Review article

Peste des petits ruminants Control Programme and Strategies in India: Current Scenario

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ABSTRACT

Peste des petits ruminants (PPR) is an acute, highly contagious, OIE notifiable and economically important transboundary viral disease of sheep and goats. PPR is enzootic in India as a greater number of outbreaks have occurred in the past and now occurring regularly round the year and throughout the country. The PPR outbreaks in sheep and goats have declined in some of the Indian states Viz., Andhra Pradesh, Telangana, Karnataka, and Chhattisgarh after implementing the strategic mass vaccination campaigns. The decreased number of outbreaks, as well as changes in the disease severity patterns and distribution, might be due to the effectiveness of the vaccine, timely vaccination, and most importantly effective implementation of the vaccination strategic plan. This review is focused upon the overall understanding of the National PPR Control Programme (PPR -CP) and its strategies vaccination implantation in India for the control and eradication of PPR.

Key Words: PPR, Sheep and Goats, Control program, Strategies, Vaccination, India

INTRODUCTION

Peste des petits ruminants (PPR) is one of the highly contagious and economically important viral diseases of small ruminants, especially goats and sheep, with morbidity and mortality rates as high as 100% and 90%, respectively. The disease is manifested by severe pyrexia, discharges from eyes and nasal orifices, necrotizing and erosive stomatitis, enteritis and bronchopneumonia (Balamurugan *et al.*, 2014a). The causative agent of the disease is small ruminant morbillivirus (SRMV), formerly known as PPR virus, which belongs to the genus *Morbillivirus* of family *Paramyxoviridae*. India has a considerable sheep and goat population of around 200 million, (2012 Census, DAHD and GOI). In India, PPR was first reported from Arasur, Villupuram district (Tamil Nadu State) during 1987 (Shaila *et al.*, 1989). The disease is restricted to southern India till 1994 and after that, it took enzootic in many northern states of India. Now, PPR is enzootic in India as outbreaks occur in small ruminants regularly throughout the country, and is a major constraint in small ruminant

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production incurring great economic losses in terms of morbidity, mortality, productivity losses, and trade restriction (Balamurugan *et al.*, 2014a). Epidemics of PPR may have enormous consequences in terms of the dramatic effects of this disease on livestock productivity and high costs of control or eradication (Govindaraj *et al.*, 2016). Epidemics affect not only individual farmers but also the livestock sector as a whole and as a consequence, the national economy. PPR is present in countries, which are either developing or under-developed thereby adding to the economic woes.

For effective control of the disease, the development of both suitable vaccines as well as rapid, specific and sensitive methods for the diagnosis is highly imperative. To control PPR, there is a need for baseline epidemiological data on the disease prevalence, strong support of diagnostic methods, and proper timely vaccination of the susceptible population. Monoclonal antibody-based competitive-ELISA(c-ELISA) and Sandwich ELISA (s-ELISA) for PPR antibody detection and antigen detection, respectively developed at Indian Veterinary Research Institute (IVRI) are the currently employed test for sero-surveillance and sero-monitoring PPR (Singh *et al.*, 2004a; Singh *et al.*, 2004b). Further, live attenuated Vero cell-based vaccine (Sungri-96 strain) developed at IVRI is being used for vaccination of susceptible populations throughout the country. Despite strict control measures including statutory regulations along with the availability of scores of vaccines and diagnostics, this infection still remains a constant threat to sheep and goats (Singh *et al.*, 2009). Vaccination is a recommended tool to support eradication efforts and limit economic losses due to PPR. The only way to control PPR is by the use of a homologous vaccine against the disease. The present review is focused upon the overall understanding of the National PPR Control Programme (PPR-CP) and its strategies vaccination implantation in India for the control and eradication of PPR.

Control strategies

Control strategies in developing or under-developed countries the choices are limited. Social acceptance, public and regulatory support is essential for the success of any disease control and eradication program. In India stamping out policy is not feasible because of economic and socio-cultural reasons (Singh *et al.,* 2009). However, society will readily accept the vaccination program without much hindrance. Hence, vaccination is a recommended tool to support control and eradication efforts. For the proper control of PPR, there is a need for strong support of diagnostic methods and proper, timely vaccination of the susceptible population upon understanding the epidemiology of the disease is imperative (Balamurugan *et al.,* 2016). Hence, the availability of attenuated cell culture vaccines and various diagnostic techniques or kits for the diagnostic of PPR, public and regulatory concern along with control measure and strategies favours for a strong recommendation of National control programme (NCP) for PPR in India in order to alleviate the poverty in the country initially and continent later. As no specific therapy is available for PPR infection, this way, at least the immediate loss could be prevented and the small and

marginal farmers rearing sheep and goats will be benefited. Therefore, PPR control and eradication depends mainly on rapid and accurate diagnosis or surveillance or monitoring and implementation of the prompt vaccination program.

Studying prevalence of SRMV antibodies in sheep and goats from different geographical areas with varying agro-climatic conditions may be helpful in devising effective appropriate disease control strategies, as the presence of SRMV specific antibodies indicated in situations where either the subclinical or in-apparent or non-lethal infection was suspected (Balamurugan *et al.*, 2014b) or in sheep or goats are exposed to virus naturally (Balamurugan *et al.*, 2012) and recovered in unvaccinated areas or immune response in vaccinated region.

Control Programme

Recent success with the rinderpest eradication program (NPRE) in the country has provided the confidence that is required to launch a similar program with PPR too initially on the lines of NPRE. All the elements (potent vaccine, kits for disease diagnosis & sero-surveillance and the tested infrastructure, etc.) required for a control program are available in the country. They have further been recommended for a collaborative nation-wide program implemented by state Animal Husbandry Departments under the direction of the Department of Animal Husbandry and Dairying (DAHD, GOI) and the co-operation of the local public under the guidance from the policymaker at the center.

Therefore, the launching of the programme appears technically feasible, economically viable and a practically attainable proposition. Hence, in the way to FMD Control Programme (FMD-CP) (DAHD), it was decided by DAHD, Government of India to undertake a national control programme on PPR (NCP-PPR) in the 11th five-year plan (2007-12) with an aim to control and eradicate this disease from India in a time-bound manner on the lines of rinderpest eradication (http://dahd.nic.in) following the eradication pathway of OIE (Balamurugan *et al.*, 2016). Accordingly, this proposed program has been initiated during the year 2010-11 with a sum of INR 432.5 million in the first phase for undertaking various activities of the program. The DAHD, GOI launched NCP for PPR would be run in three phases during India's 11th (2007–12) and 12th (2012–17) 5-year plan and 2017-2020 plan periods. Moreover, vaccination against PPR has been practiced in some states of India since 2002 to control the disease. The activities of the program include identification of animals, procurement of cold-chain equipment and vaccine, assessment of the randomly collected samples of vaccines for their quality,mass vaccination,virus typing in case of outbreaks,recording/regulation of animal movement and sero-surveillance or monitoring of animal population on a random basis(www.dahd.nic.in).

During the first phase, the states and UTs in Southern peninsular India viz. Karnataka, undivided Andhra Pradesh, Tamil Nadu, Kerala, Maharashtra, Goa and Lakshadweep, Daman & Diu, Dadra & Nagar Haveli, Puducherry, and Andaman & Nicobar Island were included in the

vaccination program (www.dahd.nic.in) (Balamurugan *et al.*, 2016). However, the remaining states and UTs of India were also included in the second phase of PPR-CP during 2014-2015 (Balamurugan *et al.*, 2016). Due to PPR-CP, the disease has been brought under control in some Indian states and PPR threat reported declined progressively and substantially in areas under continuous vaccination (Balamurugan *et al.*, 2016) and benefits outweighs the cost of a vaccination program (Govindaraj *et al.*, 2019). In some states, where focused vaccination is adopted, disease outbreaks are being reported sporadically. However, neither a surveillance plan nor a systematic sero-monitoring was initiated to assess the effectiveness of the vaccination program. In the past five years, vaccination and sero-monitoring were carried out extensively in the PPR -CP in some states of India especially Andhra Pradesh, Telangana, Chhattisgarh, and Karnataka.

The government of India also providing funding / grand in-aid under this PPR-CP to research institutions for assisting and undertaking surveillance and monitoring of PPR during the surveillance stage with states / UTs animal husbandry department. Professional commitment on the part of veterinarians and associated personnel involved in a mass immunization program is crucial to succeedingin the vaccination program.

Recent prevalence study in Andaman Nicobar (AN) Islands of India (Balamurugan *et al.*, 2019a) showed that the overall 1.39 % true prevalence of PPRV antibodies in goats, which implies that the goat population in the villages (epidemiological units) were having less than 30 % seroprevalence or free from PPRV antibodies, as there were neither PPR outbreaks reported nor PPR vaccination strategies practiced in goats in the AN Islands. This necessitates the comprehensive active intensive surveillance program and imperative for monitoring of the occurrence of sporadic outbreaks in different clinical forms of the diseases in the islands to make disease-free Islands by implementing effective disease control measures /strategies for PPR (Balamurugan *et al.*, 2019a). Further, serosurvey in the control programme implemented states in Southern Peninsular India (Balamurugan *et al.*, 2019b), showed that the immune protection in sheep and goats were greater in regularly vaccination practiced states (Andhra Pradesh, Telangana, and Karnataka), when compared with irregularly- or focused- or non-vaccinated states / UT (Puducherry, Kerala and Tamil Nadu), where the disease is endemic and outbreaks are being reported. Further, the seroprevalence study of the PPR in sheep and goats carried out in different states in the Central and Western regions of India revealed that the small ruminants in most of the epi-units (n=190) had < 70 % seroprevalence (unpublished data). This necessitates the active intensive continuous mass vaccination program for a few more years to achieve the desired protection level and surveillance programs to make these regions free from PPR. Therefore, zoning the PPR risk regions and initiating vaccination program at a specified period with complete vaccination coverage of all the risk population in the identified zone is of paramount importance along with monitoring and surveillance.

Vaccination strategies

In India, sheep and goats are an important productive asset of settlers, landless, marginal, and small landholder farmers and it generates a flow of income and employment throughout the year. A number of PPR outbreaks have occurred in the past and now being occurring regularly, round the year and throughout India, as the disease is endemic in nature (Balamurugan *et al.*, 2014b). India practiced focused PPR vaccination in outbreak places in some states since 2002 (Singh *et al.*, 2009) and in program mode in some states since 2011 even before the global framework was planned (Balamurugan *et al.*, 2016). Experimental vaccination against PPR after field testing has been practiced in 15 states of India since 2002 to control the disease during outbreaks (Singh *et al.*, 2009). On-going vaccination strategies for the control of PPRV would be slightly different from vaccination programs for rinderpest. A mass vaccination campaign to cover 80% flock immunity would be needed to account for the population dynamics of sheep and goats, disparities in sheep and goats husbandry practices and the agro-climatic conditions affecting the pattern of disease. The slaughtering of male goats at an early age combined with the high fecundity of the caprine species results in the replacement of population (~30-40% naïve population appears) every year.

Though vaccination has been successfully implemented in some states, still its implementation is largely elusive in many states. Hence, the status of PPR vaccination and the impact of the vaccination especially in the successfully implemented states is necessary to generate evidence for extending the control program. The above points highlight the necessity of sero-monitoring or surveillance in the vaccinated population as well as the impact of the vaccination in different states of India. Further, we need to generate baseline information on the antibody titers across species, geographical location and under different rearing, environments to generate evidence if the country plans to eradicate the disease from the country by 2030. It is also necessary to generate information on the impact of the vaccination including strategies or constraints for effective implementation of the control programs in the country.

In India, currently, three live attenuated PPR vaccines (Sungri 96, Arasur 87 and Coimbatore 97 stains) are available, of which, Sungri 96, developed by Indian Veterinary Research Institute (IVRI), Mukteswar has undergone extensive field trial. PPR virus is one serotype, so any vaccine lineage can protect against all other field viruses. These vaccines may be sufficient to protect against the circulating field isolates or strains of PPRV in India and provide long-term (more than 6 years) protective immunity. These vaccines can be used for the control and eradication of the disease not only from India but also from other Asian and some African countries following the example of the global RP eradication program (GREP), as now Lineage IV virus expand its geographical locations. Seroconversion and protection have been observed in vaccinates by the PPR vaccine (Singh *et al.*, 2009). With a field dose of 10^3 $TCID_{50,}$ protective immunity is ensured for >6 years (Saravanan *et al.*, 2010)

without a booster, the vaccine is well suited for mass immunization (Balamurugan *et al.*, 2016). The vaccine production and quality control technology generated in IVRI, Mukteswar has been transferred into different multinational companies (MNCs) viz. M/s Indian Immunologicals Ltd. Hyderabad, India; M/s MSD Animal health, Intervet India Pvt. Ltd. Pune India; M/s Hester Bioscience Ltd, Ahmadabad, India; and M/s Bio-Med Private Ltd. Ghaziabad, India, apart from IVRI, Uttar Pradesh and Veterinary Biological Production Units (VBPUs) or Institute of Animal Health and Veterinary Biologicals of Telangana, Karnataka, Madhya Pradesh, Punjab, Tamil Nadu, Haryana and Kerala states for commercialization.

Vaccinated animals, infected and recovered animals are protected from re-infection for the remainder of their lives. Hence, in this direction, the strategies were proposed in the PPR_CP involving intensive vaccination of all susceptible sheep and goats and their three subsequent generations (approx. 30%) with 100% fund from central assistance. The basis for selection of some states in the first phase for control program may be due to high prevalence of disease in the region or dense population of small ruminants, availability of facilities and personnel to cover the vaccination in a stipulated time periods, etc. or to make disease-free zone in case of UTs where less population of sheep and goats.

At present, the disease occurrence, severity of the clinical disease and number of outbreaks have progressively and substantially declined in areas under regular vaccination mostly under National Control Programme on PPR (NCP-PPR) and partly under ASCAD (Assistance to States for Control of Animal Diseases) of the Government of India. The situation in India is improving as a result of progressive mass vaccination. The disease incidence has been in decline over the past 5 years. In India, decreased numbers of outbreaks, as well as changes in the severity of disease patterns recently observed, might be due to the effectiveness of live attenuated vaccines, timely vaccination of sheep and goats, and circulation of a single Asian lineage IV PPRV, since the disease was first reported in India. Currently, vaccination programs are being implemented in some states of India which will alter PPR epidemiology, particularly the distribution of the disease and pattern of disease.

The second alternative strategy may be focusing vaccinations initially on high-risk group animals, namely young animals (6 months to 1 year aged) and goat population rather than sheep and migratory flocks (Singh, 2011) in a suitable period preferably during lean periods. The third strategy might be intensive vaccinations based on populations to make disease-free areas (zone) by identifying the hotspots and implementing vaccinations followed by screening, testing, and overall revaccination, if required, in those areas as reported earlier (Balamurugan *et al.*, 2014b; Singh, 2011). However, keeping in mind the current approach and achievements, as a novel alternative strategy suggested by Cameron (2019), that a trench warfare approach, where the eradication strategy should be modeled on guerrilla tactics: use exceptionally good, locally relevant and timely intelligence; strike rapidly

and effectively in small areas with high vaccination coverage; achieve the goals, and keep moving. The author also points out that to achieve this developing powerful, effective and sustainable surveillance systems is essential (Cameron, 2019). This strategy may be followed if required for a national control program.

Overall, fixed strategies may not work for all the states or regions or countries. However, in the mass vaccination in pulse polio model covering entire population initially, followed by biannual vaccination in a pre-designated stipulated period, covering the naïve young population of sheep and goats at least four to five years will have a tremendous impact on the control of PPR outbreaks in sheep and goats. Thus, after three to four rounds of vaccination, the population in the state may be immune to the disease, but the threat persists from ingress of disease from other bordering states, hence vaccination on the migratory population at the check post or border regions of the states or inter-state border or in the place of entry or place of trade market of animal through transport from other states are to be targeted for mass vaccination as and when required. Finally, it is hoped that PPR in the direction of RP will be eradicated in India within a decade or few more years.

National PPR Control and Eradication Strategy

Recently DAHD department, Ministry of Animal husbandry and Fisheries, Govt. of India prepared the strategic planning for National PPR Control and Eradication Strategy (NPCES) by 2025 with a hope that PPR in the direction of RP will be eradicated in India within a decade or even earlier. The silent features of this strategy include intensive vaccination with 100 % coverage of sheep and goat populations till 2022, with attaining targeted herd immunity and stoppage of virus circulation through clinical surveillance by 2023/24 and freedom from PPRV infection by 2025. The mass vaccination will be in pulse polio model in the designated time period with two to three cycles of vaccination to reach 70-80 % immunity level, with each cycle of covering entire population of sheep and goats initially, subsequently bi-annual vaccination covering the 30% naïve young population in each of the states with traceability of the vaccinated animals. Moreover, at the time of declaring India is provisionally free from PPR, surveillance of PPR in different states /UT also needs to be carried out as per GCEP guidelines to support the demonstration of freedom from disease in unvaccinated populations.

Prospective

At present, the disease has been brought under control in goats and sheep by available effective and safe live attenuated cell culture PPR vaccine. In overall, the present scenario of PPR in India warrants the studies to be undertaken with the objective to know the effect of agro-climatic changes on the occurrence of PPR in small ruminants in different agro-climatic zones and to analyze the relationship of disease occurrence and risk factors to formulate modules for forecasting and forewarning. The epidemiology of PPR is likely to change due to vaccination as the disease occurs more severely in the naïve

population. This warrants the study to be undertaken to know the changing pattern of the disease and its severity in vaccinated and unvaccinated regions. Andhra Pradesh, Telangana, Karnataka, and Chhattisgarh states have shown a declining trend with more than 90% reduction in the number of reported PPR outbreaks during the preceding five years due to implementation of strategic mass vaccination plan. Implementation of vaccination and control strategies adopted for PPR in sheep and goats by India may motivate other countries for similar initiatives leading to progressive mass vaccination and control of PPR.

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CONFLICT OF INTEREST

No conflict of interest exists.

AUTHORS' CONTRIBUTION

V. Balamurugan planned and wrote the draft of the manuscript, K. VinodKumar and G. Govindaraj provided inputs, support, and edited & formatted the manuscript and Parmal Roy provided guidance and support.

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