Sheep and Goat Pox Virus

Control Tools

Diagnostics availability

Commercial diagnostic kits available worldwide

No: At present there is no universal diagnostic test for the diagnosis of sheeppox and goatpox available commercially.

Commercial diagnostic kits available in Europe

None.

Diagnostic kits validated by International, European or National Standards

None.

Diagnostic method(s) described by International, European or National standards

Routine methods are described in the OIE Manual of Diagnostic Tests and Vaccines

1. Identification of the agent

- Virus isolation using cell culture
- Electron Microscopy
- Histology
- Immunological (antigen detection ELISA, AGID, Fluorescent Antibody
- Nucleic acid recognition (PCR)

2. Serological

- Virus neutralisation
- ELISA (antibody detection)
- Western blot

GAPS:

- Immunohistochemical staining methods
- Formal validation of most, if not all, of these tests has not been undertaken (particularly to the level required by the OIE). Although primary diagnosis using tests such as virus isolation, electron microscopy and PCR is considered relatively straightforward, reliable high-throughput serological testing remains problematic due to insufficient sensitivity of currently available tests. Unfortunately, the ELISA which is described in the OIE Manual is not very effective.

Commercial potential for diagnostic kits in Europe

Limited as disease only occurs occasionally in southern Europe.

DIVA tests required and/or available

DIVA for both antigen and antibody are required but are not available.
GAP: there are no DIVA tests or vaccines developed for sheeppox and goatpox.

Opportunities for new developments

There are several reports on the development of diagnostic tests for sheeppox and goatpox such as counterimmunoelectrophoresis, indirect ELISA, PCR, PCR-RFLP and real-time PCR, but none is available commercially.

However, there are some tests like PCR-RFLP (P32 and attachment gene based) and duplex PCR (fusion and attachment gene based) that have been reported for the specific detection and differentiation of sheeppox and goatpox viruses, but these are not available commercially.

A systematic approach is required to bring these diagnostics, in the form of kits/pen side tests, on to the market as a priority.

Intensive quality control studies (sensitivity, specificity, repeatability, reproducibility and accuracy) and approval of the OIE are required to make them available commercially.

• Currently developed diagnostics need to be validated and, once validated, used in the field. It is possible that more expensive cutting edge serology tests may be more sensitive than current diagnostics.

• Establishing a collection of well-characterised samples from experimentally and naturally infected or vaccinated animals will be required for effective test development and validation.

• An indirect ELISA kit for antibody detection is under evaluation and development e.g. by JOVAC. An indirect ELISA based on recombinant structural proteins and an ELISA based on inactivated purified SPPV have been described by other research groups.

• A real-time PCR assay with melting curve analysis to differentiate between SPPV and GTPV.

Vaccines availability

Commercial vaccines availability (globally)

Several live attenuated vaccines are currently available. A number of strains of capripoxvirus have had widespread use as live vaccines, for example the Kenya sheep and goat pox 0240 strain used in sheep and goats, the Romanian and RM-65 strains used mainly in sheep, and the Mysore and Gorgan strains used in goats.

GAP: the mechanism of attenuation is unknown for live vaccines. Sequencing of these vaccines would likely be able to help identify virulence factors.

Commercial vaccines authorised in Europe

No. Live capripoxvirus vaccines are not used in Europe or in other countries where capripoxviruses are non-endemic.

Marker vaccines available worldwide

No.

Marker vaccines authorised in Europe

No.

Effectiveness of vaccines / Main shortcomings of current vaccines

Inactivated vaccines do not provide long term immunity. A single strain of capripoxvirus will protect against all other known strains in both sheep and goats whether the strain originates in Africa or Asia.

The poor success of the dead vaccines made from inactivated tissue cultures is due to a number of factors. These include the change in the virion and the fact that immunity to capripoxviruses is mainly cell mediated, which is better stimulated by the use of a live vaccine.

GAP:
• See Section concerning method of production of inactivated vaccines.
• There is a need for intensive evaluation of immunity levels, either cell mediated or humoral, and how they correlate with protection.

**Commercial potential for vaccines in Europe**

None.

**Regulatory and/or policy challenges to approval**

Use of genetically modified vaccines might be problematic in some countries. The field trials may need specific regulation regarding the release of GMOs into the environment.

**Commercial feasibility (e.g manufacturing)**

No demand in Europe.

**Opportunity for barrier protection**

Could be used in the event of an incursion into Europe.

**Opportunity for new developments**

To develop recombinant vaccines based on capripoxvirus as the vector and including genome material from PPRV and other viruses of small ruminants. Immunity against a range of related viruses following a single vaccination could help to reduce the economic damage caused by capripoxviruses and PPR on small ruminants.

**GAPS:**

• Poxviruses are ideal vaccine vectors that can be used for vaccinating against several diseases using multiple antigens.
• Recombinant vaccines have been developed and shown to be effective against multiple agents.
• Using LSDV as replication defective vaccine vectors for SPPV and GTPV.
• Using virus-like particle technology to develop new vaccines.

**Pharmaceutical availability**

**Current therapy (curative and preventive)**

None.

**Future therapy**

Antivirals may play a role but unlikely.

**Commercial potential for pharmaceuticals in Europe**

None.

**Regulatory and/or policy challenges to approval**

None.
Commercial feasibility (e.g. manufacturing)

Depends on demand.

Opportunities for new developments

Unlikely due to a lack of a profitable market. Nevertheless, several candidate antiviral therapeutics have been developed for use against smallpox virus in the event of a possible pandemic arising through an act of bioterrorism, and these might lead to more ready identification of candidate drugs for use against capripoxviruses in sheep and goats.

GAPS:
- New ELISA for the detection of antibodies
- Molecular-based assays (PCR, a real-time PCR, microarrays for multiple disease diagnosis)
- RNA interference strategy to overcome the SPPV and GTPV infections (unlikely)

New developments for diagnostic tests

Requirements for diagnostics development

Diagnostic tests must be validated and have a reasonable sensitivity and specificity. An antibody detection ELISA based on recombinant antigens, with no requirement for infectious reagents, would be a desirable test format.

GAPS:
- Reliable high-throughput antibody detection is problematic (due to insufficient sensitivity of currently available tests).
- Without finding enough characterized positive samples is difficult to validate current experimentally used tests.
- Differentiation between infected and vaccinated animals and differentiation between SPPV and GTPV through real-time PCR and ELISA based on recombinant structural proteins.

Time to develop new or improved diagnostics

In general the development of tests is much faster and less expensive than developing vaccines. From development through validation to commercial availability will be time consuming and can take years.

GAPS:
- Real-time PCR and ELISA diagnostics have been described in the scientific literature. However, these tests require validation with greater numbers of samples to become validated to the OIE standard.
- Tests need to be validated in each country of intended use.

Cost of developing new or improved diagnostics and their validation

The development and validation of new tests is time consuming, labour intensive and costly. Costs cannot be specified as they will depend on the nature of the test and the cost of producing reagents and supplying reading or processing machines if necessary. Once validated there will need to be a commercial company willing to market the test.

Research requirements for new or improved diagnostics

The ability to identify infected herds at the population level may be suitable to demonstrate freedom from disease. It would be ideal if a serological test was sensitive enough to detect exposure to the disease in individual animals. The identification of immune dominant antigens should facilitate the development of improved antibody detection tests.

GAP:
- The sensitivity of currently used experimental serological tests is not sufficient to identify vaccinated animals or animals that have been infected and shown mild clinical signs.
- Research to identify proteins inducing a very good humoral immunological response to develop a specific and highly sensitive ELISA for Capripox serological diagnosis.
Need to re-evaluate, validate and compare the present diagnostic tools.

Technology to determine virus freedom in animals

Tests required for the identification of infected animals.

GAPS:
- Current tests for antibody detection are not sufficiently sensitive to be used on an individual animal basis. No tests to detect cell mediated immunity are currently available.
- Current PCR methods suitable for the detection of viraemic animals and virus persistence in the skin, mucous membranes, saliva, eye and nasal discharges, and semen.

New developments for vaccines

Requirements for vaccines development / main characteristics for improved vaccines

The vaccine must be attenuated in all species of sheep, goats and cattle that are susceptible to capripoxvirus. A single live attenuated vaccine that is molecularly characterized and effective in preventing clinical disease would be desirable.

GAPS:
- Identification and characterisation of proteins with putative virulence and host range functions, as well as those involved in modification/evasion of the host immune response, should facilitate the development of an improved, “universal” live attenuated vaccine.
- Identification of genes and virokines, involved in the pathogenicity of Capripoxvirus and a rational deletion of some of them for the development of very safe, risk of reversion quite nil, and very potent vaccine.
- The development of new vaccination program rather than new vaccines.
- New adjuvants and developing multivalent vaccines

Time to develop new or improved vaccines

Depending on when a candidate vaccine could be identified the timescale will be 5-10 years. This will involve development, clinical trials and licensing. Potential vaccines need to be identified and subjected to initial trials, and depending on the outcome will determine the time to commercial availability.

Cost of developing new or improved vaccines and their validation

Expensive with the need to develop and undertake all the relevant tests to provide data to enable the product to be authorised. Field trial will be difficult as will be evaluation of the results.

Research requirements for new or improved vaccines

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- New adjuvants and developing multivalent vaccines

New developments for pharmaceuticals

Requirements for pharmaceuticals development
Unlikely due to a lack of a profitable market.

**Time to develop new or improved pharmaceuticals**

Time to develop would depend on the product and the trials necessary to validate the efficacy and safety. Commercial production would then take further time. Five to 10 years seems a realistic timeframe.

**Cost of developing new or improved pharmaceuticals and their validation**

Expensive but difficult to assess as it will depend on the product and the trials necessary to validate and license.

**Research requirements for new or improved pharmaceuticals**

A better understanding of the molecular basis of capripoxvirus pathogenesis is required, so that candidate therapeutic agents can be identified. Advances in the development of antiviral therapeutics against smallpox virus might facilitate the identification of candidate drugs for use against SPPV and GTPV.

**Disease details**

**Description and characteristics.**

**Pathogen**

Sheeppox virus (SPPV) and Goatpox virus (GTPV) belong to the genus Capripoxvirus in the family Poxviridae, subfamily Chordopoxvirinae. Sheeppox virus and GTPV are antigenically and genetically closely related to each other and to Lumpy skin disease virus (LSDV), the other member of the genus Capripoxvirus. All three viruses, nevertheless, are considered distinct species.

**GAPS:**

- Need to sequence more virus isolates to confirm that distinction between sheep and goat isolates remain, and there is not a continuum.
- To identify more diagnostic targets within capripoxvirus genomes suitable for genotyping.

**Variability of the disease**

Sheeppox and goatpox are caused by strains of capripoxvirus, which infect sheep and goats. There is a breed-linked predisposition and the disease is dependent on the strain of capripoxvirus. Strains of SPPV do pass between sheep and goats, and vice versa. Typically, however, distinct host preferences exist such that most strains of SPPV or GTPV exhibit greater virulence in the homologous host, while some are equally virulent in both species. Recombination may occur which results in a range of host susceptibility and virulence. SPPV and GTPV share ~96% nucleotide identity over their entire genome length, while SPPV and GTPV share ~97% nucleotide identity to LSDV. SPPV and GTPV are distinct and likely derived from an LSDV-like ancestor.

**GAPS:**

- Possible continuum of strains with different host specificities.
- Identify genes involved in host tropism and virulence for sheep and goats such as kelch-like gene SPPV-019 (a putative virulence gene in SPPV).
- The molecular determinants of host range/virulence are poorly understood.
- Many conflicting reports exist on the epidemiology of sheeppox and goatpox. Genome sequencing of many strains, together with molecular epidemiology and pathogenicity studies, are required to resolve them.

**Stability of the agent/pathogen in the environment**

The Virus survives for many years in dried scabs at ambient temperatures. Virus remains viable in wool for 2 months and in premises for as long as 6 months.

**GAPS:**

To evaluate the infectivity of scabs (as an aerosolized dust):
Species involved

Animal infected/carrier/disease

Sheep and goats are the natural hosts of SPPV and GTPV. No carrier status has been recognized following infection with either virus.

GAPS:

- To investigate why sheeppox and goatpox are not present in Africa, south of the Equator, and why goatpox is not found in northern Africa.
- No data are available on the role of wildlife as a potential reservoir host.
- SPPV and GTPV replicate in cattle but do not cause clinical disease, which may indicate same potential in wild ruminants.

Human infected/disease

No.

Vector cyclical/non-cyclical

Insect vectors are not thought to play a prominent role in transmission of SPPV or GTPV. However, mechanical transmission by biting flies has been demonstrated experimentally.

GAP: the importance of arthropod vectors in the spread of disease needs to be clarified, particularly considering the high concentrations of infectious virus in skin.

Reservoir (animal, environmental)

Sheep and goats are the only hosts.

GAP: Reports of wildlife reservoirs need confirmation.

Description of infection & disease in natural hosts

Transmissibility

Direct or indirect contact with infective material.

GAP: identify if arthropod vectors can transmit sheeppox and goatpox viruses.

Pathogenic life cycle stages

Not applicable.

Signs/Morbidity

Infected animals show inappetence and a rise in body temperature, pulse and respiratory rates. In the acute phase (within 24 hours after appearance of the skin lesions) the animals develop conjunctivitis, nasal discharge, and excessive salivation. They may show arched back, hypersensitivity, coughing and pneumonia, constipation and scanty urine. Usually an enlargement of superficial lymph nodes (especially the prescapular lymph nodes) is also a prominent feature.

One to two days after the onset of fever, skin eruptions appear over the less wooly parts of the body. The lesions undergo macular, papular, vesicular (rare), and pustular stages typical of any pox disease. Papules on the eyelids may cause blepharitis and oedema.
Scabs persist for up to 6 weeks and after healing cicatrix may remain. Pox lesions on the mucous membranes of the mouth, eyes, and nose ulcerate leading to mucopurulent discharge and crust formation in the muzzle. In severe cases pox lesions appear throughout the whole respiratory and digestive tracts, and also in other internal organs.

A fatal septicaemia and pyaemia may develop and the virus itself may result in the death of the animal during the febrile eruptive phase of the disease. Mouth lesions constitute an important source of virus spread.

Severity depends on breed, age, nutritional and immune status, virus strain, virulence, the nature of the secondary infection and organs involved. Septicemia/pyaemia and pneumonia due to secondary bacterial complications may lead to death.

Aggravations of latent brucella, tendovaginitis, orchitis, abortion and peripheral paresis have also been reported after sheeppox infection.

**Incubation period**

The incubation period ranges between 8 to 13 days following contact but varies depending on the route of infection. A shorter period may be observed depending on the route of infection especially with mechanical transfer by insects resulting in intradermal inoculation.

**Mortality**

The mortality rate varies but in the endemic areas may be between 5 and 10%. It can approach 100% in imported sheep which are fully susceptible. Death can be frequent when complications such as secondary pneumonia and fly strike occur.

**Shedding kinetic patterns**

Virus is abundant in skin and mucosal lesions. Virus is excreted in nasal, oral and conjunctival secretions, milk, and possibly urine and faeces.

**GAP:** infectivity highest during clinical disease, but role of scabs in transmission is not clear

**Mechanism of pathogenicity**

Lesions are found in the epidermis and include congestion, haemorrhage, oedema, vasculitis and necrosis. All layers of the epidermis, dermis and sometimes musculature are involved. Typical pox lesions are also found in the respiratory and gastrointestinal tracts, as well as in other internal organs including lymph nodes, liver and kidneys.

Multiple virus-encoded factors are produced during infection, which influence pathogenesis and disease.

**GAPS:**

To improve understanding of pathogenesis will require:

- Identification of receptors for viral attachment.
- Characterization of proteins with putative virulence and host range functions.
- Characterization of proteins involved in modification/evasion of the host immune response.

**Zoonotic potential**

**Reported incidence in humans**

Capripoxvirus is not infectious to humans.

**Estimated level of under-reporting in humans**

None.

**Risk of occurrence in humans, populations at risk, specific risk factors**
Disease with associated mortality and morbidity is a welfare problem.

**GAP:** Wild small ruminants are likely susceptible, but solid data in support of this are lacking.

Slaughter of the infected herd if disease is found in a previously free country or region.

Sheeppox and goatpox occur in Africa (north of the Equator), the Middle East, Turkey, Iran, Iraq, Afghanistan, Pakistan, India, Nepal, in some parts of the People's Republic of China, Bangladesh, Vietnam and Mongolia. Most of Europe and the Americas are now free from endemic sheeppox although, recently, it has made frequent incursions into Greece.

**GAPS:**
- Need to clarify why:
  - Sheeppox and goatpox are not present in Africa, south of the Equator.
  - Goatpox is not present in North Africa while sheeppox is widespread.

**Seasonal cycle (seasonality)**

No.
**Speed of spatial spread during an outbreak**

Can be rapid. Will also depend on other diseases that disrupt epithelium, such as foot-and-mouth disease, orf (contagious ecthyma) and peste des petits ruminants (PPR), but also type of forage (e.g. thorns). Other factors that may influence the speed of the spread of the disease are immune status and age of animals, parasites, other stress factors and the virulence of the virus.

**Transboundary potential of the disease**

Movement of infected sheep and goats or their products (such as wool).

**GAP:** need to identify high risk countries where there is potential spread of disease. e.g. from Turkey into Greece and from China into Vietnam and Mongolia.

**Seasonal cycle linked to climate**

No.

**Distribution of disease or vector linked to climate**

No.

**GAP:** little data currently available.

**Outbreaks linked to extreme weather**

No.

**GAP:** no data available.

**Sensitivity of disease or vectors to the effects of climate change (environmental changes/land use)**

No.

**GAP:** the role of potential insect vectors in transmission of disease requires clarification.

**Route of Transmission**

**Usual mode of transmission (introduction, means of spread)**

Sheeppox and goatpox are highly contagious diseases. The viruses are thought to be transmitted directly by short distance aerosols or indirectly by entry of virus through cuts and abrasions in skin and mucosae following contamination of the environment with virus shed by infected animals. Transmission may also occur through contact with fomites and, possibly, by biting insects acting as mechanical vectors. The common practice of herding caprines in to enclosures at night in enzootic countries provides adequate exposure to maintain infection.

**GAPS:**

- The role of arthropod vectors in transmission of the viruses requires clarification.
- The evaluation of the potential mode of transmission by arthropods.
- Potential transmission by insect vectors over longer time intervals than would be consistent with usual mechanical transmission.
- Are the viruses able to replicate in insect cells?
- The attachment of the viruses to insect cell receptors.
- Potential mechanical transmission by humans after handling infected animals.
Occasional mode of transmission

Additionally, animal rearing areas are easily accessible to biting flies (occasional carriers), which are thought to be capable of transmitting the viruses mechanically.

**GAPS:** see gaps under usual mode of transmission.

Conditions that favour spread

Close contact between infected and susceptible animals.

**GAPS:**

Need to evaluate the influence of various factors:

- Farm management practices
- Climatic conditions
- Contact with potential wild life reservoirs
- Abundance of arthropod vectors.

Detection and Immune response to infection

**Mechanism of host response**

**Immunological basis of diagnosis**

Immunity to capripoxviruses is thought to be mainly cell mediated. Antibody detection is not reliable due to the insufficient sensitivity of currently available tests, and false negative results may be obtained.

**GAP:** antibody will neutralize virus in vitro, although virus will break away from antibody in the VN test. New indirect enzyme-linked immunosorbent assays (ELISA) have been published; validation of these tests is on-going. No tests for cell mediated immunity are currently available.

**Main means of prevention, detection and control**

**Sanitary measures**

- Elimination of infected and exposed flocks by slaughter;
- Proper disposal of animals and contaminated material;
- Cleaning and disinfection of contaminated premises and equipment.

**GAP:** further studies are required on the survival of the viruses in the environment.

**Mechanical and biological control**

Sheeppox and goatpox viruses have major impacts on small ruminant production, but can be controlled by vaccination. Ring vaccination of susceptible animals on premises surrounding the infected flock should be considered. If the disease has spread over a large area, the most effective means of controlling losses is vaccination.

**Diagnostic tools**

- Virus isolation using cell culture.
- Identification of virus by electron microscopy (EM) or agar gel immuno-diffusion (AGID).
- Antigen detection (ELISA, immunohistochemistry).
- Genome detection (conventional or real-time PCR).

Current serological tests are either not sufficiently sensitive or they are expensive. The neutralization tests, which are considered the “gold standard” for antibody detection, are not suited to high-throughput screening of sera.
GAPS:
- Formal validation of most, if not all, tests have not been undertaken (particularly to the level required by the OIE).
- A simple, validated conventional PCR method for the differentiation of SPPV from GTPV.
- A PCR method for the differentiation of SPPV and GTPV from lumpy skin disease virus.
- Recombination between SPPV and GTPV can complicate identification of the viruses.
- A highly sensitive and specific ELISA to detect antibodies against capripoxviruses in vaccinated animals as well as in infected animals is required.

Vaccines

Live and inactivated vaccines have been used. Live attenuated vaccines are recommended since inactivated vaccines only give short term immunity. Vaccines will provide protection against all strains of capripoxvirus as all strains so far examined share a major neutralisation site. Immunity generated following vaccination with live attenuated strains is expected to last more than 1 year.

GAPS:
Inactivated vaccines usually have predominance of intracellular mature virus as production of vaccine requires disruption of infected cells. Extracellular enveloped virus antigens therefore not in vaccine and will not protect against aerosol spread. A combination of both live attenuated and inactivated vaccines to be evaluated for providing solid immunity. A recombinant vaccine combining PPRV and GTPV has been shown to protect goats against both PPR and goatpox. The protection provided and the duration of the immunity have not been fully evaluated under field conditions and, currently, no recombinant vaccines against capripoxviruses are commercially available.
No DIVA vaccines against capripoxviruses have been developed.

Therapeutics

Only symptomatic treatment and treatment of secondary infections.

Biosecurity measures effective as a preventive measure

Cleaning and disinfection, separation of flocks.

Border/trade/movement control sufficient for control

Special veterinary requirements, restrictions or ban of transfer of live animals or their products from endemic countries to countries free of disease.
Restrictions or ban of movement of live animals or animal products during disease outbreaks.

Prevention tools

Vaccination.

Surveillance

Sheeppox and goatpox are classified as notifiable by the World Organization for Animal Health (OIE). A presumptive diagnosis is usually based on highly characteristic clinical signs, but the diagnosis must be confirmed by laboratory testing.

Past experiences on success (and failures) of prevention, control, eradication in regions outside Europe

Successful vaccination is the only effective control in endemic countries. A slaughter policy with movement controls can be effective when the disease is introduced into a previously free country.
Costs of above measures

Although live vaccine against SPPV and GTPV is very cheap to produce the control of the disease is usually expensive in terms of vaccine campaigns or stamping-out and movement controls.

Disease information from the OIE

Disease notifiable to the OIE

Yes.

OIE disease card available

http://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/SHEEP_GOAT_POX_FINAL.pdf

OIE Terrestrial Animal Health Code (reference)


OIE Terrestrial Manual (reference)


Socio-economic impact

Zoonosis: Impact on affected individuals and/or aggregated DALY figures

Not applicable.

Zoonosis: cost of treatment and control of the disease in humans

Not applicable.

Direct impact (a) on production

Presence of sheeppox and goatpox in a country limits the trade of new breeds and development of intensive sheep production. A survey conducted in the Maharashtra state (India) revealed that the disease has major impact on the economy with average morbidity and mortality rates of 63.5 and 49.5%, respectively. The effect is such that it would take 6 years for a flock to recover from an outbreak with average income losses up to 30–43% of total annual revenue depending on flock type and owners’ actions.

Direct impact (b) cost of private and public control measures

Costs of disease, and control using vaccines.

Indirect impact
The level of impact varies from country-to-country, both qualitatively and quantitatively.

### Trade implications

**Impact on international trade/exports from the EU due to existing regulations**

High impact. Standards for movement are specified in the OIE Terrestrial Animal Health Code.

**Impact on EU intra-community trade due to existing EU regulations**

None apart from sporadic incursions into the EU when movement controls are imposed on regions involved.

**Impact on national trade due to existing regulations**

None.

### Main perceived obstacles for effective prevention and control

Efficacious vaccines are needed to reduce the incidence of the disease in sheep and goats, and the associated economic losses. Differentiation of SPPV and GTPV may help in the specific use of sheeppox and/or goatpox vaccines, although any live attenuated capripoxvirus vaccine should be protective in sheep and goats. Lack of an effective veterinary infrastructure in some developing countries.

**GAPS:**

- In countries where both sheeppox and goatpox outbreaks occur vaccine challenge trials should be carried out.
- A standardized, molecularly characterized live attenuated virus vaccine suitable for use in sheep, goats and cattle is lacking.

### Main perceived facilitators for effective prevention and control

- Viral genomes have now been sequenced.
- Subunit vaccines are being developed for other related poxviruses.
- Combined vaccines for PPR and sheeppox.
- An efficacious vaccine is needed to reduce the incidence of disease in sheep and goats and decrease economic losses.
- Establishment and maintenance of an effective veterinary infrastructure.

**GAP:** multivalent recombinant capripox-based vaccines to control more than one small ruminant disease is desirable because it will allow cutting down the cost of vaccination.

### Risk

Capripoxviruses are one of the potential animal bioterrorist agents as they

(i) cause high morbidity and mortality,

(ii) have potential for rapid spread,

(iii) have potential to cause serious socio-economic consequences and

(iv) are of major importance in the international trade of animals and animal products.

SPPV/GTPV is one of 15 animal pathogens listed by the World Organization for Animal Health (OIE) and one of 23 listed by the Animal and Plant Health Inspection Agency USDA which can be used as an animal biological warfare agent. Hence, their bio-security is of paramount importance. Sheeppox virus and GTPV have been listed as a Risk Group II viral agent by the Centers for Disease Control
GAP: Capripox also has a long incubation period; animals intentionally infected can travel a considerable distance before showing the disease and can therefore disperse and spread disease.

Main critical gaps

Conclusion

Research in this field may lead to a reduction in the incidence, and therefore in the impact, of capripoxvirus associated disease. Sheeppox is primarily a problem in developing countries. The current research should focus on:

- development of monoclonal antibody (MAb) based assays (cELISA) or DNA based assays like PCR, PCR-REA and nucleic acid hybridization
- regular vaccination with attenuated vaccines
- education of farmers through extension activities
- and effective implementation of regulations to avoid alternative vaccination methods.

If all these aspects are taken care of well, the control and eradication of the disease will be a reality globally. Like smallpox, it is possible to eradicate capripoxvirus through vaccination.

GAP: Capripox can be a good animal model for smallpox in humans.

Sources of information

Name of expert group leader

Expert group members are included where permission has been given

Eeva Tuppurainen - Institute for Animal Health Pirbright, UK – [Leader]

David Wallace, Onderstepoort Veterinary Institute (ARC-OVI), South Africa
Paul Kitching, Canadian Food Inspection Agency, Canada
Shawn Babik, Canadian Food Inspection Agency, Canada
Adama Diallo, International Atomic Energy Agency, Austria
Koos Coetzer, University of Pretoria, South Africa
Timothy Bowden, Australian Animal Health Laboratory, Australia
Faisal A. Abedeldayem, Jordan bioindustries center (JOVAC), Jordan

Name of reviewers

Project Management Board

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References

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