
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Ile Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

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Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Thr
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Asp Tyr Gln His Gly Gln Leu
370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
385 390 395 400

Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly
435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

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Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Arg Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 12
<211> 579
<212> PRT
<213> Porcine parvovirus

<400> 12

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Gly Gly Gly Gly Gly Gly Gly Gly
20 25 30

Gly Arg Gly Ala Gly Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

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Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

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Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
385 390 395 400

Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly
435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

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Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 13
<211> 579
<212> PRT
<213> Porcine parvovirus

<400> 13

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Gly Gly Gly Gly Gly Gly Gly Gly
20 25 30

Gly Arg Gly Ala Gly Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala

50

55

60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
 65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
 85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
 100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
 115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
 130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
 145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
 165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
 180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
 195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
 210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
 225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
 245 250 255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys

260

265

270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
 275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
 290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
 305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
 325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
 340 345 350

Phe Ile Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
 355 360 365

Pro Asn Gly Gly Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
 370 375 380

Ile Thr Ser Ser Gln Glu Val Glu Arg Tyr Thr Phe Asn Pro Gln Arg
 385 390 395 400

Lys Cys Gly Arg Gly Ala Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
 405 410 415

Asn Ile Gln Asn Thr Asn Asn Gly Thr Ile Leu Pro Ser Asp Pro Ile
 420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Pro Asn Thr Tyr Gly
 435 440 445

Pro Leu Thr Ala Val Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
 450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val

465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
 485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
 500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
 515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
 530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
 565 570 575

Lys Leu Tyr

<210> 14
<211> 579
<212> PRT
<213> Porcine parvovirus

<400> 14

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Gly Gly Gly Gly Gly Gly Gly Gly
 20 25 30

Gly Arg Gly Ala Gly Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
 35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
 50 55 60

His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Ala
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu His Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Ile Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Asp Tyr Gln His Gly His Leu
370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
385 390 395 400

Lys Cys Gly Arg Thr Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Asn Thr Leu Asn Thr Tyr Gly
435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Lys Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 15
<211> 579
<212> PRT
<213> Porcine parvovirus

<400> 15

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Gly Gly Gly Gly Gly Gly Gly Gly
20 25 30

Gly Arg Gly Ala Gly Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

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His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
225 230 235 240

Asp Ile Met Phe Tyr Thr Ile Glu Asn Ala Val Pro Ile His Leu Leu
245 250 255

Arg Thr Gly Asp Glu Phe Ser Thr Gly Ile Tyr His Phe Asp Thr Lys
260 265 270

eolf-othd-000002.txt

Pro Leu Lys Leu Thr His Ser Trp Gln Thr Asn Arg Ser Leu Gly Leu
275 280 285

Pro Pro Lys Leu Leu Thr Glu Pro Thr Thr Glu Gly Asp Gln His Pro
290 295 300

Gly Thr Leu Pro Ala Ala Asn Thr Arg Lys Gly Tyr His Gln Thr Ile
305 310 315 320

Asn Asn Ser Tyr Thr Glu Ala Thr Ala Ile Arg Pro Ala Gln Val Gly
325 330 335

Tyr Asn Thr Pro Tyr Met Asn Phe Glu Tyr Ser Asn Gly Gly Pro Phe
340 345 350

Leu Thr Pro Ile Val Pro Thr Ala Asp Thr Gln Tyr Asn Asp Asp Glu
355 360 365

Pro Asn Gly Ala Ile Arg Phe Thr Met Gly Tyr Gln His Gly Gln Leu
370 375 380

Thr Thr Ser Ser Gln Glu Leu Glu Arg Tyr Thr Phe Asn Pro Gln Ser
385 390 395 400

Lys Cys Gly Arg Ala Pro Lys Gln Gln Phe Asn Gln Gln Ser Pro Leu
405 410 415

Asn Leu Gln Asn Thr Asn Asn Gly Thr Leu Leu Pro Ser Asp Pro Ile
420 425 430

Gly Gly Lys Thr Asn Met His Phe Met Ser Thr Leu Asn Thr Tyr Gly
435 440 445

Pro Leu Thr Ala Leu Asn Asn Thr Ala Pro Val Phe Pro Asn Gly Gln
450 455 460

Ile Trp Asp Lys Glu Leu Asp Thr Asp Leu Lys Pro Arg Leu His Val
465 470 475 480

eolf-othd-000002.txt

Thr Ala Pro Phe Val Cys Lys Asn Asn Pro Pro Gly Gln Leu Phe Val
485 490 495

Lys Ile Ala Pro Asn Leu Thr Asp Asp Phe Asn Ala Asp Ser Pro Gln
500 505 510

Gln Pro Arg Ile Ile Thr Tyr Ser Asn Phe Trp Trp Lys Gly Thr Leu
515 520 525

Thr Phe Thr Ala Lys Met Arg Ser Ser Asn Met Trp Asn Pro Ile Gln
530 535 540

Gln His Thr Thr Thr Ala Glu Asn Ile Gly Asn Tyr Ile Pro Thr Asn
545 550 555 560

Ile Gly Gly Ile Lys Met Phe Pro Glu Tyr Ser Gln Leu Ile Pro Arg
565 570 575

Lys Leu Tyr

<210> 16
<211> 579
<212> PRT
<213> Porcine parvovirus

<400> 16

Met Ser Glu Asn Val Glu Gln His Asn Pro Ile Asn Ala Gly Thr Glu
1 5 10 15

Leu Ser Ala Thr Gly Asn Glu Ser Gly Gly Gly Gly Gly Gly Gly Gly
20 25 30

Gly Arg Gly Ala Gly Gly Val Gly Val Ser Thr Gly Ser Phe Asn Asn
35 40 45

Gln Thr Glu Phe Gln Tyr Leu Gly Glu Gly Leu Val Arg Ile Thr Ala
50 55 60

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His Ala Ser Arg Leu Ile His Leu Asn Met Pro Glu His Glu Thr Tyr
65 70 75 80

Lys Arg Ile His Val Leu Asn Ser Glu Ser Gly Val Ala Gly Gln Met
85 90 95

Val Gln Asp Asp Ala His Thr Gln Met Val Thr Pro Trp Ser Leu Ile
100 105 110

Asp Ala Asn Ala Trp Gly Val Trp Phe Asn Pro Ala Asp Trp Gln Leu
115 120 125

Ile Ser Asn Asn Met Thr Glu Ile Asn Leu Val Ser Phe Glu Gln Glu
130 135 140

Ile Phe Asn Val Val Leu Lys Thr Ile Thr Glu Ser Ala Thr Ser Pro
145 150 155 160

Pro Thr Lys Ile Tyr Asn Asn Asp Leu Thr Ala Ser Leu Met Val Ala
165 170 175

Leu Asp Thr Asn Asn Thr Leu Pro Tyr Thr Pro Ala Ala Pro Arg Ser
180 185 190

Glu Thr Leu Gly Phe Tyr Pro Trp Leu Pro Thr Lys Pro Thr Gln Tyr
195 200 205

Arg Tyr Tyr Leu Ser Cys Thr Arg Asn Leu Asn Pro Pro Thr Tyr Thr
210 215 220

Gly Gln Ser Glu Gln Ile Thr Asp Ser Ile Gln Thr Gly Leu His Ser
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