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(54) **Title**: SCHMALLENBERG VIRUS (SBV) VACCINE, METHODS OF PRODUCTION, AND USES THEREOF

(57) **Abstract**: The present invention relates to the field of vaccines and medicaments for the prophylaxis and treatment of infectious diseases in ruminants. In particular, it relates to inactivated Schmallenberg virus (SBV) useful as vaccine or medicament for preventing or treating viremia, the transmission and clinical symptoms, in particular malformations in newborn ruminants such as cattle, sheep and goats, induced by SBV.

Boehringer Ingelheim Vetmedica GmbH
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SCHMALLENBERG VIRUS (SBV) VACCINE, METHODS OF PRODUCTION, AND USES THEREOF

SEQUENCE LISTING

[0001] The instant application contains a Sequence Listing which has been submitted in ASCII format via EFS-Web and is hereby incorporated by reference in its entirety. Said ASCII copy, is named 01-2825-PCT-SEQ.txt and is 33,696 bytes in size.

BACKGROUND OF THE INVENTION

TECHNICAL FIELD

[0002] The present invention belongs to the field of vaccines and medicaments for the prophylaxis and treatment of infectious diseases. In particular, it relates to inactivated viruses useful as vaccine or medicament for preventing or treating viremia, the transmission and clinical symptoms, in particular malformations in newborn ruminants such as cattle, sheep and goats, induced by Schmallenberg virus.

BACKGROUND INFORMATION

[0003] A novel orthobunyavirus, the Schmallenberg virus (SBV), was discovered in Europe in November 2011. After the first detection, the reported cases of SBV in sheep, cattle, and goats dramatically accumulated in several European countries to several thousand cases of PCR-positive malformed lambs and calves (*1*, *2*). The virus was detected by metagenomics at the Friedrich-Loeffler-Institut (FLI) in samples of cattle with milk drop and fever. The investigated samples were collected in a farm near the city of Schmallenberg (North Rhine-Westphalia, Germany), and consequently the virus was named Schmallenberg virus (SBV). SBV is a member of the genus *Orthobunyavirus* within the family *Bunyaviridae*. It is related to the so-called Simbu serogroup viruses (*1*).

[0004] Orthobunyaviruses have a segmented, negative stranded RNA genome and are mainly transmitted by insect vectors like midges and mosquitos. The three segments (S, M and L) of the Orthobunyavirus genome allow genetic reassortment, which naturally occurs resulting

in the emergence of viruses with new biological properties (*3*). The largest segment L encodes the RNA-dependent RNA polymerase. The M-segments encodes the viral surface glycoproteins Gn and Gc which are responsible for cell fusion, viral attachment and the induction of neutralizing antibodies. The small S-segment encodes the nucleocapsid N which is also involved in complement fixation (*4*). The relationship between Orthobunyaviruses was often only determined by serological cross-reactivity (*5*). In the era of DNA sequencing, phylogenetics has additionally been assessed by comparison of partial genome sequences (full N and partial Gc gene) (*6*). Therefore, available and published genome sequence information of full-length genomes is sparse. As a consequence, in-depth phylogenetic analyses are difficult. In conclusion, a detailed and reliable taxonomic classification of SBV could not be made. Preliminary investigations showed similarities of the M- and L-segment sequences to partial AKAV and Aino virus (AINOV) sequences. The N gene was most closely related to Shamonda virus (SHAV) (*1*).

[0005] SBV is like Akabane virus (AKAV) able to cross the placental barrier in pregnant cows and sheep, infect the fetus and cause fatal congenital defects during a susceptible stage in pregnancy (*2*). The Simbu serogroup, named after the prototype virus, is the largest serogroup of Orthobunyavirus and contains at least 25 viruses, among them medically important viruses such as Akabane virus, Oropouche virus, Sathuperi virus or Douglas virus, most of which can cause malformations in new born ruminants, but also human beings can be affected. Akabane virus, for instance, causes congenital defects in ruminants and circulates in Asia, Oceania and Africa, whereas Oropouche virus is responsible for large epidemics of Oropouche fever, a zoonosis similar to dengue fever, in human populations in South America. Sathuperi virus has lent his name to the Sathuperi serogroup, to which belong also Douglas virus and SBV.

[0006] SBV was the first orthobunyavirus of the Simbu serogroup detected in Europe. The virus is appararently transmitted by arthropod vectors. Biting midges probably play an important role in transmission. According to the current state of knowledge, ruminants are susceptile to infection with SBV. Adult animals may develop mild disease, if any. However, transplacental infection occurs frequently and can lead to severe congenital malformation of the vertebral column (Kyphosis, lordosis, scoliosis, torticollis) and of the scull (macrocephaly, brachygnathia

inferior) as well as variable malformations of the brain (hydracephaly, porencephaly, cerebellar hypoplasia, hapoplasia of the brain stem) and of the spinal cord in lambs, kids and calves. The infection spread rapidly over large parts of North Western Europe. Belgium, Germany, France, Italy, Luxembourg, the Netherlands, Spain and the United Kingdom have been affected so far.

[0007] Therefore, SBV is a serious threat to ruminant livestock in Europe since vaccines are currently not available.

[0008] Thus, there is a strong need for vaccines and medications effecting a rapid induction of neutralizing antibodies for the prophylaxis and treatment of Schmallenberg virus infection.

DESCRIPTION OF THE INVENTION

[0009] The solution to the above technical problem is achieved by the description and the embodiments characterized in the claims.

[0010] Thus, the invention in its different aspects is implemented according to the claims.

[0011] In one aspect, the invention provides an immunogenic composition containing one or more antigens of the Schmallenberg virus (SBV), wherein the immunogenic composition preferably comprises the SBV.

[0012] Preferably, SBV is thus contained as the one or more antigens of SBV in the composition of the invention, or the one or more antigens of the SBV is/are preferably SBV, respectively. Hence, the immunogenic composition of the invention is in particular an immunogenic composition comprising Schmallenberg virus (SBV).

[0013] As used herein, the term "antigen" in particular refers to any molecule, moiety or entity capable of eliciting an immune response. This includes cellular and/or humoral immune responses. Depending on the intended function of the composition, one or more antigens may be included be included.

[0014] In a further preferred aspect, the antigen of SBV or the SBV contained in the immunogenic composition of the invention is inactivated.

[0015] According to one aspect, the immunogenic composition of the invention is thus preferably an immunogenic composition comprising inactivated Schmallenberg virus (SBV).

[0016] The term "inactivated", as used herein, means that the antigen does not cause disease, when administered to a mammalian host or does not replicate in a host cell.

[0017] The invention also provides an immunogenic composition comprising SBV or an antigen of SBV, wherein the SBV comprises

- a small (S) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 97.8 %, preferably at least 99 % sequence identity with the nucleic acid sequence of SEQ ID NO:1 or SEQ ID NO:7,
- a medium (M) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 82.2 % sequence identity with the nucleic acid sequence of SEQ ID NO:2, and/or
- a large (L) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 93 % sequence identity with the nucleic acid sequence of SEQ ID NO:3.

[0018] Preferably, said SBV comprises said small (S) RNA segment, said medium (M) RNA segment and said (L) RNA segment.

[0019] According to another aspect, the SBV or the antigen of the SBV is obtainable by the inactivation of SBV or the antigen of SBV, wherein said SBV comprises

- a small (S) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 97.8 %, preferably at least 99 % sequence identity with the nucleic acid sequence of SEQ ID NO:1 or SEQ ID NO:7,
- a medium (M) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 82.2 % sequence identity with the nucleic acid sequence of SEQ ID NO:2, and/or

- a large (L) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 93 % sequence identity with the nucleic acid sequence of SEQ ID NO:3.

[0020] All sequences of the sequence listing are typed in 5' - '3 direction. The sequences of SEQ ID NOs.1 to 3 and 7 code for cDNAs having a positive polarity (+ strand). The term "inverse complementary" means that the sequence is anti-parallel to the reference sequence.

[0021] Preferably said SBV comprises said small (S) RNA segment, said medium (M) RNA segment and said (L) RNA segment.

[0022] It is understood that the term "RNA segment", as used herein, is equivalent to "genome segment" or "segment", as frequently used in the context of Schmallenberg virus.

[0023] Preferably, the small (S) RNA segment mentioned herein has an RNA sequence that is inverse complementary to a DNA sequence having at least 97.8 %, more preferably at least 98.5 %, even more preferably at least 99 %, still more preferably at least 99.5 % or in particular 100 % sequence identity with the nucleic acid sequence of SEQ ID NO:1, or preferably, the small (S) RNA segment described herein has an RNA sequence that is inverse complementary to a DNA sequence having at least 97.8 %, more preferably at least 98.5 %, even more preferably at least 99 %, still more preferably at least 99.5 % or in particular 100 % sequence identity with the nucleic acid sequence of SEQ ID NO:7.

[0024] Preferably, the medium (M) RNA segment mentioned herein has an RNA sequence that is inverse complementary to a DNA sequence having at least 83 %, more preferably at least 85 %, even more preferably at least 90 %, still more preferably at least 95 % or in particular 100 % sequence identity with the nucleic acid sequence of SEQ ID NO:2.

[0025] Preferably, the large (L) RNA segment mentioned herein has an RNA sequence that is inverse complementary to a DNA sequence having at least 94 %, more preferably at least 96 %, still more preferably at least 98 % or in particular 100 % sequence identity with the nucleic acid sequence of SEQ ID NO:3.

[0026] As used herein, the term "immunogenic composition" in particular refers to a composition that will elicit an immune response in a mammal and/or an insect that has been exposed to the composition. An immune response may include induction of antibodies and/or induction of a T-cell response.

[0027] Sequence identity in the context of the invention is understood as being based on pairwise sequence alignments. For purposes of the present invention, pairwise sequence alignments are done with ClustalW as implemented in Mega5 (K. Tamura et. al., MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods. Mol. Biol. Evol. 28, 2731-2739 (2011)), using the default settings (gap opening penalty of 15 and gap extension penalty of 6.66; DNA weight matrix: ClustalW 1.6; Transition weight of 0.5). Sequence identities of the aligned sequences are calculated using BioEdit version 7.0.9.0.

[0028] It is understood that the term "sequence identity to", as used herein, herein, is equivalent to the term "sequence identity with the nucleic acid sequence of". Thus, as mentioned herein, the term "sequence identity to SEQ ID NO:4 or SEQ ID NO:8" is equivalent to the term "sequence identity with the nucleic acid sequence of SEQ ID NO:4 or SEQ ID NO:8", the term "sequence identity to SEQ ID NO:5" is equivalent to the term "sequence identity with the nucleic acid sequence of SEQ ID NO:5", and the term "sequence identity to SEQ ID NO:6" is equivalent to the term "sequence identity with the nucleic acid sequence of SEQ ID NO:6".

[0029] As used herein, it is in particular understood that the term "sequence identity with the nucleic acid sequence of SEQ ID NO:X" is equivalent to the term "sequence identity with the nucleic acid sequence of SEQ ID NO:X over the length of SEQ ID NO: X" or to the term "sequence identity with the nucleic acid sequence of SEQ ID NO:X over the whole length of SEQ ID NO: X", respectively. In this context, "X" is any integer selected from 1 to 8 so that "SEQ ID NO: X" represents any of the SEQ ID NOs mentioned herein.

[0030] In a further preferred aspect of the invention, the SBV mentioned herein comprises

- an S RNA segment, characterized in that the S RNA segment has a sequence having at least 97.8 %, preferably at least 99 % sequence identity to SEQ ID NO:4 or SEQ ID NO:8,
- an M RNA segment, characterized in that the M RNA segment has a sequence having at least 82.2 % sequence identity to SEQ ID NO:5, and/or
- an L RNA segment, characterized in that the L RNA segment has a sequence having at least 93 % sequence identity to SEQ ID NO:6,

and wherein in particular said SBV comprises said small (S) RNA segment, said medium (M) RNA segment and said (L) RNA segment.

[0031] Preferably, the SBV mentioned herein comprises

- an S RNA segment, characterized in that the S RNA segment has
  - an RNA sequence having at least 97.8 %, more preferably at least 98.5 %, even more preferably at least 99 %, still more preferably at least 99.5 % or in particular 100 % sequence identity to SEQ ID NO:4, or
  - an RNA sequence having at least 97.8 %, more preferably at least 98.5 %, even more preferably at least 99 %, still more preferably at least 99.5 % or in particular 100 % sequence identity to SEQ ID NO:8; and/or
- an M RNA segment, characterized in that the M RNA segment has a RNA sequence having at least 83 %, more preferably at least 85 %, even more preferably at least 90 %, still more preferably at least 95 % or in particular 100 % sequence identity to SEQ ID NO:5; and/or
- an L RNA segment, characterized in that the L RNA segment has a RNA sequence having at least 94 %, more preferably at least 96 %, still more preferably at least 98 % or in particular 100 % sequence identity to SEQ ID NO:6.

[0032] The term "having 100% sequence identity", as used herein, is also understood to be equivalent to the term "being identical".

[0033] Preferably, the inactivated SBV is obtainable by the inactivation of SBV by heat treatment or preferably with a virus inactivating agent, wherein in particular an aziridine compound, most preferably binary ethyleneimine (BEI), is used for the inactivation.

[0034] According to one preferred aspect, BEI is added to the antigen in a final concentration of 10 mM or less, wherein it has been surprisingly found that a final concentration of less than 4 mM is sufficient for the inctivation of the antigen. Thus, BEI is preferably added to a final concentration of less than 4 mM to the antigen, more preferably to a final concentration of 0.5 to 3.5 mM, most preferably to a final concentration of 1 to 3 mM.

[0035] After the addition of BEI, the mixture is preferably kept in agitation for 48 h or less, preferably for 24 h or less, most preferably for between 6 h and 18 h, such as e.g. for 12 h. The temperature of the mixture while the mixture is being agitated is preferably 37+/-5°C, most preferably 37+/-1°C.

[0036] Further, it has been found that only one inactivation step, e.g. by adding BEI to the antigen, is sufficient for the inactivation of the antigen.

[0037] After the inactivation procedure, the residual virus inactivating agent is preferably neutralized by adding a neutralizing agent to the mixture, in particular in a molar excess in comparison to the amount of virus inactivating agent added to the antigen. If an aziridine compound is used for the inactivation, then preferably a nucleophile which opens the three-membered ring is used for the neutralization. BEI is preferably neutralized by the addition of sodium thiosulphate, in particular in a 1.1 to 10 fold molar excess, most preferably in a 2 to 8 fold molar excess in comparison to the amount of BEI added to the antigen.

[0038] In a preferred aspect, the immunogenic composition of the invention comprises an amount of SBV which is equivalent to a virus titre of at least about 10^5 $TCID_{50}$/mL per dose, preferably between 10^5 to 10^7 $TCID_{50}$/mL per dose, more preferably about 10^6 $TCID_{50}$/mL per dose.

[0039] Surprisingly, it has been found that an immunogenic composition of the invention comprising an amount of SBV which is equivalent to a virus titre of less than $10^{5.5}$ $TCID_{50}$/ml per dose, preferably less than 10^5 $TCID_{50}$/ml per dose, is sufficient to prevent SBV RNAemia in an animal, in particular in sheep.

[0040] Thus, the immunogenic composition of the invention preferably comprises an amount of SBV which is equivalent to a virus titre of less than $10^{5.5}$ $TCID_{50}$/ml per dose, preferably less than 10^5 $TCID_{50}$/ml per dose, more preferably between 10^3 to 10^5 $TCID_{50}$/mL per dose, most preferably between 10^4 to 10^5 $TCID_{50}$/mL per dose, in particular for use in a method for inducing an immune response against SBV and/or for preventing or reducing viremia or malformations induced by SBV and/or for preventing or reducing the transmission of SBV, preferably in sheep.

[0041] "RNAemia" as described herein is in particular understood as the detection of RNA (e.g., by nucleic acid sequence–based amplification or reverse transcription PCR) in a sample of an animal, in particular in samples of plasma, serum or whole blood.

[0042] It is thus in particular understood, according to the invention, that viremia induced by SBV goes hand in hand or is accompanied, respectively, with SBV RNAemia in a sample of blood serum of an animal. Hence, viremia induced by SBV can be examined by detecting specific SBV RNA in the serum of animals.

[0043] In another preferred aspect, the immunogenic composition of the invention contains SBV having a pre-inactivation titre of at least about 10^6 SBV particles per milliliter, preferably between 10^6 to 10^8 $TCID_{50}$/mL SBV particles per milliliter, more preferably about 10^7 SBV particles per milliliter.

[0044] The term "pre-inactivation titre", as used herein, in particular refers to the amount of suspended SBV which is inactivated.

[0045] In particular, the immunogenic composition of the invention, further contains one or more pharmaceutically acceptable carriers or excipients, wherein said one or more

pharmaceutically acceptable carriers or excipients are preferably selected from the group consisting of solvents, dispersion media, adjuvants, stabilizing agents, diluents, preservatives, antibacterial and antifungal agents, isotonic agents, and adsorption delaying agents.

[0046] In a particular preferred aspect, the immunogenic composition of the invention further contains one or more adjuvants, preferably aluminium hydroxide and/or saponin, e.g. Alhydrogel and/or Quil-A, wherein a combination of aluminium hydroxide and saponin is most preferred.

[0047] Another aspect concerns the immunogenic composition of the invention for use as a medicament, preferably as a vaccine.

[0048] A further aspect relates to the immunogenic composition of the invention for use in a method for inducing an immune response against SBV and/or for preventing or reducing viremia or malformations induced by SBV and/or for preventing or reducing the transmission of SBV.

[0049] This aspect in particular relates to the immunogenic composition of the invention for use in a method for inducing an immune response against SBV in a ruminant and/or insect and/or for preventing or reducing viremia in a ruminant and/or insect and/or for preventing or reducing malformations induced by SBV in a ruminant fetus or newborn and/or for preventing or reducing the transmission of SBV by arthropod vectors, preferably insects and/or for preventing or reducing the transmission of SBV from the pregnant animal (the mother) to the fetus.

[0050] As used herein, the term “inducing an immune response” to an antigen or composition is the development of a humoral and/or cellular immune response in an animal to an antigen present in the composition of interest.

[0051] The term "prevention" or "reduction" or “preventing” or “reducing”, respectively, as used herein, means, but is not limited to a process which includes the administration of a SBV antigen, namely of the antigen of SBV according to the invention which is included in the composition of the invention, to an animal, wherein said SBV antigen, when administered to said

animal elicits or is able to elicit an immune response in said animal against SBV. Altogether, such treatment results in reduction of the clinical signs of a disease caused by SBV or of clinical signs associated with SBV infection, respectively. More specifically, the term "prevention" or "preventing", as used herein, means generally a process of prophylaxis in which an animal is exposed to the immunogenic composition of the present invention prior to the induction or onset of the disease process caused by SBV.

[0052] Herein, "reduction of clinical signs associated with SBV infection" means, but is not limited to, reducing the number of infected subjects in a group, reducing or eliminating the number of subjects exhibiting clinical signs of infection, or reducing the severity of any clinical signs that are present in the subjects, in comparison to wild-type infection. For example, it should refer to any reduction of pathogen load, pathogen shedding, reduction in pathogen transmission, or reduction of any clinical sign symptomatic of SBV infection, in particular of the transmisson of SBV from the mother to the fetus or of the malformations induced by SBV in a ruminant fetus or newborn. Preferably these clinical signs are reduced in subjects receiving the composition of the present invention by at least 10% in comparison to subjects not receiving the composition and may become infected. More preferably, clinical signs are reduced in subjects receiving the composition of the present invention by at least 20%, preferably by at least 30%, more preferably by at least 40%, and even more preferably by at least 50%.

[0053] The term "reduction of viremia induced by SBV" (or, alternatively, "reduction of RNAemia induced by SBV") means, but is not limited to, the reduction of SBV virus entering the bloodstream of an animal, wherein the viremia level, i.e. the number of SBV RNA copies per mL of blood serum or the number of plaque forming colonies per deciliter of blood serum, is reduced in the blood serum of subjects receiving the composition of the present invention by at least 50% in comparison to subjects not receiving the composition and may become infected. More preferably, the viremia level is reduced in subjects receiving the composition of the present invention by at least 90%, preferably by at least 99.9%, more preferably by at least 99.99%, and even more preferably by at least 99.999%.

[0054] As used herein, the term "viremia" is particularly understood as a condition in which Schmallenberg virus particles reproduce and circulate in the bloodstream of an animal, in particular of a mammal or of an insect.

[0055] The term "animal", as used herein, in particular relates to a mammal or to an insect.

[0056] Preferably, the mammal as mentioned herein is a ruminant. More preferably, the ruminant as mentioned herein is selected from the group consisting of cattle, sheep, goats, deer, elk, giraffes, bison, moose, yaks, water buffalo, camels, alpacas, llamas, antelope, pronghorn, and nilgai. Most preferably, the mammal or ruminant as mentioned herein is selected from the group consisting of cattle, sheep and goats.

[0057] The insect, as mentioned herein, is preferably selected from the group consisting of midges, in particular *Culicoides spp.*, biting flies and mosquitoes.

[0058] Further, the invention provides a vaccine composition for the treatment or prevention of SBV or for the prevention or reduction of the viremia of malformations induced by SBV and/or for the prevention or reduction of the transmission of SBV, wherein the vaccine comprises the immunogenic composition of the invention.

[0059] In particular, the invention provides a vaccine composition, which comprises the immunogenic composition of the invention, for use in a method for inducing an immune response against SBV in a ruminant and/or insect and/or for preventing or reducing viremia in a ruminant and/or insect and/or for preventing or reducing malformations induced by SBV in a ruminant fetus or newborn and/or for preventing or reducing the transmission of SBV by arthropod vectors, preferably insects.

[0060] The term "malformations", as used herein, in particular relates to a malformation selected from congenital malformation of the vertebral column (Kyphosis, lordosis, scoliosis, torticollis) and/or of the scull (macrocephaly, brachygnathia inferior), variable malformations of the brain (hydracephaly, porencephaly, cerebellar hypoplasia, hapoplasia of the brain stem) and

of the spinal cord, malformations and/or stiffening of fore and/or hind legs. More particular, the term "malformations" relates to malformations in lambs, kids and calves.

[0061] The invention also provides a method for the production of infectious SBV, comprising the steps of

- infecting cells, preferably mammalian or insect cells, with a SBV,
- cultivating the infected cells,
- harvesting the SBV produced by said cells.

[0062] The term "infecting", as used herein, in particular refers to the process of contacting cells with SBV, such as by inoculation.

[0063] Said infection of the cells with a SBV in particular includes attachment of the virus to a cell, entry of the virus into the cell, uncoating of the virion in the cytoplasm, replication and transcription of the viral genome, expression of viral proteins and assembly and release of new infectious viral particles.

[0064] The term "cultivating", as used herein, is particularly directed to the maintenance and preferably the growth of cells under suitable conditions.

[0065] The term "harvesting", as used herein, in particular refers to the taking of cell supernatant which contains viral particles, such as by centrifugation of a container containing a culture of virus infected cells and subsequent decantation of the cell supernatant.

[0066] Surprisingly, it has been found that SBV remains infectious, and thus also remains its antigenic potential, when it is alternately passaged between insect cells and mammalian cells.

[0067] Thus, the invention in particular concerns a method for the production of preferably infectious SBV, in particular the above-mentioned method, wherein the SBV is passaged alternately between insect cells and mammalian cells.

[0068] Hence, the method for the production of infectious SBV according to the invention in particular comprises the steps of:

(a) infecting insect cells with a SBV,
(b) cultivating the infected cells of step (a),
(c) harvesting the SBV produced by said cells in step (b),
(d) infecting mammalian cells with the SBV harvested in step (c),
(e) cultivating the infected cells of step (d), and
(f) harvesting the SBV produced by said cells in step (e)

or comprises the steps of

(d) infecting mammalian cells with a SBV,
(e) cultivating the infected cells of step (d),
(f) harvesting the SBV produced by said cells in step (e)
(g) infecting insect cells with the SBV harvested in step (f),
(h) cultivating the infected cells of step (g), and
(i) harvesting the SBV produced by said cells in step (h).

[0069] In this regard, the numeration of the steps (d)-(i) is equivalent to the numeration (a´)-(f´) and has been chosen for reasons of clarity in view of the further steps described herein (starting with the step "(j)").

[0070] Preferably, the method for the production of SBV of the invention comprises the steps of:

(a) infecting insect cells with a SBV,
(b) cultivating the infected cells of step (a),
(c) harvesting the SBV produced by said cells in step (b)
(d) infecting mammalian cells with the SBV harvested in step (c),
(e) cultivating the infected cells of step (d),
(f) harvesting the SBV produced by said cells in step (e)
(g) infecting insect cells with the SBV harvested in step (f)

(h) cultivating the infected cells of step (g), and

(i) harvesting the SBV produced by said cells in step (h).

[0071] More preferably, the method for the production of infectious SBV according to the invention further comprises the steps of

(j) infecting mammalian cells with the SBV harvested in step (i),

(k) cultivating the infected cells of step (j), and

(l) harvesting the SBV produced by said cells in step (k),

and optionally

(m) infecting insect cells with the SBV harvested in step (l),

(n) cultivating the infected cells of step (m), and

(o) harvesting the SBV produced by said cells in step (n).

[0072] Thus, in one aspect, the method for the production of infectious SBV according to the invention comprises the steps of

(a) infecting insect cells with a SBV,

(b) cultivating the infected cells of step (a),

(c) harvesting the SBV produced by said cells in step (b)

(d) infecting mammalian cells with the SBV harvested in step (c),

(e) cultivating the infected cells of step (d),

(f) harvesting the SBV produced by said cells in step (e)

(g) infecting insect cells with the SBV harvested in step (f)

(h) cultivating the infected cells of step (g),

(i) harvesting the SBV produced by said cells in step (h)

(j) infecting mammalian cells with the SBV harvested in step (i),

(k) cultivating the infected cells of step (j), and

(l) harvesting the SBV produced by said cells in step (k),

and optionally

(m)infecting insect cells with the SBV harvested in step (l),

(n) cultivating the infected cells of step (m), and

(o) harvesting the SBV produced by said cells in step (n).

[0073] The insect cells used in the method for the production of SBV of the invention are preferably KC cells.

[0074] As mammalian cells preferably BHK cells, in particular BHK-21 cells, are used in the method for the production of SBV according to the invention.

[0075] Most preferably, in the method for the production of SBV according to the invention the insect cells are KC cells, and the mammalian cells are BHK cells, in particular BHK-21 cells.

[0076] Further, the invention also comprises the SBV obtainable by the method for the production of SBV according to the invention.

[0077] The invention further provides a method for the production of inactivated SBV or of an immunogenic composition of the invention comprising the steps of:

(A)infecting cells with a SBV, wherein the cells are in particular monkey kidney cells, preferably Ma104 cells or Ma104-AK cells, or wherein the cells are BHK cells, preferably BHK-21 cells,

(B) cultivating the infected cells,

(C) harvesting the SBV produced by said cells, and

(D) inactivating said SBV by heat treatment or with a virus inactivating agent

[0078] If preferably Ma104 cells or Ma104-AK cells are used in the method for the production of inactivated SBV or of the immunogenic composition of the invention, this has the advantage that adverse reactions, in particular allergic reactions, can be reduced or minimized if the inactivated SBV or the immunogenic composition produced by said method is administered to an animal.

[0079] In particular, it is preferred if in step (A) of the method for the production of inactivated SBV or of the immunogenic composition of the invention the cells are infected with a SBV obtainable by the method for the production of SBV of the invention.

[0080] The invention thus also provides the combination of (i) the method of producing an infectious SBV of the invention and (ii) the method for the production of inactivated SBV or of the immunogenic composition of the invention, wherein said methods are performed subsequently.

[0081] Preferably, in the method for the production of infectious SBV of the invention and/or in the method for the production of inactivated SBV or of the immunogenic composition according to the invention, the cells are infected with SBV at an MOI of 0,00001 – 0,01, preferably at an MOI of 0,0001 – 0,001.

[0082] In particular it is preferred, if in the method for the production of SBV according to the invention and/or in the method for the production of inactivated SBV or of the immunogenic composition of the invention, the cells are cultivated in a medium containing 1-10 % FCS, more preferably containing 2-6 % FCS, and/or if the cells are cultivated at a temperature of 25-38°C, preferably of 36-38°C, more preferably of about 37°C. It is also possible to cultivate the cells in the absence of FCS.

[0083] Also, the invention comprises SBV obtainable by the method for the production of inactivated SBV or of the immunogenic composition of to the invention, and, moreover, the invention also provides inactivated SBV obtainable by the combination of (i) the method of producing an infectious SBV of the invention and (ii) the method for the production of inactivated SBV or of the immunogenic composition of the invention, wheren said methods are performed subsequently.

[0084] In another aspect, it is preferred if in the method for the production of infectious SBV of the invention and/or in the method for the production of inactivated SBV or of the immunogenic composition of the invention, the SBV comprises

- a small (S) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 97.8 %, preferably at least 99 % sequence identity with the nucleic acid sequence of SEQ ID NO:1 or SEQ ID NO:7,
- a medium (M) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 82.2 % sequence identity with the nucleic acid sequence of SEQ ID NO:2, and/or
- a large (L) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 93 % sequence identity with the nucleic acid sequence of SEQ ID NO:3,

and/or wherein said SBV comprises

- an S RNA segment, characterized in that the S RNA segment has a sequence having at least 97.8 %%, preferably at least 99 % sequence identity to SEQ ID NO:4 or SEQ ID NO:8,
- an M RNA segment, characterized in that the M RNA segment has a sequence having at least 82.2 % sequence identity to SEQ ID NO:5, and/or
- an L RNA segment, characterized in that the L RNA segment has a sequence having at least 93 % sequence identity to SEQ ID NO:6.

[0085] The invention also provides a SBV, preferably an isolated SBV, comprising

- a small (S) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 97.8 %, preferably at least 99 % sequence identity with the nucleic acid sequence of SEQ ID NO:1 or SEQ ID NO:7,
- a medium (M) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 82.2 % sequence identity with the nucleic acid sequence of SEQ ID NO:2, and/or
- a large (L) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 93 % sequence identity with the nucleic acid sequence of SEQ ID NO:3.

[0086] The invention further provides a preferably isolated SBV, in particular the aforementioned SBV, which comprises

- an S RNA segment, characterized in that the S RNA segment has a sequence having at least 97.8 % sequence identity to SEQ ID NO:4 or SEQ ID NO:8,
- an M RNA segment, characterized in that the M RNA segment has a sequence having at least 82.2 % sequence identity to SEQ ID NO:5, and/or
- an L RNA segment, characterized in that the L RNA segment has a sequence having at least 93 % sequence identity to SEQ ID NO:6.

[0087] Also the invention comprises a composition of matter obtainable by any of the aforementioned methods, wherein the composition is preferably an immunogenic composition, in particular a vaccine.

[0088] A further aspect of the invention relates to the use of the immunogenic composition of the invention for the preparation of a medicament for treating or preventing SBV and/or treating or preventing viremia or malformations induced by SBV and/or preventing or reducing the transmission of SBV in an animal in need of said treatment.

[0089] Also, the invention provides a method of generating an immune response to SBV in an animal comprising administering to said animal the immunogenic composition of the invention.

[0090] In another aspect, the invention provides a method of treating or preventing SBV or treating or preventing viremia or malformations induced by SBV in an animal in need of said treatment, comprising administering to said animal a therapeutically effective amount of the vaccine composition of the invention.

[0091] The invention further provides a method for inducing an immune response against SBV and/or preventing or reducing viremia or malformations induced by SBV and/or preventing

or reducing the transmission of SBV in an animal or a herd of animals comprising the step of administering the immunogenic composition of the invention to an animal in need thereof.

[0092] In the aforementioned methods, the immunogenic composition of the invention or the vaccine of the invention, respectively, is preferably administered in a single dose or more preferably in two doses.

EXAMPLE 1

[0093] Details about first SBV isolation

[0094] BHK-21 cells have been extensively used for growth of Orthobyniaviruses. Following this, SBV virus was successfully isolated for the first time using this cell line, by FLI researchers in November 2011. Except for the BHK, *Culicoides variipennis* larvae cells (referred to as KC cells from Collection of Cell Lines in Veterinary Medicine, Friedrich-Loeffler-Institut, Greifswald-Insel Riems, Germany) were used. KC cells were incubated for 10 days with ultrasonically disrupted blood diluted in Schneider's media. The cells were then lysed by freezing and thawing. A monolayer of baby hamster kidney-21 cells (BHK, clone 13) was inoculated with the lysate. The inoculums was removed after 1 hour and replaced by Eagle minimal essential medium (EMEM). A strong cytopathic effect was visible after 5 days, and the culture supernatant tested positive for the novel virus, with a Cq value of approximately 14 in the specific cRT-qPCR (isolate 2) and $3x10^6$ TCID50 per ml.

[0095] Manufacturing process: General description

[0096] The manufacturing process, as described below, is carried out following standard manufacturing methods, e.g. under conditions of sterility and after verification of correct operation conditions such as air filtration.

[0097] Description of manufacturing process:

1. Production of MSV (master stock virus)

[0098] The SBV isolate 2 was used for MSV (Master Stock Virus) production. Roller bottle plated with BHK-21 cells ($5x10^7$ cells) were infected at moi 0,0001. After 54h of incubation roller bottle is frozen at -20, thawed and centrifugated at 2000g for 5min. Supernatant was collected and aliquots of 1ml were stored at -80C until further process.

2. Production of SBV antigen

[0099] The BHK-21 cells (working cell stock - WCS) are stored frozen in liquid nitrogen. WCS was thawed and expanded on cell culture flasks ($T160cm^2$) using EMEM media and 10% gamma irradiated FCS. Cells were trypsinised using recombinant (non animal origin) trypsin. One T160 flask was trypsinied and resuspended in 150ml of EMEM media containing 2% FCS. This cell suspension was used to seed one roller bottle ($495cm^2$). Roller bottles containing cell suspension were placed in 37C incubator and roller at 0,5 rpm. Twelve to 16h post plating cells were plated at density $5x10^7$ per bottle. Infection using moi 0,0001 was used. Cells were continuously incubated at 37C and rolled at 0,5 rpm for 50-56h until specific SBV cytopathic effect (CPE) don't reach about 60-70% of cells. At this time point the complete roller bottle flasks were frozen at -20C and thawed in 37C water bath and stored at -80C until further process.

[00100] The virus titration is performed following procedure:

[0100] Materials needed

1. BHK-21 cells (clone 13)
2. T75 flasks
3. Flat bottom 96 wells plates
4. Flat bottom 48 wells plates
5. Thermo 8-channel matrix pipette + tips
6. Eppendorf 8-channel pipette 50-1250 + tips
7. Reservoir for multichannel pipettes
8. Trypisn+edta
9. Media ZB5
10. Pipettes 5, 10 and 25ml

11. Pipetboy
12. Inverted microscope

[0101] Procedure

- Highly confluent T75 flask trypsinize and cells nicely resuspend in 20ml of media (10%FCS).
- Add 100ml of media (0% FCS) and mix well
- This cell suspension pours into reservoir for multichannel pipettes
- Use multichannel pipette to fill 100µl of cell suspension into the wells of first 8 collumns of 96 wells plates
- Leave plates at 37°C in CO2 incubator for 6-12h to attach
- After this time prepare 48 wells plate and fill 1080µl of serum free media in each well
- In the wells of the first column inoculate 120µl of material for titration
- Using eppendorf 8-channel pipette with the program P/M (pipette 120µl and mix 620µl four times) firstly mix the first column where the material is inoculated
- Discard tips
- From the wells of the first column (with the new tips) pipette 120µl into second and mix
- Discard tips
- Repeat this process until you finish the last column
- Using matrix pipette aspirate 800µl from the first row of 48 well plate (which contains serial dilutions of one sample)
- When attaching tips press firmly, but not too strong as the matrix function will not work
- Dispense 100µl in 8 rows of 96wells plate
- Incubate at 37C for period of 3-4 days
- Read results on inverted microscope

3. Vaccine formulations

[0102] 3.1 Inactivation procedure

[0103] The process of inactivation of the final antigen lasts for a total of 72 hours, and the concentration of BEI used is 15 mM. Final antigen is inactivated by adding BEI 0.1 M at a proportion of 100 ml per liter of antigen being inactivated (final concentration 10 mM). After the addition of the BEI the mixture is homogenized for at least 15 minutes and the pH is verified. After the homogenization process, the mixture is decanted into a sterile container where it is kept in agitation, at 37+/-1°C, for 24 hours. After 24 hours, a second inactivation of the final antigen is carried out by means of adding BEI 0.1 M at a proportion of 50 ml per liter of antigen being inactivated (final concentration 5 mM). After the second addition of BEI, the process is repeated under the same conditions as described above for the first addition, but maintaining the mixture in agitation for 48 hours.

[0104] 3.2 Neutralization of residual BEI

[0105] Once the inactivation process has been completed, 1 M sodium thiosulphate solution is added at the proportion of 5 ml per liter of inactivated antigen (final concentration 5 mM), in order to neutralize the BEI. After the mixture has been homogenized, the pH is verified. If necessary,an adjustment is done with hydrochloric acid, to obtain a pH of 7.2+-0.2.

[0106] 3.3 Adjuvants

[0107] Alhydrogel (aluminium hydroxide) and Quil-A (saponin) are used as adjuvants.

4. Proof of concept experiment in cattle.

[0108] Eighteen (18) - 7 month old cattle are used for the experiment. Animals are been divided into four groups with four animals in each group, while other two animals are used as contact controls. All animals are SBV sero-negative at the beginning of experiment. First group (of four animals) is vaccinated with the vaccine dose containing 10^6 SBV TCID50/ml, the second with 10^5 SBV TCID50/ml, third with 10^4 SBV TCID50/ml and finally fourth group is not vaccinated as well as two animals within contact control. Within each group 4 animals are vaccinated by the subcutaneous route (2 mL) and revaccinated 3 weeks later. All animals in the study are challenged two weeks after re-vaccination (challenge dose = 10^7 TCID50 of live virus / animal) except of contact control animals. All non vaccinated animals develop viremia upon SBV challenge, staring at 3 dpi (days post infection) and lasting 2-3 days. Animals vaccinated

show significantly lower viremia and reduced to no clinical symptoms compared to non-vaccinated animals after the SBV challenge.

EXAMPLE 2

1. Introduction

[0109] In this study, several inactivated vaccine formulations have been produced and subsequently tested in sheep and cattle regarding their ability to induce neutralising antibodies and to prevent viraemia after experimental challenge infection.

2. Materials and methods

[0110] Vaccines

[0111] Five different prototype vaccine formulations were produced (Table 1); all of them were inactivated SBV preparations in aqueous solution. SBV was either grown on two different baby hamster kidney (BHK-21) cell lines (vaccines "BHKCT-HT", "BHK13-HT", "BHK13-LT") or on MA-104 cells (vaccines "MA-HT" and "MA-LT").

[0112] The antigen-concentration was formulated using the infectious titre of SBV before inactivation with binary ethylenimine (BEI) using either a long (using 10 mM of BEI for 72 hours at 37°C) or a short (using 2 mM of BEI for 12 hours at 37°C) protocol.

[0113] Vaccine candidates contained antigen concentration as follows: 6.1 log10 50% tissue culture infectious doses per ml ($TCID_{50}$/ml) (MA-HT) or 5.7 log10 $TCID_{50}$/ml (BHKCT-HT, BHK13-HT, MA-LT) or 4.7 log10 $TCID_{50}$/ml (BHK13-LT). Saponin and aluminium hydroxide were used as adjuvants (0,125 µg Saponin per 1 ml and 6,65 mg aluminium hydroxide per ml in all vaccine candidate formulations). All formulations were tested for the absence of bacterial contamination and in duplicates for successful inactivation by two subsequent passages in BHK-21 cells. The pH values of each prototype vaccine were adjusted at 6.8-7.2 at 20° C. The vaccines were kept at 4°C until use.

[0114] **Table 1:** Vaccines and animal groups.

Vaccines				Animals	
Name	Cell line	Infectious titre used	Inactivation	Animal group	Animal number

BHKCT-HT	BHK-21 clone CT	5.7 log10 $TCID_{50}$/ml	long protocol	A (sheep)	S01 - S05
				G (cattle)	C01 - C06
BHK13-HT	BHK-21 clone 13	5.7 log10 $TCID_{50}$/ml	short protocol	B (sheep)	S06 - S10
BHK13-LT	BHK-21 clone 13	4.7 log10 $TCID_{50}$/ml	short protocol	C (sheep)	S11 - S15
MA-HT	MA-104	6.1 log10 $TCID_{50}$/ml	short protocol	D (sheep)	S16 - S20
				H (cattle)	C07 - C10
MA-LT	MA-104	5.7 log10 $TCID_{50}$/ml	long protocol	E (sheep)	S21 - S25
				I (cattle)	C11 - C16
unvaccinated control				F (sheep)	S26 - S30
				K (cattle)	C17 - C22

[0115] Animals

[0116] Twenty-five SBV-naive sheep of European domestic breeds (7 – 9 months of age) were assigned to 5 groups of 5 animals each, which were immunised subcutaneously with one of the prototype vaccines (see table 1). Another 5 sheep were kept as unvaccinated controls. Male and female animals were distributed equally.

[0117] In addition, 22 SBV antibody-negative female Holstein-Friesian cattle were assigned to four groups of four (group H) or six animals (groups G, I and K) each. Animals in group G, H and I were immunised subcutaneously with vaccines BHKCT-HT, MA-HT and MA-LT, respectively. Cattle in group K were kept as unvaccinated controls. On the day of the first vaccination, the animals were between 8 and 12 months of age.

[0118] In each case, the animals were vaccinated twice three weeks apart and three weeks after the second vaccination both vaccinated and control animals were inoculated with 2 x 0.5ml of an SBV field strain that was only passaged in the natural host. During the entire study, rectal body temperatures were measured daily, and the animals were examined for clinical signs by veterinarians.

[0119] Sampling, real-time RT-PCR and serology

[0120] Following the first vaccination, serum samples were collected at days 0, 3, 4, 7 and weekly thereafter. After the second vaccination, serum samples were taken in weekly intervals.

Following challenge infection, serum samples were taken daily during the first eight days and on days 14 and 21. Samples of spleen, tonsils, and mesenteric and mandibular lymph nodes were taken at autopsy on days 22 - 29 after challenge infection and homogenized in 1 ml MEM.

[0121] RNA from serum and tissue samples taken at autopsy was extracted using the MagAttract Virus Mini M48 Kit for automated extraction (Qiagen, Germany) according to the manufacturer's recommendations. SBV genome loads were determined by a reverse transcription real-time PCR (RT-qPCR) (*7*) with an external standard based on the S genome segment. Furthermore, serum samples were analyzed with a commercially available SBV antibody ELISA (ID Screen® Schmallenberg virus Indirect, IDvet, France) using the recommended cut-off of 70% relative optical density compared to the positive control, and in a standard micro-neutralisation assay.

3. Results

[0122] Clinical observations and post-mortem examinations

[0123] Following the first vaccination with the vaccine prototypes no adverse side effects were observed; none of the animals showed fever or any other clinical sign. After the second vaccination one cattle immunised with vaccine MA-HT (group H) developed a low-grade swelling at the injection site for 2 days.

[0124] After the challenge infection, one unvaccinated cattle developed fever on day 3, another showed mild diarrhoea for three days. One animal out of group I had nasal discharge for one day.

[0125] Autopsy of the animals did not reveal any significant gross lesions. The mesenteric lymph nodes of all but one (S30) unvaccinated animals were PCR-positive; on average 2.86E+03 genome copies per mg (copies/mg) were detected. In addition, SBV RNA was found in the mandibular lymph nodes of 3 out of 5 unvaccinated sheep (S27 – S29) and of all control cattle (average 2.68E+01 copies/mg), the tonsils of S27 – S29 and C18 – C20 (average 9.90E+01copies/mg), and spleens of 4 out of 5 unvaccinated sheep (S26 – S29; average 4.57E+03 copies/mg) and of two control calves (C17, C21; average 1.40E+01 copies/mg). No viral RNA was detected in any of the vaccinated animals.

[0126] Antibody response

[0127] On the day of the first vaccination, all animals were negative in both serological assays.

[0128] Before challenge infection, no antibodies could be detected in the unvaccinated animals. Three weeks after infection all but one (S30) control sheep and cattle scored positive in the neutralisation assay. Antibodies were found in cattle and in 2 out of the 5 unvaccinated sheep (S26, S29) by ELISA as well. Despite an increasing sample OD relative to the positive control OD value (S/P) both the control sheep S27 and S28 scored negative in the ELISA.

[0129] Three weeks after the first immunisation with vaccine BHKCT-HT, BHK13-HT or BHK13-LT (SBV grown on BHK cells), all sheep and cattle were negative in the ELISA, while in S07, S08, S10 (BHKCT-HT), and S04 (BHK13-HT) low antibody titres were detected in the neutralisation assay. Following the second vaccination antibodies were detected in at least one serological assay, in most cases a considerable increase of neutralising antibodies was seen. Three weeks after challenge infection 8 out of 15 sheep (S04, S06, S07, S09, S10, S11, S12, S15) and 5 out of 6 cattle (C01 – C05) were positive in both assays, 7 sheep (S01 - S03, S05, S08, S13, S14) and the remaining cattle (C6) were positive in the neutralisation test only, and S15 in the ELISA assay only.

[0130] After one immunisation with vaccines MA-HT or MA-LT (SBV grown on MA-104 cells), all cattle and all but two sheep scored negative in both serological assays. S22 and S23 had titres of 1:5 and 1:7, respectively, in the neutralisation assay. Following the second vaccination, in S19, S24, C08, and C14 no antibodies could be detected. S16, S21, C07, C09, and C10 scored positive in both serological assays, while the remaining animals were positive in the neutralisation assay only. Three weeks after challenge infection all sheep of group D and 4 out of 5 sheep of group E were positive in the neutralisation assay, in animal S16 antibodies could be detected by the ELISA, and animal S24 was negative in both assays. In all cattle of group H (high titre of SBV) antibodies were detectable by ELISA and neutralisation assay. The same is true for C12 and C13 (group I, low SBV titre), C11, C15, and C16 scored positive only in the neutralisation assay, and in C14 no antibodies could be detected by any test.

[0131] After the second immunisation an increase of the average neutralising antibody titers were observed, while after challenge infection, most of the neutralisation titers remained constant in all vaccinated groups.

[0132] Real-time RT-PCR

[0133] Following the first vaccination SBV genome was not detected in any animal (data not shown), confirming the successful inactivation of SBV with short and long BEI inactivation procedure.

[0134] After challenge infection, all but one (S30) unvaccinated sheep scored positive in the RT-qPCR between day 2 and 4 (S27 - S29) or 5 (S26). In 1 out of 6 unvaccinated cattle (C19) SBV-genome was first detectable on day 1 after infection, the other 5 calves scored positive on day 2 for the first time. SBV genome remained detectable until day 5 (C17, C19 - C21), 6 (C22) or 7 (C18). Three out of 6 cattle immunised with vaccine MA-LT (C12, C13, C16) were positive in the RT-qPCR on day 3, while the animals vaccinated with MA-HT vaccines did not develop RNAemia (RNA in the blood) upon challenge.

[0135] In serum samples taken from all vaccinated sheep, from control sheep S30, and from all cattle of groups G and H (high titer vaccine groups), viral RNA could not be detected following challenge infection.

4. Conclusion

[0136] Five different inactivated vaccine formulations have been developed and were subsequently tested in cattle and sheep. In the experiments none of the animals showed significant adverse effects and all of the animals seroconverted upon vaccination. Furthermore, majority but not all the animals developed detectable neutralizing SBV antibodies levels upon vaccination. Importantly, upon challenge infection, RNAemia was completely prevented by four prototype vaccines and considerably reduced by the fifth. Those data suggest that protection from virus infection is only partially mediated by neutralizing antibodies and that additional still undetermined mechanisms, most likely associated with cellular immunity, essentially contributed to virus clearance upon SBV challenge. The two major characteristics of inactivated vaccines are (i.) the complete inactivation of the infectious virus, which was demonstrated by cell culture

passages and the missing RNAemia after the first immunisation, and (ii.) the induction of protective immunity. Although neutralising antibodies were not detected in every vaccinated animal prior to challenge infection, RNAemia was completely prevented by four prototype vaccines and considerably reduced by the fifth. The detection of viral RNA in the lymphoreticular system was used as diagnostic tool apart from RNAemia in the present study. In contrast to the controls all vaccinated animals were clearly negative for SBV-RNA in the lymphoid system (in the lymphoid organs at the time of autopsy) like the mesenteric lymph nodes. One of the unvaccinated control sheep showed neither RNAemia, nor RT-qPCR-positive tissue samples, nor seroconversion after challenge infection, the reason for that observation remains unclear. Possible explanations are a failed injection or a status of (natural) resistance to SBV infection.

[0137] Nevertheless, the absence of detectable RNA in most vaccine groups allows to draw the conclusion that, if even no viral genomes can be detected (in the serum), no challenge virus could be transmitted to the foetus.

[0138] Although RNAemia was prevented or markedly reduced by vaccination, antibodies were not detected in every animal prior to challenge infection in every test. Overall, the correlation of ELISA test and neutralisation assay was greater in bovine than in ovine samples, especially after challenge infection of unvaccinated animal.

[0139] The highest levels of antibodies of all sheep groups were detected by neutralisation test after challenge infection of unvaccinated sheep. The same was observed after immunisation with several Rift Valley fever vaccines and subsequent challenge (*8*), where the applied vaccines, however, did not provide sterile immunity, but only a reduction of viraemia. As opposed to this, the SBV vaccine prototypes characterized in this study prevented RNAemia in sheep completely despite a low level of neutralising antibodies.

[0140] In our study, the titre of neutralising antibodies was influenced by the production cell line and the viral titre prior to inactivation. A dose dependence of the cell culture supernatant used for vaccine preparation was described for AKAV as well, independent whether inactivated or attenuated live vaccines were used (*9*; *10*). At least 10^5.5 $TCID_{50}$/ml of virus were reported to be necessary for vaccine development. As 2 ml of a vaccine containing 6.1 log10 $TCID_{50}$/ml

virus grown on MA-104 cells prevented RNAemia completely, but in half of the calves which were immunized with 5.7 log10 $TCID_{50}$/ml viral genome was detectable for one day, a similar minimal dose may be assumed for SBV. However, in vaccines produced on BHK-21-cells, the lower viral titre (5.7 log10 TCID50/ml) prevented RNAemia completely in both animal species, in sheep merely 4.7 log10 TCID50/ml were necessary.

[0141] In conclusion, in this proof-of-concept characterization of different vaccine candidates, a high efficacy could be demonstrated for four out of five SBV vaccine prototypes in both major target species. As a result, the development of a killed vaccine against Schmallenberg virus, which is efficacious and safe in cattle and sheep, is demonstrated. The results obtained in this study show that inactivated SBV vaccine can be successfully applied to support efforts for SBV spread control as well as disease prevention in domestic ruminants.

EXAMPLE 3

[0142] In the following, an alternative inactivation procedure and subsequent neutralization process is described, which also allowed the production (the further steps of production were performed in accordance with Example 1) of an effective vaccine for a successful prevention of infection with SBV:

[0143] Inactivation procedure

[0144] The process of inactivation of the final antigen lasted for a total of 12 hours, and the concentration of BEI used was 2 mM. Final antigen was inactivated by adding BEI 0.17 M at a proportion of 11.9 ml per liter of antigen being inactivated (final concentration 2 mM). After the addition of the BEI, the mixture was kept in agitation, at 37+/-1°C, for 12 hours.

[0145] Neutralization of residual BEI

[0146] Once the inactivation process has been completed, 1 M sodium thiosulphate solution was added at the proportion of 10 ml per liter of inactivated antigen (final concentration 10 mM), in order to neutralize the BEI.

EXAMPLE 4

[0147] Hereinafter, an alternative production of MSV (master stock virus) is described, which likewise enabled the manufacturing (the further steps of the manufacture process were performed in accordance with Example 1, wherein the inactivation procedure was done as described in Example 3) of an effective vaccine for a successful prevention of infection with SBV:

5. Production of MSV (master stock virus)

[0148] The SBV isolate 2 was used for MSV (Master Stock Virus) production. Roller bottle plated with Ma104-Ak ($5x10^7$ cells) were infected at moi 0,0001. After 54h of incubation roller bottle is frozen at -20, thawed and centrifugated at 2000g for 5min. Supernatant was collected and aliquots of 1ml were stored at -80C until further process.

6. Production of SBV antigen

[0149] The Ma104-Ak (working cell stock - WCS) are stored frozen in liquid nitrogen. WCS was thawed and expanded on cell culture flasks ($T160cm^2$) using EMEM media and 10% gamma irradiated FCS. Cells were trypsinised using recombinant (non animal origin) trypsin. One T160 flask was trypsinized and resuspended in 150 ml of EMEM media containing 2% FCS. This cell suspension was used to seed one roller bottle ($495cm^2$). Roller bottles containing cell suspension were placed in 37C incubator and roller at 0,5 rpm. Twelve to 16 h post plating cells were plated at density $5x10^7$ per bottle. Infection using moi 0,001 was used. Infected cells were continuously incubated at 37C and rolled at 0,5 rpm for 72-96h until specific SBV cytopathic effect (CPE) don't reach about 60-70% of cells. At this time point the complete roller bottle flasks were frozen at -20C and thawed in 37C water bath and stored at -80C until further process.

IN THE SEQUENCE LISTING:

SEQ ID NO:1 corresponds to the complete genomic sequence of a S segment of an infectious Schmallenberg virus (BH80/11-4),

SEQ ID NO:2 corresponds to the complete genomic sequence of a M segment of an infectious Schmallenberg virus (BH80/11-4),

SEQ ID NO:3 corresponds to the complete genomic sequence of a L segment of an infectious Schmallenberg virus (BH80/11-4),

SEQ ID NO:4 corresponds to anti-parallel (i.e. complementary and inverse) RNA sequence of SEQ ID NO:1,

SEQ ID NO:5 corresponds to the anti-parallel RNA sequence of SEQ ID NO:2,

SEQ ID NO:6 corresponds to the anti-parallel RNA sequence of SEQ ID NO:3,

SEQ ID NO: 7 corresponds to SEQ ID NO:1, wherein the nucleotide at position 9 is "a" instead of "g", and

SEQ ID NO: 8 corresponds to the anti-parallel RNA sequence of SEQ ID NO:7 and thus corresponds to SEQ ID NO:4, wherein the nucleotide at position 831 is "u" instead of "c".

REFERENCES:

All references cited herein are hereby entirely incorporated by reference.

1. B. Hoffmann ., M. Scheuch, D. Höper, R. Jungblut, M. Holsteg, H. Schirrmeier, M. Eschbaumer, K. V. Goller, K. Wernike, M. Fischer, A. Breithaupt, T,C. Mettenleiter, M. Beer, Novel orthobunyavirus in Cattle, Europe, 2011. *Emerg. Infect. Dis.* **18**, 469-472 (2012).

2. M.-M. Gariglinany *et al.*, Schmallenberg virus in calf born at term with porencephaly, Belgium. *Emerg. Infect. Dis.* **18** (2012), doi: 10.3201/eid1806.120104.

3. M. D. Bowen *et al.*, A reassortant bunyavirus isolated from acute hemorrhagic fever cases in Kenya and Somalia. *Virology.* **291**, 185-190 (2001).

4. A. M. Q. King, M. J. Adams, E. B. Carstens, E. J. Lefkowitz, Eds., *Virus Taxonomy: Ninth Report of the International Committee on Taxonomy of Viruses.* (Elsevier, San Diego, USA, 2011), pp 725-731.

5. R. M. Kinney, C. H. Calisher, Antigenic relationships among Simbu serogroup (Bunyaviridae) viruses. *Am. J. Trop. Med. Hyg.* **30**, 1307-1318 (1981).

6. M. F. Saeed, L. Li, H. Wang, S. C. Weaver, A. D. Barrett, Phylogeny of the Simbu serogroup of the genus Bunyavirus. *J. Gen. Virol.* **82**, 2173-2181 (2001).

7. Bilk S, Schulze C, Fischer M, Beer M, Hlinak A, Hoffmann B. Organ distribution of Schmallenberg virus RNA in malformed newborns. Veterinary microbiology 2012 Mar 30.

8. Kortekaas J, Antonis AF, Kant J, Vloet RP, Vogel A, Oreshkova N, et al. Efficacy of three candidate Rift Valley fever vaccines in sheep. Vaccine 2012 May 14;30(23):3423-9.

9. Kurogi H, Inaba Y, Takahashi E, Sato K, Goto Y, Satoda K, et al. Development of inactivated vaccine for Akabane disease. National Institute of Animal Health quarterly 1978 Winter;18(3-4):97-108.

10. Kurogi H, Inaba Y, Akashi H, Takahashi E, Sato K, Satoda K, et al. Immune response of various animals to Akabane disease live virus vaccine. National Institute of Animal Health quarterly 1979 Summer;19(1-2):23-31.

CLAIMS

What is claimed is:

1. An immunogenic composition comprising one or more antigens of the Schmallenberg virus (SBV).

2. The immunogenic composition according to claim 1, wherein the immunogenic composition comprises the SBV.

3. The immunogenic composition according to claim 1, wherein the antigen of SBV or the SBV is inactivated.

4. The immunogenic composition according to claim 1, wherein the SBV comprises:

- (a) a small (S) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 97.8 % sequence identity with the nucleic acid sequence of SEQ ID NO:1 or SEQ ID NO:7;
- (b) a medium (M) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 82.2 % sequence identity with the nucleic acid sequence of SEQ ID NO:2;
- (c) a large (L) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 93 % sequence identity with the nucleic acid sequence of SEQ ID NO:3; or
- (d) combinations thereof.

5. The immunogenic composition according to claim 1, wherein the SBV is obtainable by the inactivation of SBV comprising:

- (a) a small (S) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 97.8 % sequence identity with the nucleic acid sequence of SEQ ID NO:1 or SEQ ID NO:7;
- (b) a medium (M) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 82.2 % sequence identity with the nucleic acid sequence of SEQ ID NO:2;

- (c) a large (L) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 93 % sequence identity with the nucleic acid sequence of SEQ ID NO:3; or
- (d) combinations thereof.

6. The immunogenic composition according to claim 1, wherein said SBV comprises:

- (a) an S RNA segment, characterized in that the S RNA segment has a sequence having at least 97.8 % sequence identity to SEQ ID NO:4 or SEQ ID NO:8;
- (b) an M RNA segment, characterized in that the M RNA segment has a sequence having at least 82.2 % sequence identity to SEQ ID NO:5;
- (c) an L RNA segment, characterized in that the L RNA segment has a sequence having at least 93 % sequence identity to SEQ ID NO:6; or
- (d) combinations thereof.

7. The immunogenic composition according to claim 3, wherein SBV is inactivated by heat treatment or with a virus inactivating agent.

8. The immunogenic composition according to claim 7, wherein virus inactivating agents is an aziridine compound.

9. The immunogenic composition according to claim 8, wherein the aziridine compound is binary ethyleneimine (BEI).

10. The immunogenic composition according to claim 2, comprising an amount of SBV which is equivalent to a virus titer of at least about 10^5 $TCID_{50}$/mL per dose

11. The immunogenic composition according to claim 2, wherein the SBV has a pre-inactivation titer of at least about 10^6 SBV particles per milliliter.

12. The immunogenic composition according to claim 1, further containing one or more pharmaceutically acceptable carriers or excipients.

13. The immunogenic composition according to claim 12, wherein said one or more pharmaceutically acceptable carriers or excipients are selected from the group consisting

of solvents, dispersion media, adjuvants, stabilizing agents, diluents, preservatives, antibacterial and antifungal agents, isotonic agents, and adsorption delaying agents.

14. The immunogenic composition according to claim 1, further comprising aluminum hydroxide, saponin or combinations thereof.

15. A vaccine composition for the treatment or prevention according to SBV comprising the immunogenic composition according to claim 1.

16. A vaccine composition for the prevention or reduction of the viremia or malformations induced by SBV comprising the immunogenic composition according to claim 1.

17. A vaccine composition for the prevention or reduction of the transmission of SBV, which comprises the immunogenic composition according to claim 1.

18. A method for the production of SBV, comprising the steps of:

- (a) infecting cells with a SBV;
- (b) cultivating the infected cells; and
- (c) harvesting the SBV produced by said cells.

19. The method for the production of SBV according to claim 18, wherein the SBV is passaged alternately between insect cells and mammalian cells, and wherein the method further comprises the steps of

(a) infecting insect cells with a SBV;
(b) cultivating the infected cells of step (a);
(c) harvesting the SBV produced by said cells in step (b);
(d) infecting mammalian cells with the viral particles harvested in step (c);
(e) cultivating the infected cells of step (d); and
(f) harvesting the SBV produced by said cells in step (e).

20. The method for production of SBV according to claim 19, wherein the method further comprises the steps of:

(d) infecting mammalian cells with a SBV;
(e) cultivating the infected cells of step (d);

(f) harvesting the SBV produced by said cells in step (e);

(g) infecting insect cells with the viral particles harvested in step (f);

(h) cultivating the infected cells of step (g); and

(i) harvesting the SBV produced by said cells in step (h).

21. The method according to claim 18, comprising the steps of

(a) infecting insect cells with a SBV;

(b) cultivating the infected cells of step (a);

(c) harvesting the SBV produced by said cells in step (b);

(d) infecting mammalian cells with the SBV harvested in step (c);

(e) cultivating the infected cells of step (d);

(f) harvesting the SBV produced by said cells in step (e);

(g) infecting insect cells with the SBV harvested in step (f);

(h) cultivating the infected cells of step (g); and

(i) harvesting the SBV produced by said cells in step (h).

22. The method according to claim 21, further comprising the steps of:

(j) infecting mammalian cells with the SBV harvested in step (i);

(k) cultivating the infected cells of step (j); and

(l) harvesting the SBV produced by said cells in step (k).

23. The method according to claim 30, further comprising the steps of:

(m) infecting insect cells with the SBV harvested in step (l);

(n) cultivating the infected cells of step (m); and

(o) harvesting the SBV produced by said cells in step (n).

24. The method according to claim 19, wherein the insect cells are KC cells and the mammalian cells are BHK cells.

25. The method according to claim 24, wherein the mammalian cells are BHK-21 cells.

26. A method for the production of inactivated SBV or of an immunogenic composition according to claim 3, comprising the steps of

(A) infecting cells with a SBV;

(B) cultivating the infected cells;

(C) harvesting the SBV produced by said cells; and

(D) inactivating said viral particles by heat treatment or with a virus inactivating agent.

27. The method according to claim 26, wherein the cells are monkey kidney cells or BHK cells.

28. The method according to claim 27, wherein the monkey kidney cells are Ma104 cells or Ma104-AK cells, and the BHK cells are BHK-21 cells.

29. The method according to claim 26, wherein the cells are infected with SBV at an MOI of 0.00001 – 0.01.

30. The method according to claim 26, wherein the cells are infected with SBV at an MOI of 0.0001 – 0.001.

31. The method according to claim 26, wherein the cells are cultivated in a medium comprising about 0 % FCS.

32. The method according to claim 26, wherein the cells are cultivated in a medium comprising about 1-10 % FCS.

33. The method according to claim 26, wherein the cells are cultivated in a medium comprising about 2-6 % FCS.

34. The method according to claim 26, wherein the cells are cultivated at a temperature of 25-38°C.

35. The method according to claim 26, wherein the SBV comprises:

- (a) a small (S) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 97.8 % sequence identity with the nucleic acid sequence of SEQ ID NO:1 or SEQ ID NO:7;

- (b) a medium (M) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 82.2 % sequence identity with the nucleic acid sequence of SEQ ID NO:2;
- (c) a large (L) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 93 % sequence identity with the nucleic acid sequence of SEQ ID NO:3; or
- (d) combinations thereof.

36. The method according to claim 26, wherein said SBV comprises:

- (a) an S RNA segment, characterized in that the S RNA segment has a sequence having at least 97.8 % sequence identity to SEQ ID NO:4 or SEQ ID NO:8;
- (b) an M RNA segment, characterized in that the M RNA segment has a sequence having at least 82.2 % sequence identity to SEQ ID NO:5;
- (c) an L RNA segment, characterized in that the L RNA segment has a sequence having at least 93 % sequence identity to SEQ ID NO:6; or
- (d) combinations thereof.

37. A SBV comprising:

- (a) a small (S) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 97.8 % sequence identity with the nucleic acid sequence of SEQ ID NO:1 or SEQ ID NO:7;
- (b) a medium (M) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 82.2 % sequence identity with the nucleic acid sequence of SEQ ID NO:2;
- (c) a large (L) RNA segment having a sequence that is inverse complementary to a nucleic acid sequence having at least 93 % sequence identity with the nucleic acid sequence of SEQ ID NO:3; or
- (d) combinations thereof.

38. A SBV comprising:

- (a) an S RNA segment, characterized in that the S RNA segment has a sequence having at least 97.8 % sequence identity to SEQ ID NO:4 or SEQ ID NO:8;
- (b) an M RNA segment, characterized in that the M RNA segment has a sequence having at least 82.2 % sequence identity to SEQ ID NO:5;
- (c) an L RNA segment, characterized in that the L RNA segment has a sequence having at least 93 % sequence identity to SEQ ID NO:6; or
- (d) combinations thereof.

39. A composition of matter obtainable by the method according to claim 26.

40. The composition according to claim 39, wherein the composition is an immunogenic composition.

41. The composition according to claim 39, wherein the composition is a vaccine.

42. A method of generating an immune response to SBV in an animal comprising administering to said animal the immunogenic composition according to claim 1.

43. A method of treating or preventing SBV in an animal in need of said treatment comprising administering to said animal a therapeutically effective amount of the immunogenic composition according to claim 1.

44. A method of treating or preventing viremia or malformations induced by SBV comprising administering to said animal a therapeutically effective amount of the immunogenic composition according to claim 1.

45. A method for inducing an immune response against SBV in a herd of animals comprising the step of administering the immunogenic composition according to claim 1 to such animals in need thereof.

46. A method for preventing or reducing viremia or malformations induced by SBV in a herd of animals comprising the step of administering the immunogenic composition according to claim 1 to such animals in need thereof.

47. A method for preventing or reducing the transmission of SBV in a herd of animals comprising the step of administering the immunogenic composition according to claim 1 to such animals in need thereof.

48. The method according to claim 42, wherein the immunogenic composition is administered in a single dose or in two doses.

49. The method according to claim 43 wherein the immunogenic composition is administered in a single dose or in two doses.

50. The method according to claim 44, wherein the immunogenic composition is administered in a single dose or in two doses.

51. The method according to claim 45, wherein the immunogenic composition is administered in a single dose or in two doses.

52. The method according to claim 46 wherein the immunogenic composition is administered in a single dose or in two doses.

53. The method according to claim 47, wherein the immunogenic composition is administered in a single dose or in two doses.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/043146

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07K14/175 A61K39/12
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61K C07K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, EMBL, BIOSIS, Sequence Search, EMBASE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BERND HOFFMANN ET AL: "Novel Orthobunyavirus in Cattle, Europe, 2011", EMERGING INFECTIOUS DISEASES, vol. 18, no. 3, 1 March 2012 (2012-03-01), pages 469-472, XP055054135, ISSN: 1080-6040, DOI: 10.3201/eid1803.111905 cited in the application	1-4, 10-25, 37-53
Y	page 469, left-hand column, paragraph 2 - page 471, left-hand column, paragraph 3 -/--	26-36

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search	Date of mailing of the international search report
9 July 2013	18/07/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Montero Lopez, B

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	& DATABASE EMBL [Online] 16 January 2012 (2012-01-16), "Schmallenberg virus genes for nucleocapsid protein and non-structural protein, segment S, genomic RNA, isolate BH80/11-4", retrieved from EBI accession no. EM_STD:HE649914 Database accession no. HE649914 sequence	

Y	IKEGAMI T ET AL: "Rift Valley fever vaccines", VACCINE, ELSEVIER LTD, GB, vol. 27, 5 November 2009 (2009-11-05), pages D69-D72, XP026694008, ISSN: 0264-410X, DOI: 10.1016/J.VACCINE.2009.07.046 [retrieved on 2009-10-28] page D69, left-hand column, paragraph 1 - page D70, right-hand column, paragraph 3	26-36

A	MUTIEN-MARIE GARIGLIANY ET AL: "Schmallenberg virus: A new Shamonda/Sathuperi-like virus on the rise in Europe", ANTIVIRAL RESEARCH, ELSEVIER BV, NL, vol. 95, no. 2, 25 May 2012 (2012-05-25), pages 82-87, XP028426110, ISSN: 0166-3542, DOI: 10.1016/J.ANTIVIRAL.2012.05.014 [retrieved on 2012-06-05] the whole document	1-53

A	TOHRU YANASE ET AL: "Genetic reassortment between Sathuperi and Shamonda viruses of the genusin nature: implications for their genetic relationship to Schmallenberg virus", ARCHIVES OF VIROLOGY ; OFFICIAL JOURNAL OF THE VIROLOGY DIVISIONOF THE INTERNATIONAL UNION OF MICROBIOLOGICAL SOCIETIES, SPRINGER-VERLAG, VI, vol. 157, no. 8, 16 May 2012 (2012-05-16), pages 1611-1616, XP035091855, ISSN: 1432-8798, DOI: 10.1007/S00705-012-1341-8 page 1611, right-hand column, paragraph 2 - page 1616, left-hand column, paragraph 1; table 2	1-53

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/043146

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	KERSTIN WERNIKE ET AL: "Inactivated Schmallenberg virus prototype vaccines", VACCINE, 1 May 2013 (2013-05-01), XP55070055, ISSN: 0264-410X, DOI: 10.1016/j.vaccine.2013.05.062 the whole document -----	1-53
X,P	KERSTIN WERNIKE ET AL: "Schmallenberg virus challenge models in cattle: infectious serum or culture-grown virus?", VETERINARY RESEARCH, BIOMED CENTRAL LTD, LONDON, UK, vol. 43, no. 1, 11 December 2012 (2012-12-11), page 84, XP021134454, ISSN: 1297-9716, DOI: 10.1186/1297-9716-43-84 the whole document -----	18-20, 24,25, 37,38
X,P	ELLIOTT RICHARD M ET AL: "Establishment of a reverse genetics system for Schmallenberg virus, a newly emerged orthobunyavirus in Europe.", THE JOURNAL OF GENERAL VIROLOGY APR 2013, vol. 94, no. Pt 4, April 2013 (2013-04), pages 851-859, XP002700255, ISSN: 1465-2099 abstract page 852, left-hand column, paragraph 2 - right-hand column, paragraph 1 page 852, right-hand column, paragraph 4 - page 853, right-hand column, paragraph 2 page 857, left-hand column, paragraph 2 - paragraph 3 -----	18-39