Rinderpest and Peste des petits ruminants: a century of progress and the future

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Summary

Rinderpest and Peste des petits ruminants (PPR) are two closely related viral diseases affecting ruminants caused by viruses belonging to the genus *Morbillivirus*. Both diseases are notifiable to the World Organisation for Animal Health (WOAH) due their high contagiosity and economic importance. Scientific developments have led to the eradication of rinderpest, which was celebrated in 2011, 250 years after the creation of the first veterinary school in Lyon. On the other hand, the geographical distribution of PPR has expanded to many regions of Africa, the Middle East and Asia. It now constitutes a major concern for small ruminants globally. Following the lessons learnt from the Global Rinderpest Eradication Programme, efforts have been initiated to control and eradicate PPR. The PPR Global Control and Eradication Strategy which was established in 2015 by the Food and Agriculture Organization of the United Nations and WOAH, aims to eradicate PPR by 2030. The key factors in favour of PPR eradication are the limited number of natural hosts, the absence of a vector, the availability of an effective vaccine, and the availability of diagnostic tools. Challenges are the mobilisation of sufficient resources, better understanding of the epidemiology, improving vaccines for differentiation between vaccinated and infected animals, and adapting diagnostic tests for atypical hosts. Eradicating PPR will not only represents a scientific milestone but also aligns with broader goals of poverty alleviation and economic stability in regions heavily dependent on small ruminants.

Keywords

Diagnostic tests – Eradication – Global coordination – Live attenuated vaccines – Peste des petits ruminants – Rinderpest.

Introduction

Rinderpest and Peste des petits ruminants (PPR) are viral diseases of ruminants with significant importance for the veterinary community caused by two viruses belonging to the *Morbillivirus* genus [1]. As a result of their high contagious, morbidity and mortality, Rinderpest and PPR are notifiable to the World Organisation for Animal Health (WOAH), as 'economically important animal diseases that must be reported to WOAH', according to the *Terrestrial Animal Health Code*.

Rinderpest devastated livestock for hundreds of years in Asia, Europe and Africa. It is estimated that earliest reports on that plague date back to the siege of Troy in the 12th century BCE [2]. The first well-documented clinical description of the disease, including its contagious nature, was made in November 1711 by Bernadino Ramazzini, professor of medicine at the University of Padua in Italy [2, 3]. In 1715, Giovanni Maria Lancisi, the physician of Pope Clement XI, elaborated the first sanitary measures to control rinderpest with stamping out of infected animals, control of animal movements and adoption of hygiene measures [2, 3] which remain relevant today. Until the mid of 1700s, animal diseases were managed by human medical doctors. The devastating rinderpest epidemics that affected Europe between 1709 and 1760 highlighted the urgent need for the development of veterinary medicine as a distinct profession. And so, the first veterinary school was established in France by Claude Bourgelat in 1761 in Lyon [2, 3, 4, 5]. Rinderpest was then successfully eradicated from Europe by the end of 19th century following strict applications of zoo-sanitary measures. But in 1920, the disease reappeared in Belgium through the port of Antwerp from infected zebus in transit from Asia and to Brazil which were probably in incubation phase [6]. Over the years, rinderpest and PPR have undergone in different epidemiological evolutions. The first has been eradicated and the second is targeted as the second animal disease to be eradicated.

Rinderpest control and eradication: the establishment of WOAH and other international organisations, and key scientific contribution

The control efforts of the reintroduction of rinderpest in Belgium led to the establishment of the Office International des Epizooties (OIE) in 1924 in Paris, now known as World

Organisation for Animal Health (WOAH), to collect and share information, and encourage international collaboration for the control and eradication of diseases [7]. After the Second World War, the Food and Agriculture Organization of the United Nations (FAO) was created, and one of its objectives was to control and eradicate rinderpest [7]. In Africa, the Inter African Bureau for Epizootic Diseases (now Inter African Bureau for Animal Resources of the African Union [AU-IBAR]) was established in 1951 to control rinderpest [8]. After eradication of in Europe in 1928, rinderpest remained a major constraint for livestock production in Africa, Asia, the Middle East and the Near East. Efforts to develop an effective vaccine against rinderpest began in the 18th century, with first trials carried out in England and the Netherlands, that showed that calves from previously infected and immunised dams resisted infection for a certain period of time [9]. In Africa, after the introduction of rinderpest from Asian zebus to Eritrea at the end of the 19th century [10], Danysz, Bordet and Theiler concluded their work in 1897 by proposing the injection of hyperimmune serum and virulent substance (the serum immunisation protocol) [9, 10]. This protocol, together with zoo sanitary measures, contributed to the elimination of rinderpest in Europe after its accidental introduction into Belgium in 1920, but was not ideal. In 1928, James Edwards, a British microbiologist working in India, attenuated the rinderpest virus by serial passages on goats, as did Junji Nakamura by serial passages on rabbits. The goat adapted rinderpest virus vaccine was used in India from 1930s to early 1973, and in Africa until mid of 1960s while the lapinized rinderpest vaccine was used only in Korea [10, 11]. At the end of the 1950s, W. Plowright developed the tissue culture-derived rinderpest vaccine (TCRV) through serial passages on bovine kidney cells [12, 13]. This vaccine is safe and highly effective, providing immunoprotection for the entire life of cattle [14] and also protects small ruminants against rinderpest and peste des petits ruminants [15, 16]. The availability of a thermostable TCRV vaccine [17] allowed community-based vaccination strategies [18]. Assessing the quality of the TCRV vaccine in Africa inspired the establishment of the key Pan African Veterinary Vaccine Centre (PANVAC) in 1986 [19]. PANVAC became a specialised technical office of African Union and is now a WOAH Collaborating Centre for animal disease vaccine quality control. The use of TCRV, together with globally coordinated programmes, i.e. the Pan African Rinderpest Control Campaign (PARC) 1986 to 1999; the Pan African Programme for the Control of Epizootics (PACE) 1999 to 2007; the West Asia Rinderpest Eradication Campaign (WAREC) and the South Asia Rinderpest Eradication Campaign (SAREC) succeeded in rinderpest eradication in 2011. Rinderpest is the first animal disease officially declared eradicated worldwide and the second infectious disease after smallpox (1980). Development of diagnostic tools also contributed to the eradication of rinderpest; molecular techniques allowed the identification of virus lineages reflecting the geographical origin [20]. Serological tests have been used for monitoring of rinderpest vaccination programmes [21, 22], surveillance and confirmation of rinderpest free status. Following the global eradication of rinderpest, a coordination strategy for post-eradication monitoring was established by WOAH and the FAO (see Bataille and Baron in this section [23]).

The next step: the eradication of Peste des petits ruminants

After the successful eradication of rinderpest, PPR, a disease similar to rinderpest [24, 25, 26] was targeted for eradication. PPR is a contagious viral disease of sheep, goats and wild small ruminants described for the first time in 1942 in Côte d'Ivoire [27] and caused by a variant of rinderpest virus [28]. The PPR virus (PPRV) was later identified as a distinct entity in the *Morbillivirus* genus [29, 30]. The development of specific diagnostic tests, started in the 1980s, enabled genetic characterisation of the four PPRV lineages I, II, III and IV [31, 32, 33] and a better understanding of their geographical distribution. The disease is now reported from many parts of Sub-Saharan and North African Countries, the Middle East, Eurasia (Bulgaria, Georgia and Turkey) and Asia [31, 32, 33, 34, 35, 36, 37, 38]. In fact, PPR may have been confused with other infectious diseases such as rinderpest and pasteurellosis. Drawing lessons learned from the Global Rinderpest Eradication Programme (GREP), the FAO and WOAH had developed a PPR Global Control and Eradication Strategy (PPR-GCES) which was adopted in 2015 in Abidjan, Côte d'Ivoire [39]. Whereas the global eradication of rinderpest took more than 250 years, the PPR-GCES aims to eradicate PPR by 2030 based on:

- Limited number of the natural hosts;
- No vector-borne transmission;
- Availability of a very efficient vaccines [40, 41] providing lifelong immunity against all virulent PPRV strains [42, 43, 44, 45], easy to produce and easy to use. Like for rinderpest, the thermostability of PPR vaccines during manufacturing has been improved [46, 47, 48, 49, 50];
- Availability of laboratory tests for surveillance of vaccination and disease such as enzyme-linked immunosorbent assay (ELISA) tests [51, 52] and commercial penside tests for field use;
- Appropriate guidelines with PPR Monitoring and Assessment Tool (PMAT) developed by WOAH (in collaboration with FAO) to be used by countries to monitor the implementation of their activities and their progress towards the disease eradication;

- Regional and global coordination: a joint PPR Secretariat FAO/WOAH and PPR Advisory Committee (PPR-AC) has been established to advise on the technical and resource management operations of the implementation of the PPR-GCES. In addition, the PPR Global Research and Expertise Network (PPR-GREN) guides on research needs to speed up the PPR eradication process. A PPR *ad hoc* group at WOAH evaluates the dossiers for PPR free declaration. At regional level, roadmap meetings were established to exchange information on the eradication progress.

The economic implications for decision-making and resource allocation are challenging. The socio-economic aspect is often overlooked in support of disease control advocacy. While cattle may grab more attention due to their higher individual value, goats, often referred to as 'the cattle of the poor', play a vital role in the livelihoods of vulnerable communities as lifeline for smallholder farmers, providing milk, meat, and other by-products for sustainability and income. Their resilience in diverse environments and their ability to thrive with limited resources make them a valuable asset for those with fewer means. If all the factors are favourable to the global eradication of PPR, scientific research should accelerate the implementation of the programme and improve the effectiveness of activities, in the fields of epidemiology, improvement of vaccines and its delivery, diagnostic tests for atypical hosts and socio-economic for resources mobilisation.

Conclusions

The goal of eradicating PPR by 2030 is ambitious but feasible with the right resources and commitment. Learning from the successful eradication of rinderpest, targeted efforts and adequate funding can make a significant impact. The estimated cost of around USD 5.5 billion for rinderpest eradication provides a useful benchmark. If half of that amount can be mobilised, it would be possible to achieve PPR eradication. Allocating the necessary funds would not only contribute to the health of small ruminant populations but also have broader implications for poverty alleviation and economic support in affected regions. Eradicating PPR isn't just a scientific milestone; it aligns with the broader goals of preserving livelihoods, particularly in regions heavily dependent on small ruminants.

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