Sheep and Goat Pox

Disease Monograph Series – 22

Virus | Capripoxvirus | Poxviridae| Sheep | Goats

IDRC | Bartay

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Acronyms

AU	African Union
AU-IBAR	African Union Inter-African Bureau for Animal Resources
BBRSC	Biotechnology and Biological Sciences Research Council
BMGF	Bill and Melinda Gates Foundation
CaPV	Capripox virus
CVO	Chief Veterinary Officer
DIVA	Differentiate infected from vaccinated animals
DVS	Director Veterinary Services
ELISA	Enzyme-linked immunosorbent assay
FAO	Food and Agriculture Organization of the United Nations
GPV	Goat pox virus (also shown sometimes as GTPV)
IAEA	International Atomic Energy Agency of the United Nations
IFAT	Indirect fluorescent antibody test
IM	Intramuscular
KS-1	Kenyan sheep pox vaccine strain
KSGV	Kenyan sheep and goat pox virus
LSD	Lumpy skin disease
LSDV	Lumpy skin disease virus

NGO	Non-governmental organization
OIE	World Animal Health Organization
PANVAC	Pan African Vaccine Center
PCR	Polymerase chain reaction
SGP	Sheep and goat pox
SPV	Sheep pox virus (also SPPV)
SHF	Small holder farmer
TPP	Target Product Profile
WHO	World Health Organization of the United Nations

Executive Summary

Etiology and relevance

Sheep and goat pox (SGP) is probably one of the most serious infectious diseases of small ruminants in parts of Africa and Asia where the diseases occur. Sheep pox and goat pox are viral diseases of sheep and goats characterized by fever, generalized papules or nodules, vesicles (rarely), internal lesions (particularly in the lungs), and death. The two diseases result from infection with strains of capripoxvirus, all of which can infect sheep and goats. Despite the fact that most of the strains studied to date cause more severe clinical disease in either sheep or goats, some of the isolates are equally pathogenic in both species.

Sheep pox virus (SPV) and Goat pox virus (GPV), along with lumpy skin disease virus are members of the viral genus Capripoxvirus, in the family Poxviridae. SPV and GPV cannot be distinguished from each other with serological technique, and used to be considered strains of a single virus. Through genetic sequencing it has now been demonstrated that these viruses are distinct, but recombination can occur between them. Recombinant strains usually have intermediate host specificity.

As for other poxviridae, SPV and GPV are double-stranded DNA virus, with a large size genome, which has been extensively exploited in generating recombinant multivalent vaccines by inserting foreign viral genes. They are also very stable viruses.

Epidemiology and transmission

Sheep and goat capripoxviruses cause diseases only in these two species, with some variation in the susceptibility of different breeds and strains of sheep and goats to the two viruses.

The disease is prevalent in Africa North of the Equator, although it is also present in Tanzania, the Middle East, Turkey, Iran, Iraq, Afghanistan, Pakistan, Nepal, India, China, Bangladesh, Vietnam and Chinese Taipei.

SPV and GPV are often transmitted by the respiratory route during close contact, and may also enter the body through other mucous membranes or abraded skin. These viruses can be found in saliva, nasal and conjunctival secretions, milk, urine and feces, as well as in skin lesions and their scabs. The viruses can also be spread on fomites or transmitted mechanically by insects such as flies. There is no evidence that SPPV can replicate in arthropod vectors.

Transmission of infection occurs by contact through abraded skin and inhalation, or mechanically by flies. Chronically infected carriers do not occur in sheep and goat pox.

Sheep and goat pox are economically important in countries where the diseases occur, due to mortality and high morbidity. Economic losses result from decreased milk production, damage to the quality of hides, as seen in

Ethiopia, and wool, as well as other production losses. Sheep and goat pox can limit trade and prevent the development of intensive livestock production. They may also prevent new breeds of sheep or goats from being imported into endemic regions

Clinical signs

The clinical signs vary from mild to severe, depending on the animal's age, breed, immunity and other factors, with possibility of inapparent infections. The course of the disease in sheep and goat are similar, with first signs often including fever, depression, rhinitis, conjunctivitis and lacrimation. Cutaneous lesions develop after

–J or 2 days, and they progress through the macular, papular, vesicular and pustular stages until scabs are formed. Lesions are not only on the skin: mucosae of the mouth, anus, and prepuce or vagina are also affected and may become necrotic. In animals that survive acute phase, the papules become necrotic from vascular thrombosis and ischaemic necrosis. During healing, they are susceptible to fly strike. Secondary bacterial infections, including pneumonia, are common, and death can occur at any stage of the disease. Recovery can be slow if the animal was severely affected.

Diagnostics

Clinically a presumptive diagnosis of the disease can be made based on highly characteristic clinical signs of Sheep and goat pox, including full–thickness skin lesions and enlarged lymph nodes; although mild disease may be difficult to diagnose and can be confused with parapoxvirus causing orf or urticaria from multiple insect bites.

At laboratory level the identification of the agent can be conducted through genome detection through PCR, electron microscopy of biopsy or crusts, and virus isolation. There is also the antigen ELISA that has been described. Capripoxvirus antigen and inclusion bodies may also be seen in stained cryostat or paraffin sections of biopsy or post-mortem lesion material. Serological tests include virus/serum neutralisation (golden standard test for serology), indirect fluorescent antibody test, capripox antibody ELISA and seldom Western Blot. Most serological tests however would not differentiate between different capripox.

Control

If sheep or goat pox occurs in a previously free country, eradication is usually by slaughter of all infected and in-contact animals. Animals and movement controls should be implemented.

The most commonly used control strategy is through vaccination with live attenuated vaccines. All the commercially available vaccines for SP and GP are live attenuated, prepared with a limited number of strains.

Most of the vaccine strains have been derived from local pathogenic strains isolated in different parts of the world and by passage in cell culture or embryos.

Inactivated vaccines had been developed but are almost not used as they give, at best, only short-term immunity.

In African the Kenyan strain, KSGP (also called KS-1 024) has been used extensively for the control of sheep and goat pox. Isolated from sheep and initially believed to be a sheep pox virus, the KSGP has been shown through molecular methods to be actually a lumpy skin disease virus. The sheep pox Romania strain is widely used in the Middle East and India, while many other strains are used in different affected regions.

One multivalent vaccine, consisting of SGP Romania strain and PPR is currently commercially available in Africa by MCI Santé animale.

Because of the large size of poxviridae genomes, several research groups have worked in generating recombinant vector virus vaccines, where capripox non-essential genes have been replaced by foreign viral genes, therefore generating multivalent vaccines. But to date none of these vaccines have been commercialised.

While research on the use of capripox as vector for the expression of foreign genes is still ongoing, opportunities for generating safer attenuated vaccines by knocking out virulent genes but maintaining the immunogenicity are been explored. The technology could also be used to generate DIVA vaccines.

In Africa and Asia there is a need to increase the vaccination cover to SP and GP in poor livestock communities, who depend on their small ruminants for their livelihood. With the global PPR eradication strategy, through which large PPR vaccination campaigns will be taking place, multivalent vaccines including PPR and SGP vaccine could provide a great opportunity to widely control sheep and goat pox in regions that otherwise wouldn’t have had access to the vaccines.

Clinical disease overview

Etiology

Although initially regarded as two entities, sheep and goat pox are now considered to be a single disease entity (5) caused by a pox virus. Early reports of goat pox date around 200 AD. Sheep pox virus (SPPV) and goat pox virus (GTPV) belong to the family *Poxviridae*, the subfamily *Chordopoxvirinae* and the genus *Capripoxvirus*. The third species of this genus is lumpy skin disease virus (LSDV) (15). All three contain double-stranded DNA genomes approximately 150 kb in size (Figure 1).

The 3 capripox viruses share a high degree of sequence homology, with 96% identity between SPPV and GTPV, and 97% identity between LSDV and both GTPV and SPPV genomes, suggesting that GTPV and SPPV are derived from a common LSDV ancestor (4). The genomes of all three species encode for at least 147 genes. The genomes of the capripox viruses include a large number of nonessential regions which are often targeted for inserting large exogenous genes and generating recombinant vectored vaccines.

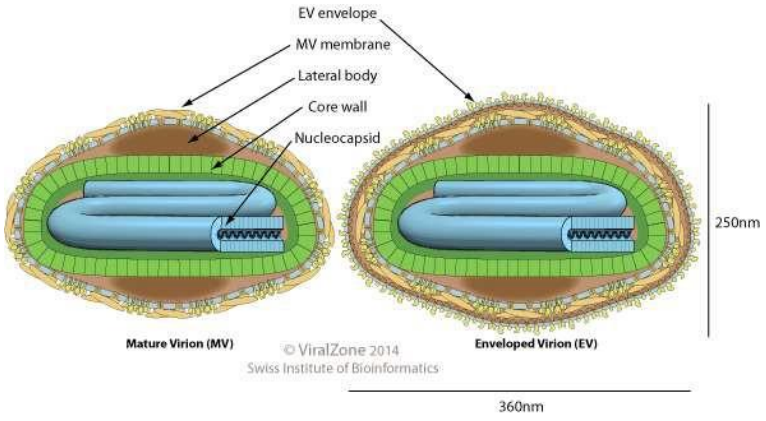

Figure 1: Capripox virion: Enveloped, brick-shaped, 300×270x200nm. The linear, dsDNA genome is about 154kb. The surface membrane displays surface tubules or surface filaments. Two distinct infectious virus particles exists: the intracellular mature virus (IMV) and the extracellular enveloped virus (EEV); http://viralzone.expasy.org/all_by_species/152.html

There are two antigenic forms of capripoxvirus, the intact virion covered in short tubular elements, and the intact virion additionally covered in a host-cell-derived membrane (Figure 1). The latter is the form usually produced by the infected animal, whereas the former is that seen when virus is produced by freeze–thawing infected tissue culture (15). The significance of these form for live or inactivated vaccines is discussed in section 6.

Although sheep pox and goat pox are distinct viruses, recombination can occur between them. There are data showing that SPPV or GTPV strains may recombine in the field (6). The viruses cannot be distinguished from each other with current serological techniques. Only one serotype exists, which encompasses the two viruses. They show different levels of host adaptation for either sheep or goats in different parts of the world. The various host-adapted strains are indistinguishable serologically but molecular studies have revealed differences. The viruses are thought to have prolonged survival in the environment; they can remain infectious for up to six months in sheep pens, and may also be found on the wool or hair for as long as three months after infection.

Epidemiology

Susceptible animal species

Sheep and goat capripoxviruses cause disease only in these two species. Many SPV isolates are specific for sheep, and many GPV strains are specific for goats, but some strains of these viruses readily affect both species. Infections have not been reported in wild ungulates (5,6,10).

Virtually all of the known species of goats and sheep from different parts of the world are susceptible to host-specific and other strains of the virus. Most strains cause more severe clinical disease in only one species. Native breeds in endemic areas are far less susceptible than introduced breeds of European or Australian origin – morbidity and mortality may approach 100% (6,9,10).

Only local lesions may follow the inoculation of some of the well adapted, host-specific strains in the alternative host, such as a host-adapted sheep pox into goats or vice versa. Of some of the viruses found in goats, Kenyan and Yemen isolates, as well as an Oman sheep isolate, infect sheep and goats equally. Usually, Middle East and Indian isolates are host specific and do not infect sheep (4).

Difference in sheep and goats breed specificity seems also to be occurring with SGP. It appears also that the host preference shown by different strains is due to their adaptation to either goats or sheep in a restricted geographical area. Goat pox is more common and severe in younger animals, lactating females and older animals, although it affects goats of all ages, sex and breeds. European breeds are particularly susceptible. (5,12)

Distribution

SPP and GTP are enzootic in Africa North of the Equator, across the Middle East and the Indian subcontinent, Iran, Iraq, Russia, Kazakhstan, Kyrgyzstan, Afghanistan, Pakistan, Nepal, Mongolia, China, Bangladesh, Vietnam (OIE WAHID) and Chinese Taipei where the first outbreak in Chinese Taipei occurred in 2008 and was eradicated by stamping out and movement control. The diseases are also endemic in Turkey and between 2013 and 2015 four outbreaks occurred in Bulgaria and several outbreaks were reported in Greece. See Figure 2.

According to the OIE WAHID database, the incidence of SPP in Greece is still continuing in 2015 despite implementation of an extensive stamping out policy (6).

Figure 2: Figure 2: Map showing the global distribution of SGP (14)

Transmission

Transmission is usually by aerosol after close contact with severely affected animals containing ulcerated papules on the mucous membranes. Through close contact the transmission is via the respiratory route. The SGV and GPV may also enter the body through other mucous membranes.

The SP and GP viruses can be found in saliva, nasal and conjunctival secretions, milk, urine and feces, as well as in skin lesions and their scabs. Ulcers on the mucous membranes are important sources of virus.

There is no transmission in the pre-papular stage, e.g. animals early in disease or those dying peracutely. There is reduced transmission once papules have become necrotic and neutralising antibody produced (about one week after onset). Animals with mild localised infections also rarely transmit disease.

Some important elements in SGP transmission:

- Chronically infected carriers do not occur
- Indirect transmission by contaminated implements, vehicles or products (litter, fodder) occurs
- Indirect transmission by insects (mechanical vectors) has been established (minor role)

In endemic areas the morbidity rate of SGP varies between 70 and 90%, while the mortality rate is 5–10%, although can approach 100% in imported animals (10).

Immunology of the disease

Infection with poxviruses evokes both humoral and cell-mediated immune responses (5). With the observation that heterologous vaccines do generally work, the relative importance of circulating antibodies versus cytotoxic T-lymphocytes in the suppression of the infection is not fully understood. However, it is quite clear that on the appearance of circulating anti-viral antibodies, infection subsides in hosts (5). Circulating antibody derived through natural infection or vaccination may limit spread of virus in the animal, but it is the cell- mediated immune response that eliminates infection (6). Cell-mediated immunity is likely to be the most significant component in recovery from infection and in long-term protection, as evidenced by the protection afforded by vaccination. The immune status of a previously infected or vaccinated animal cannot be related to serum levels of neutralizing antibody (9), and current serological tests are unable to distinguish reliably between susceptible and immune animals.

Clinical Signs

The clinical signs vary from mild to severe, depending on the animal's age, breed, immunity and other factors. Inapparent infections also occur. The diseases are more severe in lambs and kids than adults.

Disease begins with:

- Sudden onset of fever
- Discharges from the nose and eyes, and salivation
- Loss of appetite

- Reluctance to move
- Skin lesions appear in 1-2 days, extending all over the skin, but are most obvious on face, eyelids and ears, perineum and tail. Lesions may also be seen on the mucous membranes of the nostrils (Figure 3a), mouth and vulva
- Acute respiratory distress
- Mortality peaks about two weeks after the onset of the skin lesions (Figure 3b)
- Lesions begin as an area of reddening, progressing over two weeks to a papule, vesicle, pustule with exudation and scab formation

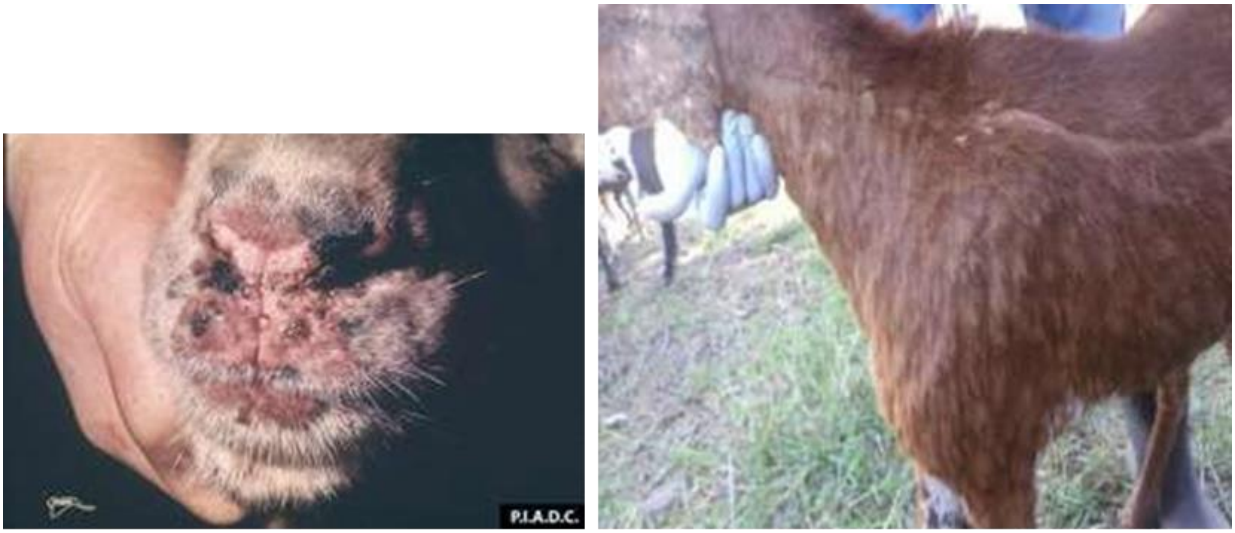

Figure 3: a. Nostril exudation and scab linked to SGP infection (source: CSFPH) b. Goat pox Skin lesions (photo courtesy Dr. C Ayebazibwe, Entebbe, Uganda)

Lesions that develop on the mucous membranes and internal organs may cause systemic signs. In some cases, these symptoms may precede the onset of skin lesions by a day or two. Lesions in the mouth, nares, eyes or eyelids can cause salivation or inappetence, as well as rhinitis, conjunctivitis or blepharitis with mucopurulent discharges (12).

Nodules in the intestines can cause diarrhea. Depression and emaciation may be seen in some animals. Abortions can occur but are not common. Some breeds of sheep can die of acute disease before the characteristic skin lesions appear.

Capripox lesions can take several weeks to heal, and may leave permanent scars on the skin. During healing, they are susceptible to fly strike. Secondary bacterial infections, including pneumonia, are common, and death can occur at any stage of the disease. Recovery can be slow if the animal was severely affected.

In animals that survive the acute disease, the following can be observed:

- papules become necrotic from vascular thrombosis and ischaemic necrosis
- papules form scabs in the next 5–10 days, which persist for up to 6 weeks, leaving small scars
- skin lesions are susceptible to fly strike
- secondary pneumonia is common
- anorexia is unusual unless mouth lesions physically interfere with feeding
- abortion is rare

Diagnosis

The incubation period for sheep and goat pox is 8–13 days (10,12). The diagnosis could be based on clinical signs and lesions, as well as laboratory diagnosis.

Clinical Diagnosis

Suspicion of SGP could be made in febrile animals with the characteristic full–thickness skin lesions and enlarged lymph nodes.

Differential Diagnosis

The differential diagnoses include contagious ecthyma (contagious pustular dermatitis), bluetongue, dermatophilosis/ streptothricosis, mange (e.g., psoroptic mange/sheep scab), photosensitization or urticaria, PPR, parasitic pneumonia, multiple insect bites and caseous lymphadenitis.

Pathology and post-mortem diagnosis

Gross pathology and histopathology can be used for SGP. The following lesions are characteristic of SGP (10):

- Skin lesions: congestion, hemorrhage, oedema, vasculitis and necrosis. All the layers of epidermis, dermis and sometimes musculature are involved.
- Lymph nodes draining infected areas: enlargement (up to eight times normal size), lymphoid proliferation, oedema, congestion, hemorrhage.

- Pox lesions: on mucous membranes of the eyes, mouth, nose, pharynx, epiglottis, trachea, on the rumenal and abomasal mucosae, and on the muzzle, nares, in the vulva, prepuce, testicles, udder, and teats. Lesions may coalesce in severe cases.
- Lung lesions: severe and extensive pox lesions, focal and uniformly distributed throughout the lungs; congestion, oedema, focal areas of proliferation with necrosis, lobular atelectasis. Enlargement, congestion, oedema and haemorrhages of mediastinal lymph nodes.

Laboratory diagnosis

Rapid diagnostic confirmation of the tentative field diagnosis is fundamental for the successful control and eradication of SPP in endemic and non-endemic countries. Diagnostic methods are aimed at either identifying the virus, or serological. Figure 4 provides an overview of different available or possible diagnostic options

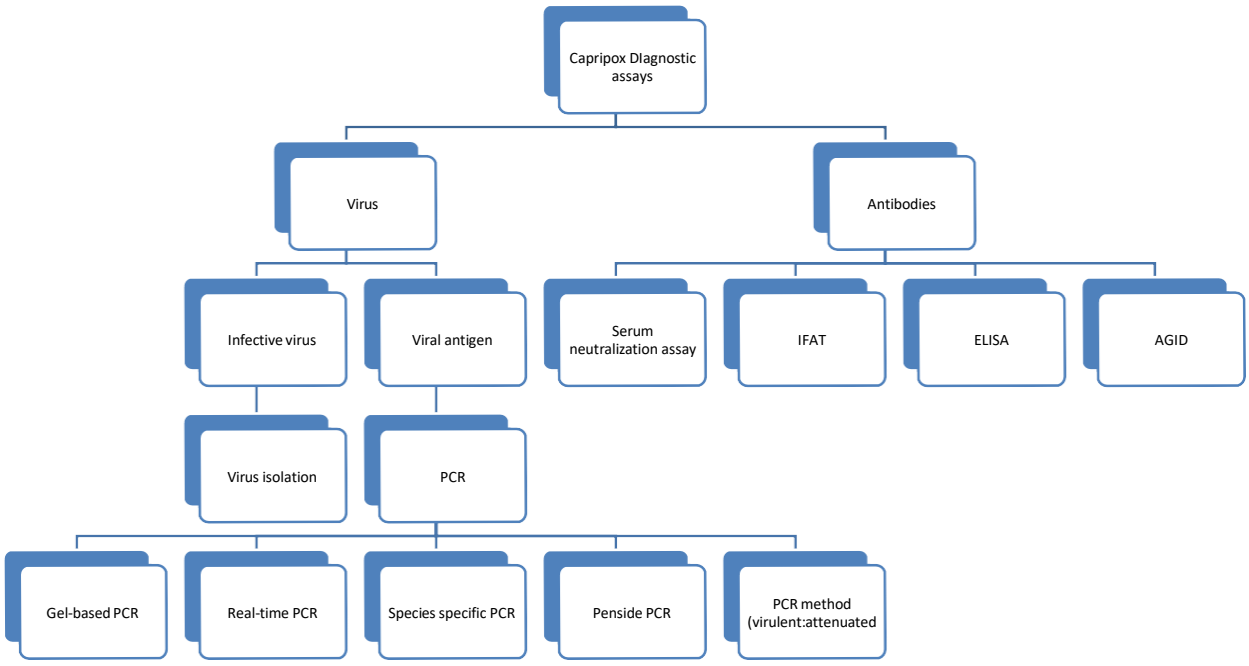

Figure 4: Diagnostic methods currently used for the detection of a SPP viral antigen or antibodies (6)

Agent identification

Because of the characteristic morphology of the capripox virus particles which are different to other small ruminants' poxviruses, sheep or goat pox can be tentatively diagnosed by electron microscopy (csfph). Virus isolation allows a more definitive diagnosis. A number of cells can be used to isolate SPV and GPV: lamb testis, sheep or goat kidney cell cultures, as well as in other (less sensitive) sheep, goat or bovine cell lines (15). The

appearance of CPE may take 4–12 days, intracytoplasmic inclusions are clearly seen by haematoxylin and eosin staining, and antigen can be detected by immunoperoxidase or immunofluorescence staining techniques (10,15).

PCR assays can detect capripoxvirus genomes in tissue samples or cultures, but cannot identify whether the virus is SPV or GPV. The two viruses can be distinguished by combining PCR with a restriction fragment length polymorphism (RFLP) assay. Recombination between SPV and GPV can complicate identification of the virus (12).

Viral antigens can be detected in tissues of lymph gland biopsy material taken from an early case, by agar gel immunodiffusion (AGID). There are also various antigen ELISAs.

In histopathological slides, capripoxvirus antigen and inclusion bodies may also be seen in stained cryostat or paraffin sections of biopsy or post-mortem lesion material.

Antibody detection

Serology can identify GPV and SPV as capripoxviruses, but cannot distinguish the two viruses from each other. Antibodies to capripoxviruses can be found approximately one week after the skin lesions appear. Serological tests include virus neutralization, AGID, the indirect fluorescent antibody test (IFA), ELISAs and immunoblotting (Western blotting). Virus neutralisation is the most specific serological test, but not sufficiently sensitive since immunity to capripox infection is predominantly cell mediated – infected animals may only produce undetectable low levels of neutralising antibody. Cross–reactions occur with other viruses in the AGID and IFA tests. Western blotting uses P32 antigen of capripoxvirus for reaction with test sera; the assay is sensitive and specific, but is expensive and difficult to carry out.

Incidence and Prevalence in Selected Countries

Global

Incidence data by country

Although SGP is very widespread in Africa North of the Equator, there is very limited reporting on the occurrence of the disease, due to limited interest in monitoring health status of small ruminants, beside the work done through externally funded projects.

Table 1: Number of SGP outbreaks reported to the OIE between 2005-2015 (Numbers given only for the target countries). Source: OIE.
http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statusdetail

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Asia											
Bangladesh	-	-	+	+	+	+	+	+	0	0	-
India	529	1,389	777	63	105	241	197	116	55	88	-
Indonesia	0	0	-	0	-	-	-	-	-	-	-
Myanmar	0	0	-	-	-	-	-	-	0	0	0
(Burma)											
Nepal	14	10	2	4	10	8	+	0	0	0	0
Vietnam	15	+	>1	+	+	+	+	+	0	0	0
West Africa											

Burkina Faso	>3	+	+	+	+	+	+	9	2	6	-
Ivory Coast	+?	0	0	0	0	0	0	0	>1	-	-
Mali	2	3	2	0	0	1	0	0	0	0	-
Senegal	9	6	4	+	5	7	7	5	10	3	5
East Africa											
Ethiopia	58	500	179	297	270	310	197	301	342	104	>17
Kenya	1	0	0	0	?	0	0	0	0	0	-
Rwanda	-	0	0	0	0	-	-	?	?	-	-
Tanzania	0	+	+	0	0	0	0	0	0	0	3
Uganda	-	-	-	-	-	-	-	+	+	+	-
Southern Africa											
Madagascar	0	0	0	0	0	0	0	0	0	0	-
Malawi	0	0	0	0	0	0	0	0	-	-	-
Mozambique	0	0	0	0	0	0	0	0	0	0	-
South Africa	0	0	0	0	0	0	0	0	0	0	0
Zambia	-	-	-	-	-	-	-	?	0	0	-

- No information,+ Present but quantitative data not known, ? Disease suspected

2- AU-IBAR: The number of outbreaks reported to AU-IBAR is included in the Pan African Animal Resources Year Book. (**http://www.au-ibar.org/pan-african-animal-resources-yearbook?showall=&limitstart**=) and can be seen for the countries of interest in Table 2 below.

Table 2: Number of SGP outbreaks reported to the OIE between 2005-2015 (Numbers given only for the target countries). Source: OIE.
http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/statusdetail

Country	2005*	2006**	2007	2008	2009	2010***	2011	2012	2013	2014	2015
West Africa											
Burkina Faso									4	6	
Ivory Coast											
Mali											
Senegal			5	1	5		7	6	9	2	
East Africa											
Ethiopia				3	5	283	223	428	697	139	
Kenya			6579 cases			855 cases	2	4		4	
Rwanda											
Tanzania									1	2	
Uganda											
Southern Africa											
Madagascar											
Malawi											
Mozambique											
South Africa											

Zambia					1						

*AU-IBAR didn't start yet producing data for SGP
**No individual country report available;
***The 2010 results seem to be incorrect as there are incidence reports in countries known to be free of SGP, such as South Africa, Zimbabwe etc.

Regional

Prevalence data by country

- Sources: PubMed, and internet engine searches (English and French when applicable).
- Efforts have been made to include the year of the study, and not the year of the publication. If they are known to be different, the year of publication is included in the reference.
- Note that not all papers have been read in full. In many cases, only the abstracts have been read. Critical evaluation of the papers for inclusion has not been conducted. If a review paper included some references, the source of the review is mentioned.

ASIA

The disease has never been reported in Myanmar and Indonesia.

No (recent) data was found for SGP prevalence in Bangladesh, India, Nepal and Vietnam.

AFRICA

The disease has never been reported in Madagascar, Malawi, Mozambique, South Africa and Zambia.

No (recent) data was found for SGP prevalence in any of the other countries of interest, except for Ethiopia.

Ethiopia

Year	Area	Species of animal	No. samples tested	% positive	Reference
2006	Oromia National Regional State, about 95 Km Southeast of Addis Ababa	Sheep and goats	377 sheep and 295 goats	Sheep (10.34%) and in goats (12.88%)	Yacob et al; 2008
2013-2014	North Gondar zone in Amhara regional State; 740km northwest of Addis Ababa	Sheep and goats	631 sheep and 152 goat	5.94%	Teshome D. Austin J Vet Sci & Anim Husb. 2016; 3(1): 1019

Economic and Social Impacts at Global and Regional Levels, and in Selected Countries

SGP is probably the most serious infectious disease of small ruminants in many parts of the world, responsible for tangible (direct) and intangible (indirect) economic losses to small ruminant productivity (5). Although direct losses through mortality may be low, the disease inflicts substantial losses in terms of reduced productivity and lower quality of wool and leather. It poses a major obstacle in the intensive rearing of sheep and goats and also greatly hampers international trade. It is suggested that goat pox is the most important of all pox diseases of domestic animals causing high mortality in kids and significant economic losses

In one study performed in Israel, it was found that SPP and GTP, in endemic areas, are associated with significant production losses because of reduced milk yield (up to 30 %), high mortality in lambs (95 %), decreased average conception rate (32 %) in the year following the outbreak, decreased weight gain, increased abortion rates (3 %), damage to wool and hides and increased susceptibility to pneumonia and fly strike (16).

In India, where the disease is endemic, a survey conducted in Maharashtra state revealed that the disease has a 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 six years for a flock or herd to recover from an outbreak, with average income losses up to 30–43 % of the total annual revenue depending on flock type and owners' actions. Statewide, around 5 000 flocks and herds are affected annually, incurring losses in the range of Indian Rupies 107.5 million (7).

In a study conducted in Ethiopia to evaluate the impact of major cattle, sheep and goat diseases impacting on the Hides and skins industry, whose exports average a yearly value of $52,160,000 USD, it was found that SGP had a prevalence of 5.94%, impacted accordingly to losses incurred by the country in that sector of the economy (13)

In an ILRI report on **Animal diseases Impact on the poor,** SGP ranks as one of the top ten small ruminants diseases, and within the top 20 most important disease in pastoral systems.

As part of their disease prioritization effort, the Bill and Melinda Gates Foundation identified SGP as the seventh of 14 diseases that negatively impact on poor livestock keepers. The total annual losses to small farmers in Africa and South were estimated to be USD 479.90 million and USD 234.30 million respectively (2).

Disease Prevention and Control Methods

Treatment (Control)

Successful control and eradication of SPPV and GTPV relies heavily on early detection of early cases, rapid implementation of stamping-out of all infected and in-contact animals, strict movement control, quarantine and disinfection. Different sanitary prophylactic measures can be employed in countries previously free, including slaughtering or culling of infected herd if possible, isolation of infected herds and sick animals for at least 45 days after recovery (OIE disease card). Experience obtained from the FAO Regional Animal Disease Surveillance and Control Network for SPP eradication programme in 2000 within North African countries (Maghreb) countries demonstrated that a considerable reduction in SPP cases was achieved when the goal for vaccination coverage was set between 75 and 90 % (8).

The most commonly used control measure in enzootic regions is vaccination, generally with the different live attenuated vaccines discussed in section 6 of the present document.

Annual vaccinations using live attenuated SPP vaccines provide good protection and are able to control the outbreaks when the minimal coverage of 75 % is reached and maintained (6). Although capripoxviruses are considered to be cross-protective, the use of homologous vaccine is generally recommended since there have been unsuccessful attempts to protect either goats with sheep capripoxvirus vaccines or sheep with goat capripoxvirus vaccines (11).

Treatment is not effective in the control of SGP; it is more a supportive action aimed at reducing secondary bacterial infections and fly strike (9).

Countries free of the disease may restrict and prevent importation of live sheep and goat from infected countries; the OIE Terrestrial animal Code for sheep and goat pox (**OIE Code CHAPTER 14.9.**) provides guideline on importation from infected countries.

Prophylaxis (Prevention)

Disease situation and government policies by country

Tables 3 and 4 below have been completed with the information received so far from the questionnaires sent to the DG and DVS for PPR. This information will be updated and completed once the results from the different countries are received.

Table 3 covers the disease situation (if it is notifiable or not), the presence of official surveillance and/or control programs, and the treatment situation. Table 4 refers to the vaccination situation.

The definitions that were given to the respondents are:

1Surveillance: is the systematic ongoing collection, collation and analysis of data and the timely dissemination of information to those who need to know so that action can be taken.

2Control: a program which is approved, and managed or supervised by the Veterinary Authority of a country

for the purpose of controlling a vector, pathogen or disease by specific measures applied throughout that country, or within a zone or compartment of that country.

Table 3: Official status, official programs for SGP in the countries of interest
Information provided by the questionnaire sent to the DG/DVS as part of this monograph.

Country	Notifiable (yes/no)	Official surveillance[1] program (yes/no) (if yes, active or passive)	Official control[2] program (yes/no)	Treatment (Chemotherapy)	
				Treatment authorised (yes/no)	Frequently practiced (yes/no)
ASIA					
Bangladesh	Yes	Yes, passive	Yes	-	-
India					
Indonesia					
Myanmar (Burma)	No	Yes, passive	No	No	Yes

Nepal	Yes	Yes, passive	No	No	No
Vietnam	Yes	Yes, passive	No	Yes	Yes
AFRICA					
Burkina Faso					
Côte d'Ivoire (Ivory Coast)	Yes	Yes, passive but active if outbreak	No	-	-
Ethiopia					
Kenya	Yes	Yes, passive	No	No	No
Madagascar					
Malawi	Yes	Yes, passive	No	N/A	N/A
Mali	Yes	Yes, passive	Yes	No	No
Mozambique					
Rwanda	-	-	-	-	-
Senegal					
South Africa					
Tanzania	Yes	Yes, active and passive	No	No	No
Uganda	Yes	No	No	Yes (secondary infections)	No
Zambia	Yes	Yes, passive	No	No	No

Table 4: Vaccination for SGP in the countries of interest
Information provided by the questionnaire sent to the DG/DVS as part of this monograph.

Country	Vaccination			
	Compulsory vaccination (yes/no)	Who pays for the vaccine (Government, farmers, combination, others-specify)	Who delivers the vaccine (official, private vaccinators or both)	Species vaccinated (cattle, sheep, goats, pigs, poultry)
ASIA				
Bangladesh	No	Combination. Government subsidy, farmers pays a service charge	-	Goat and sheep
India				
Indonesia				
Myanmar (Burma)	No	-	-	-
Nepal	No	N/A	N/A	N/A
Vietnam	No	Farmers	Private vaccinators	Sheep and goats
AFRICA				
Burkina Faso				
Côte d'Ivoire (Ivory Coast)	-	-	-	-
Ethiopia				
Kenya	No	Combination	Both	Sheep and goats
Madagascar				

Malawi	No	N/A	N/A	N/A
Mali	No	Combination	Official	Sheep and goats
Mozambique				
Rwanda	-	-	-	-
Senegal				
South Africa				
Tanzania	No	Farmer/private	Private	Goats and sheep
Uganda	No	Government	Both	Goats and sheep
Zambia	No	N/A	N/A	N/A

Vaccines Available

Current vaccine types

In endemic regions, live and inactivated vaccines have been used for the control of capripox. Inactivated vaccines give, at best, only short-term immunity, and are therefore not routinely used. There have been several publications on recombinant SGP vaccine candidates, but none has reached the commercialization stage.

MCI Santé animale in Morocco has so far registered the only combination SGP-PPR vaccine, which is already being used in a number of African countries.

All strains of capripoxvirus so far examined share a major neutralization site and will cross protect, although homologous strains provide better protection.

Live attenuated SGP vaccines

The commercially available SPP and GTP vaccines are live attenuated vaccines, prepared with a limited number of strains as shown in Tables 5 and 6.

Table 5: Vaccination for SGP in the countries of interest
Information provided by the questionnaire sent to the DG/DVS as part of this monograph.

Disease	Capripox vaccine strain	Major animal targeted	Comments
SGP	Romania (SPV)	Goats & sheep	
	RM-65 (SPV)		Used in cattle at x10 the SG dose
	Mysore (GPV)		
	Gorgan (GPV)		

	KSGP (KS-1 /O240 ,LSDV)		
LSD	KSGP (KS-1/024 ;LSDV)	Cattle, sheep and goat	Used for SGP and LSD

While in Africa the KSGP strain is widely used for the production of the SGP vaccine (Table 5), other parts of the world use different strains as shown in Table 6.

The use of the Kenya KSGP (or KS-1/0240) strain for SGP is discouraged in countries free of LSD, since sequencing data had identified the virus as a LSD virus (6).

As stated earlier cross protection between different strains in different ruminant types (sheep, goat or cattle) is not always effective: according to the OIE Manual, the KSGP 0240 strain should not be used in *Bos taurus* breeds of cattle (15).

Live attenuated vaccines have been used for decades in SPP-endemic countries. Sufficiently attenuated and tested vaccines are safe (can be used in pregnant animals providing three months of immunity to lambs) and effective though some strains may have unacceptably high levels of residual pathogenicity and may cause skin lesions and generalised disease in some animals (6,14). Local reaction at the inoculation site and transient raise in body temperature are typical of live attenuated poxvirus vaccines and should be accepted as an indicator of virus replication, which is required for the production of strong cell-mediated immunity in vaccinated animals (14).

The recommended dose of most commercially available SGP vaccines is 10–2.5 TCID 50. The protective dose of live attenuated SGP vaccines depends on the vaccine strain used. Immunity in sheep and goats against capripox following vaccination with the KSGP 0240 strain lasts over a year, and will probably provide lifelong protection against lethal challenge. Similarly, the Romanian strain gave protection for at least 30 months (15).

SPV vaccines are thermostable in lyophilised form and only a single immunisation is required. Generally, protection provided by live attenuated vaccines lasts 12–23 months and annual vaccinations are recommended (6).

The Indian IVRI has been involved in developing Vero cell adapted sheep or goat pox vaccine strains which are then transferred to different vaccine manufacturers in the country.

Table 6: Vaccination for SGP in the countries of interest
Information provided by the questionnaire sent to the DG/DVS as part of this monograph.

Strain/subtype	Licensed countries	Performance	Safety	Notes	References
Romanian (SSP)	Morocco, India	87.5–100 % protection against disease development with homologous vaccine	No safety issues reported for sheep. Local reaction at the inoculation site and transient hyperthermia. No spread of vaccine strain	Regulatory safety issues and loss of disease-free status within non-endemic regions	(Chaudhary et al., 2009; Gomes et al., 2010; Yogisharadhya et al., 2011)
RM-65 (SPP)	Pakistan, Algeria, Afghanistan, Albania, Bahrain, Ethiopia, Iraq, Iran, Jordan, Kuwait, Lebanon, Libya, Malaysia, Oman, Pakistan, Syria, United Arab Emirates, Yemen	80–100 % protection against disease development	No safety issues reported for sheep. Local reaction at the inoculation site and transient raise in body temperature	Regulatory safety issues and loss of disease-free status within non-endemic regions	(Abbas et al., 2000; Ramyar and Hessami, 1970)

Strain/subtype	Licensed countries	Performance	Safety	Notes	References
MLV* Gorgan (GTP)	Afghanistan, Albania, Bahrain, Ethiopia, Iraq, Iran, Jordan, Kuwait, Lebanon, Libya, Malaysia, Oman, Pakistan, Syria, United Arab Emirates, Yemen	100 % protection against disease development with homologous vaccine	No adverse reaction in vaccinated	Incomplete cross-protection in sheep, to be used only as homologous vaccine for goats against GTP	(Abbas et al., 2010) (Haqiqi et al., 2008)
KSGP 0240 (Kenyan strain, lumpy skin disease virus)	Afghanistan, Albania, Bahrain, Ethiopia, Iraq, Jordan, Kuwait, Lebanon, Libya, Malaysia, Oman, Pakistan, Syria, United Arab Emirates, Yemen	94–100 % protection against disease development in both sheep and goats	No adverse reaction	Not to be used within the EU for sheep and goats, since based on a lumpy skin disease virus	(Ayalet et al., 2012; Kitching, 1986; Sadri and Fallahi, 2010)
SPPV (Bk)	Turkey	100 % protection against disease development with homologous vaccine	na	Referred to passive immunisation in lambs	(Gulyaz, 1999)

Inactivated vaccines

There are almost no inactivated commercial vaccines. Inactivated SGP vaccines produced from tissue culture are almost entirely naked virions, and when used as vaccines do not stimulate immunity to the membrane- bound virion (Figure 1). This in part explains the poor success of inactivated capripox vaccines (5). An additional factor is that inactivated vaccines are less effective than live, replicating vaccine virus in stimulating the cell-mediated immune response, which is the predominant protective response to poxvirus infection. Dead capripox vaccines provide, at best, only temporary, short term protection.

Recombinant SGP vaccines

Several experimental recombinant vaccines have indeed been described expressing genes from different viruses, including PPR virus, rabies virus, Rift Valley fever virus, bluetongue virus; and with inactivated recombinant epsilon toxin of enterotoxaemia (4,6,14). In addition, the development of a subunit vaccine has been reported. None of them has been developed for commercial use. In addition, in these vaccines, the replicating virus is a genetically modified capripoxvirus and therefore may not be authorised for use in non-endemic countries on safety grounds. Novel approaches for the development of recombinant vaccines against GPV have been described using Semliki Forest virus as a vaccine vector into which the immunogenic regions for GTPV were inserted. This vaccine provided partial protection against GTPV (6).

Important to note that in some cases where recombinant capripox vector have been described, the intention was not always to generate simultaneous protection to sheep or goat pox, but rather as a vaccine exclusively to the insert.

Commercial vaccines manufactured in Africa and Asia

A large number of vaccine manufacturers in Africa, Asia and part of Europe produce the sheep or goat pox vaccines. The Jordanian manufacturer, JOVAC, exports into African countries. Table 7 below provide lists of manufacturers in Asia, North Africa and Europe, while Table 8 provides information on Sub-Saharan Africa manufacturers.

Table 7: The different commercially available SGP vaccines produced in North Africa, Asia and Europe (adapted from 12)

Company (Country)	Product Name	Type	Strain/Subtype	Adjuvant
Agrovet (Russia)	Sheep Pox vaccine	Not Available	NISHI	None

Biopharma (Morocco)	Name Not Available	Live	Romanian	None
MCI Santé Animale (Morocco)	Lyopox	Live	Romania	
	Lyopox-PPR (Combination SGP-PPR vaccine)	Live		
Dollvet (Turkey)	Poxdoll	Live	SPV	None
FGBI - Federal Centre for Animal Health (Russia)	Sheep Pox Cultyral Dry	Live	Not Available	None
Hester Biosciences Limited	Goat Pox Vaccine	Live	Uttarkashi	None
Indian Immunologicals Limited (India)	Raksha SP	Live	Romanian (Sheep Pox)	None
Institut Pasteur d'Algerie (Algeria)	Name Not Available	Live	RM-65	None
Institute of Animal Health and Veterinary Biologicals (India)	Sheep Pox Vaccine	Not Available	Not Available	Not Available
Institute of Veterinary Preventive Medicine (India)	Sheep Pox Vaccine	Live	Ranipet	Aluminum Hydroxide
Intervac (PVT) Ltd. (Pakistan)	Intervac Sheep Pox Vaccine	Live	RM/65	None
Jordan Bio-Industries Center (JOVAC) Jordan	JOVIVAC (Sheep Pox)	Live	RM-65	None
	CAPRIVAC (Goat Pox)	Live	MLV Gorgan	None
	KENYAVAC	Live	KSGP 0240	None
Razi Vaccine & Serum Research Institute (Iran)	Goat Pox Vaccine	Live	Gorgan	None
	Sheep Pox Vaccine	Live	RM-65 strain	None
Tiankang Biopharmacuetical (China)	Orf	Live	Not Available	Not Available

Vetal Company (Turkey)	Poxvac™	Live	Not Available	None
Veterinary Research Institute (Malaysia)	S/GP-VAC	Killed	Not Available	Alum
Veterinary Serum and Vaccine Research Institute (Egypt)	Tissue Culture Sheep Pox Vaccine	Live	Not Available	Not Available
	Freeze Dried BCG Vaccine	Live	Not Available	None

Table 8: SGP vaccines produced by Sub-Saharan African manufacturers

Vaccine name	Manufacturer	Hosts	Pathogens vaccinated against
S&G VAX TM	Kenya Veterinary Vaccines Institute-KEVEVAPI	Sheep and goat	0240 Kenya sheep and goat pox strain of the capripox virus
Sheep and goat pox vaccine	National Veterinary Institute of Ethiopia (NVI)	Sheep and goat	0180 15LK/1EBL/4ero
NODULOVAX	LANAVET; Garoua, Cameroun	Sheep, goat and Cattle	KSGP strain; also for SGP
DERMAPOX	LCV Bamako, Mali	Sheep and goat	KSGP strain; also for SGP
CLAVESEC	ISRA Senegal	Sheep and goat	No strain information

Commercial vaccines imported into Africa and Asia

The information summarised in Table 9, is based on a questionnaire send to the Director of Veterinary Services office and regulators of the countries of interest. Note that some vaccines might have been imported under DVS dispensation, and they are not necessary licensed in the country.

To the best of our knowledge, none of the target countries, in the exception of South Africa, Zambia and to a limited extend Mozambique, practices vaccination.

Table 9: SGP vaccines imported into the different focus countries

Country	Vaccine name	Strain or type	Country of origin	Doses imported 2015	Doses imported 2014	Doses imported 2013	Doses imported 2012
ASIA							
Bangladesh	No	-	-	-	-	-	-
India							
Indonesia							
Myanmar (Burma)	-	-	-	-	-	-	-
Nepal	-	-	-	-	-	-	-
Vietnam	-	-	-	-	-	-	-
AFRICA							
Burkina Faso							
Côte d'Ivoire (Ivory Coast)	-	-	-	-	-	-	-
Ethiopia							
Kenya	-	-	-	-	-	-	-
Madagascar							

Malawi	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mali	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mozambique							
Rwanda	-	-	-	-	-	-	-
Senegal							
South Africa							
Tanzania	-	-	-	-	-	-	-
Uganda							
Uganda	Lyopox PPR	Romania strain SPV + Nigeria strain PPR	Morocco	1,000,000 (first importation)	0	0	0
Zambia	-	-	-	-	-	-	-

Other comments

JOVAC, the manufacturer from Jordan was also sent a questionnaire designed for key importers into the region. They confirmed that they export Kenyavac, a SGP vaccine, strain KSGP 0240 to Africa and Asia. They did not specify the countries or the volumes.

Characteristics of Ideal Vaccine Candidates for Smallholders

Table 10: Target Product Profile (TPP) SGP vaccine – Proposal:

	Attribute	Minimum (current available vaccine)	Ideal
1	Antigen	Immunogen with protective antigens of capripox viruses that protects against SGPV infection	Immunogen capable of providing full protection in sheep and goat against SGPV infection
2	Indication for use	For active immunization of sheep & goats	For active immunization of sheep, goats and all susceptible animals
3	Recommended species	Sheep and goats	All capripox susceptible livestock
4	Recommended dose	2 ml	1 ml or less
5	Pharmaceutical form	Reconstituted injectable solution/suspension (freeze-dried vaccine)	Reconstituted injectable solution/suspension (freeze-dried vaccine) or ready to use solution
6	Route of administration	intramuscular	SC, Intramuscular or pour on
7	Regimen - primary vaccination	Single dose	Single lifetime dose
8	Regimen - booster	Single annual booster	Lifelong immunity after primary vaccination
9	Epidemiological relevance	Protection against all geographically distinct strains of SGP	Protection against capripox viruses and prevention of virus transmission
10	Recommended age at first	Animals over 3 months: one injection	From 1-2 months of age

	vaccination		
11	Onset of immunity	2-3 weeks following primary vaccination	One week following primary vaccination
12	Duration of immunity	At least 1 year	Lifelong immunity
13	Expected efficacy	To prevent disease (morbidity) & prevent mortality.	To prevent infection and transmission. No disease & no mortality in vaccinated animals after virus challenge.
14	Expected safety	In animals under 6 months of age, a transient pyrexia reaction can occur. A transient nodular reaction of varying importance, may appear at the injection site, it progressively disappears within 1 to 2 months. Only vaccinate pregnant animals on emergency.	No post-vaccinal reactions at any age. Safe for pregnant animals. No carrier form in vaccinated animals
15	Withdrawal period	Nil	Nil
16	Special requirements for animals	Do not vaccinate un-healthy animals	Do not vaccinate un-healthy animals DIVA
17	Special requirements for persons	None	None
18	Package size	50 doses	Multiple pack size from 50 doses
19	Price to end user	Not more than $0.50/dose	$0.20/dose at end user
20	Storage condition and shelf-life as packaged for sale	12 months at 4-8° C	24 months 4-8° C and/or 48 hours at 30° C
21	In-use stability	1 hour	24 hours

Overall conclusion for improved SGP control through vaccination

SGP is one of the major challenges in small ruminants' production in most parts of Africa and South Asia. In most of these regions, small ruminants are owned by the poor livestock keepers and are not often included in national disease control programs. The current global effort to eradicate PPR offers a great opportunity to control several small ruminants' diseases such as SGP. Combination PPR-based vaccines should therefore be promoted as much as possible in order to take advantage of the big global investment to be likely directed toward PPR eradication.

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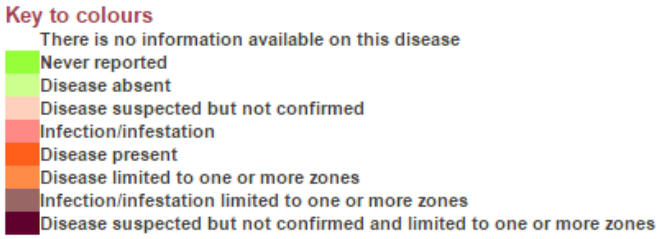
ANNEX 1: Additional data on disease presence and incidence

Reports to OIE on SGP:



When different animal health statuses between domestic and wild animal population are provided, the box is split in two: the upper part for domestic animals, and the lower part for wild animals.

SGP in Asia: Bangladesh, India, Indonesia, Myanmar, Nepal and Vietnam

SGP in Western Africa: Burkina Faso, Ivory Coast, Mali and Senegal

SGP in Eastern Africa: Ethiopia, Kenya, Rwanda, Tanzania and Uganda

SGP in Southern Africa: Madagascar, Malawi, Mozambique, South Africa and Zambia