Peste des Petits Ruminants (PPR)

Author: Prof Moritz van Vuuren


Licensed under a Creative Commons Attribution license.

TABLE OF CONTENTS

Introduction ................................................................................................................... 2
Epidemiology ................................................................................................................. 2
Pathogenesis ................................................................................................................. 4
Diagnosis and differential diagnosis ........................................................................... 4
  Clinical signs and pathology .......................................................................................... 4
  Laboratory confirmation ............................................................................................... 10
  Differential diagnosis .................................................................................................. 11
Control / prevention .................................................................................................... 11
Socio-economics ......................................................................................................... 12
Faqs .............................................................................................................................. 12
References ................................................................................................................... 14
INTRODUCTION

Peste des petits ruminants (PPR) is an acute or subacute, contagious viral disease of predominantly goats, and also sheep, camels and several wild ruminant species in captivity. It is clinically and pathologically similar to rinderpest, and is the most economically important virus disease of small ruminants in the areas where it occurs. It is characterized by high fever, conjunctivitis, rhinitis, necrotic stomatitis, gastroenteritis and pneumonia.

The disease was first described in 1942 during investigations into a previously unreported syndrome in sheep and goats in Côte d'Ivoire. Because of its clinical and pathological resemblance to rinderpest (RP), the disease was called “peste des petits ruminants” (PPR).

In Africa today, PPR is widespread in the sub-Saharan and Sahelian zones. However, it was isolated to the Sahel, Sudan and Ethiopia until relatively recently. The eradication of rinderpest may have influenced a southern movement which was detected first in Uganda in 2004 amongst wildlife species through serological surveillance. This was followed by the livestock outbreak in Kenya in 2006-7 and cases occurring subsequently in Tanzania. The chronological sequence of new reports of PPR gives the impression that the disease has spread steadily east- and southwards from its origin in West Africa.

The virus and its disease are also widespread in Asia having been reported in epidemic form affecting both sheep and goats in India, Iran, Israel, Pakistan, Turkey and much of the Arabian peninsula.

EPIDEMIOLOGY

The virus belongs to the genus *Morbillivirus* in the family *Paramyxoviridae*. In consonance with viruses in the genus *Morbillivirus*, it is an enveloped virus and therefore sensitive to environmental influences. Only one virus serotype is currently recognized. It has a linear, single-stranded, negative sense, unsegmented RNA genome. The genome which is approximately 15-16 kb in size was sequenced and the full length sequence published in 2005. Phylogenetic analyses have revealed four linages. Lineage I and II are restricted to western and central Africa, whereas lineage III is common to eastern Africa and southern part of the Middle East. Lineage IV is limited to the Middle East and Asia.

According to sero-surveys, PPR virus had already been circulating in Kenya and Uganda during the 1980’s but has been officially declared to the OIE as endemic in Kenya since 16 May 2007, and in Uganda since 10 Aug 2007. The first occurrence of PPR in Morocco in 2008 indicated that the virus had crossed the natural barrier of the Sahara with concomitant risks for North Africa. Following its spread into Tanzania in early 2009, the FAO published in November 2010 a warning about the potential spread of PPR to southern Africa, and emphasized that PPR is posing a mortal threat to more than 50 million sheep and goats in 15 countries. PPR has been reported annually in the Comoros islands since 2010. The disease is now (2013) recognized as also being present in the Democratic Republic of Congo and northern Angola. It is therefore clear that although PPR was
Livestock Health, Management and Production › High Impact Diseases › Contagious diseases › Peste des Petits Ruminants

formerly restricted to Africa, Asia and the Middle East, its distribution has expanded in the last 10 years.

The host range of PPR includes goats and sheep with cattle and swine only becoming subclinically infected. Infection of camels may result in limited disease events in camels. African antelope species are susceptible but clinical disease has only been described in captive or semi-captive animals. A carrier state has not yet been described in wildlife.

Outbreaks tend to be associated with direct contact between shedding and susceptible animals. Infectious virus can be detected for at least seven days after the onset of pyrexia in the ocular and nasal secretions, urine and faeces of infected animals. Transmission takes place directly through respiratory and lachrymal secretions, faeces and other body fluids. Fomites may be another means of spread as infectious material can also contaminate water, feed troughs and bedding for very short periods. The food chain is of no significance and very little spread over distance will occur without animal movement.

The acute form of the disease frequently seen in goats is rare in sheep. The morbidity can vary between 70-90% and the mortality between 10-90%. In the goat population, the highest incidence occurs in young animals (1-6 months of age) with losses in the order of 50%. Protective immunity develops after infection and is probably life-long.

The role of wildlife in the epidemiology of PPR remains largely unclear. Opportunistic sampling in some wild ungulate species or outbreak investigations in wildlife collections living in semi-free-range conditions have shown that many species of ungulates including gazelles, impala, duiker and even buffalo are susceptible to infection. The lack of evidence for disease in wildlife in Kenya and Tanzania during the quite serious outbreaks in 2006-7, despite a good surveillance network and sensitivity to disease in wildlife, suggests either low morbidity or perhaps resistance to infection in some wildlife populations, or the virus may not have entered the wildlife system in that region. It is currently not known whether wildlife is infected by the virus circulating in the domestic livestock or if wildlife plays a
role in the maintenance and spread of PPRV, although the former is the most likely mode of transmission. Given the situation in captive wildlife, where mortality can be severe, it is surprising to not have some evidence of disease in free-ranging populations in Africa. There is evidence from free-ranging ibex in Pakistan and elsewhere, showing serious disease and mortality so it is probably only a matter of time before reports of the disease in African wildlife will emerge.

**PATHOGENESIS**

During the incubation period the virus replicates in the draining lymph nodes of the oropharynx before spreading via the blood and lymph to other tissues and organs, including the lungs with resultant primary viral pneumonia where it expresses its tropism for epithelial tissue. This pneumonia is invariably followed by secondary bacterial infections which are a major feature of the pathology of the disease and cause of death.

Virus and viral antigens can be detected in blood, body secretions and lymphoid organs during the early stages of clinical disease. Titres of infectivity can reach 4,0 \( \log_{10} TCID_{50} \) in oral, nasal, ocular and pharyngeal swabs and 5,0 \( \log_{10} TCID_{50} \) per gram of faeces. During the later stages of disease both infectious virus and antigen are increasingly difficult to detect, probably as a result of the rising antibody levels.

**DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS**

Due to similarities to other mucosal and diarrhoeal diseases, diagnosis is dependent upon the submission of specimens to a diagnostic laboratory. Specimens in the live animal can include ocular swabs, whole blood and serum, gum debris and lymph node aspirates. Necropsy material in formalin should include mesenteric lymph nodes, spleen, tonsil and third eyelid.

Diagnostic tests are available for detection of viral antigens, viral genome, virus-induced antibodies and viral isolation. Antigen detection can be accomplished with the aid of direct immunostaining, agar-gel immunodiffusion or immunocapture ELISA.

Detection of viral genome can be done by means of reverse transcription polymerase chain reaction assays. A variety of serological tests has been developed that include virus neutralization, competitive ELISA and the indirect fluorescent antibody test. Morbilliviruses are so closely related antigenically that serum raised against any 1 of them cross-reacts with all others in the genus in a variety of tests. Histopathological examination of tissues may reveal lympholytic lesions and inclusion bodies.

**Clinical signs and pathology**

An incubation period of 3-6 days following entry through the respiratory system is followed by duration of disease of 2 weeks or more.
The clinical signs are very similar to those that were associated with rinderpest and that are seen in dogs with canine distemper.

Conjunctivitis and nasal discharge in sand gazelles suffering from PPR

Hyperaemia and congestion of the conjunctiva

The first clinical sign is a rise in temperature that reaches 40 to 41 °C within two or three days. This is followed by depression, inappetence and development of serous nasal and ocular discharges that progressively become purulent and more profuse. The nasal discharge may block the nares and encrust the muzzle, causing the animal to snort and sneeze and the ocular discharge may mat the eyelids together.

Mucopurulent discharges from the eyes and nasal cavities

Severe purulent nasal exudate

One to two days after the start of pyrexia the buccal mucosa becomes congested and pale areas of necrosis become visible on the gums.
Erosions and ulcerations on the mucous membranes of the lips

Necrotic tissue accumulating on the buccal mucosa

In severe cases these increase in size and extend to involve the cheeks, dorsum of the tongue, hard palate and dental pad. The caseous epithelium easily sloughs, leaving shallow red erosions.

Accumulation of necrotic material and ulcerations on the dorsal surface of the tongue

Diarrhoea begins two or three days after the onset of pyrexia and death may occur some three to seven days later.
PPRV-induced diarrhoea in a sand gazelle

Less severe and mild cases also occur in which all or some of the signs develop to a lesser degree and the mortality rate is much lower.

Infected goats develop leukopenia, the degree of which may correlate with the severity of clinical disease. Eosinopenia, monocytosis and a rise in the packed cell volume, presumably due to haemoconcentration resulting from the diarrhoea, have also been reported.

The carcass is frequently emaciated, soiled with faeces, and the eyelids, nares and lips encrusted with discharges.

Severe necrosis of the buccal mucosa  Swollen lips with erosions

Erosions are found throughout the buccal cavity and pharynx, and, less frequently, the oesophagus.
Erosions and ulcerations on the soft palate in a sand gazelle

Necrosis and erosions on the side and at the base of the tongue in a sand gazelle

Erosions and ulcerations on the tongue and soft palate

As with rinderpest, erosive lesions in the forestomachs are often absent but may occasionally be found on the ruminal pillars and the leaves of the omentum. The abomasum and small intestine are usually dark red and congested rather than eroded and haemorrhages have been reported.
Marked congestion in the wall of the small intestine

Peyer’s patches may be necrotic, and erosions and congestion can be found on the ileocaecal valve. Marked congestion of the apices of the longitudinal folds of mucosa (zebra striping) may be seen in the large intestine and rectum.

Congestion and haemorrhage in the intestines

Marked congestion of the apices of the longitudinal folds of the mucosa of the large intestine (zebra striping)

The upper respiratory tract mucosa is usually congested, erosions in the nares may be present, and tracheitis has been described. The lungs may be partly or diffusely congested, the affected areas appearing red and firm due to interstitial pneumonia. Changes in the trachea and lungs are more severe if there is concurrent bacterial infection.
Peripheral and visceral lymph nodes may be oedematous and friable, occasionally enlarged or haemorrhagic. The spleen is often congested and firm. The female genital mucosa may be congested and show epithelial erosions.

Lymphoid tissues are depleted of lymphocytes with germinal centres particularly being affected. Pyknosis and karyorrhexis of lymphocytes are present in the cortex, and there is proliferation of reticuloendothelial cells along the medullary cords and in the sinuses. Comparable changes are seen in the Malpighian bodies of the spleen. Necrosis throughout the Peyer’s patches has been described, although a mere reduction in the numbers of lymphocytes without necrosis may be all that is evident in this tissue.

Isolated areas of epithelial necrosis occur in the deep glands of the abomasum, and similar but more widespread changes are seen throughout the intestine together with atrophy of villi and accumulation of debris in the glandular crypts. The lamina propria is infiltrated with lymphocytes, macrophages and eosinophils.

The respiratory tract mucosa may have areas of necrosis and hyperplasia, and inclusion bodies in epithelial cells. Interstitial pneumonia characterized by the infiltration of lymphocytes and neutrophils, and proliferation of pneumocytes is common. A striking feature that was seen in rinderpest but is characteristic of measles, is severely enlarged multinucleate cells often containing intracytoplasmic and intranuclear viral inclusions in the alveoli and terminal bronchioles. It seems probable that the virus is responsible for a primary pneumonia that is readily superinfected with secondary pathogens.

**Laboratory confirmation**

A presumptive diagnosis of PPR can be made from clinical signs and lesions supported by epidemiological evidence such as the introduction of new and possibly diseased stock. In epidemic or virgin areas the diagnosis must be confirmed in the laboratory, either by the detection of virus specific antigen or nucleic acid, or by the isolation of virus in cell culture. Demonstrating a rise in specific antibody in paired sera gives retrospective confirmation.
Specimens should be collected from up to ten acutely affected animals with fever and early mucosal lesions. Clotted blood and whole blood in anticoagulant, together with ocular, nasal and oral swabs should be collected from live animals. If possible two or three animals should be slaughtered and 20 to 30 grams each of spleen, lymph nodes, lung and gut mucosa also collected. The specimens should be chilled on ice, but not frozen, and despatched to the laboratory as soon as possible.

Viral antigens can be detected by immunohistochemical staining of tissues, and by monoclonal antibody-based enzyme-linked immunosorbent assay (ELISA) techniques.

Specific nucleic acid sequences can be detected by DNA probes and by polymerase chain reaction (PCR) techniques. The latter test has the advantage of producing large quantities of nucleic acid that can be sequenced to provide extra information about the lineage, or sub-type of PPRV involved. This information is particularly important for tracing the origin of epidemic outbreaks.

The virus is isolated by inoculating swab material,uffy coat or ten per cent tissue suspensions onto young monolayers of primary sheep or goat kidney cells. Vero cells, some lines of primary bovine kidney and bovine lymphoblasts are also sensitive. Cytopathic effects develop after four days and are characterized by rounding and shrinking of cells, strand formation and large flat syncytia. The identity of the virus is confirmed as PPRV by serological tests in which hyperimmune or convalescent sera are used.

If antigen or infectious virus cannot be detected, survivors should be bled two to four weeks after the first sampling and the paired sera assayed for antibody levels to the virus in neutralization tests. A four-fold or greater increase in titre confirms the presumptive diagnosis. It is essential to use the homologous virus since titres to heterologous virus may be too low to show a four-fold rise. Other techniques for detecting and quantifying specific antibody to PPRV that have been developed include haemagglutination inhibition and ELISA. Recent ELISAs take advantage of highly specific and pure antigens prepared by recombinant technology.

**Differential diagnosis**

PPR can be confused with several diseases that cause respiratory problems and mortality in small stock. To facilitate early detection and response in the event of introduction into a previously free country, it should be included in differential diagnostic lists for respiratory tract disease. Such a list includes mycotic stomatitis, bluetongue, epizootic haemorrhagic disease, pneumonic pasteurellosis, contagious caprine pleuropneumonia (not present in southern Africa), coccidiosis, sheep and goat pox (absent in southern Africa) and contagious pustural dermatitis (Orf).

**CONTROL / PREVENTION**

Sick and in-contact goats and sheep should be isolated from other stock and effective quarantine imposed until at least one month after the complete recovery of the last clinical case. Strict control of
animal movement is, however, often difficult to achieve. Goats and sheep, being more portable than cattle, are constantly transported long distances by motor vehicle, airplane and bicycle.

Attenuated PPRV vaccines which protect goats against experimental challenge have been developed and are being manufactured and marketed in Africa and Asia. Recombinant poxvirus vaccines expressing PPRV H and F antigens also protect against challenge with virulent PPRV. Animals vaccinated properly with attenuated vaccines can develop sterile protective immunity which persists for at least three years and may last for life.

Infected premises should be thoroughly cleaned and disinfected with solvent, or high or low pH based agents.

If control measures in non-endemic countries do not include stamping-out/modified stamping-out/slaughter or vaccination, it may lead to continuous circulation of the virus (endemic situation) with periodic exacerbations.

**SOCIO-ECONOMICS**

PPR is considered the most important single cause of morbidity and mortality in small stock and thus causes severe economic effects to small stock producers, especially under the traditional husbandry systems with its associated high disease and parasite burden. Epidemics in sheep and goats, the mainstay of subsistence farming in the developing world can cause mortality rates of 50-80% in naïve populations.

This disease has a significant impact through loss of production, and deprivation of households of a ready source of needed cash in an emergency. The disease is not zoonotic and poses no risk to human health. As a result of the high economic impact of PPR, the FAO has included it as a priority disease in its Emergency Preventive System programme and it is an OIE-notifiable disease.

With the outbreak of PPR in Morocco in 2008, the risk of spread to southern European countries became apparent, especially countries that maintain close trade relations with North African countries. For North African countries the control of animal movements over borders is difficult, especially in the southern part of the region where herdsmen follow a nomadic lifestyle. Animals belonging to these nomads play an important role in supporting the livelihoods of millions of families.

**FAQs**

1. **Which wild ruminant species are susceptible and develop infection or disease?**

   The disease has been reported in wild captive ruminants and include Dorcas gazelle, Thompson’s gazelle, Nubian Ibex, Laristan sheep, gemsbok, Indian buffalo, African grey duiker, Arabian oryx,
Livestock Health, Management and Production › High Impact Diseases › Contagious diseases › Peste des Petits Ruminants

Bubal hartebeest, African buffalo, Defassa waterbuck, kobs, Arabian mountain gazelles, springbuck, Barbary sheep, bushbuck, impala and Rheem gazelle.

2. **Does any long or intermediate carrier state develop in wildlife?**

This is unlikely given the characteristics of members of the family *Paramyxoviridae* and the fact that this phenomenon has not been described in livestock. It is currently well accepted that PPRV is unable to sustain itself in wildlife. There is currently no reason to believe that PPRV circulates in wild animals and acts as a potential source of virus for domestic species.

3. **If there is no carrier state, how does this virus survive during the inter-epidemic period?**

The virus requires close contact between shedding and susceptible animals and is most likely maintained in nature by mild or subclinical infections that continue throughout the year in low numbers of animals. It is possible that diminished virulence may help to sustain the virus, even in an extensive population.

4. **Is the current PPR vaccine safe and efficacious to use in our range of wild ruminants?**

PPR vaccines have not been tested for safety and efficacy in wild ruminants. There is therefore some risk of adverse effects when using modified-live PPR vaccines in such species.

5. **How sensitive and specific are the current ELISA tests for PPR in livestock for various African wildlife species?**

The validity of the tests was never designed for a wide range of species but competitive ELISA is theoretically robust across species. The evidence from the rinderpest wildlife work was that the c ELISA test for rinderpest and PPR were very specific but lacked sensitivity when compared to the gold standard virus neutralization (VN) test. Overall they are good tests but should be used sensibly and with VN backup if there is any doubt about the validity of the results.

6. **How big is the risk that PPR may enter South Africa?**

Only Mozambique, Zambia, Zimbabwe and Namibia stands between South Africa and other infected SADC countries. One only needs to consider for example the extent of small stock (goats) movement from North to South in Mozambique to realize that it could spread the length of that country in a very short time.

7. **Will vaccination of small stock against PPR be as successful as the vaccination programme that enabled the eradication of rinderpest?**

Achieving satisfactory PPR vaccination coverage of small ruminants is difficult (compared to cattle rinderpest vaccination), particularly in goats. This is mainly due to their reproduction rate, namely shorter gestation and high twinning percentage. You will need 2-3 rounds of vaccinations per year. However, excellent vaccines exist to protect small ruminants from PPR, and these can be a key weapon in combating it. Rinderpest was eradicated only thanks to the full commitment from
donors, the scientific community, development organizations, the FAO, OIE and the International Atomic Energy Agency (IAEA), member governments, and farmers the world over. The same can be done with PPR if the political will is there.

REFERENCES


