Global rinderpest eradication and the South Asia Rinderpest Eradication Campaign

The idea of the South Asia Rinderpest Eradication Campaign (SAREC) evolved alongside similar campaigns in Africa (PARC) and West Asia (WAREC). In 1983, FAO organized an Expert Consultation on Requirements for the Rinderpest Eradication Campaign in South Asia, which was held in India. Following the consultation, FAO commissioned a team to visit the five countries of Bangladesh, Bhutan, India, Nepal and Sri Lanka to study ongoing activities and identify further requirements for eradication of this serious cattle disease from the region. Based on findings from this visit, a regional project proposal was submitted to UNDP and the EU for funding, but the project did not come to fruition.

Meanwhile, the FAO Animal Production and Health Commission for Asia and the Pacific (APHCA) – formed in 1975 and based at the FAO Regional Office in Bangkok – held its annual session, which was attended by senior livestock officials of member countries, including four of the five SAREC countries (Bhutan joined APHCA later, in 2000). During the late 1980s and mid-1990s, a key agenda item at APHCA sessions was how to establish a regionally coordinated campaign for rinderpest eradication in South Asia. APHCA developed and promoted an action-oriented programme for SAREC, including the dissemination of information about the animal movement control and quarantine procedures applicable to the prevailing regional situation, and the organization of a series of training programmes on diagnosis and surveillance for rinderpest eradication in South Asia. The EU provided bilateral assistance to Bhutan, India and Nepal, and with APHCA providing its member countries with the momentum for regionally coordinated disease control activities, the successful eradication of rinderpest in South Asia was assured.

India

Rinderpest was probably first introduced into India around the middle of the eighteenth century. It was first reported from Assam in 1722, Madras in 1848, Calcutta in 1864, Varanasi in 1869, and subsequently in most parts of the country. Efforts to control rinderpest in India were initiated in 1868 with the constitution of a Royal Commission. This recorded outbreaks in sheep in Meerut District in 1866, and in goats in Etawa District in 1867, and farmers' evidence from North-West Frontier Province (NWFP, now in Pakistan), Punjab and Uttar Pradesh in 1871. In the early 1950s, about 400 000 rinderpest cases occurred in 8 000 reported outbreaks a year, resulting in the death of about 200 000 animals from a bovine population of approximately 150 million. The case fatality rate generally observed in outbreaks was 60 percent. Rinderpest also occurred in sheep and goats from 1967, initially in...
southern states, but later extending into western, central and northern states (although some of these cases were likely to have been peste des petits ruminants); in pigs in three southern states (1976 to 1985); in mithuns (*Bos gaurus*) in Arunachal Pradesh (1981 and 1984); in wild buffaloes in Assam, Andhra Pradesh and Kerala (1982); and in nilgai or blue bulls (*Boselaphus tragocamelus*) in Madhya Pradesh in the mid-1970s. The last confirmed rinderpest outbreak in India was detected in the North Arcot District of Tamil Nadu in October 1995.

The constant menace of rinderpest provided impetus for the establishment of civil veterinary departments across the country and the Indian Veterinary Research Institute (IVRI) at Mukteshwar. Initially, the serum-virus simultaneous method was used to vaccinate animals. Later, with development of the goat tissue rinderpest vaccine (GTV), by Edwards at IVRI in 1927, several GTV production centres were established, and GTV was used to control field outbreaks in the predominantly indigenous cattle population until 1964. India's first pilot control project, the National Rinderpest Eradication Programme (NREP), was launched in 1954 in 18 districts of Andhra Pradesh, Karnataka and Maharashtra, and was expanded in 1956/1957 as a mass vaccination campaign of bovines over six months of age, using GTV and with the goal of immunizing at least 80 percent of the bovines in target areas within a period of five years. Initially, Tamil Nadu, Karnataka and Kerala were excluded, as they were free from rinderpest at that time, but they were included later, in 1965/1966. Through follow-up vaccination of newborns and animals that had previously been missed, 73 percent of the population was vaccinated. The number of outbreaks declined dramatically, from 8,156 in 1956/1957, to 960 in 1960/1961, and to about 300 in 1964 to 1966.

In the early 1980s, the Government of India realized that despite the regular mass vaccination of the previous few decades, much higher annual vaccination coverage was necessary to sustain the status quo. A Task Force on Rinderpest was constituted in 1983, to review and to suggest future eradication plans. The task force noted that only eight states had remained rinderpest-free from 1980 to 1983. No particular epidemiological reason could be given to explain the outbreak patterns: Arunachal, Assam, Punjab, Meghalaya, Bihar, West Bengal, Gujarat, Madhya Pradesh, Rajasthan, Tamil Nadu and Kerala States had fewer than five outbreaks each; a mid-range of outbreak numbers was reported from Maharashtra (six outbreaks), Orissa (15) and Karnataka (48); while Andhra Pradesh had an average of 116 outbreaks, of which more than 50 percent were in sheep and goats. Based on these outbreak patterns, the task force divided the Indian states into three categories.

The introduction of a tissue culture rinderpest vaccine (TCRPV) in the 1960s greatly strengthened NREP’s efforts, and most state vaccine production units switched to freeze-dried TCRPV production. There was a steady increase in vaccine coverage during the 1980s, with rinderpest outbreaks continuing in the range of 140 to 160 per annum by the end of the decade. In January 1990, given the reasonably low and
stable rinderpest situation in the country, the Government of India launched its final thrust campaign – the National Project on Rinderpest Eradication (NPRE), with an outlay of rupees (INR) 4.05 billion: INR 3.41 billion from the government, and 640 million from the EU, as a component of the Strengthening of Veterinary Services in India for Disease Control project (ALA/89/04).

NPRE’s components included mass immunization, strengthening of tissue culture vaccine production and diagnostic facilities, vaccine quality control, sero-monitoring, sero-surveillance, mass communication, and training workshops. Research on vaccine improvement and quality control, the epidemiology of rinderpest in small ruminants and the development of diagnostic kits for sero-monitoring, sero-surveillance and differential diagnosis of pest des petits ruminants was also supported. The adoption of a landscape epidemiological approach to eradicating rinderpest, with an appropriate vaccination strategy according to the OIE Pathway, was the keystone for successful implementation of NPRE. India was divided into four zones according to the historical and current epidemiological situation of rinderpest: zone A comprised the seven northeastern states; zone B 21 states in the Indo-Gangetic region; zone C five southern states; and zone D two island territories. This strategic approach benefited from the gains made from more than 40 years of mass vaccination campaigns.

Following the OIE Pathway, zones A and D were declared (Figure 1) provisionally free from rinderpest in 1994, followed by zone B in 1996, and zone C in 1998. The second stage in the OIE Pathway, freedom from rinderpest disease, was declared for zone A in 1998, and for zones C and D in 2001. Although mass vaccinations in all the 21 states of zone B stopped on 1 March 1998, vaccinations continued in a 30-km belt bordering Pakistan in the three states of Punjab, Rajasthan and Jammu and Kashmir, until March 1999, July 2000 and October 2000 respectively. Consequently, 18 states in zone B attained freedom from rinderpest disease status in March 2001, with Punjab following in April 2002, Rajasthan in July 2003, and Jammu and Kashmir in October 2003. The third stage in the OIE Pathway, freedom from rinderpest infection, was executed in three phases for three consecutive years, from November 2001 to October 2004, following a rigorous rinderpest sero-surveillance programme in all four zones.

The ELISA Testing and Data Management Center at the Project Directorate of Animal Disease Monitoring and Surveillance in Bangalore designed the modality for stratified random sampling. The whole country was divided into three strata based on the epidemiological pattern of rinderpest described by the Task Force on Rinderpest in 1983, with the objective of achieving 95 percent probability of detecting 1 percent prevalence of rinderpest among herds (villages) and 5 percent prevalence within a herd (village). In all three phases, the 100 percent target for village sampling was achieved: with 74 178 cattle, 34 236 buffaloes, 12 546 sheep and 54 556 goats sampled in 3 866 villages. As well as sero-surveillance, states tested bovine stomatitis/enteritis cases; NPRE created a national network of 33 state-level rinderpest ELISA laboratories and 417 rinderpest vigilance units, which operated as check posts for regulating animal movements. The overall sero-conversion was more than 70 percent by the end of the national vaccination campaign in 2000.
Based on a dossier of evidence, OIE declared India free from rinderpest infection in 2003. The total cost of the vaccination campaign from 1955 until 2000 was nearly INR 1 668 billion (USD 33.36 billion). India has constituted a high-level National Animal Disease Emergency Committee to combat rinderpest immediately, should it re-emerge. At the state level, state animal disease emergency committees have been established, with a state rinderpest officer and supporting units functioning at the divisional level. A stockpile of 1.5 million doses of vaccine for emergency deployment within 24 hours is available; master stock of TCRPV vaccine seed virus is deposited at IVRI; NPRE has ensured that there are no potentially infected/virulent samples within the country, and rinderpest research is not allowed. State authorities have been instructed to report any suspected case of rinderpest immediately to the Government of India, and to initiate immediate zoo-sanitary and containment measures. The National Animal Disease Control Act (2009) will be enforced in the case of an emergency.

India has implemented long and arduous campaigns to achieve rinderpest eradication, through focused and committed approaches at central and state agencies, the coordination and monitoring of field operations, the mobility of field staff, vaccine quality control, the establishment of cold chains, sero-monitoring and sero-surveillance, and essential political and administrative support. The success of India’s NREP was a critical step towards the achievement of rinderpest control and eradication in the rest of South Asia.

Pakistan
Although Pakistan only came into existence in 1947, familiarity with rinderpest extended back over several centuries (Chaudhry and Akhtar, 1972). In 1947, rinderpest broke out owing to the large-scale livestock movements that took place at the time.
of independence (Khan, 1991), but the situation had been brought under control by 1950, through massive vaccination coverage. In the mid-1950s, the disease re-entered several districts of Punjab from India, and was finally controlled by 1961/1962. From 1958 to 1962 (Qureshi, 1972), outbreak reports from NWFP suggested that hundreds of thousands of animals had died (Raja, 1996), but there were no official statistics. Over the decade 1962 to 1972, the incidence of rinderpest was greatly reduced owing to a nationwide prophylactic vaccination campaign using live attenuated goat tissue and live attenuated lapinized vaccines that were believed to provide three years of immunity. Despite this large-scale vaccination, outbreaks occurred in Balochistan in the autumn of 1967 (Ali and Babar, 1987) and in the Swat District of NWFP in 1970. In 1958, rinderpest entered the Landhi Cattle Colony (LCC) of Karachi District, Sindh Province. Thousands of cases were seen every year, mostly during the winter. Localized outbreaks were reported from elsewhere in the country, including one in the autumn of 1987 in and around Quetta, and others in 1991 (Taylor, unpublished observations) and 1995 (Hussain et al., 2001).

The dairy cattle colonies around Karachi and Hyderabad drew constant supplies of replacement cattle and buffaloes from the interior districts of Sindh and Punjab Provinces. At the end of their lactation, most of these animals were slaughtered locally to meet the high demand for meat in the Karachi metropolis, but an increasing proportion were returned to the districts for repeat breeding. In LCC, 9,000 cases were recorded in 1969, and an annual average of 4,700 cases were observed from 1970 to 1974. The annual mortality rate dropped after 1975, when the Veterinary Research Institute (VRI) at Lahore started to manufacture TCRPV but in 1984 rinderpest was still killing about 700 cattle a year in LCC. Under a UNDP programme, FAO carried out a retrospective examination of the rinderpest cases reported by the LCC veterinary hospital from July 1983 to June 1984. This study showed that the virus was present in LCC throughout the year, but was more common in the winter months. In 1993, any local optimism that rinderpest was no longer causing outbreaks in LCC was dashed when the presence of the virus was confirmed by the World Reference Laboratory at Pirbright in the United Kingdom.

Although infected animals from Sindh endemic areas were probably occasionally traded in neighbouring Punjab Province, Punjab was never endemically infected, according to participatory disease search (PDS) interviews with village livestock farmers. Sindh Province was most likely the ultimate source of infection for outbreaks near Lahore in 1994 and in Rawalpindi in 1997 (Hussain, Haq and Naeem, 1998).

In March 1994, presumably through the transport of infected livestock by road, rinderpest broke out in the Northern Areas (NA) (Rossiter et al., 1998). Escalating in virulence to reach an 80 percent mortality rate in cattle and nearly 100 percent in yaks and yakmos (a yak-cow hybrid), within a short period the virus was responsible for the deaths of some 40,000 bovines in NA. FAO provided an expert mission in
less than a week to confirm the diagnosis. After confirmation, the EU, FAO and Italy implemented a series of emergency control projects (four FAO TCP projects, two EU projects on rinderpest, and an Italian project on transboundary animal diseases). Emergency rinderpest vaccination by the NA Department of Livestock Services began in August 1994, using vaccine manufactured by VRI, Lahore, but this could not eliminate the virus. In 1995, vaccination was repeated with imported vaccines, and with support from the EU and FAO. This second round of vaccination was apparently successful, and no further outbreaks were reported in NA after November 1995. Through implementation of these projects, diagnostic capabilities were enhanced at the district, province and federal levels, foreign manufactured vaccines were procured, the PDS system was set up, national veterinary laboratories were upgraded, and epidemiological units were established in all provinces.

From 1975, routine rinderpest vaccination was conducted using rinderpest vaccine available from VRI, Lahore. Vaccine was distributed annually, in accordance with the demands of the district veterinary authorities, which were responsible for its administration. It was most needed in Sindh, where it took seven years to achieve cumulative vaccination numbers that equalled the total number of livestock. Nevertheless, the judicious use of vaccine succeeded in breaking the transmission chain within the interior of this province. A massive uptake of vaccine in Karachi in 1989 to 2000 probably ensured that any rinderpest reaching the district did not become established or recycled. Further evidence was provided through the PDS programme, funded by FAO and operational from 2003 to 2005. Under this programme, departmental officers trained in PDS techniques visited all provinces covered by the Village-Based Active Disease Search Programme (Mariner et al., 2003). No clinical evidence of rinderpest was found. A total of 10 352 of Pakistan’s 75 702 villages were visited: 1 088 out of 1 644 villages in Azad Jammu and Kashmir; 888 out of 7 586 in Balochistan; 110 out of 150 in Islamabad Capital Territory; 823 out of 566 in NA (some villages were visited twice); 1 328 out of 14 325 in NWFP; 2 973 out of 26 174 in Punjab; and 3 142 out of 25 000 in Sindh. There were no official reports of rinderpest for three years after 1997. Although indirect evidence from Karachi and Quetta pointed to the existence of endemic foci in interior districts of Sindh throughout the 1980s and 1990s, the epidemiology was poorly understood. Most of the reported outbreaks were from Karachi, although outbreaks were occasionally reported in other districts. In spite of PDS evidence suggesting a possible continued rinderpest presence in Thatta District, Sindh Province, the absence of an official report for three years prompted the (premature) conclusion that rinderpest had died out in Pakistan (Hussain et al., 2001). However, the last outbreak in Pakistan was in 2000, on a farm at Memon Ghot Township, Karachi District, Sindh Province. This outbreak was discovered and confirmed due to heightened surveillance, supported by FAO, and was eliminated accordingly. Rinderpest was never again confirmed in Pakistan.

As vaccination had ended in 2000, a population of rinderpest-susceptible animals was available for sampling by 2003. To obtain serological proof of final rinderpest eradication, more than 70 000 animals nationwide were sampled during 2003, From 1975, routine rinderpest vaccination was conducted using rinderpest vaccine available from VRI, Lahore.
2004 and 2006, and tested using the OIE-approved, rinderpest competitive ELISA. For the sake of completeness, a similar data set was developed from 30 000 small ruminant sera with no indication of rinderpest virus in the population. None of these surveys found any incidence of positive rinderpest samples above the non-specific threshold.

In the light of these findings, a dossier of evidence was prepared and submitted to OIE in 2006. Accordingly, after approval from the International Committee of OIE, Pakistan gained entry to the OIE list of rinderpest-free countries in May 2007. Ultimate success was the result of transparent reporting of the presence of rinderpest in NA during 1994, emergency and follow-up support from FAO, EU support in providing high-quality vaccines, and federal and provincial livestock departments’ efforts in implementing the various initiatives for rinderpest eradication. Prior to this, the FAO Animal Production and Health Commission for Asia and the Pacific, in Bangkok (Thailand), had persistently encouraged member countries, including Pakistan, to develop and launch national rinderpest control projects/programmes to achieve the targets for rinderpest eradication set by GREP. All the facilities, systems and awareness that emerged within the veterinary and livestock communities helped finally to eradicate rinderpest from Pakistan.

Other South Asian and neighbouring countries

Bangladesh

Although the last recorded rinderpest outbreak was in 1958, because of the large number of cattle migrating from India to Bangladesh for slaughter, the following control measures were put in place: creation of an immune belt along the border, with regular vaccination, including of calves from three months of age, and revaccination within 12 months; routine vaccination of the susceptible population along the highway used to transport animals from border areas; and targeted vaccination in strategic areas. There were an estimated 5 million susceptible animals in border areas, and 2 million along the highway leading to large cities such as Chittagong and Dhaka. To meet the demand for large numbers of quality vaccine doses, a vaccine production centre was established in 1984 with support from the Asian Development Bank (ADB). In 1991/1992, annual production of goat tissue vaccine and tissue culture vaccine was 10.7 and 2.4 million doses, respectively. Over time, vaccine production shifted from goat tissue to the more reliable tissue culture vaccine; village-level veterinary personnel were significantly enhanced through training; and one central and nine district disease investigation centres were established to facilitate the prompt diagnosis and reporting of the disease nationwide. Vaccination ceased in 1999, and Bangladesh was declared officially free from rinderpest in 2010.

Bhutan

The last recorded outbreak was in 1969. Bhutan became a member of OIE in 1991, and declared itself free from rinderpest. Under the EU-funded Strengthening of Veterinary Services for Livestock Disease Control project, implemented in 1992,
Bhutan’s disease reporting, surveillance and diagnostic facilities were strengthened. A network of rinderpest vaccine stock was established at all zone (equivalent to district) veterinary laboratories, to meet the emergency requirements for a possible outbreak of rinderpest. Bhutan was declared officially free from rinderpest in 2005.

**Myanmar**

Although the last outbreak of rinderpest in Myanmar was in 1957, to prevent re-introduction of the disease, the country continued its vaccination programme along the international border in Rakhine State, Kachin State, Sagaing Division and Shan State, until 1994. With initiation of the OIE-supported Southeast Asia Foot-and-Mouth Disease Control Project and the FAO Greater Mekong Transboundary Animal Diseases Project, subregional collaboration and cooperation on disease control measures were strengthened, including through improved understanding and information exchange on the cross-border movement patterns of large ruminants. These epidemiological developments contributed to the overall understanding of transboundary animal diseases in Myanmar, and supported the OIE declaration of the country’s freedom from rinderpest infection in 2006.

**Nepal**

Nepal can be divided into three broad agro-ecological zones – Mountain, Hill and Terai (the Indo-Gangetic plain area) – and five regions: Eastern, Central, Western, Mid-Western and Far-Western. Rinderpest was first recorded in 1939, in the Kathmandu Valley (Hill zone), Central Region; the second outbreak was recorded in 1953 in the Pokhara Valley (Hill zone), Western Region. A serious outbreak occurred in Birganj (Terai zone), Central Region in 1954/1955. The outbreaks in the 1950s were brought under control by vaccination. FAO fielded an expert, who recommended the creation of an immune belt about 800 km long and 25 to 30 km wide, along the border with India; the establishment of internal check posts between the Terai and Hill zones; and capacity building in animal health. Severe outbreaks occurred in 1963/1964 in four districts in the Terai and one district in the Hill zone of Central Region, and from 1965 to 1969 in 26 districts, mostly in Far-Western and Mid-Western Regions and involving all ecological zones (Terai, Hill and Mountain). With the support of FAO, the EU and ADB, a mass vaccination programme was implemented. In 1964, FAO provided technical assistance for establishing a veterinary laboratory to produce rinderpest vaccine in Nepal, and the disease was brought under control. In 1973, rinderpest reappeared in eight districts in three regions, all in the Terai zone. The government continued to maintain the immune belt through regular vaccination. Rinderpest cases were reported in Kathmandu Valley (Hill zone), Central Region in 1984 and 1986, both in imported animals. An outbreak was also observed in Kailali District (Terai zone), Far-Western Region in 1986. These outbreaks were brought under control through ring vaccination and movement control. The last rinderpest outbreak was in 1990, and OIE recognized Nepal as free from rinderpest infection in 2002.
Sri Lanka

Sri Lanka was free from rinderpest for four decades from 1946 until its reappearance in 1987, in Eastern Province where civil disturbance persisted. A shipment of goats brought in by the Indian peacekeeping force was widely recognized as the source of infection. Mass vaccination was initiated in 1988, and as Sri Lanka did not have its own rinderpest vaccine production facilities, it had to import all the vaccine required, mainly from India. In 1988, a total of 638 000 vaccinations of cattle, buffaloes and small ruminants were carried out, representing coverage of 51.5 percent of the target livestock. The last vaccination was in 1997. OIE recognized Sri Lanka as free from rinderpest infection in January 2011.

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