Rev. sci. tech. Off. int. Epiz., 2011, **30** (3), 879-887

Control strategies for peste des petits ruminants in small ruminants of India

R.P. Singh

Division of Biological Products, Indian Veterinary Research Institute, Izatnagar-243 122, Bareilly, India
E-mail: rpsingh@dr.com, rpsingh@ivri.res.in

Submitted for publication: 4 September 2009
Accepted for publication: 1 April 2011

Summary
Peste des petits ruminants (PPR) is a contagious viral disease of small ruminants. It is endemic in several African, Middle Eastern and Asian countries, including India. India has recently taken comprehensive steps to deal with PPR through the development and production of potent vaccines and monoclonal-antibody-based diagnostic kits, while also gathering baseline information on the disease situation and human resources. As a result, PPR can now be controlled by focused vaccinations in high-risk populations of sheep and goats, followed by mass vaccination campaigns. Mass vaccination campaigns must achieve high levels of herd immunity (70% to 80%) to block the epidemic cycle of the virus. With the tools currently available, disease control and subsequent eradication programmes for PPR may be a feasible option, following the example of the National Rinderpest Eradication Programme, which has successfully eradicated rinderpest from India. An understanding of the cultural and socio-economic circumstances of goat and sheep owners and a keen watch on the endemic nature of PPR in neighbouring countries will enhance the success of this approach. Coordinated efforts from all stakeholders, combined with proper funding and execution of control programmes, will be needed to achieve the goal of a PPR-free India. In addition, the availability of effective combined vaccines of PPR with goat pox or sheep pox offers a cost-effective way of simultaneously launching control programmes against all three of these diseases.

Keywords
Caprines – Disease control – Disease eradication – Goats – India – Ovines – Peste des petits ruminants – Sheep – Small ruminants – Vaccination campaign.

Introduction

Peste des petits ruminants (PPR) virus infection is characterised by severe bronchopneumonia, mucopurulent nasal discharge, stomatitis and enteritis, followed by recovery or death. The disease causes high morbidity and mortality in susceptible sheep and goats. Peste des petits ruminants is widely prevalent and endemic in almost all parts of India, as well as several areas of Africa, the Middle East and other Asian countries (4). Although a devastating disease, it has been assigned relatively little importance by policy-makers. Thanks to concerted efforts by scientists, monoclonal-antibody-based diagnostic tests have been developed (17, 22, 23) in India. At the same time, a very potent and safe vaccine has also been developed, using PPR lineage 4 virus (24). At first, differential diagnosis of PPR in India was carried out using internationally accepted diagnostic kits developed by the World Reference Laboratory for PPR and rinderpest (1, 12). However, the significance of this disease and its endemic nature only became evident when locally developed diagnostic tools were applied on a mass scale in the target population (21).

Controlling PPR may seem to be relatively easy compared to other economically important viral diseases, such as foot and mouth disease and bluetongue. This may be attributed to high antigenic stability, a single serotype of the virus and

the induction of a life-long immune response after vaccination (5, 26). High antigenic stability provides scope for using a single vaccine and a single diagnostic technique, irrespective of the type of disease occurrence. Baseline information on the clinical and seroprevalence of PPR is also helpful (21), as it provides disease status information that may be translated into data about real economic losses for the feasibility studies used to prioritise nationwide disease control programmes. In addition, effective combined vaccines of goat pox with PPR (9) and sheep pox with PPR (3) are available in India. Use of these combined vaccines will reduce the overall cost of simultaneously controlling these three important viral diseases of small ruminants. This paper aims to make stakeholders more aware of the possibilities available for launching PPR control programmes, both in India and other PPR-endemic countries.

Disease trend in India

In spite of the fact that PPR disease outbreaks are under-reported, due to the poor reporting system in India, an increasing trend has been observed in PPR outbreaks between the years 1996 and 2005 (28). The reported number of outbreaks became notably higher after 2002, which coincided with the extensive use of locally produced diagnostic kits under field conditions (22, 23). Similarly, a decline in the number of PPR outbreaks after 2005 (Fig. 1) coincided with the mass vaccination efforts carried out from 2004 under the Assistance to States for Control of Animal Diseases programme, funded by the government of India (18, 19). Between 2005 and 2007, relatively more outbreaks occurred in Karnataka, Andhra Pradesh and Orissa. These states have a high population density of small ruminants and a good disease reporting system in comparison to other Indian states. Those regions reporting high numbers of PPR outbreaks are also the major users of the PPR diagnostic kits developed in India.

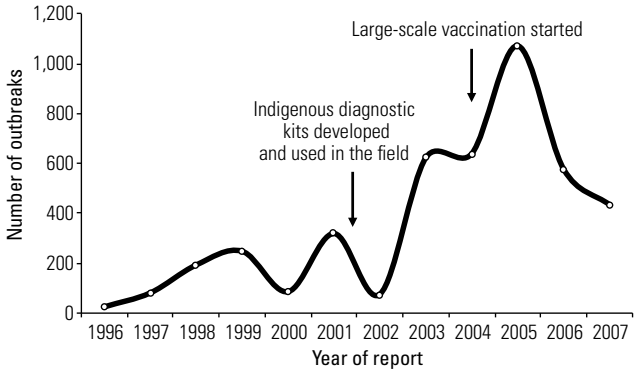

Fig. 1
Pattern of outbreaks of peste des petits ruminants in India between 1996 and 2007
Note that the number of reported outbreaks increased sharply after the introduction of peste des petits ruminants diagnostic kits from 2001/2002 to 2005. Subsequently, the number of outbreaks reduced significantly once mass vaccinations were carried out from 2004 under a government scheme

Economic losses due to peste des petits ruminants in India

India has a small ruminant population of about 200 million. As a rough estimate, PPR causes economic losses of 1,800 million Indian rupees (US$39 million) every year in India (2, 21, 26). This estimate is based on information available in the literature on PPR outbreaks without laboratory confirmation. Baseline data on the prevalence of PPR (21) indicate that one third (33% seroprevalence) of small ruminants in India test positive for the presence of antibodies against PPR. With this information, mortality and case fatality rates for small ruminants can now be estimated and actual losses due to PPR in India can be more accurately calculated. These efforts will provide the justification to convince policy-makers within India to initiate disease control measures and subsequent eradication programmes.

Epidemiology of peste des petits ruminants under Indian socio-economic conditions

Knowledge of the epidemiology of any contagious disease is essential for the successful implementation of effective disease control programmes. Peste des petits ruminants virus (PPRV) is a fragile virus (like rinderpest virus) which requires close contact between animals for disease transmission. Important factors influencing disease transmission under Indian socio-economic conditions are:

– the population density of the susceptible animals
– migratory (nomadic) flocks
– social activities, for instance: intermingling of animals, trade and transportation of animals, animal fairs, local markets, animal health camps and common grazing lands.

Similar factors may also be true for other developing countries.

Population density of susceptible animals

The population density of susceptible animals plays an important role in the transmission epidemiology of contagious infections. A high density of animals results in increased levels of contact between them. This increases

the transmission level of PPRV within susceptible populations and also helps to maintain the virus within the environment. Maintaining PPRV in the environment is especially important during the summer season, when the virus is more likely to be rapidly destroyed, due to adverse environmental conditions such as high temperatures. Small ruminants in India are mostly reared as free-ranging animals, which increases the chance of disease transmission. However, animals reared under isolated conditions are less likely to mix with infected animals and are not as involved in the transmission of PPRV (21, 25). This is further substantiated by the relatively low prevalence of PPRV seen in areas where there are lower densities of sheep and goats, e.g. the mountainous terrain of Uttarakhand and the north-eastern part of the country (21). These regions would be ideal locations for the creation of PPR-free zones in India (20).

Migratory flocks

Nomadism is deeply rooted in human ancestry (14). Migratory flocks play an important role in the transmission of PPRV to local animals. These flocks also pick up PPRV from local animals that have already been exposed to PPR, through the mixing of animals during their movement (21). To control PPR effectively, potential migratory flocks should be identified and registered by government bodies. A rough sketch of the route of migration, with timelines, should be drawn up. Two types of migratory flocks and/or nomadism are generally observed under Indian agro-climatic conditions:

– migratory flocks of small ruminants moving from dry areas, such as Rajasthan and Gujarat, to adjoining states during the summer season (21)

– migratory flocks in sub-Himalayan regions, such as Himachal Pradesh, Uttarakhand, Jammu and Kashmir. Movement in these regions is based on the availability of grazing grounds in the summer and winter seasons. The availability of these grounds depends mainly on the altitude and snowfall in the hilly terrain of the sub-Himalayan region.

Social activities

Mixing animals during animal fairs, local markets and animal health camps plays an important role in disease transmission. In the northern part of India, groups of goats are regularly pooled and taken to grazing land. This interaction increases the risk of disease transmission within the group. Furthermore, these groups sometimes mix with other similar groups in the village, which further increases the chance of disease transmission. Trade over long distances has also been blamed for PPR transmission in India (13). A rough estimate of the radius in kilometres for intermingling animals during various social activities is given below:

– trade/transportation = 1,000 km

– animal fairs/local markets = 10 km

– animal health camps = 3 km.

Disease control strategies

It is not a good option to launch a PPR control programme without seriously thinking about the net outcome, in terms of both its short-term (reduction in disease incidence) and long-term goals (disease control and eradication). Such strategies should preferably be based on a 'bottom-up' approach, i.e. farmers to field veterinarians to researchers to policy-makers. This approach is considered to be more sustainable. In addition, the availability of a sufficient quantity of high-quality PPR vaccine and the infrastructure and human resources required for vaccination at the farmer's door are all important considerations in such a strategy. To support these activities, India has large numbers (45,211) of skilled personnel and ranks 59th in terms of staff per unit area among countries listed by the World Organisation for Animal Health (OIE) (29).

To support stakeholders of all types, detailed documents on all aspects of PPR epidemiology are available, at both the national (16) and international level (6). The technology necessary for large-scale production of PPRV vaccine is available through the leading research and development organisations in India. Raising awareness about the benefits of vaccination campaigns among farmers will help in launching intensive vaccination programmes, even in areas with a low incidence of PPR (the north-eastern states and Punjab). Furthermore, to achieve maximum benefits from such a disease control programme, it is also vitally important to control PPR in neighbouring countries.

The approach to controlling PPR can be divided into three inter-dependent stages, based on prioritising available resources. These stages are:

– reducing disease intensity through vaccinating targeted populations

– controlling PPR by intensive vaccination

– implementing mass vaccination campaigns that provide high levels of vaccination coverage.

Stage 1: reducing disease intensity through vaccinating targeted populations

The first step in the control of PPRV infection in small ruminants in India, as in other developing countries,

should be reducing disease intensity through focused and organised vaccination. This approach will reduce direct economic losses and lead to a high acceptance rate of the control programme among stakeholders. Focused vaccination in high-risk groups, especially in areas of high population density, should be carried out. High-risk groups include migratory flocks, younger livestock aged approximately six to 12 months and animals taken to communal activities, such as animal fairs and markets. Goats have been shown to develop more severe infections than sheep. Therefore, goats should be preferred for vaccination over sheep (21).

A vaccination strategy aimed at reducing the initial disease burden should be designed, taking into account the important cultural and socio-economic factors in the specific area. During this stage of a disease control strategy, serosurveillance using competitive enzyme-linked immunosorbent assay (c-ELISA) may not be necessary. However, not using serosurveillance may result in wasting one third of the vaccine and vaccination effort, due to prior exposure of these animals to PPR. Keeping vaccination records at this stage is important, as this will help to avoid giving repeat vaccinations, since vaccine induces life-long immunity after a single dose.

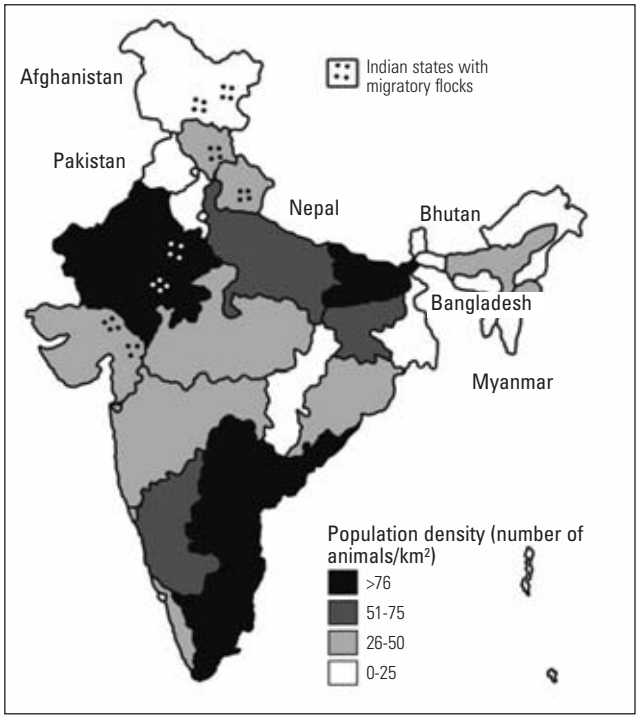

Fig. 2
Map showing the population density of small ruminants in various Indian states/administrative units and states with migratory flocks of sheep

Stage 2: controlling peste des petits ruminants by intensive vaccination

The experiences of farmers and vaccination teams during the first stage of the control programme (reduction in disease intensity) should form the basis for the second stage (intensive vaccination for disease control). Success in the first stage, in the form of reducing the number of outbreaks and the number of deaths, will be the main motivation for farmers and other stakeholders to carry out further vaccination. Stage 1 of the control strategy should result in a significant reduction in sheep and goat mortality since, at the present time, PPR accounts for a large proportion of mortalities in the sheep and goat populations in India.

Intensive vaccination should initially be targeted at states and regions with a high population density of small ruminants (e.g. Tamil Nadu, Andhra Pradesh, Bihar, Rajasthan, Puducherry and Lakshadweep), followed by vaccination in other states (Karnataka, Uttar Pradesh, Jharkhand, Maharashtra, Himachal Pradesh, Gujarat, Orissa and Assam), where the small ruminant population density is lower. The final phase should cover the remainder of the Indian states. An overview of the population density (number of animals per km²) of small ruminants in various Indian states and/or administrative units (10, 27) is presented in Table I and Figure 2.

Stage 3: mass vaccination campaigns that provide high levels of vaccination coverage

After success in the reduction of disease intensity and limited control of PPR in endemic zones, mass vaccination campaigns should be initiated. At this stage, seromonitoring vaccinated animals using monoclonal-antibody-based c-ELISA kits (23) is important. Randomised sampling strategies should be developed for serum collection from both sheep and goats. To successfully control PPR, vaccine coverage at this stage must be close to 100% to achieve 70% to 80% herd/flock immunity. Achieving this high level of flock immunity is essential to eliminate the epidemic cycle and thus avoid new epidemics. The following strategies will help in achieving the high levels of vaccination coverage necessary to successfully control PPR:

– vaccinate all sheep and goats once without serosurveillance

– keep good records of the vaccinated populations

– vaccinate kids and lambs at about six months of age

– monitor the vaccine response using a c-ELISA test kit

– investigate and evaluate vaccine failures due to improper maintenance of the cold chain and, in cases of vaccine failure, revaccinate the entire population.

Table I
Sheep and goat population density in India

Indian states	Sheep (× 1,000)	Goats (× 1,000)	Total (× 1,000)	Area (km²)	Population density (per km²)
Andhra Pradesh	21,376	6,277	27,653	275,068	100.5
Arunachal Pradesh	19	231	250	83,743	2.9
Assam	170	2,987	3,157	78,483	40.2
Bihar	382	9,490	9,872	94,164	104.8
Chhattisgarh	121	2,336	2,457	135,194	18.2
Goa	0.07	11	1,1.07	3,702	2.99
Gujarat	2,062	4,541	6,603	196,024	33.7
Haryana	633	460	1,093	44,212	24.7
Himachal Pradesh	926	1,125	2,051	55,673	36.8
Jammu and Kashmir	3,411	2,055	5,466	222,236	24.6
Jharkhand	680	5,031	5,711	79,700	71.7
Karnataka	7,256	4,484	11,740	191,791	61.2
Kerala	4	1,213	1,217	38,863	31.3
Madhya Pradesh	546	8,142	8,688	308,144	28.1
Maharashtra	3,094	10,684	13,778	307,713	44.77
Manipur	6	33	39	22,327	1.7
Meghalaya	18	327	345	22,429	15.4
Mizoram	1	17	18	21,081	0.8
Nagaland	4	175	179	16,579	10.6
Orissa	1,620	5,803	7,423	155,707	47.6
Punjab	220	278	498	50,362	9.8
Rajasthan	10,054	16,809	26,863	342,236	78.4
Sikkim	6	124	130	7,096	18.3
Tamil Nadu	5,593	8,177	13,770	130,058	105.8
Tripura	3	472	475	10,492	45.2
Uttar Pradesh	1,437	12,941	14,378	238,566	60.3
Uttarakhand	296	1,158	1,454	53,566	27.1
West Bengal	1,525	18,774	20,299	88,752	22.8
Andaman and Nicobar Islands	–	64	64	8,249	7.7
Chandigarh	0.03	1	1.03	144	7.1
Dadra and Nagar Haveli	0.05	21	21..05	491	42.9
Daman and Diu	0.12	4	4.12	122	33.8
Delhi	3	17	20	1,483	13.4
Lakshadweep	0	47	47	32	1,468.7
Pondicherry	3	48	51	492	103.6
Total	**61,469**	**124,358**	**185,827**	**328,4974**	**56.6** (Average)

Source: Basic animal husbandry statistics, 2006; Wikipedia (10, 27)

If possible, it would be advisable to carry out vaccination campaigns during winter, to avoid problems with the thermostability of the vaccine. The use of thermostable vaccines for mass vaccination campaigns, using either thermostable clones of the virus or deuterium/heavy water as the stabiliser and magnesium sulphate as a component of the vaccine stabiliser, would be preferable.

Potential reservoir hosts which may be involved in the epidemic cycle of PPR include buffalo (8), gazelles and gemsboks (7). It may be necessary to vaccinate these species during the final stages of a disease eradication programme.

Disease eradication strategies

It seems a little premature to discuss the eradication of PPR from India when there are many new outbreaks of the disease every month. However, the tools now available, in the form of vaccines and diagnostics, and the experience of eradicating rinderpest from India, make the control and eradication of PPR a real possibility. Disease control by intensive vaccination using a very potent vaccine will result in a reduced incidence of the disease. Repeated vaccination, in combination with clinical surveillance and seromonitoring of vaccinated animals, which was key to

the OIE pathway of rinderpest eradication, should be implemented (11). However, during the last phase of eradication, when differentiation between vaccinated and infected animals is of the utmost importance, the use of Differentiating Infected from Vaccinated Animals (DIVA) marker vaccines and/or chimeric vaccines would be preferable, if available.

The final phase of a PPR eradication programme should focus on detecting any remaining clinical cases of PPR. During this final stage, disease surveillance should be conducted using highly sensitive assays, such as polymerase chain reaction ELISA (15). India must also take note of the fact that all its neighbouring countries, i.e. Pakistan, Bangladesh, Nepal, Bhutan and Afghanistan, are endemic for PPR. Many of these countries may not place the same priority on the control and eradication of PPR because of economic constraints or civil unrest. The possible introduction of PPR from neighbouring endemic countries must be taken into consideration in any Indian control/eradication campaign. It should also be noted that the global eradication of PPR will only be possible through a massive coordinated campaign, as achieved with the successful Global Rinderpest Eradication Programme.

Conclusion

With the effective vaccines, diagnostics and knowledge of PPR now available to us, as well as the successful experience of eliminating rinderpest, India can achieve the goal of controlling PPR. This, in turn, will open the door for the eradication of PPR from India, as well as from other South Asian countries. The successful eradication of rinderpest in India, thanks to the efforts of all the stakeholders, as well as the international community, should be celebrated. The successful global eradication of rinderpest shows that a similar programme could now be followed to globally eradicate PPR.

Acknowledgements

The author is thankful to Dr Sanjay Kumar Pandey, Dr D.K. Sinha and Dr Mahesh Chandra of the Indian Veterinary Research Institute for their critical reading of the manuscript and valuable contributions.

Stratégies de lutte contre la peste des petits ruminants en Inde

R.P. Singh

Résumé

La peste des petits ruminants est une maladie virale contagieuse affectant les petits ruminants. Elle sévit à l'état endémique dans plusieurs pays d'Afrique, du Moyen-Orient et d'Asie, y compris en Inde. L'Inde a récemment instauré toute une série de mesures visant à lutter contre la peste des petits ruminants, notamment grâce au développement et à la production de vaccins efficaces et de trousses de diagnostic recourant à la technique des anticorps monoclonaux, tout en recueillant des données sur la situation de départ de la maladie et sur les ressources humaines disponibles. Suite à la mise en œuvre de ces mesures, la peste des petits ruminants peut désormais être maîtrisée au moyen de vaccinations ciblées des populations ovines et caprines à haut risque, suivies de campagnes de vaccination massives. Ces dernières doivent conférer une immunité de troupeau élevée (de l'ordre de 70 % à 80 %) afin de mettre un terme au cycle épidémique du virus. Grâce aux outils actuellement disponibles, la lutte contre la peste des petits ruminants et les programmes d'éradication subséquents s'avèrent une solution réaliste, dans la lignée du programme national d'éradication de la peste bovine qui a atteint ses objectifs avec succès en Inde. La prise en compte des contextes culturels et socio-économiques dans lesquels se trouvent les propriétaires de chèvres et de moutons et l'examen attentif de la nature endémique de la peste des petits ruminants dans les pays voisins devraient rendre cette démarche encore plus efficace. Afin de réussir

l'objectif d'éradication de la peste des petits ruminants en Inde, des efforts concertés entre toutes les parties prenantes seront nécessaires, ainsi qu'un financement approprié et une mise en œuvre adéquate des programmes de prophylaxie. En outre, le recours à des vaccins efficaces dirigés simultanément contre la peste des petits ruminants, la variole caprine et la clavelée ovine constitue une stratégie peu onéreuse permettant de lancer simultanément des programmes de prophylaxie contre ces trois maladies.

Mots-clés
Campagne de vaccination – Caprin – Chèvre – Éradication d'une maladie – Inde – Mouton – Ovin – Peste des petits ruminants – Petit ruminant – Prophylaxie.

Estrategias de lucha contra la peste de pequeños rumiantes en la India

R.P. Singh

Resumen
La peste de pequeños rumiantes (PPR) es una enfermedad vírica contagiosa que afecta a los pequeños rumiantes. Es endémica en varios países de África, Oriente Medio y Asia, entre ellos la India. Este último país ha adoptado últimamente ambiciosas medidas para afrontar la PPR mediante la elaboración y producción de potentes vacunas y kits de diagnóstico basados en anticuerpos monoclonales, a la vez que también reunía información de referencia sobre la situación de la enfermedad y los recursos humanos. Gracias a todo ello, ahora es posible controlar la enfermedad con campañas de vacunación selectiva de poblaciones ovinas y caprinas de alto riesgo, seguidas de campañas de vacunación masiva. Para atajar el ciclo epidémico del virus es preciso obtener con estas últimas elevados niveles de inmunidad de los rebaños (del 70% al 80%). Con las herramientas actualmente disponibles los programas de control y subsiguiente erradicación de la PPR pueden ser una opción realista, atendiendo al ejemplo del programa nacional de erradicación de la peste bovina, que ha servido para eliminar la enfermedad de la India. Tal iniciativa tendrá más posibilidades de éxito si se acompaña de una adecuada comprensión de las circunstancias culturales y socioeconómicas de los propietarios de rebaños ovinos y caprinos y de una observación atenta de la naturaleza endémica de la PPR en los países vecinos. Para lograr el objetivo de librar al país de la PPR se requerirá un esfuerzo concertado de todas las partes, junto con la debida financiación y una adecuada ejecución de los programas de lucha. Además, la existencia de vacunas combinadas eficaces contra la PPR, la viruela caprina y la viruela ovina ofrece un medio rentable de poner en marcha simultáneamente programas de lucha contra esas tres enfermedades.

Palabras clave
Cabra – Campaña de vacunaciones – Caprinos – Control de enfermedades – Erradicación de enfermedades – India – Oveja – Ovinos – Pequeños rumiantes – Peste de pequeños rumiantes.

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