

The long journey: a brief review of the eradication of rinderpest

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Summary

In 2011, the 79th General Session of the World Assembly of the World Organisation for Animal Health (OIE) and the 37th Food and Agriculture Organization of the United Nations (FAO) Conference adopted a resolution declaring the world free from rinderpest and recommending follow-up measures to preserve the benefits of this new and hard-won situation.

Eradication is an achievable objective for any livestock disease, provided that the epidemiology is uncomplicated and the necessary tools, resources and policies are available. Eradication at a national level inevitably reflects national priorities, whereas global eradication requires a level of international initiative and leadership to integrate these tools into a global framework, aimed first at suppressing transmission across all infected areas and concluding with a demonstration that this has been achieved. With a simple transmission chain and the environmental fragility of the virus, rinderpest has always been open to control and even eradication within a zoosanitary approach.

However, in the post-1945 drive for more productive agriculture, national and global vaccination programmes became increasingly relevant and important. As rinderpest frequently spread from one region to another through trade-related livestock movements, the key to global eradication was to ensure that such vaccination programmes were carried out in a synchronised manner across all regions where the disease was endemic – an objective to which the European Union, the United States Agency for International Development, the International Atomic Energy Agency, the African Union-Interafrican Bureau of Animal Resources, FAO and OIE fully subscribed. This article provides a review of rinderpest eradication, from the seminal work carried out by Giovanni Lancisi in the early 18th Century to the global declaration in 2011.

Keywords

Eradication – Rinderpest.

Introduction

Rinderpest is a disease of cloven-hoofed ruminants, including cattle, domestic buffalo, yaks and a number of wildlife species, caused by rinderpest virus (RPV), a member of the *Morbillivirus* genus within the sub-family *Paramyxovirinae* of the family *Paramyxoviridae*. Other members of this genus include the viruses of peste des petits ruminants, canine distemper, measles, phocine distemper, seal distemper and cetacean morbillivirus (1). Relaxed clock Bayesian phylogenetics was used (9) to show how the (still) closely related rinderpest and measles viruses diverged into identifiable entities between the 11th and 12th Centuries, a finding that – as far as rinderpest is concerned – is at variance with earlier proposals of an origin dating as far back as the domestication of cattle.

Early in the 18th Century, rinderpest emblazoned itself across veterinary history when the disease moved westwards out of Russia to cause a panzootic which engulfed most of Europe and caused immense losses among cattle stocks. Thereafter, rinderpest was regarded as one of the most dangerous pathogens affecting domestic ruminants, due to its frequently demonstrated ability to kill such animals in large numbers, thus striking at the very heart of attempts to modernise the livestock industry of enzootically affected countries.

The most comprehensive description of rinderpest is that given by Curasson (2), which emphasises the dramatic effects of a collision between a highly virulent strain of the virus and a totally naive livestock population, like that which occurred during rinderpest's final introduction into Africa. However, later descriptions portray a disease with a clinical intensity varying between per-acute, acute, sub-acute and even cryptic, and associated with a set of characteristic clinical signs and pathological lesions reflecting the virulence of the strain involved. These aspects of the modern disease are extensively reviewed by Rossiter (21).

The relief from this threat afforded by successful national eradication programmes and secured by incorporating them in a global programme led to the worldwide declaration of eradication in 2011. This paper reviews the 300-year-old battle against rinderpest.

Evolution, distribution and recognition

We do not have a detailed account of where rinderpest came from but we know it to be a disease caused by a virus within a genus that contains viruses affecting both humans

and a variety of domestic and wild animals, and the plausibility of a radiating spread from the heart of the Eurasian steppe country suggests that it evolved in the stock of nomadic livestock keepers at some time during the first millennium.

In the East, rinderpest was known in Korea and Japan by the 16th and 17th Centuries and in China in the 18th Century, while Spinage (24) considers that rinderpest was present in the Indian Madras Presidency in 1791. It can probably be assumed that no part of Eurasia was spared during the period of its initial distribution. Of course there were later secondary spreads to outlying islands, such as Ceylon (Sri Lanka), Taiwan, the Philippines and Indonesia. Its subsequent invasion of Africa came in the 19th Century, not by contiguous spread but as a direct result of the importation of infected cattle into Egypt and Abyssinia (Eritrea).

According to Gamgee (10), the mortality it caused among cattle throughout the whole of Europe, from 1710 to 1717, has perhaps never been equalled. In 1709, the plague passed from Tartary through Muscovy, into Poland, Bessarabia, Croatia and Dalmatia and from there into upper Italy and France. From Hungary, it travelled to the south of Germany and Switzerland and from Poland it spread north and south into Silesia, towards the shores of the Baltic. This was the start of a rinderpest epizootic which engulfed Europe and, in the ensuing century, cost the lives of millions of cattle.

At that time, the underlying engine for spreading the disease across the continent was military movement. Oxen provided the draught power for war, as individual campaigns assembled these animals in mobile groups, providing favourable conditions for internal and external disease transmission. In later centuries, livestock trade would provide the vehicle for the initiation of epizootics. However, the crucial epidemiological issue was that rinderpest transmission required close contact between infected and susceptible individuals.

With time, and presumably through exposure to different selection pressures, the rinderpest virus genome evolved into three discrete lineages which have been named in accordance with the continents where they were identified, according to modern phylogenetics, as Africa 1, Africa 2 and Asia 1. The recent realisation that strains of the Africa 2 lineage from West and East Africa had conserved their lineage inheritance while remaining geographically separated for 90 years – after an initial introduction through Abyssinia (Eritrea) – implies that the virus had changed little from that introduced into Africa from India in 1887. By the same token, it can be argued that lineage Africa 1 must have originated from a different introduction, most likely from one of the several 19th Century introductions into Egypt from southern

Europe or Mesopotamia. Fortunately, within this divergence, the virus retained serotype homology so that, when vaccines were eventually brought to bear, any given strain immunised against all others, engendering a long-lived immunity.

Several important epidemiological issues were identified at the beginning of the European epizootic of 1709. First, Johann Kanold (1679–1729), cited by Pastoret *et al.* (17), recognised the contagious nature of rinderpest, reporting in 1711 that rinderpest was transmissible and that cattle that recovered were resistant to re-infection. He also defined a ‘plague’ by three cardinal criteria: dissemination by contagion, high morbidity and mortality and with severe clinical findings.

Bernardo Ramazzini (19), the principal professor of medicine at the University of Padua in Italy, provided the first proper clinical description of bovine rinderpest. Although likening the condition to smallpox, and therefore calling it *variola bovina*, he identified the febrile nature of the disease, the associated pain, depression and anorexia, as well as the presence of characteristic nasal and oral discharges, oral necrosis and foetid diarrhoea, sometimes bloody. He also recorded the presence of skin lesions, leading to the analogy with smallpox.

Only lately have rinderpest experts come to appreciate fully the genetically controlled variations in viral virulence. Although per-acute strains of rinderpest predominated during the introduction of the disease into naive populations, such as those of Europe in the 18th Century and Africa in the 19th Century (and even in improved dairy herds maintained in Saudi Arabia and the Gulf States in the 1980s), accounts from areas associated with long-term endemicity frequently point to the emergence of strains of reduced virulence for cattle. This development would eventually require serological proof that eradication had been achieved.

Eradication became possible with zoosanitary control methods

Rinderpest has only ever existed within a simple transmission chain between susceptible animals, generally cattle but occasionally wildlife species, especially in Africa. This much was understood as early as 1715 by Giovanni Lancisi (14), the Pope’s personal physician, who considered that the disease was caused by ‘exceedingly fine and pernicious particles that pass from one body to another’. He also demonstrated the effectiveness of zoosanitary controls against rinderpest, recommending the

slaughter of all infected and exposed animals, while dismissing the vogue for treatment by stating: ‘My opinion is this. I would say that the prevention of contagion is the most excellent and only mode of averting the disease, that we must endeavour to preserve the oxen from being infected by giving them a proper diet and when they are infected the only thing which can save them from death is still a proper diet – as to bleeding and violent remedies, they are always hurtful in contagious diseases; and in a sentence of Hippocrates may here be well recalled to mind. *So act that if you do no good you at least do no harm.*’

In spite of the fact that the search for remedies and prevention through the inoculation of infectious material (17) was to continue for another century, the Lancisi principles were progressively applied across Europe during the 18th, 19th and 20th Centuries, to bring about separation, confinement, and branding of infected animals to provide traceability, isolation of infected premises, and sanitary cordons around infected farms. Subsequently, selective embargoes were introduced on the import and export of livestock during epidemics, together with health certification and quarantine of traded cattle. This policy was undoubtedly the most logical approach to combat rinderpest epizootics, but it understandably met much resistance and was therefore applied only sparingly, especially at the beginning. However, the measures were seen as too drastic and too costly. In addition, their strict application required a strong central authority, which was often lacking.

The pandemic hit England in 1714 in cattle shipped from the Netherlands. Thomas Bates, surgeon to King George I, was commanded (July 1714) by the Lord Justices to ascertain the plague’s nature and to effect its control. Bates, having been stationed as a naval surgeon in Sicily, was familiar with Lancisi’s edicts. He made six recommendations and applied them without the draconian penalties recommended by Lancisi, introducing instead a policy of indemnities. Bates’s campaign eradicated the disease from England within three months.

In France, the first effective legislation was passed on 10 April 1714: ‘Arrêt du Conseil’. This text, in addition to the stamping out undertaken beforehand, requested the disposal of carcasses and skin by burial at a depth of three feet (~0.91 m). This was reinforced on 16 September 1714 with the movement of animals from an infected area being forbidden. Unfortunately, it was impossible to apply the legislation to all areas. According to F. Vallat (30), this was due to a lack of qualified experts, uncertainty about the nature of the disease and the absence of centralised information and decision-making.

The ravages of cattle plague turned the attention of professional workers of all countries to the vast importance of studying the diseases of animals. The great want of

competent people to recognise the nature of diseases that affected cattle was one reason for the friendly support which greeted Bourgelat when, in 1761, he founded the first veterinary college in the world – that of Lyons.

In the Netherlands/Austria, the 'Edict van haere majesteit' of 10 November 1769 authorised the entire stamping out of infected and in-contact animals, with compensation. All these animals, according to the 'edict', should be disposed of, no more than ~2.4 m away from the outbreak location. In 1861, an international conference was organised in Vienna as a result of the increased incidence of the disease in Europe. The conference recommended that, in addition to studying the disease's aetiology and transmission, zoosanitary measures should also be enforced, as well as disease reporting. According to M. Hutyra (a Hungarian representative attending the 1921 international meeting on rinderpest, which was held in Paris), the implementation of the Vienna recommendations led to the eradication of the disease from Europe. The operation of a slaughter policy resulted in the obliteration of all infection from European countries, and careful regulation of the trade in livestock and their products has prevented its re-entry (30) – apart from the accidental reintroduction of rinderpest into Belgium in 1920. This dramatic event was the origin of the creation of the World Organisation for Animal Health (OIE) in 1924.

According to Spinage (24), in 1880, vigorous zoosanitary methods were implemented to combat the disease in Europe, pushing it towards the south-east, to the regions of Caspian and Caucas. In five years, the number of reported cases fell by 98%. In European Russia, 919,550 deaths were recorded in 1884 but, by 1896, Russia had also eliminated the infection. A turning point was reached in 1879, with the enactment of stringent zoosanitary legislation allowing the immediate slaughter of affected animals. These measures are credited with the eradication of rinderpest from European Russia by 1908, with only a few remaining pockets in eastern Russia.

Vaccine development for rinderpest control

This section attempts to recount the various steps in the development of prophylactic measures against rinderpest.

A group led by Professor Semmer (23) was employed by the Russian Emperor to develop an anti-rinderpest vaccine. The group had sought to experimentally immunise animals with an inactivated preparation of blood and nasal mucus (which could have worked), but ran into severe bureaucratic constraints. Instead, in 1893, Semmer and colleagues found that, if serum collected from recovered

cattle was inoculated into susceptible cattle, the latter were protected against rinderpest.

By the turn of the 19th Century, rinderpest had spread from East Africa to southern Africa, where the governments involved (Cape Colony, Natal and Transvaal) invited various European scientists (Robert Koch, Paul Kohlstock, Jules Bordet, Jan Danysz) to help them find a method of controlling the disease, as well as using zoosanitary measures. Robert Koch advocated immunising with the bile of an infected ox which apparently worked, but not always. Presumably the lipid solvents in the bile inactivated the virus beforehand. In 1897, Koch's reputation was further enhanced when the German government requested that he leave the Union of South Africa and visit India where, at the Imperial Veterinary Laboratory at Mukteswar, he declared that the disease known as rinderpest in South Africa and cattle plague in India were one and the same. In the end, though, the bile method did not gain the widespread acceptance obtained by a simultaneous serum-virus method of active immunisation (28, 29). The latter was based on an earlier discovery by Semmer of the protective power of immune serum. This technique became the standard prophylactic procedure until the 1920s, helping to eradicate rinderpest from southern Africa and, until the advent of live attenuated vaccines, to control it elsewhere.

In the 1920s, a number of workers succeeded in actively immunising cattle against rinderpest using inactivated preparations based on lipid solvents. Daubney (3) felt that such preparations were cheaper than the costly and laborious simultaneous serum-virus method. In 1926, in India, Edwards began an attempt to exclude bovine piroplasm from the inoculum to be used in the simultaneous serum-virus method of immunisation. His initial choice of host was rabbits, but when the Mukteswar rabbit colony was lost he began to adapt the virus to goats, only to find that serial passage in this species resulted in attenuating the virus's effect when inoculated into cattle, without the addition of immune serum (4). Goat tissue vaccine (GTV), as it became known, was widely used in India in the 1930s and 1940s and in 1953 Daubney recommended that it should be employed in an attempt to eradicate rinderpest from India. Scott (22) suggests that, by this time, the virus would have undergone approximately 600 passages in goats. Goat tissue vaccine remained in production in India until 1973. In Africa, the Kenyan 'Kabete O' strain of rinderpest was separately attenuated in goats around 1940 and became known as Kabete attenuated goat (KAG) vaccine.

In 1938, a valuable vaccine was developed in Korea by Junji Nakamura by adapting the virulent Pusan strain to rabbits. This product (lapinised rinderpest vaccine or LRV) was widely used and the Food and Agriculture Organization of the United Nations (FAO) promoted eradication campaigns

in the Far East during the 1950s, at which time Chinese workers were independently sub-passaging the virus in goats and sheep to attenuate it for use in yaks.

Each of the above vaccines could assume a degree of virulence in either hyper-susceptible or debilitated animals and, as rinderpest control levels grew and the fear of rinderpest declined, there was a demand for a safer attenuated vaccine. The problem was solved when Plowright and Ferris (18) grew the Kabete O rinderpest virus in tissue cultures of calf kidney cells and demonstrated that, by the 90th serial passage, the virus (tissue culture rinderpest virus [TCRV]) was stably attenuated and both easy and cheap to produce. It quickly became the vaccine of choice in all control and eradication programmes and would still be used by most of the world if a fresh need ever arose. More recently, Mariner *et al.* increased the unprotected shelf-life of lyophilised TCRV vaccine to 30 days at 30°C (16).

During the past decade, recombinant rinderpest vaccines were developed in Britain, Japan and the United States (USA). However, they were not acknowledged by any National Licensing Agency and are not included in the OIE *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals* (32).

The impact of different control and eradication models involving the vaccination of cattle

While acknowledging that a stamping-out policy is undoubtedly the most efficient method to rid a country of an infectious disease, in some parts of the world, for economic or religious reasons, other methods have had to be applied. In effect, this has meant the use of vaccines to reduce the incidence of the disease with the option of

upgrading the intensity of coverage to deny transmission opportunities and achieve eradication.

National control campaigns against rinderpest were first begun in several African countries and Asia in the middle and late 1940s, with considerable success. With time, rinderpest vaccination became the preferred means of attempting to eradicate the virus. However, initial successes, both in Africa and India, were eroded due to the transboundary nature of the disease and the lack of epidemiological follow-up measures. Nonetheless, with time and a growing awareness of the need to concentrate vaccination in areas where the virus was epidemiologically active, success ensued. In the last 50 years of eradication, almost three billion cattle were vaccinated worldwide (Table I), based on the different models described below.

Edwards's Union of Burma vaccine model (1936 to 1940)

Shortly after developing the goat-attenuated strain of rinderpest, and long before the concept of global eradication was mooted, in the Union of Burma (Myanmar), Edwards (4) noted the effects of raising the national herd's immunity level against rinderpest through successive annual vaccination campaigns. This vaccination strategy benefited considerably from a prior understanding of the local epidemiology of the virus, which maintained an epidemic prevalence in the central Irrawaddy River valley but was only occasionally present in the surrounding hill tracts. Vaccination campaigns were deliberately varied in intensity between epidemic zones, which were the initial targets, and the surrounding endemic zones, so that in a given year immunisation rates varied from 20% to 88%. In other words, the use of vaccination was maximised at the point where maximum virus transmission was occurring. Edwards understood that the effectiveness of his live attenuated goat vaccine could be exploited to eradicate rinderpest in two ways. The ideal method would be to administer a pulse of vaccine across the entire susceptible bovine population in a short period of time but he lacked the capacity to achieve this. More pragmatically, he

Table I
Total vaccination by region

Decade	Region							Total
	West & Central Africa	East Africa	Egypt	Near East	South Asia	South-East Asia	China	
1950s	7,521,563	13,416,545	0	1,225,263	51,660,000	6,152,359	23,059,708	103,035,438
1960s	101,863,954	43,337,940	0	14,283,458	244,110,636	7,959,715	0	411,555,703
1970s	88,544,286	88,502,190	0	36,652,622	522,338,765	9,220,000	0	745,257,863
1980s	155,867,844	81,274,910	39,502,931	66,946,391	698,262,930	3,341,000	0	1,045,196,006
1990s	119,189,782	163,573,067	19,993,589	102,938,147	298,275,783	44,000	0	704,014,368
2000s		1,131,032						
Total	472,987,429	390,104,652	59,496,520	222,045,881	1,814,648,114	26,717,074		3,009,059,378

proposed the value of raising the population immunity level to 60% as the minimum rate for ensuring that the virus could not maintain itself within a closed population, and exploiting the lasting immunity conferred by a live attenuated rinderpest vaccine to build up the immunity level over more than one vaccination season. Unfortunately, Edwards's wisdom was never fully understood or put into practice.

The Chinese eradication model (1950 to 1957)

Before 1949, rinderpest was endemic in China and broke out at intervals of three, five or ten years, causing the deaths of thousands of cattle. Between 1938 and 1941, an outbreak struck Sichuan, Tibet and Qinghai, causing the deaths of more than one million cattle and great economic losses. After the founding of the People's Republic of China in 1949, it was seen that there could be no agricultural development until eradication had been accomplished; accordingly, strict rinderpest prevention and control measures were carried out. Many different types of rinderpest vaccines, suitable for use in China, were successfully developed and, consequently, rinderpest was soon brought under control. Rinderpest was known to be seasonally epidemic in China, occurring mostly in winter and spring. By adopting an integrated approach that combined epidemiological knowledge with compulsory vaccination, and zoosanitary measures based on rigorous stamping out, disinfection and surveillance against reintroduction, China became the first country in the modern era to succeed in eradicating rinderpest. An intensive vaccination programme was the method of choice. Early live vaccines retained unacceptable virulence for some breeds of Chinese cattle but especially for yaks. However, this problem was resolved with the development from the Japanese lapinised vaccine virus of a live goat-and sheep-attenuated vaccine, made from the lymph nodes, spleen and blood of affected animals. After intensive vaccination campaigns of short duration (1950 to 1955), no outbreak has occurred since 1955.

This is an example of how an integrated approach, combining zoosanitary measures with vaccination and epidemiological understanding, produced an eradication programme that could be efficiently managed for a rapid result. This model stands in contrast to the Indian model (see below), which failed to achieve similar success.

The Indian model (1956 to 1996)

With Edwards's GTV becoming available in 1931, rinderpest vaccination was increasingly being implemented throughout India but never at an annual uptake rate of more than 15% to 20% which, not surprisingly, made little impact on the six-figure annual rinderpest death rate (11).

A National Rinderpest Eradication Programme was launched in 1954, essentially following the Burma (Myanmar) model of employing vaccination alone, as zoosanitary measures, such as stamping out, were culturally unacceptable in India; although movement control measures were attempted in the initial phases of the programme. There was, however, no prior examination of the epidemiology of the virus or investigation into how intensive vaccination could be used to achieve maximum effectiveness.

The objective of the campaign was to build up to an 80% prevalence of immunity within a national bovine population of 300 million, within five years, and then to continue with annual vaccination campaigns in yearlings. Individual state government Veterinary Services were responsible for implementing the programme. Initially, spectacular results were achieved and within five years the rate of infection fell from 2,000 per million head of cattle to 7 per million head. Between 1954 and 1990, almost 1.5 billion cattle were vaccinated (6).

An inherent weakness in the programme lay in the fact that, while rinderpest was widely endemic across the Deccan Peninsula, the programme adopted a phased approach, with uptake progressing from the southern states northwards and westwards. In most states the initial thrust was greatly reduced, and there was a general failure to eliminate the virus. Then, with inter-state movement of cattle proving difficult to control, the virus gradually reasserted an enzootic profile, so that, in spite of annual vaccination for the next 30 years, rinderpest remained entrenched in southern India.

Although much had been achieved, this vaccination-only model seemed destined to fail in eradicating rinderpest in India. In 1983, therefore, the government of India commissioned a Rinderpest Task Force Report that called for a fresh programme, based on the best epidemiological understanding then available. The recast programme (the National Programme for Rinderpest Eradication – NPRE), introduced in 1990 and jointly supported by the Indian government and the EU, was provided with a central coordinating unit and a limit of five years in which to achieve success. Giving the programme a deadline had a catalytic effect across the country. It also aided the programme managers in their adoption of the newly proposed OIE Rinderpest Pathway (verification and accreditation of rinderpest freedom), which also incorporated a timetable for delivering evidence that a country (or zone within a country) had achieved freedom from infection.

The states of north-east India, which were apparently free of endemic infection without vaccination, were added to the OIE Pathway as Zone A; the states of north-central India became Zone B and, with no evidence of enzootic

infection, were encouraged to end vaccination before joining the Pathway. At the time, this was seen as involving considerable risk but was central to the time limit, while the enzootically infected states of southern India became Zone C and adopted a pulsed, immunosterilising, two-year-long intensive vaccination strategy which was highly successful and led to the eradication of rinderpest. The last case was detected in 1995 in Tamil Nadu.

The resolution of the seemingly intractable problem of enzootic rinderpest in southern India came from the creation of a central coordinating unit, pushing a policy of intensified vaccination in southern India that would eradicate the disease within a short period of time, even if this involved apparently taking some risks by ignoring the possible presence of sub-clinical infection and ending vaccination in states that were no longer reporting clinical disease. Serosurveillance results not available at the time later confirmed the absence of sub-clinical strains. The development and promulgation of the OIE Rinderpest Pathway were of immense assistance in this respect. These results also demonstrated that pulsing vaccination of a residually infected area could eliminate the virus.

The African model (1890 to 1981)

By the early years of the 20th Century, rinderpest had been eliminated from the southern part of the African continent through a mixture of pragmatic zoosanitary controls and the introduction of the simultaneous serum-virus method of immunisation.

In the ensuing years, East and West Africa (and Egypt) remained enzootically infected as individual government Veterinary Services constantly endeavoured to control the disease through vaccination, quarantine measures and movement controls. However, as nomadic pastoralists were frequently involved, the slaughtering of sick animals was not employed as a stamping-out method.

Tanzania took on a unique role in the control of Africa's rinderpest situation, with its national Veterinary Service assuming responsibility for preventing any repetition of the disastrous spread of rinderpest to its southern neighbours, where cattle populations were again totally susceptible. Tanzania thus became 'keeper of the gate', a position the country maintained for almost a century. The gate needed to be strengthened during World War I (1914 to 1918), when there were both German and British troop movements in the south of the country. Consequently, at the behest of South Africa, between 1917 and 1918, an immune belt of cattle was established between Lake Nyasa and Lake Tanganyika. The belt was kept for several years although the disease was enzootic between the two tropics. In Tanzania and elsewhere, rinderpest, either through reductions in virus virulence or rising levels of population

immunity, no longer maintained the same 'plague' profile as on its first introduction.

In 1961, the Interafrican Bureau of Animal Health, under the direction of W. Beaton, having observed the development of various rinderpest vaccines, envisaged the possibility of a continent-wide rinderpest eradication scheme. At a conference held in Kano, and attended by representatives from Cameroon, Niger, Nigeria and Chad, a decision was taken to launch a regional campaign in the river states of the Lake Chad Basin. Thus began the first international rinderpest eradication campaign (Joint Programme 15 or JP15). With a remit supported by the Scientific and Technical Committee of the Organization of African Unity, and with funding from the European Development Fund and the United States Agency for International Development (USAID), this programme proceeded to enrol the cattle of West and East Africa in three successive annual rinderpest vaccination programmes, a phased approach which aimed to deliver herd immunity levels in excess of 90%. This objective was accomplished, and JP15 succeeded in eradicating rinderpest from a number of Central and West African countries.

Unfortunately, JP15 had neglected to develop an exit strategy. In the absence of the OIE Pathway at that time, although residual immunity levels persisted and national Veterinary Services made attempts to maintain them, a few years after JP15 ended, rinderpest returned to all countries across the sub-Saharan region, causing what became known as the second African epizootic. The virus spread rapidly along trade routes: lineage 1 spreading from Ethiopia, through Sudan and Chad, to eastern Nigeria, while lineage 2 spread from Mali, through Haute Volta (Burkina Faso) and Niger, into western Nigeria and also invaded a number of the coastal states of West Africa.

Synchronised recourse to vaccination; the international eradication model based on simultaneous action in all residually affected areas

With the collapse of the post-JP15 immunity levels and the resumption of rinderpest transmission across sub-Saharan Africa, new initiatives were called for. The FAO became involved through the provision of highly successful emergency assistance to West African countries attempting to regain control of the disease. However, at much the

same time, there were indications that the Indian government's Operation Rinderpest Zero was not yielding the desired result. In addition, there was an upsurge of rinderpest outbreaks in various non-enzootic Gulf States (25), caused by poorly regulated trade in infected live cattle from the sub-continent.

Both the OIE and FAO realised that it was essential to eradicate rinderpest in India and Pakistan because rinderpest had been shown to persist as a cryptic infection in cattle, able to regain virulence and re-infect territories from which it had been cleared. For global eradication to stand a chance of success, it was imperative that the virus be attacked across its entire distribution range at the same time.

Through a series of meetings, such as the 1983 Expert Consultation in Izatnagar, India, for a rinderpest eradication campaign in South Asia, and the 1987 Expert Consultation in Rome, on a global strategy for the control and eradication of rinderpest, including vaccination campaigns, a consensus programme was initiated, involving the Pan African Rinderpest Eradication Campaign (PARC), the West Asia Rinderpest Eradication Campaign (WAREC) and the South Asia Rinderpest Eradication Campaign (SAREC). In Africa, the EU undertook to support the new Organization of African Unity in its aim of eradicating the disease through PARC. India was already involved in a (stalled) eradication programme. The EU supplied the impetus for a further effort to achieve eradication within a given deadline through NPPE. The EU did not favour a South Asian coordination unit but nevertheless supported bilateral rinderpest eradication programmes in Nepal, Bhutan and Pakistan from 1989 to 1997. A companion programme, WAREC, was begun in 1989 with funding from the United Nations Development Programme. Heavily supported by the OIE and FAO, the PARC-WAREC-SAREC concept – for which Dr Yoshihiro Ozawa (Chief of the Animal Health Service of FAO at that time) was responsible – ensured that parallel vaccination campaigns took place in all affected territories at the same time, thereby eliminating or greatly reducing the chances of movement of the virus from one infected country to another, or the survival of residual pockets of infection at the conclusion of the campaigns.

Hard on the heels of these initiatives came the report of the OIE Expert Consultation on Rinderpest Surveillance Systems in 1989, which developed a set of criteria within a defined time frame to successfully demonstrate freedom from rinderpest infection. The most important criterion was that, where a country (or zone) had experienced no clinical disease for two years, vaccination should end and a set of serological and clinical surveillance criteria should be initiated. The significance of this report can scarcely be overstated as, once accepted by a country trying to

eradicate rinderpest, it finally provided a means of either detecting residual cryptic infection (and dealing with it) or verifying the total absence of virus transmission. The application of a set of easily understood criteria in a post-vaccination situation was a novel step and one that was to drive the process of rinderpest eradication to a logical conclusion.

In 1995, OIE Member Countries established the procedure for official recognition of freedom from rinderpest and endorsed the decision to establish a baseline list of OIE Member Countries that had historically been rinderpest-free. The Foot and Mouth Disease and Other Epizootics Commission (today, the OIE Scientific Commission for Animal Diseases), in turn, forwarded its proposals on the recognition of rinderpest-free status of Countries and Territories to the World Assembly of OIE Delegates for adoption (31).

The West Asian model (1989 to 1994)

The West Asia Rinderpest Eradication Campaign aimed to establish the capability to:

- determine levels of immunity in participating countries
- identify areas where revaccination was required
- rapidly create a situation where immunity levels were sufficiently high (over 85%) to break virus transmission and lead to eradication.

The immediate objectives were to minimise the high losses associated with livestock deaths and poor productivity if they recovered, as well as to create confidence in the ability of the vaccination programme to eradicate the virus. Although the Gulf War caused the relocation of WAREC management from Baghdad to Amman, it nevertheless succeeded in intensifying vaccination across the West Asian region and eliminating several troublesome foci of infection.

The new African model (1982 to 2003)

After JP15, with the decline of veterinary activities in the field, the level of immunity also declined and a new panzootic of the disease swept across equatorial Africa from 1978 to 1983, killing hundreds of thousands of domestic and wild animals from Mauritania to the Sudan. The spread of the disease was stopped through emergency vaccination campaigns, organised in the majority of countries from 1978 to 1985, with the help of various sources of funding: FAO, EU, France, the World Bank, Official Development Assistance (ODA/UK), USAID. In particular, the responsiveness of FAO to the emergency led to a rapid curtailment of the disease in Central and West

Africa and provided a breathing space for the launching in 1987 of a fresh, internationally funded PARC. The Pan African Rinderpest Eradication Campaign's main activities, supported by the European Development Fund, included mass vaccination, disease surveillance, and the restructuring of Veterinary Services, including partial privatisation of activities (to stimulate more participation from livestock keepers).

Based on the success of its emergency vaccination campaigns, and with the benefit of a Japanese trust fund, FAO maintained an epidemiology unit within the PARC management system and modelled strategies for the most effective use of vaccination within the programme. The proposed FAO-PARC strategy was to put an early end to vaccination in West Africa (apparently freed of rinderpest in 1987), build a protective barrier of immune cattle in Central Africa (the Central African Republic and Chad) and concentrate epidemiological efforts in Sudan and Ethiopia (26). However, bearing in mind the risk of a re-incursion, due to a complex epidemiological situation, the Interafrican Bureau of Animal Resources (IBAR) and the governments involved continued annual vaccination campaigns in West Africa, thereby delaying their countries' first steps along the OIE Pathway and the timely production of clinical and serological surveillance data.

For six years after its inception, PARC was unaware of the presence of a further residual focus of enzootic rinderpest in the cattle of southern Somalia, associated with a mild strain of the virus (as were the Somali Veterinary Authorities). In 1993, this virus strain entered eastern Kenya, then believed to be rinderpest-free, initiating a transmission chain associated with clinical disease among various wildlife species but not in cattle. Mortality estimates exceeded 29,000 Cape buffalo, 3,000 eland and 7,000 giraffes (12, 13). The source was attributed to a group of refugee-owned cattle that crossed into Kenya from Somalia. The virus also spread within northern Tanzania, without initiating a clinically obvious [Taylor] cattle epidemic (27), and was eradicated using the vaccine-induced 'immunosterilisation' model.

Towards the end of 2000, rinderpest was reported from the Upper Nile region of Southern Sudan (20). In a complicated endeavour to reach this war-torn area of Africa, the FAO (with the project Operation Lifeline Sudan of PARC) worked with the United Nations Children's Fund (UNICEF) and the US Office for Foreign Disaster Assistance to deliver thermostable rinderpest vaccine to the owners of the affected livestock and eradicate the last vestige of lineage 1 from Africa. PARC was followed by the Pan-African Programme for the Control of Epizootics (PACE), with the OIE chairing the advisory committee of the latter. Between 1986 and 1997, a total of

350,484,854 animals were vaccinated. The last use of vaccine on the African continent was in 2003 (on the Kenya–Somalia border) (6).

The South Asia Rinderpest Eradication Campaign model (1989 to 2000)

Contrary to the opinion that international coordination was required for these campaigns, with external support from the EU, national Veterinary Services clearly appreciated that they were participating in a global thrust against rinderpest and formed a loosely coordinated network to fulfil SAREC's objectives. The South Asia campaign consisted of a series of independent projects: one in India, one in Nepal and one in Bhutan, which were paid for by their national governments and the EU. Pakistan did not enter the initial SAREC network but later participated with the assistance of an FAO trust fund established by the EU. However, the projects were timed to coincide with the FAO concept that all rinderpest-affected countries should act at the same time (7).

The South Asia Rinderpest Eradication Campaign avoided the widespread use of mass vaccination, concentrating its use in foci where virus transmission was known to be occurring. The last occurrence of rinderpest in India was in 1995 and in Pakistan in 2001.

Conclusions on the use of vaccine to achieve eradication

Regarding the use of rinderpest vaccine as a tool to eradicate the virus, two important conclusions may be drawn. First, as shown during JP15 and during the first 30 years of vaccination in India, mass vaccination of entire, epidemiologically graded populations is an extremely blunt and expensive tool. While undoubtedly able to reduce the rate of virus transmission in affected areas, concentrating on repeatedly vaccinating extremely large numbers of animals – most of which were not at risk – distracted attention from the existence of residual foci and the persistence of the virus in contaminated trading environments.

The corollary to this was that, when the use of vaccine was concentrated on transmitting populations, a successful outcome rapidly ensued. This was a lesson that should have been learned from Edwards's work in the 1930s. It continued to prove its worth during the FAO-supported emergency vaccination campaigns in West Africa in the early 1980s, and in the terminal stages of NPRES in India, when mass vaccination was ended in the non-reporting states of North and Central India to concentrate on the still-affected states of southern India.

At times, there might be non-compliance with blanket vaccination for a variety of reasons:

- livestock keepers knew about rinderpest and were aware that there was no risk of it occurring at that time
- conflict with neighbouring clans made it dangerous to move livestock to the vaccination point
- lack of grazing at the vaccination point
- the presence of other diseases (e.g. tick-borne disease) in the vaccination area.

Several problems were encountered: instability in several countries (Central Asia, the Horn of Africa, etc.); limited human resources and stakeholder involvement; an inadequate cold chain and problems with transport and equipment; insufficient finance for effective delivery of veterinary services; poor infrastructure, and inadequate communication and consultation between the field staff and their headquarters. The uncontrolled movement of livestock across borders within countries compounded the problem, as vaccination, surveillance and general disease management were extremely difficult in times of civil strife.

The only country which reduced its rinderpest incidence to zero, without recourse to a mass vaccination campaign, was Pakistan where the last detected outbreaks occurred in Karachi in 2001. However, detailed back-tracing failed to reveal one source of infection, leading to the conclusion that these stock had become contaminated in transit. The reason for success in Pakistan is difficult to pinpoint. Given the country's poor use of vaccine in the preceding years, it undoubtedly included non-specific factors, such as higher levels of veterinary policing in markets and an awareness of what had already been achieved in neighbouring SAREC countries.

Technical constraints and solutions during the surveillance phase of eradication

More than zoosanitary controls and vaccination were required to reduce the incidence of reported rinderpest to zero. A further massive surveillance effort, based on serosurveillance in unvaccinated livestock, plus intensive clinical searches of village livestock, was needed to bring the global eradication effort to a timely conclusion. There were effectively two distinct phases in the rinderpest eradication process: the first being to drive the virus to extinction and the second, to prove that this had happened.

The surveillance phase was initially built around the OIE Pathway. It was also intended to generate enough data for the OIE and FAO to be able to confidently announce the global eradication of rinderpest and the abolition of rinderpest-imposed restrictions on international livestock trade. The technical areas where attention was required are discussed below. The guidelines for surveillance were originally developed and published in 1989 by the OIE to assist its Member Countries in demonstrating freedom from rinderpest after vaccination. Surveillance was a prerequisite to ending vaccination and to proceed to the next step of the Pathway leading to disease freedom (31).

Diagnostics

As part of the effort to achieve global eradication, there was a great need to improve the existing diagnostic tests to detect the virus and develop more rapid tests to confirm the virus. At the beginning of JP15, confirming rinderpest using an agar gel immunodiffusion test (AGID) required 4 days but that time was eventually reduced to 2 hours. Virus isolation in cell cultures took 14 to 28 days and, even then, neutralisation tests were required to confirm identification of the virus (or reference to experimental cattle). Thus, there was a need to develop methods that would both identify the virus rapidly and, to assist tracing back, determine the lineage of the virus causing the particular outbreak. By the end of the programme, using polymerase chain reaction (PCR) technology, reference laboratories could confirm the identity of the virus and its lineage with considerable precision.

Last remaining foci and mild rinderpest strains

Some forms of rinderpest were very mild and could remain in a few areas in a more or less cryptic state. An intensive campaign in early 2000 by the Global Rinderpest Eradication Program (GREP) was able to target the six areas (Yemen/Saudi Arabia, Turkey/Iraq, Pakistan/Afghanistan, Mongolia/China/eastern Russia, southern Sudan and the Somali ecosystem) where the virus was suspected to be present, areas that could be determined since surveillance data had become available (20). The mild strains (believed to be only in the Somali ecosystem focus) were maintained in susceptible yearling cattle after the waning of maternally acquired immunity. This mild strain had been observed in pastoral areas of Africa since the late 1950s and early 1960s. Piecing together all participatory disease search or surveillance (PDS) information available, it was possible in retrospect to see a pattern of related events. In the Somali pastoral ecosystem of north-eastern Kenya and southern Somalia, rinderpest reappeared periodically, showing a cycle of about five to six years in alternation with a more virulent form (5). Thus, in these six areas, FAO suggested a strategy of 'seek, contain, eliminate and verify'. In other words,

surveillance should identify the areas of endemic maintenance and, within these areas, the foci of active disease transmission. The surveillance tools included PDS and wildlife surveillance. This PDS approach would have been able to identify the endemic maintenance areas and trigger management strategies based on the risk. Apart from the Somali ecosystem, disease search, as well as verification, was employed. Focused vaccination campaigns would then be used to 'immunosterilise' these foci.

Vaccine quality assurance

In Africa and India, vaccine quality control became an issue when a few manufacturers were unable to maintain potency levels – a fact demonstrated in 1984 by the Institute for Animal Health (IAH), Pirbright. With an internationally sponsored PARC campaign about to begin, this situation required remedial action. The answer came with the establishment of FAO Pan African Veterinary Vaccine Centres (PANVAC) in Ethiopia and Senegal, providing independent rinderpest vaccine quality assurance as well as training in production procedures. This initiative proved to be a real success, with the African Union taking over and sustaining PANVAC in Debre Zeit (Ethiopia) as one of its regional institutions.

In 1991, the OIE Biological Standards Commission began a programme to develop international standards for the laboratory diagnosis of rinderpest and the manufacture of rinderpest vaccines. The resulting guidelines were incorporated into the rinderpest chapter of the OIE *Terrestrial Manual*, with regular revision. This resulted in the harmonisation of test protocols and the designation of reference reagents to be used in these tests, facilitating surveillance and greatly contributing to the successful outcome of the campaign for rinderpest eradication. The technical expertise was provided to the OIE and its Member Countries by two FAO/OIE Reference Laboratories on rinderpest; namely, IAH (Pirbright, United Kingdom) and CIRAD (Agricultural Research for Development) (Montpellier, France).

Seromonitoring

With the genesis of PARC and the need to strengthen Veterinary Services in Africa came the realisation that a technique was needed to monitor the uptake of vaccination in cattle, under any strategy, and the extent of the coverage achieved, where a seroconversion rate of 80% was the objective. This task was funded by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture or AGE. In each country, the cattle population's immunity level to rinderpest was monitored by collecting seromonitoring data, which gave an idea of the efficacy of the vaccination campaign in each country. The

seromonitoring teams were provided with vehicles and equipment and their sole duty was to collect sera and screen them for antibodies against rinderpest, using enzyme-linked immunosorbent assay (ELISA). At first, this was an indirect ELISA but then a competitive test was used. The seromonitoring results were presented at the annual AGE Research Coordination Meetings and published afterwards. If the seroconversion rate was shown to be sufficient, the country could declare itself as being provisionally free from rinderpest to the OIE, and begin to follow the next steps along the Pathway.

Pathway surveillance methods

A number of rinderpest surveillance issues arose as a result of the development of the OIE Pathway. Its initial purpose was to provide a five-to-six-year framework, within which a country that had previously reported rinderpest could qualify as being rinderpest-free for the purposes of international trade. To this end, the Pathway required that a country in which vaccination had been used to apparently reduce the clinical incidence to zero should publicly cease vaccination in a declaration of provisional freedom from rinderpest. The country's task was then to provide evidence of this freedom through structured clinical surveys and serological evaluations, the results being encapsulated in a dossier of information submitted to the OIE for evaluation (31). Over the last 25 years of the eradication process, almost two million serum samples were collected and analysed.

Clinical surveillance

Surveillance systems to detect clinical rinderpest in cattle or buffalo were adapted and applied to different situations in individual countries and ecosystems, as well as answering the needs of the prescribed stages of global eradication. The AGE guidelines on performance indicators for the completion of the eradication effort were seminal for their scope and depth. Outbreaks of rinderpest were, of course, reportable to the OIE but the thrust of this extremely important programme was to generate data based on meaningful veterinary searches within the community that had previously experienced rinderpest infection, in the form of negative incidence reports. These would later be included in a country's dossier of evidence of freedom from rinderpest.

While on the Pathway, villages' livestock populations or other defined pastoralist livestock holdings were subject to an annual Veterinary Services search for rinderpest during each of the five years after vaccination ended. A statistical formula could be applied to determine the required number of searches. In a number of countries, past exposure to the disease had created government Veterinary Services that were skilled in rinderpest

recognition and well qualified to undertake village searches. In India, where government veterinary outreach provided one veterinarian to every five or so villages, every village in the country was searched on several occasions each year.

In Pakistan and elsewhere, these searches were undertaken by specially trained animal health assistants, working at the village level and using PDS to determine when livestock keepers first noticed the absence (or last noted the presence) of the disease (15). Elsewhere, the same methodology was adopted by community-based animal health worker networks.

In Africa, after PARC, a continuity programme for the control of epizootics (PACE) was initiated (from 1999 to 2006), with the financial support of the EU and under the guidance of an international advisory committee, chaired by the OIE and comprising FAO, IAEA and rinderpest reference laboratories (Pirbright and Montpellier). This programme aimed at strengthening and establishing sustainable animal disease surveillance in sub-Saharan Africa, covered 32 sub-Saharan countries, and was coordinated through IBAR. It had considerable success and, in the end, the disease appeared to be restricted to two main regions; namely, southern Sudan and the southern Somali ecosystems, two areas affected by chronic conflict. Countries were reliant on PACE to develop their OIE Pathway surveillance data.

The PACE programme helped to collect information for accurate disease reporting, risk analysis and determination of animal health status, for international trade as well as for internal decision-making. Surveillance data underpin the quality of disease reporting and provide the basis for accurate risk analysis. Such data are also essential to support claims for a particular disease/infection status. Within PACE epidemicsurveillance, clinical and serological surveillance systems and laboratory networks were established, together with disease data management systems and diagnostic skills.

Serological surveillance

The other essential component in demonstrating that rinderpest eradication had been achieved within a population was to sample unvaccinated cattle and buffalo for rinderpest antibodies using an indirect ELISA. A test using a specific monoclonal antibody was widely adopted across countries involved in rinderpest eradication, a notable exception being India, where a separate competitive ELISA was developed. After self-declaration of provisional freedom from the disease, each country was to assess, through serosurveillance, the trend of antibodies in its population. Statistically significant numbers of samples were collected to obtain evidence of freedom from disease as well as freedom from infection status (31). The

serosurveillance results for individual countries were included in their submission dossiers to the OIE.

Clinical and serological surveillance in wildlife

When clinical rinderpest erupted in wildlife in Tsavo National Park, Kenya, in the mid-1990s, there was a realisation that highly susceptible species, such as eland and lesser kudu, had acted as sentinels for a mild (cryptic) strain of rinderpest that was affecting cattle sub-clinically (12, 13). From these extremely important observations grew the awareness that thorough surveillance in game species was a prerequisite of global eradication. Training workshops were held on wildlife epidemicsurveillance and also on wildlife game capture techniques. Efficient wildlife epidemicsurveillance could only be carried out through consolidation of regional teams and working at an ecosystem level, pooling resources and sharing transboundary data (15). This has both scientific and practical benefits and has facilitated the preparation of OIE Pathway dossiers for applications on freedom from disease and therefore from infection.

The Somali Ecosystem Rinderpest Eradication Coordination Unit

The Somali Ecosystem Rinderpest Eradication Coordination Unit (SERECU) was developed at the end of PACE, to monitor and eradicate by vaccination the mild virus existing within the cattle of Somali livestock owners living in southern Somalia, north-east Kenya and south-eastern Ethiopia (the Somali ecosystem). This unit was established to clarify the situation of the mild form of the disease and to ensure that the three areas contributing to the ecosystem (south-east Ethiopia, north-east Kenya and south-west Somalia) would become internationally recognised as being free of rinderpest through an epidemiologically driven strategy. Random map coordinate surveillance and other epidemiological tools were used, considering the three countries as one stratum. The FAO commissioned a meta-analysis to assess the effectiveness of the ecosystem epidemicsurveillance strategy. Success in the Somali ecosystem eliminated lineage 2 from Africa.

Partnerships

Partnerships worked at the global, regional and national levels, and were successfully built among international agencies (the OIE, FAO and IAEA), between international and regional agencies (AU-IBAR, AU-PANVAC and the South Asian Association for Regional Cooperation, and between these bodies and national governments, particularly state Veterinary Services and non-governmental organisations (NGOs). Other successful

partnerships included laboratory and surveillance networks. Considerable support was shown for public–private partnerships, in which private veterinary practitioners, working under a *mandat sanitaire*, and sometimes with community-based animal health workers, cooperated with state Veterinary Services to carry out the tasks required to eradicate rinderpest. Strong regional and global coordination provided scientific and operational direction and constant encouragement to national programmes. It was argued that national actions could lead to only temporary improvements unless livestock populations were isolated from one another. It was only in 1992 that regional coordination of campaigns was confirmed as the only realistic approach to rinderpest control. The Food and Agriculture Organization fostered all of the following: the concept of a coordinated African regional programme (JP15); the Near East Animal Health Institute’s regional project, MINEADEP; PARC; SAREC and WAREC. The Pan African Rinderpest Eradication Campaign was followed by PACE (with the OIE chairing the advisory committee) and SERECU, in whose area of activity the last circulation of the rinderpest virus was reported. The South Asia Rinderpest Eradication Campaign was succeeded by a project in Central Asia funded by the government of Italy (Fig. 1).

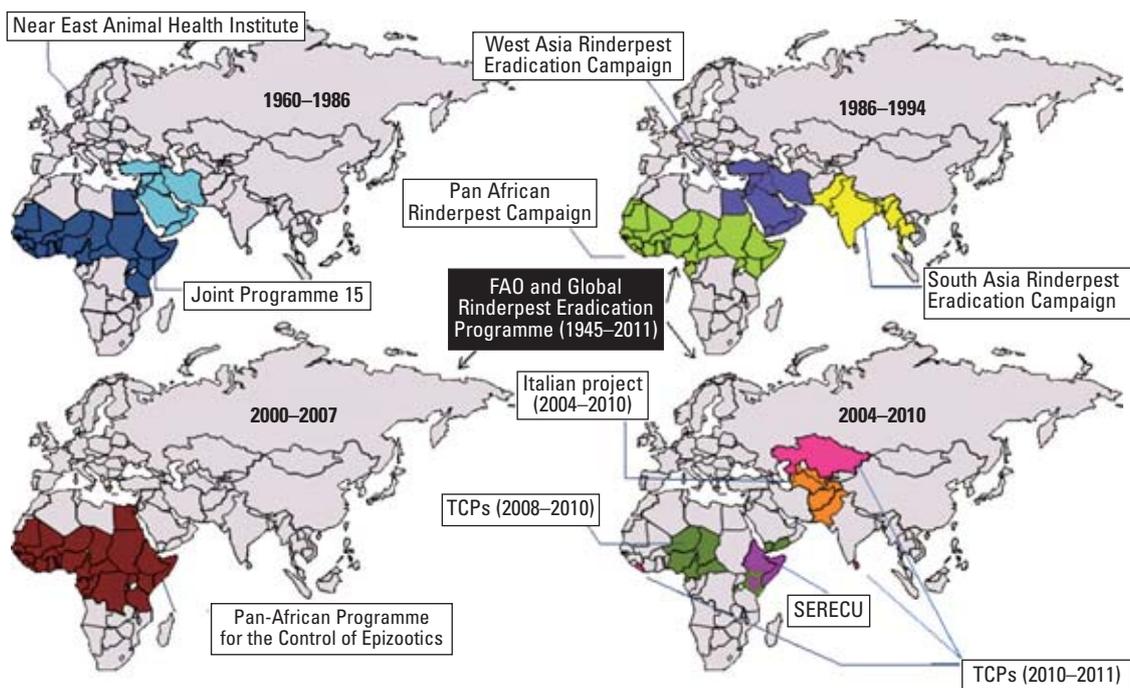
This partnership between FAO and the various campaigns was designed to ensure that national campaigns were kept fully abreast of technical issues, as well as to foster the

opportunity to exchange information about disease occurrence, incidence and prevalence at the national and regional level. These efforts were intended to guide countries in vaccine production and quality control and emergency vaccination campaigns, as well as along the OIE Pathway. Such collaboration also provided assistance in surveillance activities and in assembling the evidence needed to prepare country dossiers, which in turn were evaluated by the OIE (8, 15, 20, 21). The surveillance guidelines established by the OIE and the AGE performance indicators helped countries to demonstrate their continuing freedom from rinderpest after vaccination. They allowed countries to cease vaccination and proceed along the next steps of the Pathway, leading to disease freedom (8, 31). More than 260 dossiers from countries and territories were evaluated by the OIE Scientific Commission for Animal Diseases for their rinderpest status between 1999 and 2011.

As a final step to declaring global freedom from rinderpest, the OIE and FAO established a Joint FAO/OIE Committee for Global Rinderpest Eradication (Joint Committee) in 2009, to determine whether the world could be declared free of rinderpest and/or recommend the actions to be taken for this achievement to be confirmed. The final report included 20 recommendations to be implemented by the FAO, OIE and their Member States to protect the world from the resurgence of rinderpest in the post-eradication era (8).

Fig. 1
Regional programmes and projects to eradicate rinderpest

Adapted from the Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (6)



FAO: Food and Agriculture Organization of the United Nations
 SERECU: Somali Ecosystem Rinderpest Eradication Coordination Unit
 TCPs: Technical Cooperation Programmes

The EU has made a major contribution towards the control and eradication of rinderpest, being a consistent and principal donor over time. The European Commission (EC), in addition to being a leading force in this challenge, has also taken advantage of it to build a solid policy of long-term capacity-building in animal health and livestock services. Over 40 years, the EC has contributed close to €340 million worldwide. However, this figure is not intended to dwarf the contributions of non-EU donors (particularly the USA, Canada, Japan, Italy, Ireland, France and Switzerland, among others), and – of course – the participation of beneficiary countries. Other regional organisations, such as IBAR, have played a considerable role in the eradication of rinderpest in Africa. Member Countries have also provided important contributions to this endeavour. Private and public veterinarians of the variously affected countries, at different stages in the eradication process, have also been crucial in reaching this considerable achievement.

Discussion and conclusion

The model examples described above demonstrate that, except perhaps for China, programmes established for the national (and later international) eradication of rinderpest and the countries in which they were implemented have been heavily reliant on the use of vaccines: first to immunise bovine populations in sufficient depth that fresh transmission chains could not be established, and secondly, to ‘stamp out’ the infection in enzootic areas by high-intensity, pulsed vaccination of the affected bovine population.

In the late 1950s, stable, safe and cheap rinderpest vaccines became available, enabling the lifelong immunity of susceptible livestock, once they had been vaccinated. From the 1960s onwards, the OIE, FAO and various regional organisations launched and coordinated several large-scale campaigns to strengthen the capacity of countries to eradicate rinderpest and control other major transboundary diseases. Through these intensive control programmes, based mainly on mass vaccination but also on movement control and stamping out of affected herds, the eradication of rinderpest was achieved in most areas of the world. However, the disappearance of clinical disease led to the discontinuation of vaccination campaigns, even in regions where there were no effective measures against a potential re-introduction of the virus. As a consequence, a devastating re-emergence and spread of the virus took place on the African continent in the 1980s, beginning in East Africa. Continuous development of better-adapted diagnostic tools, vaccines and surveillance methods was necessary to support a second round of control programmes, in order to survey and eradicate the disease, region by region, once and for all.

Along with these large-scale rinderpest eradication campaigns, OIE Member Countries asked for more guidance on how to conduct and standardise rinderpest surveillance, so that they could substantiate their claims of freedom from rinderpest to their trading partners or assess whether a neighbouring or exporting country’s surveillance was trustworthy and transparent. An OIE Expert Consultation on Rinderpest Surveillance Systems (held in Paris, in August 1989) led to the development of the widely known ‘OIE Rinderpest Pathway’, a step-by-step process that, if followed properly, would lead to certified freedom from rinderpest infection within five years of ceasing vaccination. These ‘Recommended Standards for Epidemiological Surveillance for Rinderpest’, developed by experts, were discussed during several General Sessions, amended by the ‘Foot and Mouth Disease and Other Epizootics Commission’ (now the Scientific Commission for Animal Diseases), and finally adopted by OIE Members in 1998. These surveillance guidelines for rinderpest paved the way for the certification process of rinderpest-free status for countries and zones.

There remains one last challenge: what is known as the post-eradication phase. Although the rinderpest virus no longer circulates amongst live animals, it is still present in certain laboratories, mainly to produce vaccines if the disease ever reappears, due to an accident or an act of bioterrorism. Clinical samples containing rinderpest virus and virus isolates are still kept in a number of laboratories in the world. These materials must be either safely destroyed or transferred to bio-secure, approved laboratories. International coordination and cooperation will once again prove crucial in defining acceptable conditions for the possession and use of the virus still present in laboratories. The OIE, in collaboration with FAO and Member Countries, is committed to ensuring that this process is carried out in a reliable and transparent manner.

The international community and individual countries must implement effective surveillance and notification mechanisms, including rumour tracking and rapid investigation. Contingency plans should be established at the national and international levels, ensuring that the vaccines are made available in a timely manner, in case of emergency. While the disappearance of the disease has, we hope, forever relieved countries and farmers from the heavy economic losses due to outbreaks, investment in post-eradication activities must continue. The OIE and FAO are committed to working closely with their partners, to keep the world free from rinderpest.

The global eradication of rinderpest is a major achievement for humanity, and in particular for veterinary professionals. This process has witnessed many success stories but also taught some bitter lessons. The eradication of rinderpest would not have been possible without international

solidarity, such as the support provided by the EU and other donors to eradication programmes across the three continents involved. This being said, the main contribution to the global eradication of rinderpest came from the countries themselves, and countless numbers of highly dedicated individuals, whether farmers, veterinarians, scientists or local community workers.

The combined efforts of all those charged with the eradication programme, the individuals, countries and international organisations, are testament to good planning

and cooperation and also to the importance of the disease itself. The FAO, OIE and their partners have been successful in achieving their stated objective of eradicating rinderpest virus by 2010 (the last outbreak was in 2001 and vaccine was used for the last time in 2006). The socio-economic and risk analyses carried out during the course of the eradication programme and the FAO meta-analysis were also vital components in this great achievement. ■

Un long cheminement : histoire en bref de l'éradication de la peste bovine

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Résumé

En 2011, par une résolution conjointe adoptée lors de la 79^e Session générale de l'Assemblée mondiale des Délégués de l'Organisation mondiale de la santé animale (OIE) et de la 37^e Conférence de l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO), ces deux organisations ont officiellement proclamé l'éradication mondiale de la peste bovine et recommandé les mesures de suivi à mettre en place pour préserver ce nouveau statut sanitaire, si difficilement acquis.

L'éradication est un objectif atteignable pour toutes les maladies des animaux domestiques, à condition que leur épidémiologie ne soit pas trop complexe et que l'on consacre à sa réalisation les outils, les ressources et les politiques nécessaires. Au niveau national, l'éradication tient inévitablement compte des priorités du pays ; au niveau mondial, elle exige la mise en place d'initiatives et d'un leadership internationaux, afin d'intégrer ces outils dans un cadre mondial destiné, en premier lieu, à éliminer toute possibilité de transmission dans les zones affectées, puis à apporter la preuve que cet objectif a été atteint. En raison de la simplicité de sa chaîne de transmission et de la grande fragilité du virus bovine dans le milieu extérieur, la peste bovine a toujours été considérée comme une maladie qui pouvait être contrôlée, voire éradiquée, dans le cadre d'une démarche zoonositaire.

Avec le tournant productiviste de l'agriculture à partir de 1945, les programmes de vaccination tant nationaux que mondiaux ont pris de plus en plus d'importance et d'ampleur. Étant donné que la peste bovine se propage le plus souvent suite aux mouvements de bétail liés aux échanges internationaux, il était crucial d'assurer une synchronisation des programmes de vaccination dans toutes les régions où la maladie est présente à l'état endémique, objectif auquel ont pleinement souscrit l'Union européenne, l'Agence pour le développement international des États-Unis, l'Agence internationale de l'énergie atomique, le Bureau interafricain des ressources animales de l'Union africaine, la FAO et l'OIE. Les auteurs retracent l'histoire de l'éradication de la peste bovine depuis les travaux de pionnier de Giovanni Lancisi au début du 18^e siècle jusqu'à l'éradication mondiale réalisée en 2011.

Mots-clés

Éradication – Peste bovine. ■

El largo camino. Breve repaso a la erradicación de la peste bovina

F. Njeumi, W. Taylor, A. Diallo, K. Miyagishima, P.-P. Pastoret, B. Vallat & M. Traore

Resumen

En 2011 la Asamblea Mundial de la Organización Mundial de Sanidad Animal (OIE), en su 79ª Sesión General, y la Conferencia de la Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO), en su 37º periodo de sesiones, aprobaron una resolución en la que declaraban que el mundo estaba libre de peste bovina y recomendaban medidas complementarias para preservar los beneficios de la nueva situación, que tanto costó alcanzar.

La erradicación es un objetivo asequible en el caso de toda enfermedad del ganado cuya epidemiología no sea complicada, siempre y cuando existan las herramientas, los recursos y las políticas que se requieren para ello. La erradicación a escala nacional es reflejo, inevitablemente, de las prioridades de cada país, mientras que a escala planetaria ese objetivo exige cierto grado de iniciativa y liderazgo internacionales que sirvan para integrar esas herramientas en un dispositivo mundial, destinado en primer lugar a acabar con la transmisión de la patología entre todas las zonas infectadas y a evidenciar después que se ha logrado esa meta. Siempre ha estado ahí la posibilidad de controlar e incluso erradicar por medios zoonosarios la peste bovina, que se caracteriza por una cadena de transmisión sencilla y por la fragilidad ambiental del virus.

Sin embargo, en la búsqueda de una mayor productividad agrícola que se inició a partir de 1945 los programas nacionales y mundiales de vacunación empezaron a cobrar creciente importancia y protagonismo. Dado que la peste bovina suele propagarse de una región a otra a resultas de movimientos de ganado ligados al comercio, la clave para lograr la erradicación mundial residía en garantizar que esos programas de vacunación se aplicaran de forma sincronizada en todas las regiones donde la enfermedad era endémica, objetivo que suscribieron plenamente la Unión Europea, la Agencia de los Estados Unidos para el Desarrollo Internacional, el Organismo Internacional de Energía Atómica, la Oficina Interafricana de Recursos Animales de la Unión Africana, la FAO y la OIE. Los autores pasan revista a todo el proceso que desembocó en la erradicación de la peste bovina, desde los influyentes trabajos de Giovanni Lancisi a principios del siglo XVIII hasta la declaración mundial de 2011.

Palabras clave

Erradicación – Peste bovina.



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