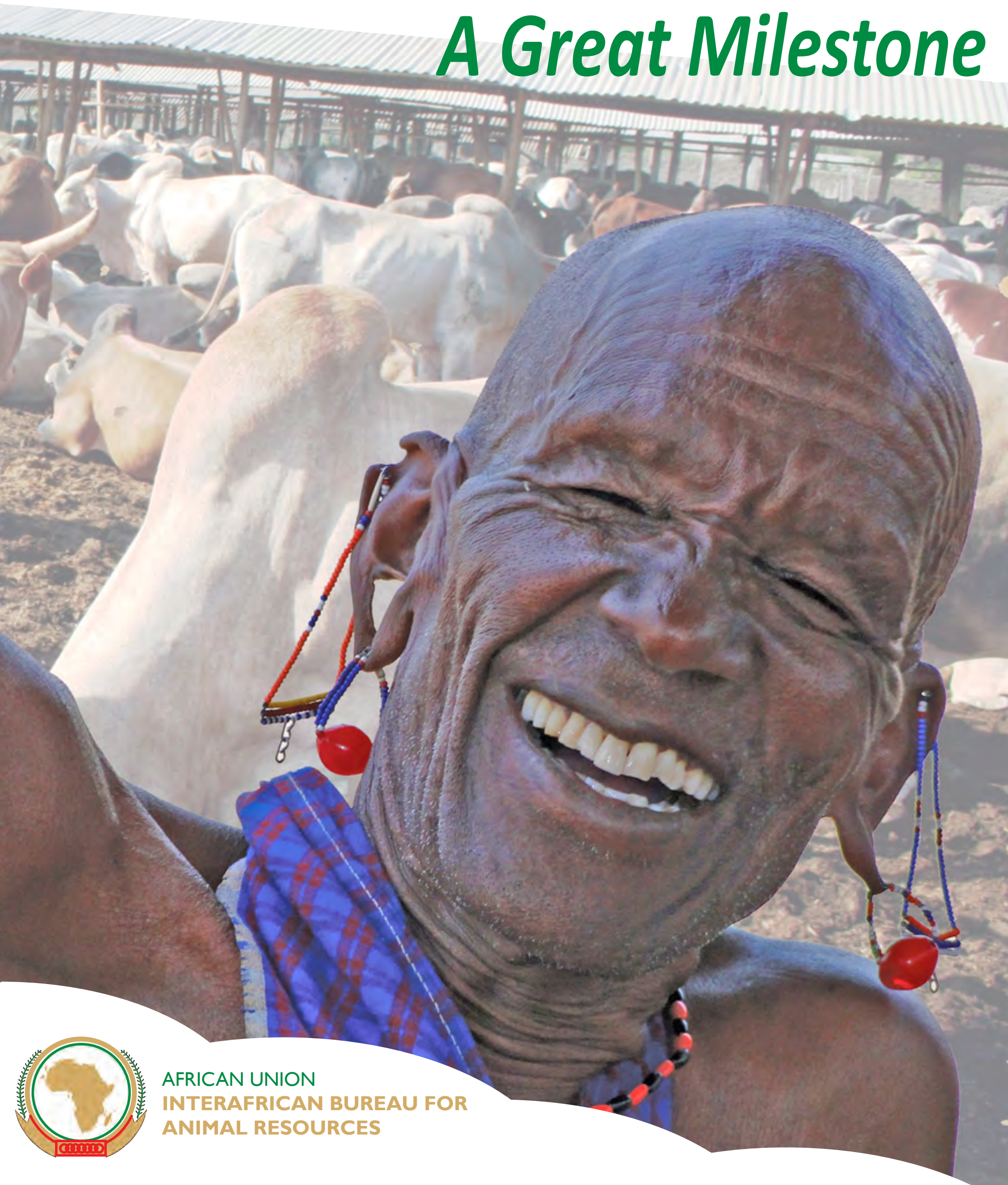
The Eradication of Rinderpest from Africa

A Great Milestone



AFRICAN UNION
INTERAFRICAN BUREAU FOR ANIMAL RESOURCES

The Eradication of Rinderpest from Africa: A Great Milestone

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ISBN: 978-9966-7456-2-0

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List of Abbreviations and Acronyms

AC	Advisory Committee
AGID	Agar Gel Immunodiffusion
ARIS	Animal Resources Information System
AU	African Union
AU-IBAR	African Union - InterAfrican Bureau for Animal Resources
Bisec	Combined Rinderpest and CBPP vaccine
CAHWs	Community Animal Health Workers
CAM	Chorio-Allantoic Membrane
CAPE	Community Animal Health and Participatory Epidemiology
CAR	Central African Republic
CBPP	Contagious Bovine Pleuropneumonia
CCTA	Commission for Technical Cooperation in Africa South of the Sahara
cELISA	Competitive Enzyme-linked Immunosorbent Assay
CFT	Complement Fixation Test
CIEP	Counter-Immunoelectrophoresis
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour Development.
DfID	UK Government's Department for International Development
DRC	Democratic Republic of Congo
EC	European Commission
ECU	European Currency Unit
EDF	European Development Fund
ELISA	Enzyme-linked Immunosorbent Assay
EM	Electron Microscopy
EMPRES	Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases
FAMA	Foundation for Mutual Assistance in Africa South of the Sahara
FAO	Food and Agriculture Organization of the United Nations
IAEA	International Atomic Energy Agency
IBED	Inter-African Bureau of Epidemic Diseases
ICE	Immunocapture ELISA
IF	Immunofluorescence
IHA	Indirect Haemoagglutination
IPS	Immunoperoxidase Staining

JP15	Joint Project Number 15
KARI	Kenya Agricultural Research Institute
KARI-VRC	Kenya Agricultural Research Institute- Veterinary Research Center
K-LIFT	Kenya life stock Finance Trust
K-O	Kabete-O strain of Rinderpest virus
KVAPS	Kenya Veterinary Association Privatisation Scheme
LANAVET	Laboratoire National Vétrinaire
LD	Letter of Declaration
MECU	Million European Community Units
MOU	Memorandum of Understanding
NGO	Non-Governmental Organisation
OAU	Organisation of African Unity
OIE	Office International des Epizooties
PACE	Pan-African Programme for the Control of Epizootics
PANVAC	Pan-African Vaccine Centre
PARC	Pan-African Rinderpest Campaign
PCR	Polymerase Chain Reaction
PDS	Participatory Disease Search (Survailance)
PRCA	Participatory Rural Communications Appraisal
RCU	Regional Co-ordination Units
RP	Rinderpest
RPV	Rinderpest Virus
RT-PCR	Reverse Transcription - Polymerase Chain Reaction
SAHSP	Somali Animal Health Services Project
SERECU	Somali Ecosystem Rinderpest Eradication Co-ordination Unit
SES	Somali Ecosystem
TCID50	Median Tissue Culture Infectious Dose
STRC	Scientific and Technical Research Commission
TADs	Transboundary Animal Diseases
TCP	Technical Cooperation Project
TCRV	Tissue Culture Rinderpest Vaccine
ThermoVax	Thermostable Rinderpest Vaccine
UNICEF	United Nations Children’s Fund
USAID	United States Agency for International Development
VNT	Virus neutralisation test
VSF	Vétérinaires sans Frontières

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Foreword

Rinderpest is the greatest plague ever to assail livestock and wildlife in history. The disease, previously occurring frequently in Eurasia, first visited Africa following shipment of cattle from Asia and Europe. This eventually caused an epidemic that established the virus on the continent in the 1880s.

This period recorded mortalities approaching 100 per cent in susceptible livestock in sub-Saharan Africa. In addition, it decimated wild buffalo, giraffe, kudu and wildebeest populations. The loss of draught animals, dairy and beef herds resulted in famines that caused the deaths of one third of the human population in Ethiopia and two-thirds of the Maasai people of Kenya and Tanzania. West Africa and Egypt reported similar catastrophes. Linked to the need to control rinderpest outbreaks were the establishment of the first veterinary school on the continent in Egypt, the Inter-African Bureau for Animal Resources (AU-IBAR), originally as the Inter-African Bureau of Epidemic Diseases in 1951 and many National Veterinary Laboratories across the continent.

Epidemics continued to occur in tropical Africa and many parts of Asia despite the eradication of the rinderpest virus from Europe early in the 20th century. In areas where the disease persisted, rinderpest became the main constraint to livestock production and world wars and civil conflicts exacerbated it. Numerous rinderpest eradication campaigns were conducted after World War II. The Joint Project 15 (JP15), an inter-governmental initiative started in the 1960s, coordinated the fight against rinderpest in Africa and controlled the disease in most of the continent. However, the termination of vaccination campaigns and surveillance efforts in the 1970s allowed the disease to re-emerge from a few remaining pockets of infection to spread across the continent between 1979 and 1982. As a result, the Pan-African Rinderpest Eradication Campaign (PARC), and later the Pan-African Programme for the Control of Epizootics (PACE) projects were established under the auspices of AU-IBAR. These projects made tremendous achievements in eradicating the disease and by the beginning of the 21st century, only the Somali Ecosystem (SES), an area encompassing north-eastern Kenya, south-eastern Ethiopia and Somalia was suspected to harbour foci of the disease. In response, the Somali Ecosystem Rinderpest Eradication Coordination Unit (SERECU) was mooted to ensure and confirm the clearance of the virus from SES, leading to OIE accreditation of freedom from rinderpest disease/infection.

I am delighted that this objective has been achieved and that Africa is now free of rinderpest. The benefits accruing from eradicating the disease are many. They include increased livestock population, enhancement of oppurtunities for international trade in livestock and improved livelihoods. In this regard, I wish to first thank Member States of the African Union and the European Union and other donors who were instrumental in ensuring the success of these campaigns by committing resources to the programmes spanning over four decades. Last but not least, I am indebted to all the former directors of AU-IBAR namely: Drs. William Beaton, James F C Swan, Osman M M Osman, Protus Atang, Amadou Tall, Walter Masiga, Jotham Musiime and Modibo Traoré for maintaining the vision and leadership that enabled AU-IBAR to effectively coordinate the eradication efforts.

I am also greatful to Drs. Walter Masiga and Mboya Burudi for putting together the manuscript. This will be an enduring documentation of the rinderpest scourge in Africa; a lesson on the eradication of a plague of an enormous magnitude that will serve as a model for the control and eradication of other transboundary animal diseases. Thanks are also due to Drs. Dickens Chibeu (SERECU Coordinator), Henry Wamwayi, James Wabacha, Peter Roeder and William Taylor for proof reading the manuscript as well as to Dr. Tim Leyland for his contribution to the CAHWS chapter. Finally, this publication would not have been possible without the logistical support of Ms. Shadra Zaid of AU-IBAR.

This book targets a wide range of stakeholders including policy makers, field epidemiologists and laboratory workers involved in the control and eradication of transboundary animal diseases. It can also contribute to the enrichment of veterinary education curricula as well as inform financial partners and other contributors in their efforts to support the prevention and control of other major livestock diseases.

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1. RINDERPEST: THE DISEASE

Rinderpest is a highly infectious viral disease of even-toed ungulates of the order Artiodactyla. It mostly affects cattle, domestic buffalo, and some species of wildlife. Rinderpest is a German word that is directly translated as "cattle plague" in English. The English also referred to rinderpest as "steppe murrain" reflecting the early belief in Europe that its homeland was the steppes between Europe and Asia from where waves of rinderpest swept west to the Atlantic and east to the Pacific in the retinues of marauding Asian armies (Scott, 2000). The infection does not occur in all even-toed ungulates and its preferred hosts change with time. Rinderpest virus, the causative agent of the disease, belongs to the genus *Morbillivirus* that includes measles, peste des petits ruminants, dolphin morbillivirus and canine distemper viruses. Despite its legendary virulence in fully susceptible populations, the virus is particularly fragile and is quickly destroyed by heat, desiccation or sunlight. The spread of the disease is mainly by direct contact through inhalation or ingestion of droplets from infected excretions and secretions and drinking contaminated water. Aerial transmission by aerosols can occur over short distances.

The clinical manifestation of rinderpest in cattle and buffalo shows variations from peracute, through acute to mild forms of the disease. The peracute form has a sudden onset and occurs unexpectedly. Affected animals manifest poor appetite, depression, high fever, mucosal congestion, increased pulse rate and rapid breathing. Death occurs within three days but this syndrome is rare.

The typical acute form of rinderpest is characterised by an incubation period of three to nine days followed by a prodromal fever lasting up to three days. Mucosal erosion follows, and later, diarrhoea and death or recovery. In the full-blown case, the animal is solitary, depressed with rapid and shallow respiration, starring hair-coat, running nose and lacrimation. Mucosal congestion gives way to extensive erosion and excessive salivation, which with time becomes mucopurulent. As the fever subsides, fetid and shooting hemorrhagic diarrhoea ensues. The dark loose stool contains mucus, epithelium and blood. The animals become dehydrated, emaciated and die within 6–12 days after the onset of these clinical signs. Ocular lesions of keratitis, anterior uveitis and cataract have been described in African buffalo calves and in lesser kudus, but not in cattle. Mortality rates are extremely high, approaching 100 per cent in naive populations previously unexposed to infection. Surviving animals develop a lifelong immunity to rinderpest. Pregnant cows, however, abort during the convalescent period. Carcasses with sunken eyes, scalds of mucopurulent discharge, and congested - conjunctivas are common post-mortem features. Hemorrhagic and hyperaemic lesions that appear confluent in the large intestine have been referred to as zebra striping. Histopathological sections show ballooning degeneration and syncytia formation in epithelial cells with cytoplasmic inclusions in the oral mucosa. In addition, there is lymphoid necrosis and a severe depletion of lymphocytes in lymphoid tissues (Maurer et al., 1956; Wohlsein et al., 1995).

The subacute form, also referred to as the mild form of the disease, usually affects young adults in rinderpest endemic areas. It has a long incubation period and mild clinical signs similar to those manifested in the acute form. This form is therefore difficult to detect, and presented challenges to the final stages of rinderpest eradication campaigns. The mild form of rinderpest is described elsewhere in this book.

2. HISTORY OF RINDERPEST IN AFRICA

For centuries, socio-economic realities in Africa have guaranteed a central spot for cattle in the lives of many. This has remained true over time across different communities on the continent. In the traditional setting for a long time, cattle have been a key unit in civic, social and cultural transactions. They were a measure of family wealth, a currency for paying fines for those who conflicted with the law, and of importance in negotiations for nuptials in many African communities. It follows therefore that anything affecting cattle negatively would ravage the livelihoods of communities. The introduction and spread of rinderpest in Africa was bad news for the continent and its consequences were devastating.

2.1 Early Outbreaks in Egypt

Egypt, the land of early civilisation, provides the most vivid illustration of rinderpest spread in Africa. A papyrus manuscript discovered in the country early in the 19th century described a disease of cattle, recorded at the end of the Middle Kingdom (1640 BC – 208 BC). The papyrus record gives a poetic description of the disease and says of all the afflicted animals: “their hearts weep; Cattle moan” (Becher, 1997). Whether or not this description actually refers to rinderpest is debatable and historians disagree on the date of the first introduction of rinderpest into Africa. However, what is fact is that rinderpest emanated from Europe or the Near East as early as 1805 (Curasson, 1932). The trans-Mediterranean trade of the early 17th century was a lifeline for trade and commerce between Africa and Europe, but historians now believe that the same sea trade route could have led to the disease gaining entry into Africa through Egypt.

A ship, loaded with infected animals, docked at the Egyptian port of Alexandria in 1841 and off-loaded the animals for treatment, but some had already died on board (Scott, 1964: Plowright, 1968: Spinage, 2003). Some of the animals were sold before the necessary prophylactic and sanitary measures were instituted owing to a limited understanding of the nature of the disease. This led to the spread of the disease throughout Egypt with a catastrophic loss of about 665,000 head of cattle in the country.

By 1843, the disease epidemic seemed to have burnt itself out but that respite was only short lived. In the same year, there was a resurgence of the disease that was traced to Nubian cattle brought from “southern Egypt[1]” to replenish dwindling cattle stocks. The new spread killed at least 350,000 head of cattle

[1]Present day northern Sudan

and many buffaloes, sheep and goats in a period of about three years. About 90 per cent of the existing cattle herd died in that period. The disease then became endemic in Egypt with epidemics recorded in 1863-1864, 1881, 1903 and 1926 with devastating losses in cattle herds. There are no records of the spread of the disease from Egypt to other parts of Africa and this may have reflected the direction of livestock trade flows at the time. Nevertheless, there is suspicion that this outbreak was the source of the disease that occurred later on in Chad.

Egypt bore the brunt of the early rinderpest attack in Africa and due to its experience with the disease; the country became a frontline state in efforts to control livestock diseases. Records indicate that the establishment of the first veterinary school in Africa was in Egypt following the rinderpest epidemic in draught oxen used to thresh rice (Scott, 1981).

Plate 1: Devastating effects of rinderpest in the 1880s

2.2 Origin of the Great African Rinderpest Pandemic

The rinderpest attack in Egypt was just the beginning of what would become the disease's devastation of Africa's cattle and wildlife. The worst period for Africa was the great pandemic that swept through the continent within eight years, from 1889 to 1897 (Scott, 1964; Pankhurst, 1966; Plowright, 1968; Mack, 1970; Ford 1971; Kjekshus, 1977). The pandemic caused over 90 per cent mortality in the cattle population and unquantifiable destruction in the vast free-ranging populations of fully susceptible wildlife. The possible origin of the pandemic is documented to be Ethiopia (Pankhurst, 1966; 1985; Mack, 1970). Epidemic diseases, whether human or animal, spread across the globe mainly through movement of people or animals. In the Ethiopian case, the introduction of rinderpest was by invading Italian soldiers through the Port of Massawa in November 1887. Cattle imported from India by the Italians spread the disease, according to the Ethiopians. The Ethiopians' suspicion of the Italians led them to believe that the latter could have deliberately spread the disease as part of their war strategy (Pankhurst, 1966). However, earlier records suggested that the spread might have been due to limited understanding of appropriate prophylactic and containment measures. The Italian authorities attempted to treat affected cattle on a large scale using the "caudal inoculation" method that was in use for vaccination against contagious bovine pleuropneumonia. That control method was a big mistake and it had a devastating effect. From an initial localisation in one district (Agrodat), the disease rapidly spread to other areas of Ethiopia, apparently fuelled by the "caudal inoculation" method. By 1889, it had spread from Massawa to the entire northern Ethiopia and to vast areas of southern Ethiopia (Spinage, 2003).

The rapid spread of the disease and its ramifications across Ethiopia equally shocked the Italians. The Italian envoy to Addis Ababa fully captured this concern on February 20th, 1889 when he warned that Ethiopia "was threatened with a crisis that could prove fatal to her economic life (Spinage, 2003). The high mortality figures were frightening. The first United States envoy to Ethiopia estimated that more than 90 per cent of the cattle died (Skinner, 1906). Tales from several Ethiopians in the areas affected by the disease painted a picture of great losses following the deaths of large herds of 300 to 1,000 animals within a few days. The disease, according to first hand reports, spread like bush fire across the country, causing misery, panic and despair. Even Menelik, the powerful grand Emperor of Ethiopia, suffered the consequences. He lost about 250,000 cattle with other wealthy cattle owners losing 10,000 – 12,000 head of cattle. The prevailing weather was partly to blame for the horrific scenes witnessed at the time. The period 1888-1889 was excessively hot and dry. This favoured the congregation of animals at fewer watering points, thus providing conditions for the rapid spread of the disease. As a result, only herds in very high altitude areas, 3,000 metres and above survived, as the epidemic seemed to spread slowly in such areas (Wurtz, 1898).

As in Egypt, the Ethiopian attack provides a vivid picture of the devastation that an animal disease can cause to the human population and the horrific consequences it could have on their livelihoods. In some affected areas in Ethiopia, the stories of despair were almost beyond description. In 1897, a traveller named Vigneras reported that rinderpest had invaded a plain named Bourka from Tigre rendering farming communities unable to cultivate their land for two years due to lack of draught animals. In what would look like a scene from a horror movie, wild carnivores descended on the villages and devoured weakened people. The vultures and hyenas lost interest in the numerous livestock carcasses that littered the areas under rinderpest attack. The early spread of rinderpest in Ethiopia coincided with a harvest failure due to drought, followed by outbreaks of locusts and armyworms. The consequence of the triple tragedy of rinderpest, drought and pests was the famine of 1888 and 1892, the worst ever in Ethiopian history. An outbreak of smallpox further compounded the human deaths and the prevailing desperate situation (Wurtz, 1898).

Rinderpest remained endemic in Ethiopia and an epidemic resurgence recorded in 1897 originated around Harar with initial spread to Somalia. The disease retained its virulent manifestations and large numbers of cattle had died in some areas by 1901 while elsewhere, the infection became less prevalent (Pankhurst, 1985).

The disease spread southwards causing great devastation among the Borana herds (Cipolla, 1927) and from Addis Ababa, it spread to the Somali coast. It killed cattle herds in the Luq trading centre and spread southwards to Ganale (Bottego, 1895). However, it appears that the disease did not adversely affect cattle herds in Somalia because the area west of Hargeisa had healthy herds. Low cattle densities, with camels as the predominant species in the largely arid land, probably inhibited the spread of rinderpest in Somaliland. Nevertheless, the disease spread to southern Somalia and destroyed cattle, buffalo, kudu and hartebeest populations, particularly in the Juba River region.

2.3. Rinderpest in West and Central Africa

The West African region did not escape the brush with death and destruction associated with rinderpest. As mentioned above, it is possible that the early outbreaks of rinderpest in Egypt could have spread to Chad. As early as 1865, epidemic disease episodes had occurred in the region causing widespread mortalities in cattle populations (Mettam, 1937; St. Croix, 1945). However, it is not certain that these epidemics were caused by rinderpest; contagious bovine pleuropneumonia is a plausible alternative explanation (Spinage 2003).

It was a while before the first clearly recorded cases of rinderpest would occur in West Africa, this time at Dori in Burkina Faso at the end of May 1891 (Monteil, 1895). Just like in Egypt and Ethiopia, the outbreak, which appears to have erupted in February 1891, caused extensive losses in the large nomadic Fulani

(Peulh) cattle herds from Dori to Sokoto in Nigeria. The outbreak originated from the east as recorded by Monteil (1895), who encountered it, perhaps for the first time, at Dori on his travels from the west. Typical of areas hit by rinderpest attacks, piles of rotting carcasses characterised the immense cattle mortalities previously unseen among the Fulani. An earlier traveller from Bamako in Mali to Accra in Ghana between December 1887 and January 1889 encountered herds of healthy cattle in Mali, Côte d'Ivoire and northern Ghana, an indication that these areas were unaffected by rinderpest at that time (Binger, 1892). However, in 1893, a widespread epidemic disease visited the Adamawa region of eastern Nigeria. Buffaloes, roan antelope and hartebeest were the only reported wildlife species affected in the West African epidemics at the time (Curasson, 1932). In Chad, an epidemic of rinderpest in 1893 devastated the cattle, buffalo and antelope populations.

2.4 Rinderpest in Eastern Africa

In Eastern Africa, a similar story played out. With the porous borders, trade across national boundaries and armed invasions by expansionist groups provided a perfect environment for the spread of rinderpest in the region. The Mahdist group from Sudan, for instance, could have introduced the disease in the Sudan after picking it from Ethiopia at the height of a rinderpest epidemic in March 1889. The spread of the pandemic from Ethiopia into other parts of Eastern Africa was mainly attributed to the Mahdists, known for their expansionism and military aggression (Spinage, 2003). However, available documents do not provide a clear picture of rinderpest spread in Sudan as the early history of the disease in the country is poorly documented.

Between 1890 and 1891, the rinderpest epidemic affected areas of southern Sudan where it was thought to have been introduced either by migrating wildlife species through contact with the local cattle populations or by invading Ethiopian armies (Pankhurst and Johnson, 1988). As the disease spread in southern Sudan, similar trends were evident among Maasai cattle herds in Kenya and Tanzania. This could rule out the possibility that the infection could have spread from southern Sudan to the Maasai herds. However, the disease does seem to have spread from southern Sudan to northeastern Uganda (Pankhurst and Johnson, 1988).

The never dying tradition among pastoralists in the region of rustling cattle to replenish their stocks aided the fast spread of the disease in Eastern Africa. The effects of rinderpest were observed in Kenya and Uganda from 1890, rapidly spreading because of cattle rustling among neighbouring communities. Early explorers travelling through Eastern Africa, between 1890 and 1897, recorded the rapid spread and devastating effects of rinderpest in cattle and wildlife populations, particularly buffaloes and eland in Kenya, Tanzania and Uganda (Spinage, 2003). The Maasai, whose affection for livestock is in no doubt, suffered huge losses that devastated and impoverished them. In no time, the disease spread rapidly southwards through Tanzania to Malawi and Zambia. Mortality rates of 90 per cent in cattle and more than 50 per cent in wildlife populations are on record in the different countries between 1890 and 1893. Nature temporarily came to the rescue of the local communities to the south with the Zambesi River acting as an effective natural barrier to continuous contact transmission. However, the contagious potential of rinderpest again showed as the disease crossed over the river barrier with deaths reported in the Zambesi region from February 1896.

2.5 Rinderpest in Southern Africa

Trade occupied a central role in Africa's early social and economic development, but it is through the same trade routes that the rinderpest virus was disseminated across the continent. In the Zambesi region, for instance, the movement of cattle for trade dispersed the disease in all directions south of the river (Theiler, 1897). The rapid spread of rinderpest and the destruction of cattle populations within Zimbabwe and its subsequent spread to Botswana, South Africa and Namibia are well documented (Spinage, 2003). However, unlike in some other parts of Africa where limited knowledge of the disease hampered effective response, local farmers and government authorities in this region took some restrictive measures to control the spread of the disease. The existence of official veterinary services enabled the drafting of rules and regulations as well as the enforcement of control measures that included the restriction of animal movements and slaughter of infected and in-contact cattle. Although this resulted in a decline in the number of outbreaks observed in 1899, the process was let down by the limited number of enforcement personnel and the disease continued to spread.

The spread of the disease in Southern Africa was largely blamed on the use of oxen for transport. The more the local people travelled using their favourite ox carts, the faster they spread rinderpest southwards. Despite isolated cases of the disease occurred simultaneously in South Africa and Namibia in March 1904. The last serious outbreak in Southern Africa occurred in 1901. The eradication of the disease was finally accomplished throughout Southern Africa in 1905, and no further outbreaks were reported in the region despite the existence of large populations of susceptible domestic and wild ungulates (Mack, 1970; Spinage, 2003).

2.6 Persistence of Endemic Rinderpest in Africa

Even though new research provided a much deeper understanding of the disease and reliable control measures, rinderpest remained endemic in the rest of Africa where it was responsible for recurrent epidemics throughout the 20th century with losses of millions of susceptible livestock and wildlife (Plowright, 1982). Across the continent, the disease re-emerged in different regions and its effect was as devastating as in the previous outbreaks. In Egypt, the disease recurred in a mild form that evaded detection at the quarantine station in June 1903 through cattle imported from Asia. More than a third of the Egyptian cattle were estimated to have died in less than a year because of this re-emergence (Spinage, 2003). Limited public understanding of zoo-sanitary controls, such as the need for strict animal movement controls and closure of livestock markets, fuelled the spread of the disease. The use of serum from previously infected animals as a means of protecting cattle failed to prevent the spread of the disease.

The start of World War I in 1914 interrupted the implementation of a programme for rinderpest eradication allowing the re-establishment of the disease. After the war, a consolidation of the rinderpest eradication measures, using the serum-virus simultaneous inoculation method, resulted in a progressive reduction in the incidence. No rinderpest deaths were reported by 1920. However, the continued importation of cattle from endemic areas in Sudan provided the source of sporadic outbreaks until at least the 1980s. During the last quarter of 1982, imported Sudanese cattle caused widespread outbreaks of the disease in Egypt (Nawathe et al., 1983). The disease persisted throughout 1983 and 1984 (Taylor, 1986). The disease in Egyptian cattle was relatively mild and an isolate of rinderpest virus recovered from infected cattle at a feedlot caused only mild disease in experimentally infected cattle at the Institute of Animal Health, Pirbright Laboratory in UK (Taylor, 1986).

In Central Africa, an epidemic of a mild form of the disease suspected to have originated from Darfur, Sudan, occurred in Chad in 1913. By 1914, the disease had spread rapidly throughout the country due to extensive migratory movements of cattle herds necessitated by severe drought and famine. The disease killed approximately 10 – 30 per cent of the zebu cattle, affecting mainly the young ones. It also affected buffaloes, large antelopes and warthogs, but giraffes and small antelopes appeared untouched. The epidemic subsided with the onset of the rains. Another epidemic introduced from Sudan resulted in deaths among buffaloes, hartebeest, kudu, roan antelopes and warthogs. In 1918, a virulent form of the disease spread from Sudan into Chad and it persisted throughout

1919. From 1920, the disease became endemic with sporadic outbreaks recorded annually with the death of more than 80,000 animals every year in Central and West Africa until 1964. In fact, Chad was the main source of the rinderpest outbreaks recorded in the Central African Republic in 1939, 1946, 1956 and 1968, the latter two outbreaks appearing to have affected only wildlife.

Rinderpest may have become endemic in Central and West Africa by 1915, when the disease spread into Niger from Chad. From 1916, it rapidly spread westwards through trade cattle via Mali to Senegal where it was virulently manifested with the loss of about 80 per cent of the cattle population. The epidemic then moved from Mali to Guinea and Côte d'Ivoire in 1917 and eventually to Togo (Spinage, 2003). There were recurrent episodes of the disease in this region throughout the 20th century until the start of the JP15 campaign.

In Nigeria, major epidemics occurred in 1913 – 1914 and 1919 – 1920. In 1915, the country declared rinderpest the most important disease but mortality was sometimes very low, ranging from 5 per cent to 50 per cent. This contributed to the spread of the disease as livestock owners were unconcerned by a disease that affected only a small fraction of their herds. This situation highlighted the existence of mild forms of the disease at this early stage in West Africa.

The persistence of endemic rinderpest in Sudan, following its spread via infected cattle from northern Ethiopia[2], is well documented. Sudan also served as the source of infection for the recurrent spread of the disease westwards (Spinage, 2003). The disease remained endemic in most parts of Ethiopia throughout the early 1900s with new outbreaks recorded in 1914 and 1915 in an area bordering the Red Sea, which had apparently remained free of the disease since its introduction into the country in 1887 (Zonchello, 1917). In September 1918, a small outbreak occurred among 135 Somali cattle in north western Somalia (Somaliland). Cattle from northern Ethiopia were suspected to be the source of the infection. Other reports (Adams, 1919; Maydon, 1925) indicate that evidence of the decimation of large populations of cattle was visible in Ethiopia as late as 1924.

In East Africa, the devastating effects of the first rinderpest pandemic appeared to have subsided by 1907 and many communities had replenished their cattle herds. However, between 1910 and 1960, widespread outbreaks of the disease affecting cattle and wildlife occurred in Uganda, Kenya, Tanzania, Rwanda and Burundi. Inoculation programmes limited the spread of the outbreaks, but it remained

[2]Present day Eritrea

endemic with recurrent epidemics in cattle and wildlife populations throughout this period. It particularly affected the Maasailand areas of northern Tanzania and southern Kenya and the emergence of mild forms of the disease in this area was recognised in these early years (White, 1958; Robson et al., 1959; Plowright, 1963). After JP15 the disease seemed to have been controlled. However, a major outbreak of the disease was observed in buffaloes, kudu and eland in Kenya's Tsavo National Park in December 1994 (Kock et al., 1998). Isolates of rinderpest virus from this outbreak only caused mild disease in experimentally infected cattle (Wamwayi et al., 1995; 2002). Nucleotide sequence analysis of the isolate at the Institute for Animal Health, Pirbright laboratory in UK identified the virus as belonging to Lineage 2 African Rinderpest Virus. This outbreak focused global attention on the Somali eco system, an area that needed to be addresed to ensure final eradication of rinderpest from Africa. The last confrimed outbreak of rinderpest in this area was in buffaloes in the Meru National Park in Kenya in September 2001.

3. EVOLUTION OF THE DIAGNOSIS OF RINDERPEST AND ITS APPLICATION IN AFRICA

The diagnosis of rinderpest was for a long time dependent on clinical and post-mortem examinations. Overtime, however, more robust, sensitive and specific techniques were developed. The causative agent of rinderpest initially was thought to be a bacterial-size microbe (Koch, 1897). However it was demonstrated later that a virus caused the disease (Nicolle and Adil-Bey, 1902). They first succeeded in preparing therapeutic rinderpest serum and then discovered that the rinderpest agent was a filterable virus. This discovery immortalised Nicolle's and Adil-Bey's names in veterinary and science history.

There are many tests available for laboratory confirmation of a rinderpest diagnosis as detailed by the World Organisation for Animal Health (OIE) in its Manual of Diagnostic Tests and Vaccines for Terrestrial Animals (OIE 2010). These include tests to detect the virus itself, virus antigens, virus genes and the antibodies induced by infection with the virus.

Virus isolation in cattle or, later, cell cultures, both primary cultures and cell lines, was for many years essential for confirmation of diagnosis. The development of cytopathic effects coupled with identification of the virus by neutralisation with specific antibody or immunostaining were commonly used to confirm rinderpest. Virus isolation has largely been superseded by the introduction of molecular techniques. Most African laboratories have been constrained in their use of virus isolation by lack of facilities for cell culture and its cost. This deficit was to a large degree overcome by the use of antigen detection methods, most recently the agar gel immunodiffusion (AGID) test (Scott and Brown, 1961; White, 1958), immunoperoxidase staining (IPS) technique (Selvakumar et al., 1981), the chromatographic strip test (the Penside Test) and the immunocapture ELISA (ICE)test (Libeau et al., 1997; Abraham and Berhanu, 2001). The AGID test was widely used by disease investigation staff and IBAR/PARC operated a small laboratory unit at the KARI Muguga laboratory, which produced a modest number of kits for distribution. These were widely used and became the mainstay of rinderpest diagnosis in Ethiopia during the early 1990s. A variant of this, the counter-current immune-electrophoresis test (Ali and Lees, 1979; Wafula et al., 1986), was also produced in kit form for distribution but the more sensitive Immunocapture ELISA (ICE) then replaced it. Available commercially, at a price, ICE kits were widely deployed throughout the AU-IBAR laboratory networks in both PARC and PACE. The pen-side test was extensively used in

Pakistan (Hussain et al., 2001), but did not live up to its promise as an aide to the field diagnosis of mild rinderpest in Africa.

The development of gene-based assays ranging from rinderpest-specific gene probing (Diallo et al., 1989; Pandey et al., 1992) to the reverse-transcription polymerase chain reaction (RT-PCR) assay (Barrett et al., 1993; Forsyth and Barrett, 1995) started to replace the more traditional protein-based assays. They have been used extensively at the Laboratoire Central de Pathologie Animale, Bingerville in Cote d'Ivoire for diagnosis and at the KARI Muguga Laboratory for diagnosis and research in partnership with the *Morbillivirus* Reference Laboratories at the Institute for Animal Health Pirbright Laboratory, UK, and the CIRAD Laboratory, Montpellier, France. The molecular characterisation of rinderpest virus developed rapidly during the 1990's. The gene sequencing of rinderpest virus isolates made a major contribution to the understanding of rinderpest epidemiology that underpinned the final eradication of rinderpest. Molecular epidemiology identified three distinct lineages of rinderpest virus of which two were circulating in Africa (lineages 1 and 2). The value of the technique was clearly demonstrated when it was used during the rinderpest outbreak in wildlife in Kenya in 1994. Gene sequencing confirmed infection to be due to the lineage-2 virus which had not been detected for some 30 years in eastern Africa (Barrett et al., 1998) thus indicating that the source was most unlikely to have been Southern Sudan, as had been suspected, and that another reservoir of rinderpest virus persistence was present.

The surveillance of rinderpest was an activity supported strongly by AU-IBAR throughout PARC programe. The PACE and SERECU projects required not only the timely confirmation of rinderpest but also a means of demonstrating previous infection through the detection of antibodies. This was essential for helping to demonstrate that the virus was no longer circulating and obtaining OIE accreditation of rinderpest freedom. A virus neutralisation test (Plowright and Ferris 1961), at first performed in tubes but later adapted to a microtitre format, was not widely applicable because of the constraints associated with cell cultures (Anderson et al., 1996).

The first assay developed for extensive seromonitoring, as a quality assurance check on vaccination programmes, and for serosurveillance to monitor virus circulation, was the indirect ELISA (Anderson et al., 2006) which was widely used before being replaced by the monoclonal antibody based competitive ELISA. Available in kit form, this sensitive and highly specific assay (Geiger,

2004) revolutionised the serosurveillance of rinderpest. Even though the test is not able to differentiate between antibodies due to natural infection and vaccination, a sound epidemiological sampling strategy combined with the cessation of vaccination could, with a high degree of confidence, provide evidence for the absence of rinderpest.

AU-IBAR was aided in the establishment of a laboratory network for rinderpest surveillance by international and regional laboratories funded by their host governments and international partners. Particularly valuable was the partnership with the Joint FAO/IAEA Division in Vienna which, with support from partners of which the mainstay was the Swedish International Development Cooperation Agency (SIDA) initially and then the EC, operated a diagnostic network in Africa which helped to install and support the diagnostic technology essential for rinderpest surveillance and provided a forum for technical development and backstopping. One of the legacies of the AU-IBAR laboratory network established and maintained through PARC and PACE programs is the body of laboratory expertise that was developed and still operates today.

4. EVOLUTION OF VACCINES AND VACCINATION

The fight against rinderpest in Africa was mainly dependent on immunisation. There was progressive improvement of the vaccines used, including adoption of modern technologies. Below is a brief walk through the chronology of vaccine development with respect to rinderpest eradication in Africa.

4.1 Serum Vaccines

Long before the use of live vaccines in the fight against rinderpest, it was observed that serum from a recovered animal could protect against the disease when inoculated into a naive animal (Semmer et al., 1893). This procedure was used during the great African rinderpest epidemic of early 20th century. A number of scientists, led by Arnold Theiler (Theiler, 1897), went a step further and showed that serum administered simultaneously with the virus accorded a solid and long lasting immunity. At around the same time, Drs. Bordet and Danysz of the Pasteur Institute, Paris, refined the technique and christened it the "French method" (Spinage, 2003). In 1896, Robert Koch arrived in Cape Town, South Africa and in his experiments observed that bile from an infected animal contained no infectious virus, and therefore had potential of being an inactivated vaccine. He also added his voice to the efficacy and use of the serum-virus simultaneous method and from thereon it was used widely until the advent of inactivated vaccines (Taylor et al., 2006).

During the outbreaks in Africa in the early 1900s, only the serum approach was employed, but later the serum-virus simultaneous method was adopted resulting in a better outcome (Pool and Doyle, 1922). However, this vaccination method could not be used in calves, weak animals and heavily gravid cows because of their higher susceptibility to rinderpest virus than other cattle. In addition, it required vaccinated animals to be isolated because of the risk of their acting as sources of infection for other cattle in contact. The vaccine had a short shelf life (nine days), and had the potential of transmitting other blood borne infections, most notably haemoprotozoa. In addition, vaccination and titrations of the dosage were laborious and time consuming. Although it was imperfect and caused infection in recipient animals, the virus-serum simultaneous vaccination was far more effective than any other control method hitherto used. Nevertheless, the possibility of the use of inactivated vaccines was explored in order to develop a safer and more effective vaccine.

4.2 Inactivated Rinderpest Vaccines

Early in the 20th century, inactivated preparations of rinderpest infected bovine tissues (lymph nodes, spleen, tonsils) were used as vaccines. To kill the virus, the tissues were treated with a number of inactivating agents including toluol, eucalyptol, chloroform and formalin. Using this type of vaccination, Iran and some other Asian countries apparently achieved eradication of rinderpest. Other successful applications of inactivated vaccines in rinderpest control have been discussed (Taylor et al., 2006). The types of inactivated vaccines produced at Grosse Isle in Canada were extensively used in Africa for rinderpest control (Vittoz, 1963), but with little success. The drawback with this type of vaccines was the short and inconsistent immunity they induced in vaccinated animals. The need for a vaccine that could induce a solid, long lasting immunity led to the exploration of attenuated live vaccines, starting with goat-attenuated rinderpest vaccines.

4.3 Goat Attenuated Vaccines

In one of the attempts to develop an effective long-lasting vaccine, Edwards (1930) modified rinderpest virus by passaging it serially in goats. The line stabilised after 600 passages and proved to be attenuated for Indian cattle. Moreover, the attenuated virus induced a lifelong immunity. This represented a significant breakthrough in the battle to control rinderpest. In 1936, a virus strain first isolated at Mukteswar in India was introduced to Kenya. It was tested in both zebu and grade cattle with disastrous results. Another attempt included the use of the Kabete-O (K-O) strain of rinderpest virus that had been maintained by needle passage in cattle for many years.

The development and trial of this vaccine in various breeds of cattle took cognisance of the fact that there are variations in innate immunity based on breed. In 1937, and again in 1945, Daubney and Hudson passaged the Kabete-O strain of rinderpest virus in goats in order to reduce its virulence and use it as a vaccine. This was achieved after 150 passages with only mild clinical signs being encountered in inoculated cattle and a more than 90 per cent cattle survival rate (Daubney 1949). After more than 250 passages, mortality dropped drastically to 2 per cent. At this point, the vaccine, now referred to as Kabete Attenuated Goat (KAG) was introduced for use only in zebu cattle because it was still virulent in grade (cross breeds between Bos indicus and Bos taurus) cattle. This virus underwent further goat passage in Nigeria and then Cairo, Egypt and in 1947, vaccine production on a large scale commenced.

Desiccated KAG vaccine was introduced in Egypt in 1945 following what was thought to be a re-introduction of rinderpest from Anglo-Egyptian Sudan. Availability of the mass produced vaccine enabled mass vaccination to be undertaken and by 1948, the spread of the disease had stopped following the vaccination of over 15 million cattle across East, West, Central and North Africa (Daubney, 1949). Apart from the fact that the vaccine was cheap, it was very efficacious, providing long-term immunity of up to 14 years (Brown and Rashid, 1958). The weakness of this product was the need to use the cold chain system. However, this deficit was improved by desiccating and storing the vaccine under vacuum.

4.4 Egg Attenuated Vaccines

An egg-attenuated vaccine was developed in 1947 using the K-O virus (Shope et al., 1946). In 1946, the seed virus was introduced to East Africa from Grosse Isle, Canada, by employees of the United Nations Relief and Rehabilitation Administration. Dr. KVL Kesteven acquired two samples of the chorioallantoic membrane (CAM)-passaged virus from Kabete, Kenya. One of them had been CAM-passaged twice. It was again passaged twice, this time in calves before being passaged again in 10-day old CAMs and finally in the yolk sacs of embryonated eggs. After 16 such yolk passages, the virus was safe to be used as a vaccine. By varying the number of passages, it was possible to achieve different degrees of attenuation and therefore minimise the side effects of the vaccine. Attempts made at Kabete were successful after 33 CAM and 25 yolk passages, achieving a solid immunity with no side effects recorded.

4.5 Rabbit Attenuated Vaccines

Nakamura and colleagues in Japan pioneered the development of live rinderpest vaccine based on attenuation of the virus in rabbits (Nakamura et al 1938). It was introduced into China in the 1940s to combat a major outbreak of rinderpest in Manchuria, China. Despite having been used extensively in the field, the lapinised virus retained significant pathogenicity for some breeds of cattle, even at very high passage levels. When the Japanese/Chinese experience was reported at a meeting in Kenya (Cheng and Fishman 1949), it attracted much interest and the FAO arranged for distribution of a high passage virus seed to Egypt, Ethiopia and Kenya. For the next 20 years before the introduction of tissue culture grown virus vaccines, lapinised vaccine was used extensively in Africa. However, there was still need for a “perfect” vaccine, one that could give solid lifelong protection with no side effects. Therefore, work continued with attention turning to the use of tissue culture to produce a new vaccine.

4.6 Tissue Culture Rinderpest Vaccines

The development of tissue culture technology enabled scientists at the East African Veterinary Research Organisation's Muguga Laboratory to initiate studies to adapt the goat and rabbit attenuated viruses to cell cultures (Plowright and Ferris, 1961). After initial failure, their efforts succeeded when they used the K-O strain of rinderpest virus, adapting it to grow in primary bovine calf kidney cell monolayers. The virulence increased over the first 10 passages, rebounding to the level of the parent strain after 16 passages and eventually losing its virulence after 70 passages (Plowright, 1962). The dynamics of these changes in virulence may be due to the selection pressure the virus was subjected to in cell culture (De Boer and Barber, 1964). Due to the side-effects of goat and rabbit attenuated vaccines and their limitations of use in young and pregnant cattle, Plowright's findings represented a major breakthrough in the quest for a "perfect" vaccine. The Tissue Culture Rinderpest Vaccine (TCRV) was easier to test for potency by titration in cell cultures following parallel titration (calibration) in animals (Plowright, 1962, Taylor and Best, 1977); thus, eventually circumventing the need for animal testing.

The Tissue Culture Rinderpest Vaccine (TCRV) at a passage level of 90 or more had many advantages over its predecessors. It was safe to use in all ages and breeds of cattle including third trimester pregnant cows and grade cattle (Plowright 1962). The vaccine was extensively field tested in West Africa as well as India with sterling results (Johnson, 1962; Bansal et al., 1980) being obtained.

The rapidity of the antibody response following vaccination was found to be dependent on the dose of the vaccine used. The higher the dose, the earlier the response, with protection established after only four days (Plowright and Taylor, 1967; Plowright et al., 1970; 1971). One median immunising dose was shown to be equivalent to one tissue culture median infectious dose (TCID) and an internationally agreed field dose was set at 300 median TCID to allow for some degradation before inoculation. After inoculation, the virus replicated in lymphoid tissues and a low viraemia was detectable. However, the virus did not replicate in mucosal membranes and excretion did not occur, thus, there was no onward transmission of the attenuated virus to in-contact cattle, even those housed together. It was also shown that, after challenge of cattle immunised with TCRV, if the level of neutralising antibody was low, then a limited post-exposure viraemia could occur in the absence of any clinical reaction. However, virus excretion and onward transmission were extremely rare events. Comparable results were obtained with high grade animals challenged at intervals of between 6 and 10 years after vaccination. Serologically, the majority of individuals showed no increase in antibody titre following challenge, although delayed non-anamnestic increases were occasionally seen. It was, and still is, concluded that a lifelong immunity results from a single subcutaneous inoculation of a fully rinderpest-susceptible animal. Bansal and Joshi (1979) recorded resistance to virulent challenge at 8.3 years following a single vaccination.

It was demonstrated that life-long immunity was achieved with one subcutaneous inoculation of TCRV (Plowright and Taylor, 1967; Plowright et al 1970, 1971). Despite this, reports of only a short-lived immunity (Provost et al., 1969), at odds with all other findings, led some countries, especially those in West Africa, to resort to annual mass vaccination of all cattle. TCRV was used massively throughout the internationally coordinated rinderpest eradication campaigns. This tool for immunisation was improved still further with the development of a thermo-stable formulation of TCRV (ThermoVax).

4.7 Thermostable Rinderpest Vaccine (ThermoVax)

Using the live tissue culture attenuated rinderpest virus vaccine (TCRV), rinderpest was almost eradicated from the African continent under the JP15 programme. However, because the vaccine was labile both before, but especially after, reconstitution, a cold chain was required to ensure that the vaccine was still potent at the time of application. With the re-emergence of the disease in the 1980s, the rinderpest eradication campaign under PARC recognised the value of a thermostable vaccine. This was especially critical in politically unstable and highly inaccessible areas where rindrpest persisted.

Research spearheaded by Tufts University School of Veterinary Medicine, and funded by the United States Department of Agriculture, explored different stabilisers and a modified lyophilisation cycle for the tissue culture rinderpest vaccine resulting in a highly thermostable vaccine (House and Mariner, 1996). The resultant vaccine formulation, referred to as ThermoVax, has a shelf life of at least three months at high ambient temperature when compared to the parent TCRV vaccine. Nevertheless, it was recommended that the vaccine be used within 30 days of leaving refrigeration to maximise its efficacy. The introduction of this vaccine was timely as it greatly facilitated the final thrust for eradication of the disease among the pastoral tribes of Southern Sudan and in the Afar region of eastern Ethiopia, where access could be gained by CAHWs. ThermoVax made it possible to carry out mass vaccinations in civil strife and harsh environments of the continent with reduced need for the cold chain system (Leyland 1996).

4.8 Combined Vaccines

During rinderpest eradication campaigns, attempts were made to carry out simultaneous vaccination against rinderpest and contagious bovine pleuropneumonia (CBPP) using the combined vaccine (Bisec) in West and Central Africa. This was the standard vaccine used in West and Central Africa for routine mass vaccination and it seems to have been effective in both controlling rinderpest and suppressing the incidence of CBPP outbreaks. However, during the late 1990s vaccination failures against CBPP were repeatedly experienced prompting concerns about the efficacy and/or identity of the strain being used for vaccine production. This led to the discontinuation of the use of Bisec. Unfortunately, this seems to have resulted in the resurgence of CBPP in some West African countries.

4.9 New Generation Vaccines against Rinderpest

Although thermostability was improved by the development of the ThermoVax version of the TCRV vaccine, it was still not possible to differentiate clearly between vaccinated and naturally infected animals. A new vaccine was required and it was on this premise that attempts were made to develop recombinant poxvirus vaccines for rinderpest combined with tests able to differentiate between the antibodies induced by the wild and recombinant viruses

The first recombinant vaccines against rinderpest developed in the 1980s were vaccinia virus-based using the two surface glycoprotein genes of the virus (Yilma et al. 1988; Yamanouchi et al., 1998,a Barrett et al., 1989). One of these vaccines, based on the Western Reserve (WR) strain, had some shortcomings. For example, it was not well attenuated and therefore produced severe lesions in vaccinated animals (Belsham et al., 1989). The second vaccine was based on the LC16mO strain of the vaccinia virus (Verardi et al., 2002). This one produced long-term immunity, good enough to control outbreaks (Barrett and Yamanouchi, 2006).

Another generation of recombinant vaccine for rinderpest based on capripox virus was able to protect cattle against both rinderpest and lumpy skin disease (Ngichabe et al., 1997, 2002). Both the vaccinia and capripox based rinderpest vaccines were also good candidates to be marker vaccines enabling differentiation of vaccinated animals from infected ones.

Using a reverse genetics approach, it was possible to alter the genome of rinderpest virus by generating site-specific mutations allowing for custom designed marker vaccines (Barrett and Yamanouchi, 2006). Such vaccines could express inserted genes of foreign and detectable proteins such as the green fluorescent protein (GFP) (Walsh et al., 2000a). Despite the promising results obtained, there is still no validated assay available for the differentiation of vaccinated and naturally infected animals.

There are three main concerns about the use of recombinant vaccines. One is the safety of vaccinated and in-contact animals and the vaccine handlers; another is the possibility of altering the tropism of the virus in the host animals leading to novel pathogenesis and the third concern relates to the possibility that the vaccines might spread to non-target hosts in the field situation. Their use require thorough evaluation before commissioning for field release. Another problem is the absence of legal and regulatory frameworks governing the use of genetically modified organisms in African countries.

In conclusion, although long-lasting immunity is a desirable attribute, it was of limited essence in a rinderpest eradication strategy. What was required for elimination of a focus of infection was synchronised mass vaccination in the whole population irrespective of the duration of the solid immunity (Taylor et al., 2002). A summary of various attributes of different rinderpest vaccines is given in Table 1. The application of vaccination strategies to eradicate rinderpest in Africa is well covered in the sections on the respective vaccination campaigns viz. JP15, PARC and PACE, while the research input in the development of these vaccines is covered in the section on the analysis of the rinderpest eradication process.

5. CONTROL AND ERADICATION OF RINDERPEST

5.1 Control of Rinderpest Pre-JP15 (before 1962)

Early attempts to control rinderpest were more concerned with treatment of the individual animal by such means as feeding raw eggs and wine (Columella, translated in 1954) and various other polypharmacies (Paulet, 1775). Although as early as the Roman period it had been suggested that the best way to control the spread of rinderpest was by isolation of animals and quarantine it was not until the 18th Century that there was a growing understanding that rinderpest was a communicable disease. Early in the 18th Century, Giovani Maria Lancissi had protested at the earlier ineffective approaches to containing the disease by famously stating that "it is better to kill all sick and suspect animals, instead of allowing the disease to spread in order to have enough time and the honour to discover a specific treatment that is often searched for without any success" (Mantovani and Zanetti, 1993). He observed that the disease was caused by "exceedingly fine and pernicious particles that pass from one body to another". It was no wonder, then, that it was the same Lancissi who made the first breakthrough in the control of rinderpest (Lancissi, 1715), a procedure that was later adopted by Thomas Bates (Bates, 1718). Lancisi's recommendations for its containment are still valid 300 years later. Lancissi's control prescription entailed zoosanitary measures including slaughter to reduce spread, and strong legal enforcement of control measures including quarantine, restricted movement of cattle, burial of carcases in lime, and thorough meat inspection.

When the disease entered Africa, Lancissi's approach was employed to control rinderpest combined with such procedures as serum/virus vaccination. Despite global and regional disruptions, which favoured resurgence of the disease, the 20th Century witnessed an increased and improved control and a reduction of the impact of the disease. This was made easier by the advent of vaccines.

In Tanzania during the First World War, when British and German forces fought a war down the eastern side of Tanzania, rinderpest spread from northern to southern Tanzania and into Northern Rhodesia. In response, the South African Government sent a Commission to Tanzania to create a cattle-free strip of 15-30km along the Malawi-Zambia border with Tanzania. In addition, a belt of immune cattle was created 50-65km along the border using the virus-serum simultaneous method. Tanzanian authorities undertook similar immunization work in other areas south of the Central Railway and by 1918, southern Tanzania was free of rinderpest.

In the years after the war, through the efforts of the emerging Department of Veterinary Services, the British Administration began the process of containing rinderpest in northern Tanzania where it was still endemic. The control strategy involved an initial standstill of all cattle within 16Km of an infected herd, confirmation of the presence or absence of rinderpest, the moving of infected herds inwards and uninfected herds outwards to create a cattle-free area around the outbreak, and finally the immunization of in-contacts in the infected herds by giving them rinderpest hyperimmune serum and mixing them with the infected animals.

In 1922, rinderpest again moved south of the railway to the Ruaha River but was repelled through a "stamping-out" strategy. In 1931, the method for controlling rinderpest changed when the laboratory at Mpwapwa began producing an inactivated vaccine. Infected herds were quarantined and vaccine given to healthy animals in infected herds. This policy was soon abandoned because it was felt that its use promoted a smouldering and lingering infection in some herds. It was replaced by the virus-simultaneous method that had not been used until that point out of the fear that it would spread blood-borne parasites, resricting its use only to transit cattle.

Due to the global recession in the early 1930s, however, departmental budgets were reduced and it was no longer feasible to detain herds in lengthy quarantines. Consequently, the herds were released sooner than had previously been the case. It was noted in 1932 that due to the mild nature of the disease, classic symptoms only became apparent after a herd had been infected for 3-6 weeks, making it difficult to recognize the beginning of an outbreak. This observation would suggest that the virulence of the virus increased in susceptible populations but diminished when they had gained a measure of immunity. Nevertheless, once outbreaks were established, they could be extensive and involve thousands of head of cattle. As a result, all possible control techniques were employed to arrest the spread of outbreaks including vaccination, nasal swabbing with infected tissue to hasten the course of an outbreak, inoculation with serum alone or simultaneous virus-serum inoculation.

By 1936, rinderpest moved steadily southwards towards the Central Railway Line following the path of infected game animals. Mortality rates of up to 20% were recorded in fully susceptible herds. In 1937, the disease crossed both the Central Railway Line and the Ruaha River reaching the southern highlands. Buffalo and eland were frequently implicated in the spread of the disease in the north, while in the south the greater kudu hastened the process. Once again the mild nature of the disease made it difficult to recognise it during the outbreak. The situation had become so grave by 1938 that an attempt was made to create a 130km immune barrier to the disease. The attempt was determined to have been unsuccessful when in 1939, a newly constituted rinderpest surveillance service found the disease along the southern border of the country. In response, a decision was made to create another belt along the border itself from Lake Nyasa to Lake Tanganyika.

In northern Tanzania, the disease had spread southwards through illicit cattle trade to Monduli Juu at Themi holding ground, west of Arusha and surrounding areas by 1961. The Themi outbreak was remarkable in that the virus failed to regain virulence in a group of local cattle that had not been vaccinated for several years. Vaccination campaigns were mounted in Mbulu, Masailand and Arusha. After the campaigns, no outbreaks were confirmed until 1964. However the disease was reported in a single buffalo at Essimongor Mountain, and an unsubstantiated report of the disease in wildebeest around Lake Eyasi.

During the epidemic, Plowright (1963) succeeded in recovering several isolates of rinderpest virus from cattle in Arusha-Olmotoni, (RBT/1; January 1961), Monduli Juu (RBT/2; January 1961), Monduli (RBT/3), Shambarai (RBT/4; July 1961), as well as a strain from the Essimongor buffalo (R.Buff.T; July 1961). Macadam (1968) indicated that the outbreak was also observed at Digodigo, Loreshi, and Olmolog. Laboratory examinatin confirmed these isolates to be lineage 2 rinderpest virus. None of the experimentaly infected animals in which one or more of the cardinal clincal signs of rinderpest (pyrexia, mouth lesions and diarrhoea) were observed died of the disease.

Of even greater interest is the fact that Plowright (1963) noted that, when one of these mild strains was titrated in cattle, the animals that received a low dose of the virus reacted severely while those that received a high dose did not. This was interpreted to be possible evidence that such strains contain virus sub-populations with the milder virus not necessarily being the major constituent. The RBT/1 isolate that had been preserved was later shown by nucleic acid sequence analysis to belong to African Lineage 2 rinderpest virus. Despite the fact that a similar mixed virulence picture emerged with respect to another isolate of the same lineage recoverd from a sick eland in Kenya in 1996, there is room for considerable speculation on the selection pressures that might encourage one or another of these variants to predominate.

By 1961, outbreaks in both Kenya and Tanzania had apparently been eliminated in cattle populations by ring vaccination. In addition, rinderpest had died out, or was in the process of dying out in the wildebeest populations of Serengeti, Ngorongoro, Loliondo and Mara. For almost four years no outbreaks occurred in any species in Tanzania or the Kenya Masailands. In 1964, however, Branagan and Hammond wrote of the possibility that small pockets of infection might have escaped attention in Tanzania, particularly among the Masai. In this regard, the vaccination record of Loliondo was particularly significant. From 1956 to 1959, no KAG vaccination was undertaken in Loliondo Division. Although a vaccination campaign was launched in 1960, it was abandoned almost immediately in the face of an outbreak of foot and mouth disease. Heavy rain and drought prevented the campaign from continuing in 1961 and it was not until 1964 that Loliondo Division was thoroughly vaccinated using Plowright's new tissue culture rinderpest vaccine made at the East African veterinary Research Organisation (EAVRO); Muguga, Kenya.

Rinderpest control and eradication demanded huge investments in human and financial resources which African countries in the 20th Century were not able to mobilise on their own. Donor support was secured for various continent-wide programmes for the control and eradication of rinderpest.

Modern vaccines were initially used year-round to combat rinderpest outbreaks. Once they became routinely available, annual campaigns were adopted in addition to buffer zoning. By this time, the preoccupation was management of the disease and little effort was made towards its eradication until the dawn of internationally coordinated programmes, namely JP15, PARC, PACE and SERECU.

Widespread concern over the continued presence of rinderpest in Africa and the threat it presented to cattle populations in the rinderpest free regions of the world stimulated the planning and eventual implementation of campaigns. These programmes contributed immensely to the eradication of rinderpest from Africa.

5.2. The Joint Project 15 (1962-1976)

The Joint Project No. 15 (JP 15) of the Organisation of African Unity/STRC implemented from 1962 to 1976 was the first Pan-African rinderpest control/ eradication programme.

5.2.1. Genesis

In the period following the end of World War II, the strenuous and constantly repeated works of the incumbent veterinary services kept rinderpest largely in check. The great rinderpest pandemic had long since passed and a number of Southern African countries had indeed managed to throw off their rinderpest burden. On the other hand, in both West and eastern Africa, a virus that was constantly endemic and intermittently epidemic was still burdensome.

In 1948, an African Conference on Rinderpest held in Nairobi, Kenya recommended the creation of an African Rinderpest Bureau. Its creation had to await the establishment of the Commission for Technical Cooperation in Africa South of the Sahara (CCTA) and Foundation for Mutual Assistance in Africa South of the Sahara (FAMA) in 1950. A working party of this body studied the proposal for the creation of this bureau and in so doing, widened its remit to encompass all epidemic diseases prevalent on the African continent. In 1951, this bureau of the CCTA was established at Muguga, Kenya as the Inter-African Bureau of Epizootic Diseases (IBED). Its first Director was Dr. W.G. Beaton. In 1964, the Heads of State of the emergent Organisation of African Unity (OAU) decided that the CCTA would become the Scientific and Technical Research Commission of the OAU and IBED would be one of its specialist units. IBED was transformed into the Inter-African Bureau of Animal Health (IBAH) in 1965 to accommodate other animal diseases. In 1970, the bureau broadened its mandate to include animal production and was renamed the InterAfrican Bureau for Animal Resources (IBAR).

As regards rinderpest, in the period we are discussing, there was a growing understanding among Directors of Veterinary Services of the need for concerted action against this disease. The CCTA/FAMA, quickly succeeded by the OAU/STRC/IBAR, moved to begin a joint inter-African campaign against rinderpest supported by member states and by international aid bodies. Thus was born the Joint Project No.15 (JP 15) to embody both regional cooperation and coordination in an attempt to eradicate the disease. It was essentially an attempt to improve food security in member states. JP 15 was implemented in six phases. Its first work plan was drawn up at a meeting in Kano, northern Nigeria in May 1961, which called for the creation of a rinderpest-free zone across the Lake Chad basin involving the vaccination of cattle from Cameroon, Chad, and Niger to Nigeria.

i) Phase I (1962 – 1965): Within the Lake Chad basin zone, all cattle were to be vaccinated each year for three years in an immunosterilisation attempt. The

Figure 1: JP15 - Rinderpest vaccination campaign

vaccination work was undertaken in each dry season between September and April/May. Cattle were vaccinated using goat-attenuated and later tissue culture vaccine when it became available. Vaccinated animals were marked with the famous cloverleaf ear notch – a symbol carried through into PARC. STRC/IBAR and donors supplied the campaign logistics while the actual implementation was undertaken by national veterinary services. Vaccines were supplied by the laboratories at Vom in Nigeria and Farcha in Chad.

ii) Phase II (1964 – mid-1967): Such was the enthusiasm for JP15 that a Phase II was quickly conceptualised. This excluded the sparsely cattle populated tropical coastal belt but included the cattle rearing areas of Benin, Burkina Faso, Ghana, the Lobi region of Côte d'Ivoire, central and eastern Mali, Togo and those parts of Niger and Nigeria not included in Phase I.

iii) Phase III (1966-1969): This phase covered Côte d'Ivoire, Gambia, Guinea, Liberia, Western Mali, Mauritania, Sierra Leone, Senegal - and parts of Chad, which had not been included in Phase I. (Lepissier, 1971).

iv) Phases IV, V & VI were implemented in eastern Africa as follows:
- Phase IV (1968 – 1971): Kenya, Southern Somalia, Sudan, Tanzania and Uganda.
- Phase V (1970 – 1973): Ethiopia and the rest of Somalia
- Phase VI (1973 – 1976): repeated Ethiopia and Sudan

The campaign in Eastern Africa was carried out without taking into account an epidemiological study previously conducted by Atang and Plowright (1969). This study had defined two endemic areas namely the Maasailand ecosystem and a vast stretch of territory encompassing northern Uganda, northern Kenya, and southern parts of Ethiopia and Sudan. Atang and Plowright had recognised that rinderpest was still endemic in the Somali Ecosystem, a region that was later shown to be endemic for the lineage-2 rinderpest virus (Mariner and Roeder, 2003).

In retrospect, had the planners of the JP15 campaign considered the epidemiological findings of Atang and Plowright, the disease would possibly have been eradicated in Phase IV of the campaign by using a more targeted approach in immune sterilisation. Nonetheless, continued annual mass vaccination was prescribed based on the fear that there could be some residual endemic foci in the Somali and Sudan ecosystems, and the Afar rangelands in Ethiopia. Thus, the vaccination campaigns continued notwithstanding the fact that no clear benchmarks for success had been defined and no point of cessation had been identified.

5.2.2 Coordination

The appointment of Henry Lépissier in 1961 as International Coordinator assured leadership of the project. His deputies were Dr. Ian Macfarlane and Dr. H.J. Henstra. Dr. Macfarlane and later Dr. A.M. Dahab were appointed international co-ordinators for Eastern Africa. Lépissier is reported to have quickly understood the necessity to take in the whole of the inter-tropical zone of West Africa. The geographical limits of activities were consequently set at 8 and 19 degrees north. He also felt, with the benefit of hindsight, that the project would have been better laid out starting in Senegal and progressing its displacement of rinderpest eastwards. However, in view of its unique start, it took its own course.

Phase I ran under the aegis of the CCTA whereas Phases II-VI ran under the aegis of the OAU/STRC/IBAR. In essence, the donors organised the campaign for only two years and the OAU took over the rest of the programme in West, Central and East Africa as the donors' sole reference point in the implementation of the campaign.

The OAU/STRC/IBAR was essential for the smooth running of the campaign. It acted as a permanent intermediary between the Coordination Office on one hand and the States and the donors on the other even though the European Development Fund (EDF) funding was largely bilateral and did not directly involve the OAU/STRC/IBAR during JP15 campaign.

The OAU/STRC/IBAR was instrumental in maintaining open transfer of information to the OIE and ensuring that the Coordination Office kept FAO abreast of progress. The bureau was involved with coordination to the extent that the office was charged with executing conservatory measures, such as calf-hood vaccination after the end of JP15.

5.2.3. Vaccines and Immunity

At the outset of the campaign, the attenuated vaccine was grown in goats; at the end of the campaign, it was grown in tissue culture. Lesser quantities of lapinised rinderpest vaccines were also used. The vaccines were all expected to provide durable levels of immunity. A combined rinderpest and CBPP vaccine, known as Bisec, was also produced and used in West, Central and parts of eastern Africa. The target cattle population in East Africa was approximately 95 million, of which 44 million were vaccinated in total while around 33 million head were vaccinated in West Africa.

Except for Liberia and Guinea, the vaccination coverage was above 79 per cent, the highest being Gambia where 94.1 per cent coverage was achieved. Vaccination coverage achieved in Phases I, II, and III is detailed in Table 3 (estimated as vaccinations delivered in total over the three phases as a percentage of the total standing cattle population).

In the case of West and Central Africa, seromonitoring to assess vaccination efficiency was carried out at the National Veterinary Research Institute, Vom, Nigeria using the virus neutralisation test (VNT). From the 1,500 sera collected across the three years of Phase I, immunity peaked after two rounds of vaccination. In East Africa, the East African Veterinary Research Organisation, Muguga, Kenya carried out sero-monitoring using the VNT and more than 50,000 serum samples were analysed. It was clearly shown that over 70 per cent levels of immunity were attained.

5.2.4 Financing the Joint Project 15

Donor assistance came mainly from the European Development Fund (EDF) and from the United States Agency for International Development (USAID). The British, German and the Canadian governments, provided other major inputs.

Attempts have been made to arrive at a basic financial reconciliation in determining the cost of this campaign. From this, it appears that through their veterinary departments, national governments in western Africa contributed around US$ 6.5 million while external aid funds provided US$ 8.3 million. These amounts equate to approximately US$ 18.0 million and US$ 23.0 million, respectively, in the year 2000. Table 2 gives a detailed tabulation of the above figures. From the figures available, funds spent in West and Central Africa were US$ 14,762,908 and US$ 36,237,092 in Eastern Africa, making a total expenditure for JP15 of US$ 51 million (FAO, 1989; Lepissier, 1971).

5.2.5 End of JP15 and Lessons learnt

At the end of the JP15 campaign, no specific measures were defined and put in place to sustain the achievements made in reducing the incidence of rinderpest. It was assumed that states would automatically accept to stamp out any outbreaks that occurred, but this never happened. Comfort was taken in the notion that 80% vaccination coverage would automatically eliminate the virus. However, this implies a false understanding of herd immunity. In reality vaccination coverage never equates to generation of immune animals; thus this understanding takes no account of the dynamics of herd turnover and assumes that cattle populations are homogeneous, which they are not.

According to Lépissier, the recommended solution would have been for States to continue vaccinating their yearling population for several more years and to take appropriate sanitary measures should an outbreak occur. At about the same time, Provost et al.,(1969) cast doubt on the duration of immunity following rinderpest vaccination. In Nigeria, for example, for a time at least, an attempt was made to continue to try to maintain high immunity levels by implementing a mass vaccination policy using national resources. In addition, OAU/STRC/IBAR continued to monitor the rinderpest status in the event an outbreak of the disease occurred in any Member State.

Another difficulty in relation to eradicating rinderpest following the phasing formula related to the long gap between actions, for instance, the vaccinations in Niger were completed two years apart. Even the one-year discontinuity between different regions of Chad presented problems as a number of residual Nigerian outbreaks came from this source. It is now well accepted that rinderpest elimination from a population can only be achieved if the principle of immunosterilisation is applied (vaccinating the entire infected population in one intensive campaign, acting concurrently across the entire infected area (Taylor et al 2002) to arrive at a herd immunity level sufficient to eliminate infection from the population and exclude its reintroduction). This procedure was not properly implemented throughout the period of JP15 project and afterwards.

At the conclusion of JP15, approximately 64 million head of cattle had been vaccinated in Eastern Africa (FAO, 1989). It was observed that protective immunity lasted beyond 10 years following vaccination of cattle with the rinderpest tissue culture vaccine. It was also shown that 80 to 90 per cent immunity levels were attainable following intensive coverage. The tissue culture vaccine was therefore widely used in East Africa. At this time, it was clear that in order to assess herd immunity levels, clusters of various age groups had to be included in the sampling procedures (Atang and Plowright, 1969).

These experiences and challenges encountered during the JP15 campaign informed subsequent programmes for the eradication of the disease. A concept developed by the OIE in 1989, which became known as the OIE Pathway, was instrumental in this endeavour, and AU-IBAR along with other stakeholders mooted the PARC and PACE programmes in order to get rid of the virus in a straightforward feat and secure the outcome by a series of national surveillance audits to ensure continental safety.

In summary, JP15 campaign reduced rinderpest disease outbreaks substantially. It also provided good lessons for subsequent campaigns. However, pockets of infection were left despite the belief that rinderpest had been eradicated. Following rinderpest outbreaks of the 1980s, it became evident that indeed the disease had not been eradicated after all.

5.2.6 Outbreaks of rinderpest after JP15 and the emergency programme between 1980 and 1982

In the absence of an exit strategy at the end of the JP15 campaign, rinderpest remained in defined foci in West, Central and eastern Africa. Figures on vaccinations showed coverage of 78% and 79% in Mali and Mauritania respectively. However, given the dynamics of the nomadic pastoral production systems in the countries, the herd immunity profiles are likely to have declined precipitously within a short time after the JP 15 programme. This, coupled with residual foci of undetected rinderpest were instrumental in the resurgence of rinderpest epidemics in West Africa while the failure to comprehensively vaccinate cattle in the triangle of Ethiopia, Kenya and Sudan resulted in the spread of the disease in the early 1980s. Emergency intervention was necessary as explained in the following sections.

In 1985, there were still reported outbreaks of the disease in Benin, Burkina Faso, Ethiopia, Ghana, Côte d'Ivoire, Kenya, Mauritania, Niger, Nigeria, Sudan, Tanzania and Togo. This necessitated the mooting of a more comprehensive programme to build on the achievements of JP15 and ensure rinderpest eradication - the Pan African Rinderpest Campaign (PARC).

5.3 The Pan African Rinderpest Campaign (PARC; 1986-1998)

Learning from the shortcomings of JP15, and building on its achievements, PARC was mooted by the OAU as a two-pronged effort combining the regional activities of a co-ordination unit and national projects in 35 participating countries. The hallmark of PARC was to carry out a comprehensive regional undertaking aimed at complete eradication of the disease across the continent.

The PARC programme was defined in 1986 and consisted of six principal components, all essentially focussed on the control of rinderpest:

i) Technical assistance to IBAR

ii) Establishment of vaccine banks

iii) Immediate action in the areas where rinderpest was endemic

iv) Research programmes

v) A reserve fund for possible emergencies (ECU 3 million)

vi) Direct action against rinderpest in participating countries not covered by emergency actions

The PARC Project was officially launched through the signing of a financing agreement between the EU and the OAU (represented by the Secretary General) at the First Conference of Ministers of Livestock Affairs in Addis Ababa, on July 3rd, 1986. The Japanese Government through an FAO Trust Fund, the British Overseas Development Agency, and the Governments of Belgium, Italy and Nigeria provided additional support.

Having agreed on the components of national projects with the OAU-IBAR and the European Commission, countries appointed PARC National Coordinators, who became responsible for supervising local implementation in accordance with technical advice from the PARC coordination units. A PARC technical committee was constituted and met every two years to review progress in implementation and advice on future action. Donors, technical partners, member states, and OAU/IBAR attended the Technical Committee meetings.

5.3.1 The PARC technical plan for rinderpest eradication

The PARC technical plan for rinderpest eradication consisted of two elements as outlined below: the need for immediate actions to cope with the emergency of rinderpest resurgence and the long-term continent-wide vaccination campaigns to control and eradicate the disease.

5.3.1.1 Coping with the rinderpest pandemic emergency

At the end of JP15 there was epidemiological intelligence that rinderpest virus was present within two endemic areas of the Mauritania-Mali and Ethiopia-Sudan borders. By 1980, the virus was spreading across the entire sub-Saharan Africa. The catastrophe had begun to exceed the bounds of the endemic areas and was moving both east and west with infected trade cattle. In 1981, a joint OAU/IBAR/FAO/OIE meeting proposed another continental campaign for rinderpest eradication and a new funding initiative to tackle rinderpest as well as CBPP. In this proposal, one of the lessons learnt from the failure of JP15 was incorporated, namely, the need to concentrate resources in the areas where the resurgence of rinderpest was having the maximum impact.

The plan that was developed called for intensive vaccination of all cattle in a zone for five consecutive years with a combination of vaccines. Under the guidance of an international coordinator, this programme encompassed Mali, Mauritania, Burkina Faso and part of Niger. The countries were subjected to intensive vaccination ringed with a buffer zone consisting of cattle vaccinated for three consecutive years.

In eastern Africa, intensive actions would be in Ethiopia, Somalia, Djibouti, and

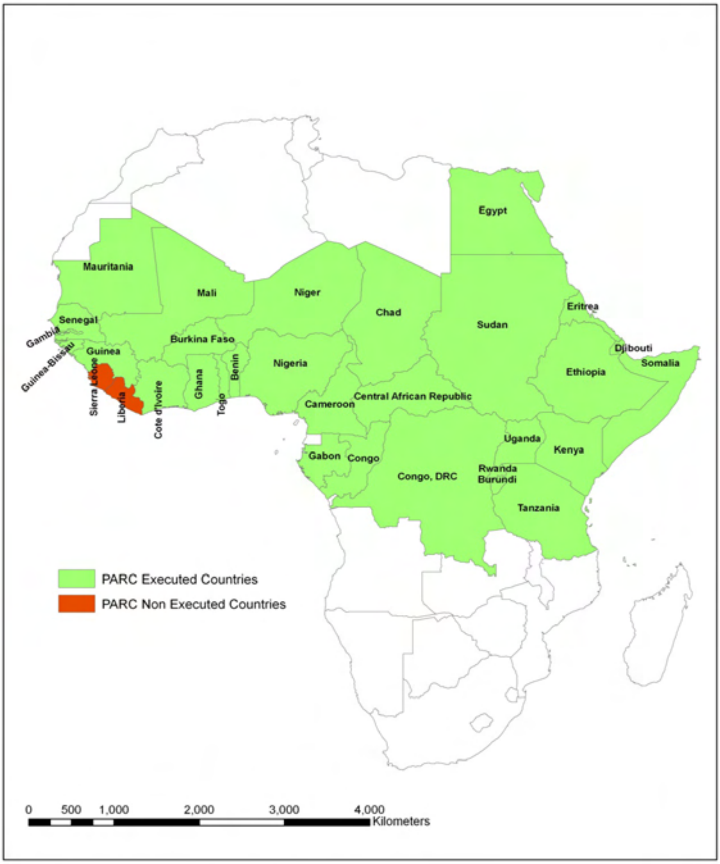

Figure 2: Countries participating in PARC

Sudan east of the Nile. This zone was designated on an understanding that the virus had survived JP15 in both Ethiopia and in southern and eastern Sudan. Unfortunately, this understanding failed to take into account the fact that the virus was already west of the Nile and was possibly present elsewhere such as the Somali ecosystem. As with West Africa, this eastern region was to be surrounded by a buffer zone.

To cope with the emergency, OAU approached the EU for ECUs 1 million with which to undertake emergency vaccinations, which were carried out in 1981. As a result, the incidence of rinderpest reduced, only to resurge in 1983. Further details are given in Table 4. FAO complemented the emergency programme through national projects in affected countries funded on a bilateral basis under its Technical Cooperation Programme. These emergency vaccinations were beneficial but did not immediately halt the progress of the epidemic.

In the meantime, the disease situation continued to deteriorate. In West Africa, the virus continued to spread south to the coastal states of Côte d'Ivoire and Ghana and in 1980 reached Sokoto in western Nigeria. The virus was later identified as African Lineage 2. In Eastern Africa, the virus spread into western Sudan and then through CAR, Cameroon and Chad into eastern Nigeria in 1982. This virus was identified as African Lineage 1. At this point, the recrudescence of rinderpest was described as the Second African Pandemic, the first having taken place roughly 100 years earlier.

By 1984, it was realised that the initial concept of two intensive action zones had been overtaken by epidemiological events. Therefore, a revised proposal called for the zone of intensive action to stretch across the entire Sahelian region and down the east coast of Africa to include the whole of Kenya and Tanzania. A buffer zone was to be limited to the stretch along the West African coast extending into Central Africa. These interventions secured a remarkable victory over rinderpest in West and Central Africa from where it was eventually eradicated as early as 1988.

5.3.1.2 The broader PARC programme

In the course of implementing the PARC programme, strategies for vaccination and seromonitoring were adjusted. Following the initial operations of PARC in 1987, the need to proactively involve all stakeholders ranging from cattle owners to government decision-makers became quite urgent. Their co-operation was vital to achieve eradication of the disease, and the delivery of livestock services to the grassroots. In addition, it was envisaged by some that the progressive control and eradication of rinderpest would result in increasing cattle and wildlife populations with potential negative impacts on the environment. Thus, the stakeholders were deemed to be pivotal in safeguarding the environment against desertification. There was also an urgent need to strengthen the public relations image of the campaign in order to achieve sufficient momentum and priority at the international level. To meet these objectives, PARC added Communication for Development as a key component in its overall strategy to improve project planning and implementation, people's participation and training through better communication among all parties involved.

When PARC was launched in 1986, the virus was still present in East, Central and West Africa. Reports received by AU-IBAR and OIE showed that the disease was more active in some countries than others and it was therefore decided to prioritise actions against the disease in accordance with its prevailing level of activity. Accordingly, the initial strategy was a fire-fighting approach in which PARC decided to take immediate action in Nigeria, Burkina Faso and Mali in West Africa and Ethiopia and Sudan in Eastern Africa. The campaigns then targeted more systematic intensive actions in the following countries: Benin, Burkina Faso, Burundi, Cameroon, CAR, DRC Congo, Djibouti, Egypt, Ethiopia, Equatorial Guinea, Gambia, Gabon, Chad, Ghana, Guinea, Guinea Bissau, Côte d'Ivoire, Kenya, Mali, Mauritania, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Togo and Uganda. It must be emphasised that although some of these countries had not reported rinderpest, they were expected to provide a buffer zone to prevent the spread of the disease from the infected countries.

The PARC funds from the European Union were destined for use in three ways. First, they were to be used to suppress virus circulation with blanket vaccination designed to boost the level of immunity of the cattle population of an entire country, or create buffer zones to block its passage in a particular direction. Later, when the incidence of infection was reduced, vaccination interventions were more targeted. By 1987, the need to include CBPP within a mass vaccination programme had been realized. Other uses of the funds included strengthening the capacity of national veterinary services to undertake vaccination campaigns (Cheneau, 1985). The veterinary services would now implement their own campaigns under the coordination of AU-IBAR in accordance with the financing agreement signed between the OAU and the EC. PARC funds were also used to support livestock policy reforms in participating countries, in order to ensure a better financial foundation and sustainability of veterinary services. Consequently, except for initial emergency or fire fighting vaccination programmes, access to funding became dependent on the articulation of policy reforms in national veterinary services.

Policy reforms were undertaken over a period of two years resulting in the following actions:

i) Support for revitalisation or restructuring of livestock services.

ii) Support for the implementation of measures on pricing policy, processing and livestock marketing.

iii) Implementation of anti-desertification measures e.g. de-stocking, planting of fodder or forestation.

iv) Support for livestock production in areas of intensive crop farming and improved control of water resources in grazing areas.

5.3.2 The PARC coordination: organisation, management and follow-up

During the PARC project implementation, AU-IBAR coordination played a key role in both the design and setting up of the strategy against rinderpest and in the reform and harmonisation of livestock policies at country level. In general, this coordination made it possible to guarantee continuous implementation of the programme as soon as local conditions permitted. The work relied on a series of visits to the countries in order to establish a policy dialogue and to assist in the preparation and follow-up of national components. This process made it possible to ensure a coordinated approach to the fight against rinderpest.

Planned initially for two years, the technical assistance element of the Coordination Unit was maintained throughout the programme. The number of Coordination Unit personnel remained relatively low with one Co-ordinator in West and Central and the other in eastern Africa. There were also three Technical Assistants, one in Bamako and two in Nairobi[3]. In addition, there was an epidemiology unit supported by FAO initially with Japanese Trust Funds and later with EU funds, in part channelled through FAO.

Although different donors financed different units, the staff generally worked harmoniously under the direction of OAU/IBAR. It is regrettable, however, that with the exception of the posts financed by the EU, the other units were discontinued due to lack of continuity of funding by other donors. Nevertheless, this did not adversely affect the operations and objectives of the programme.

5.3.3 The rinderpest eradication strategy

The epidemiology section within the PARC Coordination Unit was charged with developing an initial strategy for combating the virus. The strategy was to achieve immunity levels of 86 per cent based on epidemiological modelling.

In order to stop the spread of the disease from Sudan to West Africa, and from Eastern Africa to Southern Africa the First Technical Committee Meeting in Nairobi recommended the creation of sanitary cordons in the centre of the

[3]One surpported by UK government

continent and in eastern Africa. Within these buffer zones, mass vaccination was to be carried out to create an immunity level of at least 86 per cent. Further details are covered in the section on cordon sanitaires.

PARC also decided to use serology as a management tool by employing seromonitoring of vaccinated animals to determine the level of herd immunity achieved by vaccination campaigns and serosurveillance for virus circulation. A network of competent laboratories was established adopting ELISA technology for determining herd immunity levels to rinderpest. A massive programme to transfer the technology to national and regional laboratories was carried out by the PARC Co-ordination Unit and the FAO/IAEA Joint Division of Nuclear Techniques in Food and Agriculture. The EU provided funding for this activity.

5.3.4 Emergency preparedness

Early in the PARC programme, the issue of unexpected outbreaks of rinderpest was addressed. Countries were encouraged to develop emergency preparedness plans, which included availability of finance, equipment, materials, and personnel for immediate intervention should rinderpest recur. The following were put in place:

i) Emergency vaccine banks

ii) Emergency funds

iii) Rinderpest contingency plans

With the progressive cessation of rinderpest vaccination throughout the PARC participating countries, cattle populations became increasingly susceptible to infection and the establishment of a rinderpest vaccine bank as a precaution against a re-emergence of the disease was crucial. PARC established and maintained a stock of 500,000 doses of the vaccine at the Botswana Vaccine Institute. In addition, the project funded a bank of rinderpest vaccine in Lokichoggio in North-west Kenya and in Khartoum, Sudan, during the final stages of the rinderpest campaign in southern Sudan. The PARC contribution to emergency preparedness against rinderpest was implemented efficiently. All countries were encouraged and assisted to develop emergency preparedness plans and care was taken to ensure that the vaccine banks were replenished when stocks expired. Emergency preparedness planning was aided by FAO's EMPRES programme, which developed guidelines and regional workshops on the subject in support of PARC.

PARC paid manufacturers retention fees for maintaining the vaccine banks. The manufacturers were allowed to replace the stocks to maintain good quality vaccine and not to exceed shelf life. When batches were sold, they were immediately replaced by fresh, potent vaccine. One million doses were utilised for emergency in Kenya and Tanzania in 1995 to 1996. After 1991, only the vaccine bank at the Botswana Vaccine Institute was retained.

The EU Delegation in Kenya held a reserve fund of ECU 3 millions for emergency, obtainable by countries with approved contingency plans on assurance of subsequent reimbursement. This fund was eventually discontinued and ECU 0.5 million were transferred to OIE, Paris, as a reserve with the same understanding.

Accordingly, all countries developed contingency plans in readiness for any outbreaks.

5.3.5. The OIE Pathway for accreditation of rinderpest freedom

As no rinderpest outbreak had been reported in western and Central Africa since 1988, the joint AU/IBAR – FAO/EMPRES workshop held in Bamako in 1995 prevailed on West African PARC participating countries to end mass vaccination and declare provisional freedom from the disease.

The 5th PARC Technical Committee Meeting held in 1997 further urged countries in West and Central Africa to join the OIE Pathway immediately. A similar recommendation was made at the 6th PARC Technical Committee Meeting held in 1998. For the rest of the countries, AU-IBAR recommended a focussed vaccination strategy with rinderpest vaccination being restricted to infected and surrounding areas; elsewhere, the countries were advised to strengthen emergency preparedness, cease vaccination and declare Provisional Freedom to OIE, either as a country or as a zone within a country.

5.3.6. Communications

To give the campaign momentum and priority at the international level, it was important to increase the awareness of various organisations and the public with regard to PARC. Accordingly, Communication Units and Media Reference Centres were established within the Nairobi and Bamako PARC Co-ordination units. The aim of these units was to assist in national capacity building and for the formulation and implementation of communication components aimed at improving the linkages with rural communities. The objective then was to gain the cooperation of governments and livestock owners in the implementation of PARC strategies for policy reforms, environmental safeguards and rinderpest eradication through vaccination.

Key issues were identified through Participatory Rural Communications Appraisal (PRCA) research in 14 countries. This led to the formulation of National PARC Communications Strategies. Thereafter, communication plans were incorporated in national PARC programmes. The central communication units provided guidance in the development of television news items, radio programmes, press releases, newsletters, annual reports, transparencies, sensitisation booklets, posters, and the AU-IBAR website.

5.3.7. Economic analysis

In 1995, an Economics Support Unit was set up in collaboration with ILRI with the specific objective of estimating the economic impact of rinderpest control on livestock productivity and on the well-being of society and producers. It was also required to examine the cost effectiveness of alternative implementation methods and survey and evaluate policy reforms instituted under PARC. Results showed that the average cost of vaccinating a cow was ECU 0.42 and provided convincing evidence of the cost effectiveness of rinderpest eradication (Tambi et al., 1999).

By examining economic losses that would have accrued without PARC and measuring these against the losses that occurred with PARC, it appeared that 88 per cent of the total loss could be realised as a benefit from PARC. This suggested that PARC saved Africa ECU 99 million during its implementation span. A cost-benefit ratio estimated across 10 countries participating in PARC was 1.83:1. Internal Rates of Return varied from 11 per cent for Côte d'Ivoire to 118 per cent for Burkina Faso. All were well above the opportunity cost of capital. Total welfare gains from PARC were estimated at ECU 57.5 million, which could be partitioned into ECU 46.8 million to producers, and ECU 10.7 million to consumers.

5.3.8. Research and technology transfer under PARC

5.3.8.1. Wildlife

The PARC programme had to deal with a possible persistence of rinderpest in wildlife in northern Tanzania where an outbreak in cattle in 1982 had spread to involve buffaloes. PARC funded investigations to ascertain the infection status of wildlife. Fortunately, the results demonstrated that the virus had died out and that buffalo populations across Tanzania had not retained the virus. Similar research was undertaken in Cameroon and the results were the same as those observed in wildlife in Tanzania.

5.3.8.2 Immunosuppression

A research programme involving the Institute for Animal Health Pirbright, UK investigated the possible immunosuppressive effects of vaccination against rinderpest. The conclusion was that vaccination with the attenuated strains did not compromise the bovine immune system.

5.3.8.3. Vaccine thermostability

In 1989, a group from Tufts University working at Plum Island and in Niger showed that by a lengthened lyophilisation cycle and the use of different stablizers, it was possible to develop a thermostable rinderpest vaccine that was still potent 30 days after leaving the cold chain (Mariner et al., 1989). This product became known as Thermovax. With a view to making this vaccine available within PARC, a technology transfer project was initiated with the National Veterinary Institute, Ethiopia, the Laboratoire National Vétérinaire (LANAVET), Cameroon, and the Central Veterinary Laboratory in Mali. The technology was successfully transferred, but the product was only used within the Ethiopian national programme. It was also used in southern Sudan by the International Red Cross, VSF and UNICEF who were collaborators with PARC. The technology was later transferred to the Botswana Veterinary Institute.

5.3.9 Cordon sanitaires

Vaccine belts, popularly known as cordon sanitaires, were not a part of the JP15 strategy. As earlier stated, the success of JP15 was fleeting, and by the mid 1980s, rinderpest was marauding across sub-Saharan Africa like an army of locusts. The launch of PARC was meant to put a check on this situation. Therefore, PARC developed the concept of inter-territorial vaccine belts, with the intention of dividing the endemic regions in sub-Saharan Africa into discrete epidemiologically relevant 'cells' separated from one another with populations of well vaccinated cattle, hence the name 'cordon sanitaire'. Under this strategy, each cell would have progressed independent of the others towards eradication.

In 1988, with estimates showing that more countries in eastern Africa were infected than western Africa, PARC and FAO proposed the establishment of a ‘Central African block (CAB)’ made up of highly immunised cattle in Chad and Central African Republic (CAR), in order to prevent reinfection of West Africa from eastern Africa. The ‘West African block (WAB)’ running through Nigeria, Niger, Burkina Faso, Mali and Senegal, and adjoining the eastern end of CAB was also conceptualised. However, the improving situation in West Africa rendered WAB redundant, but the CAB was implemented in the east of Central African Republic (CAR) and Chad.

Seromonitoring results obtained from Chad, however, illustrated that the cordon sanitaire was not a success as seropositivity fell far short of the 80 per cent mark intended for immunosterilisation of the corridor. These seromonitoring results were the outcome of the 1989-1996 vaccination campaigns. The situation was no different for the other participating country, CAR. However, the presence of the cordon sanitaire enabled fast tracking of the West African rinderpest freedom accreditation process starting from 1999, by giving confidence to countries that it was safe to cease vaccination, a pre-requisite for embarking on the OIE Pathway for rinderpest.

In the meantime, to rid the Sudan of the remaining foci of rinderpest, an intensive vaccination programme of the Murle and associated Jie herds was conducted with the resultant elimination of the disease as confirmed by subsequent epidemiological investigations. The last rinderpest vaccination was in 2002 and subsequent investigations provided no basis for belief that rinderpest was still present in southern Sudan. The final stage of rinderpest eradication in southern Sudan was coordinated by two units of the United Nations Operation Lifeline Sudan (OLS). The southern unit based in Lokichoggio in North West Kenya brought together 13 NGOs collaborating with UNICEF, and later FAO humanitarian assistance operations. At this stage, the most important element of the NGO interventions surported by the PARC/PACE programmes was The Fight Against African Lineage 1 Rinderpest virus, which was executed by Vétérinaires Sans Frontières (VSF) Belgium. The other unit, the northern Coordination Unit that again came under FAO’s OLS humanitarian assistance programme collaborated closely with the Government of Sudan. Alongside the PARC and PACE programs, the Community Animal Health and Participatory Epidemiology project supported the rinderpest eradication programme by training Community Animal Health Workers (CAHWs) in Lokichoggio and by commissioning epidemiological studies. A detailed description of the role of community animal health workers is outlined elsewhere in this book. In the execution of this programme, a vaccine bank supported by PACE was established in Lokichoggio. Between 2003 and 2005, the NGO VSF Belgium was contracted by PACE to continue surveillance in southern Sudan, in both cattle and wildlife. After October 2005, VSF Belgium's activities were supported by humanitarian aid until a new contract with PACE started in May 2006, which, together with Sudanese Government Veterinary Services, supported by FAO, enabled rinderpest surveillance to continue.

In conclusion, the creation of sanitary cordons can be seen as an innovative approach to compartmentalisation, in theory at least, restricting disease spread, and thereby preventing contamination of disease free areas. As actually practised given operational constraints, its most important benefit was to provide confidence to countries in West Africa to abandon mass vaccination and proceed with accreditation of rinderpest freedom.

5.3.10 The Pan-African Veterinary Vaccine Centre (PANVAC)

Following a preparatory phase study which had shown that some rinderpest vaccine manufacturing laboratories were experiencing problems meeting international potency standards, AU-IBAR and FAO decided to establish vaccine quality control centres in Dakar, Senegal and Debre Zeit, Ethiopia. Known together as the Pan-African Veterinary Vaccines Centres they were established to carry out quality assurance testing of rinderpest vaccines for use throughout the campaign and to transfer good manufacturing practice technology, including quality assurance processes, to the African vaccine production laboratories. Funding proved difficult to sustain but the most important part of the laboratories' functions of ensuring the quality of rinderpest vaccines used in PARC was maintained continuously with a combination of UNDP, FAO Technical Cooperation Programme and FAO Trust Funds (provided by Japan and the EU). However, financial constraints forced the closure of the Dakar facility in 1993 and all activities were centred at the Ethiopian site with continuing support from the Ethiopian Government. Later in 1998, this laboratory was established as the Pan African Vaccine Centre (PANVAC), an OAU institution with the mandate to serve as an independent vaccine quality assurance laboratory and funding provided by the AU-PANVAC reversed an earlier trend that saw manufacturers releasing sub-standard vaccines. In this capacity, AU-PANVAC was integral to the success of PARC. In 1994, 78 per cent of vaccine samples reached the international potency standard of $10^{2.5}$ $TCID_{50}$ per dose while in 1996, 1997 and 1998 the figures were 82, 95 and 89 per cent respectively. The use of quality assured vaccine throughout the campaign was pivotal in the eradication of rinderpest.

5.3.11 OAU, EDF and national government support

From the outset, AU-IBAR was appointed an authorising agent for the EDF funds directly earmarked for PARC activities. IBAR's role was to:

i) Enhance political support for the campaign.

ii) Promote a more effective way of monitoring rinderpest with a view to eradication (conception, gathering and dissemination of information, and research).

iii) Initiate and coordinate national measures against rinderpest throughout Africa.

iv) Regularly follow-up vaccinations

v) Establish vaccine banks and fix the price of vaccine.

vi) Initiate immediate "fire-fighting" actions in the five countries (Burkina Faso, Mali, Nigeria, Ethiopia and Sudan).

vii) Coordinate national implementation of the programme and research.

viii) Carry out border harmonisation and promote donor and technical participation in the campaign.

5.3.12. Finance

Funds allocated to countries were made available as and when implementing protocols were signed between each country and the local EU delegation. The first financing agreement paved the way for an input of ECU 50 million. Of this, ECU 25 million was allocated to immediate "fire-fighting" actions, the creation of vaccine banks to insure against supply failures and specified research programmes. The remaining ECU 25 million were allocated within regular programmes designed to strengthen veterinary services for the control of rinderpest and to improve livestock productivity. In 1990, a further ECU 7.5 million was made available for allocation to country programmes, and by 1995, ECU 35.4 million had been added. In 1995, a further ECU 5 million was invested in controlling the outbreak of rinderpest in wildlife in Kenya, bringing the external financial inputs to PARC from the EU alone to ECU 97.9 million in the decade from 1986 to 1995.

PARC, unlike JP15, was focussed on strengthening veterinary services and implementing mass vaccination together with a parallel programme aimed at improving the efficiency of veterinary services through the creation of revolving funds, promoting the privatisation of veterinary services and the formation of herders' associations. These latter components were regarded as part of a broader structural adjustment programme. In addition to vaccination against rinderpest, there were costs related to communication campaigns, programme monitoring and technical assistance. Thus, it can be seen that PARC was about much more than rinderpest eradication even if this was its prime focus. The underlying concept relied on an understanding that veterinary services had become very weak and that only by strengthening of veterinary and other livestock services would it be possible to eradicate rinderpest. This was not universally accepted.

Studies on inputs to the PARC programme in 10 countries estimated the contributions of the national governments at around 45 per cent of that of the EDF contributions (Tambi et al., 1999). We have applied this figure across the range of PARC participating countries. These combined estimates are given in Table 7. By the conclusion of the PARC Programme, approximately Euro 106 million had been spent on rinderpest eradication without counting the considerable inputs made by international organisations such as FAO and IAEA and donors such as Nigeria, Sweden, Japan, UK, France and the USA

5.3.13. Impact of PARC on rinderpest

At the conclusion of PARC, the incidence of rinderpest in Africa had decreased dramatically (AU-IBAR PARC final report, 1999). Largely, the continent was safer than at the beginning of the programme. It was then decided to move to a process of determining the security of, and confidence in this achievement. This would require that countries with no apparent rinderpest stop vaccinating and monitor the situation. Most PARC member states in Central and West Africa were in a position to do this for several years, but never managed despite the PARC technical committee repeatedly urging them to do so.

Eventually, PARC was able to bring a number of these countries to the start line of the OIE Pathway by terminating vaccination campaigns and making a declaration of provisional freedom from rinderpest. Table 8 shows the situation at the close of PARC in 1998. One Country declared provisional freedom of rinderpest two years prior to the cessation of vaccination highlighting some of the challenges in ensuring adherence to the OIE pathway requirements.

5.3.14 Summary of achievements of PARC (1986-1998)

i) By 1998, no RP outbreak had occurred in over 10 years in western and Central Africa.

ii) Tremendous increase of cattle population on the continent due to reduced mortality due to rinderpest (based on recent cattle census results in different countries). For example in 1985, the cattle populations in Sudan and Ethiopia were 22 million and 38 million respectively. Currently the populations are 42 million and 51.8 million respectively.

iii) Sixteen countries joined the OIE pathway by declaring provisional /zonal freedom from the disease.

iv) Robust relations between AU-IBAR, FAO, OIE, CIRAD, EU, DFID, USAID and national, regional and international laboratories

v) Strengthened veterinary services through the privatisation of veterinary service delivery systems and cost sharing.

vi) Increased pastureland by planting trees and preventing soil erosion to cater for the expected increase in cattle populations following the eradication of rinderpest in Djibouti and Ethiopia

Even with the sterling achievements made under PARC, a few pockets of Rinderpest remained in eastern Africa. Therefore, in order to consolidate the success of PARC and to avoid the mistakes made in JP15, it was important to keep up sustained and vigorous efforts to eliminate the remaining endemic foci of rinderpest. Continued serosurveillance and immunosterilisation of the affected cattle populations were of the essence. For this reason, the Pan African Programme for Epizootics (PACE) was conceived to continue the rinderpest eradication and also to establish and strengthen epidemio-surveillance networks for rinderpest and other transboundary animal diseases (TADs) throughout the continent.

5.4. Pan- African Programme for the Control of Epizootics (PACE; 1999-2007)

5.4.1 Introduction

At the end of the PARC programme in 1998, two foci of endemic rinderpest had remained; these were in southern Sudan and in the Somali ecosystem, both areas affected by civil unrest and insecurity. Subsequently, the EU and AU-IBAR developed a new programme, PACE, to manage the final eradication of the disease. The programme was meant to build on the success of PARC and continue the campaign for the verifiable eradication of rinderpest.

5.4.2 Project objectives

The PACE programme was designed to meet country needs and global priorities in terms of control of rinderpest and other major epidemic diseases of livestock. Its immediate objectives were to strengthen the national and regional capability to assess the technical and economic impact of animal diseases and to generate appropriate programmes to control TADs. In contrast to PARC, it was designed as a regional programme managed and coordinated by AU-IBAR, with 32 participating countries each country being allocated a portion of the total budget. Within its budgetary limits, each country prepared a five-year global work plan of procurement, training, and other inputs. The programme was aimed to enhance the physical and technical capacities of the veterinary services to be able to diagnose and assess the epidemiology and impact of major infectious diseases.

The PACE programme was to be implemented through the development of disease surveillance and animal health information systems, continuation of rinderpest eradication and strengthening of the capacity for the control of other major epidemic diseases. In addition, PACE was to increase livestock farmers' awareness of the benefits of animal health services and strengthen linkages between central institutions and livestock farmers.

5.4.3 Rationale of PACE as a regional programme

A major objective of PACE was to build on the success of PARC and continue the campaign to eradicate rinderpest. Indeed it was originally planned to cover 32 countries but, because of their economic and political situations, two countries, Sierra Leone and Liberia, did not continue in the programme. The PACE and PARC programmes were designed to address the whole of sub-Saharan Africa, which is a huge area to effectively carry out operations under centralised management. Regionalization of the programme was therefore essential to cater for the PACE countries encompassing different agro-climatic zones ranging from marginal pastoral desert regions of the Sahara to Central African rain forest. This was addressed by opening two Regional Co-ordination Units (RCUs) - one in Nairobi, Kenya, and the other in Bamako, Mali. Each was headed by a Regional Coordinator. The Bamako RCU was responsible for the supervision and co-ordination of the 13 West African and seven Central African countries, while the Nairobi RCU co-coordinated programmes in 10 eastern African countries, in addition to overall continental coordination.

Seven common service units were established by AU-IBAR in Nairobi and Bamako, to provide specialist expertise as follows:

i) Epidemiology and surveillance systems, including a wildlife component

ii) Data management

iii) Economics

iv) Veterinary legislation and privatisation

v) Community Animal Health and Participatory Epidemiology (CAPE)

vi) Communications

vii) Financial management

AU-IBAR was the regional authorising agent for the disbursement of funds and it checked the efficiency of the PACE National Co-ordinators in the management of the programme.

5.4.4 Finance

The European Union was the main donor for the PACE programme. Other donors were the French Co-operation, the UK Government's Department for International Development (DFID), and the Italian and the Swiss Governments. The latter two funded part of the intervention in Somalia during the first phase of the programme while French Co-operation funded two regional epidemiologists in the Bamako unit. DfID funded the CAPE project, which aimed to establish sustainable animal health services to control diseases that threaten the health and productivity of livestock in the Greater Horn of Africa. One of the attempts made by PACE was to urge countries to progressively increase investment in epidemio-surveillance by providing a minimum contribution at the beginning of the project, and eventually providing 100 per cent by the end of the project. This noble approach was adhered to by a few countries, and as earlier documented (Tambi et al, 1999), the contribution of national governments was estimated at 45 per cent of the total financial input into the campaign. The total financial contribution by countries and donors is shown in Table 9.

5.4.5. Disease surveillance systems

PACE introduced and supported active surveillance including disease-searching using participatory techniques and random sample surveys. This was achieved through the development of mobile teams, which operated from the headquarters, regional offices and veterinary laboratories. In addition, collection of animal disease data was undertaken from abattoirs and markets. To harmonise surveillance activities in the different countries, PACE trained personnel in various aspects of disease surveillance and diagnosis.

5.4.6. Information systems

The PACE Information and Communications Unit introduced electronic storage and analysis of epidemio-surveillance, census and production data. An electronic Animal Resources Information System (ARIS) was created. Twenty-four of the 30 PACE countries installed ARIS at their national epidemiology units; a few went a step further and installed it at provincial and district levels.

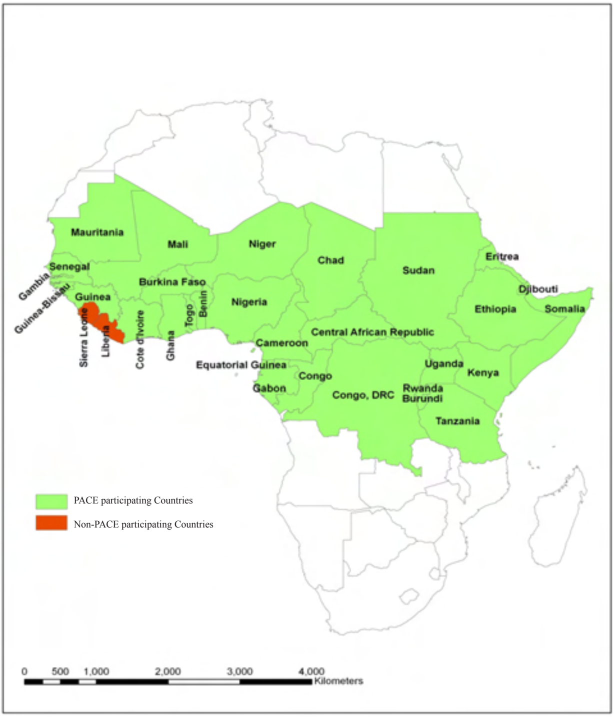

Figure 3: Countries covered by the PACE programme

5.4.7. Modifications of the vaccination strategy under PACE

During its period of management, PARC and later on PACE adopted two important changes in its vaccination strategy, namely the use of CAHWs in difficult areas and focused vaccination in identified foci of infection (immunosterilisation).

In southern Sudan and the Afar region of Ethiopia, community animal health workers operating in a private capacity became the vehicle for vaccine delivery in areas of civil conflict. Their programmes were extremely successful. In Ethiopia, epidemiological studies had suggested that rinderpest moved with trade cattle, for example from the Afar region in the northeast into the central highlands of the country. PARC Ethiopia eliminated rinderpest after three years of pioneering the focussed strategy for elimination of rinderpest reservoirs instead of mass vaccination targeted at the whole country; the Afar region was cleared of rinderpest in 1995. With appropriate guidance and emergency assistance coordinated by AU-IBAR and FAO, the elimination of rinderpest from southern Sudan was achieved in 2000. This paved the way for alleviating the threat of any further re-emergence of rinderpest from these two countries.

5.4.8. Interventions against rinderpest

At the beginning of the PACE programme, rinderpest virus lineage 1 was still circulating in southern Sudan and lineage 2 was in the Somali Ecosystem. These reservoirs could potentially act as the source of virus spread into uninfected areas. Operations in these areas were made even more difficult by the poor infrastructure, insecurity and difficulty of gaining access during the rinderpest eradication campaigns. At the end of PARC, the strategy of mass vaccination against rinderpest was replaced by a programme of surveillance using participatory epidemiology and randomised surveys to demonstrate disease absence or detect persisting infection. Where rinderpest was detected and confirmed, localised, intensive vaccination resulting in immunosterilisation was undertaken. In conflict areas, vaccinations were carried out by CAHWs, trained and managed by NGOs, some of which received financial support from PACE.

5.4.9. Rinderpest in wildlife

Rinderpest was thought to have been eradicated from the entire continent until the outbreaks of the disease in buffalo in Tsavo West National Park of Kenya in 1994 (Barrett et al., 1998). Buffalo, lesser kudu (*Tragelaphus imberbis*) and eland (*Taurotragus oryx*) were the most severely affected species during the outbreak (Kock et al., 1998). As a result of the Tsavo outbreak, there was increased coordination and integration of disease surveillance in susceptible wildlife species during the last phase of the PARC programme, and its successor

PACE. The African Wildlife Veterinary Project, encompassing nine priority countries, was established to carry out disease investigation and retrospective serosurveillance. The objective was to determine the maintenance species for rinderpest in wildlife, tracking the movement of rinderpest through wildlife populations and assessing the potential impact of rinderpest in wildlife on livestock to inform the final rinderpest eradication process in Africa. The project, concluded in 2000, shed light on the activity of the virus and its dynamics including the West African outbreaks and the more recent East African cases in buffalo (CIRAD, 2001). The vast majority of East African wildlife, including those in the Serengeti eco-system, was free from the disease. Furthermore, the study indicated that the disease was self-limiting in buffalo and therefore wildlife was not acting as reservoir.

After 2000, a wildlife surveillance component was established within the PACE Epidemiology Unit. CIRAD, France was the contract holder with a sub-contract to the Zoological Society of London. In 2001, there was an outbreak of rinderpest in buffalo in Meru National Park (Kock, 2006).

The achievements of the wildlife component were:

i) Generation of data verifying the absence of circulating rinderpest virus in high-risk areas[4] of Chad, Central African Republic, Sudan, Ethiopia, Kenya, Uganda, and Tanzani.

ii) Confirmation of rinderpest in buffalo in Tsavo National Park in 1994-1999, Nairobi National Park in 1996 and Meru National Park in 2001, all in Kenya.

iii) Increased expertise in wildlife surveillance techniques in participating countries through training of wildlife veterinarians and technicians in immoblisation, clinical examination and sampling of different wildlife species

5.4.10 Epidemiological understanding

The PACE Epidemiology Unit assisted participating countries to develop surveillance systems and linked them across the continent in what became the PACE epidemiological surveillance network. Methods for evaluating the national surveillance systems were developed and performance indicators introduced to harmonise epidemio-surveillance systems and monitor their performance.

The introduction of novel methods of epidemio-surveillance, including

[4]Areas were the virus had earlier circulated

participatory and risk based methods, together with the use of CAHWs for surveillance in conflict, areas were effective in providing disease intelligence in the remote, insecure areas, which were the last strongholds of the disease. The epidemiology unit was instrumental in assisting member countries in preparing dossiers for applying to the OIE for certification of eradication of rinderpest as outlined in the OIE Pathway for rinderpest eradication.

5.4.11. Laboratory testing capacity

Throughout PARC, the FAO-IAEA Joint Division had assisted AU-IBAR to manage a laboratory network, primarily for the laboratory confirmation of rinderpest. In 1999 the collaboration was extended by AU-IBAR signing a collaborative agreement establishing Project RAF/5/053 during the PACE programme. This project addressed diagnostic capacity building through training and technology transfer and covered a number of diseases in addition to rinderpest in conjunction with other IAEA-funded projects in Africa on, for example, CBPP and foot-and-mouth disease,

All national laboratories engaged in serosurveillance were backstopped and the results were utilised in the preparation of dossiers for submission to the OIE. This led to a reactivation in 2004 of the laboratories network established under PARC. All national laboratories in PACE countries were strengthened in their diagnostic capacity for identifying epidemic diseases, including rinderpest. In addition, the establishment and strengthening of the laboratory network was central to the epidemiological surveys for diagnostic purposes, and enabled comparison of assays across laboratories, hence ensuring quality control (AU-IBAR PACE final report 2007).

5.4.12. Summary of achievements of PACE (1999-2007)

i) Reinforced the focus on rinderpest eradication, and built the capacity of laboratories.

ii) Established epidemiological surveillance systems with electronic data storage and processing across the continent at both national and regional levels. In line with this, the PACE programme also introduced the Animal Resources Information System (ARIS).

iii) Assisted countries in the adoption of international standards for disease surveillance and protocols to obtain international recognition of freedom from disease

iv) Together with FAO-GREP and OIE, guided both PACE and non-PACE countries on the continent in following the OIE pathway for accreditation for rinderpest freedom.

v) Eradicated rinderpest from southern Sudan, one of the two remaining rinderpest disease foci at the end of PARC but mild rinderpest in SES still remained unresolved.

vi) Brought about greater privatisation of veterinary services and public/private sector linkage in the field.

vii) Enhanced the control of other epidemic diseases, especially CBPP.

viii) Established SERECU for the sustainable and effective coordination of the final efforts for the eradication of rinderpest from its suspected last remaining foci in Africa (SES) and provided its funding.

Alongside the achievements of the PACE programme, there were some lessons learned during its implementation that need to be incorporated into future programmes. Among the lessons were:

i) The need to strengthen the role, financial and human resource capacity of AU-IBAR in order to optimally operate as the fulcrum of similar programmes in future.

ii) Communication of findings, recommendations and achievements of such programmes should become an important component to ensure visibility in the international community.

iii) The success of the sustainable privatisation of veterinary service delivery in Kenya through the transformation of the Kenya Veterinary Association Privatisation Scheme (KVAPS) into a micro-credit institution, the Kenya Livestock Finance Trust (K-LIFT). This model could be extended to other African countries.

iv) The need for increased sharing of best practices between countries in areas of training, communication, laboratory practices, data management, among others. The concept of 'twinning' countries as previously operated in the EU is worthwhile.

v) It was clear that a sustainable system that would guarantee the achievements of PACE was required in order to ensure the final eradication of rinderpest. The threat posed by other transboundary animal diseases after eradication of rinderpest was deemed the next target. At the closure of PACE, it was suspected that there were pockets of the virus in the Somali Ecosystem and this needed to be addressed urgently. It was for this reason that the Somali Ecosystem Rinderpest Eradication Coordination Unit (SERECU) was mooted. Its objectives were to resolve questions over rinderpest persistence in the Somali ecosystem so that an epidemiology-driven strategy could be elaborated to bring the three concerned countries to the point of international recognition of rinderpest freedom.

5.5 Somali Ecosystem Rinderpest Eradication Coordination Unit (SERECU, 2006-2010)

5.5.1 Introduction

The detection in Kenya in 1994 of Lineage 2 rinderpest virus in wildlife marked the apparent re-emergence of a type of rinderpest virus that had not been encountered in eastern Africa for more than 30 years. The source of the virus was traced to north-eastern Kenya and southern Somalia (Kock, 2006). A pattern of cyclic rinderpest outbreaks every five to six years in a mild form in cattle, and yet virulent in wildlife, had been described by Plowright (1963) during the end of 1950s and the beginning of the 1960s. Participatory epidemiological studies conducted in 1996 (Mariner and Roeder, 2003) and by CAPE demonstrated that this was a persistent phenomenon. Subsequent surveys encountered a variety of stomatitis-enteritis syndromes in cattle in the SES (Figure 4), which was considered compatible with mild rinderpest aetiology. However, unlike the earlier situation in East Africa, no clear evidence of their relationship to rinderpest virus infection was found. Later, buffaloes sampled at the Meru National Park of Kenya in September 2001 were positive for rinderpest by both ELISA and PCR as tested at the KARI-VRC Muguga Laboratory. Nucleotide sequence analysis at the World Reference Laboratory for Rinderpest, Pirbright, UK confirmed this to be due to Lineage 2.

Concurrent clinical and serological investigations conducted in cattle within and around the park failed to demonstrate the disease infection in cattle and the disease soon burnt out in wildlife. It was highly likely therefore, that Somali migratory cattle had brought in the disease following a severe drought in southern Somalia and north-eastern Kenya in the preceding months. This was premised on the fact that the last vaccinations prior to the event had been carried out in Somalia in 1998 when around 200,000 - 300,000 cattle were vaccinated, which represented a small percentage of the total population. The results of random sero-surveys indicated the presence of clusters of high seropositivity up to approximately 16 percent which seemed too high to be attributable to vaccination and were considered to be indicative of previous natural infection.

The confirmation of rinderpest in buffalo in Meru National Park led to intensified surveillance in the three SES countries and in September 2002, PDS teams in Kenya detected rinderpest-like events at Ruga and other sites in Garissa district of Kenya on the border with Somalia. Tissue samples taken from sick and in-contact cattle were positive on immunocapture ELISA and PCR as tested at Veterinary Research Centre, Muguga. On this basis, the Kenya Government went ahead and vaccinated 150,000 cattle in the area while Somalia vaccinated 50,000 on its side of the border. However, subsequent nucleotide sequence analysis of the samples at the World Reference Laboratory for Rinderpest, Pirbright, UK detected the presence of the Kabete ‘O’ vaccine strain and concluded that it was due to laboratory contamination. This matter has never been resolved as to whether it was due to laboratory contamination or the vaccine strain, or even whether it was rinderpest at all. Therefore, the last certain detection of rinderpest virus in Africa remains the Meru National Park incident of 2001.

During PACE, activities in Somalia were conducted by PACE Somalia, implemented by an Italian NGO (Terra Nuova) in partnership with AU-IBAR, VSF-Suisse and UNA between 2001 and 2005. From 2005 to 2010, the Somali Animal Health Services Project (SAHSP) led by Terra Nuova in partnership with FAO, COOPI and VSF-Germany implemented activities. The respective national PACE projects covered the parts of the SES within Kenya and Ethiopia until a special unit to take care of the Somali Ecosystem was formed: SERECU within AU-IBAR.

SERECU arose from the Strategic Plan of the 10th PACE Advisory Committee Meeting in Bamako in March 2005. Programme estimate for SERECU was approved on November 22, 2005 and SERECU became operational in January 2006. SERECU initially operated under the aegis of the PACE programme and was mandated to develop a harmonised and coordinated surveillance programme and a strategy for rinderpest eradication to achieve “freedom from rinderpest” in the SES (Figure 4) in line with OIE guidelines.

5.5.2 Strategy of SERECU

The strategy of SERECU was to delineate endemic areas of rinderpest in the SES, followed by focused vaccination to achieve immuno-sterilisation of the targeted population. In the absence of rinderpest endemicity, countries were to pursue accreditation following the OIE pathway.

5.5.3 Activities of SERECU

Ecosystem wide random surveys carried out in 2006 ruled out rinderpest endemicity in Kenya and Ethiopia, but were inconclusive in the case of Somalia. Follow-up investigations in sero-positive sites in Somalia conducted in 2007 ruled out recent virus circulation and concluded that the previously observed sero-positivity could have been due to the sampling of ineligible cattle (below 1 year and above 3 years). Serological surveys carried out in susceptible wildlife particularly buffalo, warthog, giraffe, waterbuck and lesser kudu in north eastern Kenya, south eastern Ethiopia and southern Somalia in 2006 (SERECU Phase 1) and 2008-2010 (SERECU Phase II) demonstrated that rinderpest virus was not circulating within the wildlife populations in the region implying that despite previous infections in wildlife, the virus did not establish itself and never became endemic in wildlife. These results consolidated the findings of previous studies that dispelled the possibility of wildlife serving as a reservoir for rinderpest in this ecosystem.

5.5.4. Achievements of SERECU

SERECU was highly effective in bringing the veterinary services of the three countries comprising the SES into a harmonised effort to establish unequivocally the rinderpest status of the region (AU-IBAR SERECU final report, 2010)
Among its specific achievements were:

i) Clarification of rinderpest status in the SES: Serosurveillance carried out in both cattle and wildlife confirmed the absence of rinderpest virus circulation in the SES (Figure 5), and as a result, the three countries prepared and submitted dossiers to the OIE for accreditation of freedom from rinderpest. Accordingly, Ethiopia, Kenya and Somalia were accredited with rinderpest freedom in 2008, 2009 and 2010, respectively.

ii) Assistance to African countries: At the end of PACE, some countries had not yet fully progressed along the OIE pathway. Six of these countries, including Cameroon, CAR, Chad, Djibouti, Nigeria and Niger, needed to undertake surveillance. AU-IBAR, through SERECU II in collaboration with FAO-GREP, provided support and guidance in surveillance and dossier formulation. At the same time, the two organisations assisted Liberia, Sierra Leone, Gambia and Sao Tome and Principe, in the formulation of dossiers for submission to OIE for historical freedom from rinderpest.

iii) Emergency preparedness and contingency plans for rinderpest were developed as part of an exit strategy.

iv) Epidemiological surveillance systems were strengthened to contribute to the early warning system for emergency preparedness and as a foundation and model for the control of other TADs.

v) The history of rinderpest eradication from Africa and its impact, including lessons learnt, have been documented through SERECU. It is intended that lessons learnt from this eradication process will benefit the control and eradication of other TADs in Africa.

vi) Capacity Building: SERECU developed capacities for the three SES countries through training of personnel (disease surveillance in livestock and wildlife, laboratory diagnosis and quality assurance) and provision and maintenance of equipment. Furthermore, SERECU supported the revitalisation of veterinary services in Somalia. In addition, SERECU improved disease information sharing applicable to other transboundary animal diseases, through cross border technical meetings.

vii) Exit Strategy: Following the eradication of rinderpest and the need to safeguard against any future resurgence of the disease, an exit strategy was developed which included, virus sequestration, dealing with the hazard of rinderpest disease re-emerging from cryptic foci and the possibility of the emergence of another morbillivirus. Advocacy provided by SERECU related to destruction or sequestration in high biosecurity facilities of all the rinderpest virus strains held in African laboratories; the need to establish a syndromic surveillance system for TADs, and; the desirability of AU-IBAR continuing to play its coordinating and advocacy role and to mobilise resources.

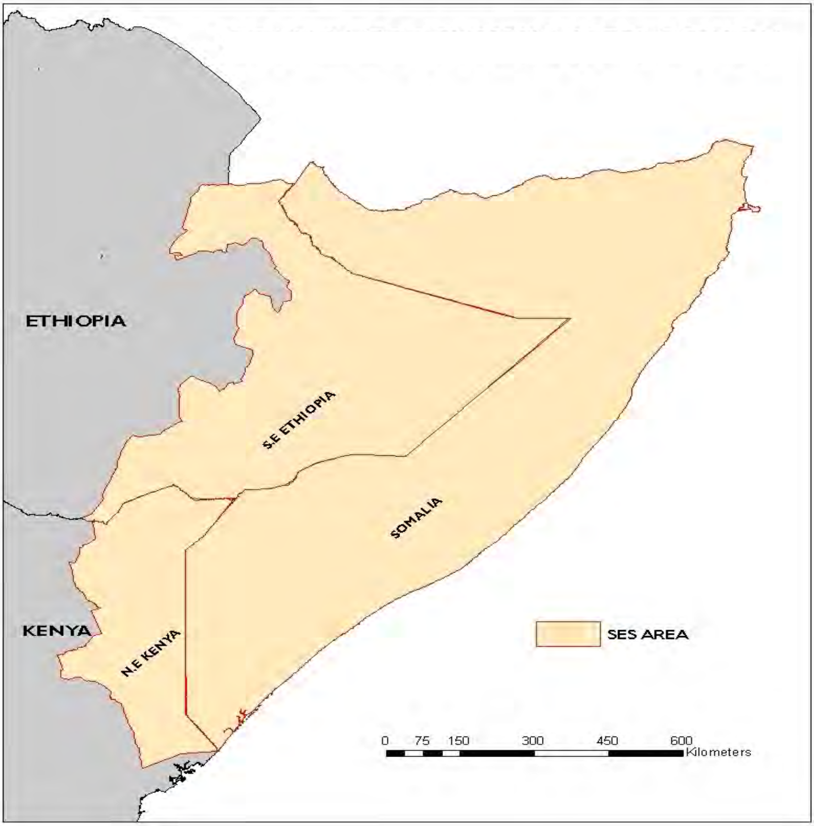

Figure 4: Somali ecosystem (SES)

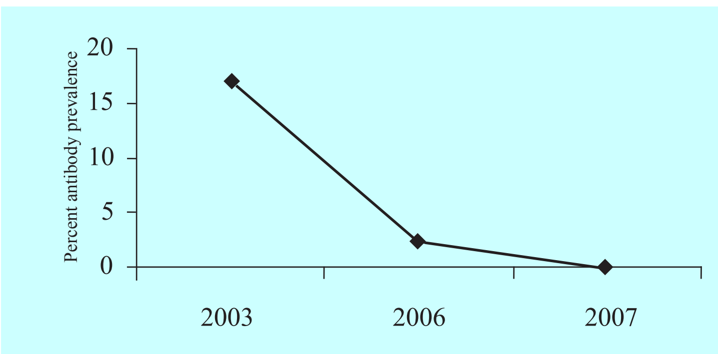

Figure 5: Seropositivity for rinderpest in Somalia.

6. ANALYSIS OF THE RINDERPEST ERADICATION PROCESS

6.1 Role of National, Regional and International Laboratories in the Eradication of Rinderpest

National laboratories played a pivotal role in the eradication of rinderpest. Over the years, laboratories in Africa participated in research and development on rinderpest. They developed diagnostic tools, vaccines and control strategies. During the eradication process, many of the diagnostic laboratories in participating countries carried out disease diagnosis, seromonitoring, serosurveillance, and vaccine production. They provided serodiagnostic facilities for analysis of samples from the field as a way of monitoring vaccination efficiency and serosurveillance.

Regional and international reference laboratories served as quality control centres for confirmatory diagnosis of rinderpest, and carried out characterisation of virus strains. In addition, they participated in the training of nationals in current research and diagnostic procedures, in the process transferring technology to national institutions. In particular, the following regional laboratories were pivotal in carrying out these operations: Laboratoire Central de Pathologie Animale (LANADA) – Bingerville, Côte d'Ivoire, for West and Central Africa, with the National Veterinary Insititute, Debre Zeit, Ethiopia and the KARI-VRC Muguga Laboratory, Kenya, for eastern Africa.

6.2. Problems and Constraints in the Eradication of Rinderpest

In the course of the various rinderpest eradication programmes, several constraints were encountered; among them insecurity, limited human resources and stakeholder involvement, inadequate cold-chain, transport, equipment and finances for effective delivery of veterinary services. Where possible, the national veterinary services addressed some of the problems by providing finance, vehicles and equipment. Insecurity constituted a major constraint in many parts of Africa over the four decades during which eradication programmes were implemented. Smooth operations were not possible in countries where there was civil strife, examples being Somalia, Sudan, the DRC, the CAR and the Afar region of Ethiopia. Worse still, in Sierra Leone and Liberia, the PACE programme was never established. Uncontrolled movement of livestock across borders and within countries compounded the problem as vaccination, surveillance and general disease management were extremely difficult in these circumstances. In addition, farmers reacted negatively to the use of some attenuated vaccines that caused disease, an example being the use of the goat-attenuated vaccine in the initial stages of the rinderpest eradication process.

There was also inadequate information, poor infrastructure across the continent and inadequate communication and consultation between the field staff and their headquarters and stakeholders. Moreover, there were logistical challenges, which included sourcing and delivery of vaccines to the field.

6.3 Major Events and Discoveries in the History of Rinderpest in Africa

The progress towards eradication of rinderpest was marked by a number of significant developments which progressively enhanced the "tool box" available to the animal health staff undertaking control and eradication of rinderpest. The following account covers the most important of these.

6.3.1 Vaccine developments

The development of goat-attenuated and tissue culture attenuated rinderpest vaccines were major milestones in the journey to rinderpest eradication. Both vaccines conferred life-long immunity after a single inoculation and the TCRV facilitated bulk vaccine production and quality testing, making mass vaccination programmes feasible. The later development of Thermovax, the more thermostable formulation of TCRV, freed vaccination campaigns from the severe constraint of cold chain maintenance in field conditions, thus, considerably reducing costs and improving field delivery of the vaccine, especially in remote areas

6.3.2 Vaccine Delivery

Structural adjustment programmes in the mid 1980s reduced the capacity of government veterinary services to deliver services to rural areas and the void was being filled by NGO sponsored initiatives. In the late 1980s and early 1990s, many organisations working with communities trained village vets, vet scouts, animal helpers, paravets, animal health auxiliaries, and others. The term community-based animal health worker, or CAHW, came to be preferred by those advancing the concept and it differentiated a CAHW from a government trained and paid animal health assistant. The key criteria for CAHWs were that they were respected, trusted and familiar with the animal husbandry of that community (Catley, A. and Leyland, T., 2001). This proved to be particularly useful for transhumance and nomadic livestock keepers.

By the early 1990's, PARC had succeeded in controlling rinderpest in West and Central Africa and most of the Horn of Africa. The disease remained endemic in a few remote, conflict prone areas such as the Afar region of Ethiopia, the

Karamoja region of northern Uganda, southern Sudan and Somalia. CAHWs were first used for rinderpest vaccination and surveillance in Sudan, Ethiopia and Uganda in the early 1990s. They were not used in Somalia until much later due to the more traditional approach of using mobile veterinary teams manned by Somali veterinarians with technical back-stopping support from expartriate personnel.

Due to the civil war in Southern Sudan, veterinary services had largely broken down. There were a few government vets stationed in the 'garrison' towns held by government forces but they were confined to the city limits and rarely encountered livestock. The countryside was largely controlled by rebel forces and their humanitarian administrators. Until 1992, the International Committee of the Red Cross (ICRC) had provided free vaccination and medicines to livestock keepers via ICRC recruited mobile veterinary teams. Due to insecurity, ICRC ceased veterinary activities in 1992. Operation Lifeline Sudan (OLS), a multi agency relief programme coordinated by UNICEF took on much of ICRCs activities in 1993 but used a participatory approach. Instead of using mobile veterinary teams, UNICEF met with livestock owning communities, discussed their livestock problems and jointly developed solutions. The result was a cadre of CAHWs trained to report rinderpest and to vaccinate against the disease. The approach was spectacularly successful. The programme achieved a 10.6 fold increase in vaccination coverage following the introduction of community-based systems. From 1993, vaccination coverage was maintained at more than 1 million cattle vaccinated/year for an estimated cattle population of 3-4 million. As a result, reported outbreaks of rinderpest in southern Sudan decreased from 14 outbreaks in 1994 to 1 outbreak in 1997 (Jones et al., 1998). Furthermore, serum samples taken from 1995 to 1997 showed a 76% sero-positive rate in vaccinated animals. This compared favourably with the vaccination efficiencies of 50 to 80% achieved generally by government veterinary services in PARC participating countries (FAO/IAEA. 1992).

Similarly, impressive results were achieved in Ethiopia. In 1994, PARC Ethiopia trained 20 CAHWs in the Afar region and supplied them with rinderpest vaccine. Prior to this activity, conventional government vaccination campaigns had vaccinated around 20,000 cattle per year in Afar and achieved approximately 60% hard immunity levels. In 1994-95, the 20 newly trained CAHWs vaccinated 73,000 cattle and achieved 83% hard immunity levels. No outbreaks of rinderpest were reported from Afar after November 1995 (Mariner, 1996). In less than 2 years, the community-based approach had controlled rinderpest in Afar, and

Ethiopia was able to declare provisional freedom from rinderpest according to the OIE pathway. Prior to PARC, the Joint Project 15 (JP15) had failed to control rinderpest in Afar using conventional vaccination programmes implemented over a 15-year period.

In Uganda, beyond delivering the bulk of rinderpest vaccination, CAHWs recognised and reported the last outscare of rinderpest in Karamoja, northern Uganda in 1994.

Despite the successful utilisation of CAHWs in the Somali region of Ethiopia and Somaliland and Puntland regions of Somalia, CAHWs were not used in southern Somalia until the late 1990's

CAHWs have not only been a vehicle for effective vaccine delivery; they have, as mentioned for Uganda, been highly effective for surveillance. By the mere fact that CAHWs are local, even moving with nomadic livestock, they provide front line outbreak reporting. If government veterinary services are prepared then early reporting makes a tremendous difference to the effectiveness of the response.

By the early 2000s, a network of over 1,000 veterinary supervised CAHWs was providing clinical services to livestock owners in southern Sudan. These workers were also the main source of clinical disease reports for investigation by professional staff (VSF Belgium 2002). At the height of efforts to detect the remaining foci of rinderpest in 2002/3, southern Sudan routinely carried out investigations of stomatitis-enteritis outbreaks, with 23 investigations in 2002, and 17 in the first half of 2003. All were negative for rinderpest (VSF Belgium 2003).

6.3.3 Laboratory Testing Techniques

In disease surveillance and monitoring of vaccination efficiency, the adoption of ELISA as a diagnostic tool was critical because it made it possible to carry out serological surveys on a grand scale. The test was reasonably robust and easy to standardise and thus technology transfer to African laboratories became feasible. Once a relatively modest set of equipment was supplied and commissioned the way was open to conducting the serosurveillance at an acceptable level of statistical significance, as required by the OIE for accreditation of rinderpest freedom. Further support for mass testing was provided by commercialisation of the kit and its mass production together with quality control standards and supportive computer software for data analysis and reporting.

The development of molecular techniques (RT-PCR and gene sequencing) for detection and characterisation of rinderpest virus nucleic acid and their availability through international morbillivirus reference laboratories. World Reference Laboratory, Pibright, UK, and the CIRAD Morbillivirus Reference Laboratory Laboratory, Montpelier, France) allowed molecular epidemiology to be applied to rinderpest thus greatly expanding understanding of the epidemiological relationships of viruses detected during outbreaks. PCR was established mainly at the African Regional Laboratories and was used as a confirmatory test during the last phases of the campaign.

6.3.4 Improvements in surveillance

Innovative surveillance tools, such as participatory disease surveillance and risk modelling were crucial in the progressive control and eradication of rinderpest. The change to focused vaccination (immune-sterilisation) required that risk analyses be conducted to inform strategy setting and these were dependent on disease intelligence provided by surveillance systems. The establishment of what came to be called epidemio-surveillance networks throughout the continent was a major breakthrough in the early warning and management of TADs while the development of national animal disease emergency preparedness plans facilitated timely response to these diseases when detected through the surveillance system.

6.3.5 The Commitment of AU-IBAR and international collaboration

The commitment of AU-IBAR was a significant factor in maintaining the momentum of the rinderpest eradication process through the mobilisation of resources and the coordination and harmonisation of interventions on a continental basis. Collaboration with FAO, OIE, national, regional and international laboratories, veterinary services and donors, especially the EU, spanning over four decades guaranteed the provision of finance and successful eradication of rinderpest from Africa. AU-IBAR was the unifying force and provided a continental platform for fund-raising, coordination and technical support for the control and eradication of the disease. AU-IBAR presented a framework for regional and international cooperation throughout the campaign over decades.

6.4 Socio-Economic Impact of Rinderpest Eradication

Rinderpest was a major obstacle to the development and utilisation of animal resources due to its high morbidity and mortality rates in cattle and wildlife.

During its endemic era with periodic epidemic upsurges, it impoverished people and curtailed access to international markets for their livestock and livestock products. The technical and financial support from AU-IBAR and the international donor community, respectively, expedited eradication of the disease. Subsequently, there has been improved livestock production and productivity, access to export markets, and improved producer income (Tambi et al., 1999). Livestock are now reared in areas where it was previously difficult to do so due to the rinderpest scourge, thus assuring food security of the people of Africa. According to Tambi and colleagues (Tambi et al., 1999) rinderpest eradication was cost effective. More recent studies in Ethiopia and Kenya estimate the benefit cost ratio for PARC to be 31.8 (Omiti and Irungu 2010). Further studies with continental coverage are in the pipeline.

6.5 Impact of Rinderpest Eradication on Veterinary Services

Over decades, veterinary services in Africa deployed many resources, financial and human, in the control of rinderpest at the expense of other programmes. The eradication of the disease has released these resources for utilisation in other veterinary service programmes. During the eradication process, diagnostic capacity of national laboratories was enhanced through the provision of equipment, reagents, vehicles, computers and technology transfer. The epidemio-surveillance networks were established in addition to providing training on disease surveillance in both livestock and wildlife. During the campaign, PARC and PACE established communication and information systems, which included the setting up of national animal health information systems (e.g. ARIS). PARC and PACE programmes also promoted the privatisation of veterinary services in many countries; a good example being the establishment of the the Kenya Veterinary Privatisation Scheme, later transformed into a self-sustaining micro-finance operation, the Kenya Livestock Finance Trust (K-Lift). Taken together,these innovations are helping to bring about a more realistic appreciation of the appropriate roles of the public and private sectors in the delivery of animal health services. In support of these changes, countries were encouraged to review or establish legislation to streamline disease control.

6.6 The Role of Research in Rinderpest Eradication

In addition to the development of the Kabete-O strain of tissue culture vaccine, and Thermovax, research played a major role in the field of diagnostics. For instance, molecular typing of rinderpest virus strains enabled the development of diagnostic tools for the precise identification of virus isolates and determining their epidemiological relationships. Molecular studies on rinderpest virus were very useful for the development of improved molecular tools for diagnosis and epidemiological tracing of disease outbreaks. To ensure complete eradication of RPV from Africa, the following research areas were investigated during the PACE period:

i) The use of PPR vaccine to protect ruminants against RP

ii) The study of cellular and humoral immune responses induced by RP and PPR

iii) The study of mild rinderpest viruses in cattle, sheep and goats

iv) The development and validation of ELISA for seromonitoring and serosurveillance

In collaboration with the World Reference Laboratory for rinderpest Pirbright UK, the KARI-VRC Muguga Laboratory in Kenya carried out research to determine whether PPR vaccine could cross protect against rinderpest without interfering with the sero-surveillance for rinderpest. This was to ensure that a safe and efficacious vaccine was available in readiness for any rinderpest outbreak in the Somali ecosystem where Lineage 2 rinderpest virus had been detected. The results of the trial failed to confirm the efficacy of PPR vaccine on rinderpest in cattle and hence the idea was abandoned.

Studies on the immune response to rinderpest virus infection were carried out at the World ref Laboratory Pirbright, UK. These studies developed improved serological assays and other diagnostic techniques that enabled differentiation between RP, PPR and vaccine strains of RP. One such technique developed was the competitive ELISA (cELISA) based on monoclonal antibodies directed against the haemagglutinin (HA) proteins of rinderpest and PPR viruses. Unlike the indirect ELISA and the virus neutralisation test (VNT), the rinderpest cELISA detected only antibodies to rinderpest virus and gave no cross-reactivity with antibodies to PPR virus, thus making it possible to distinguish between PPR and RP viruses.

Barrett (2006) at theWorld Reference Laboratory for rinderpest Pirbright UK developed a genetically marked rinderpest vaccine. This vaccine was genetically engineered to give the virus a marker gene in its genome to enable animal health workers, using ELISA, to differentiate between wild and vaccine viruses. The marker would allow differentiation between infected and vaccinated animals and, thus, the continuation of vaccination against PPR in areas declared 'rinderpest-free' would not interfere with serosurveillance of both diseases, since the marker was RPV specific. So far, two versions of the marked rinderpest virus genome have been produced, one marked with a green fluorescent protein (GFP) and the other using an influenza virus haemagglutinin. ELISA tests were developed and validated to detect antibodies to the two inserted proteins (Walsh et al., 2000b). However, rinderpest was eradicated before this technology became available for field use. Nonetheless, it could be useful for future emergency control if rinderpest were to re-emerge.

6.7 Effective Communication as a Tool for Rinderpest Eradication

In order to have an effective disease eradication drive, it was imperative to enlist the support and participation of all stakeholders. It was with this understanding that, during the rinderpest eradication campaign, communities were sensitised to participate in and comply with the eradication programmes. Veterinary services, farmers and donors were kept well informed of the campaign activities. In addition, communities were educated on disease reporting, particularly regarding rinderpest outbreaks and to avail their animals for sampling and vaccination. Also brought on board were governments and other policy makers who availed national resources for the campaign. Finally, donors and technical agencies that provided financial and technical support were central to the successful eradication of rinderpest.

6.8 Recommendations for Future Contingencies

Based on the experience gained from the rinderpest eradication process, the following measures are recommended to mitigate potential risks of re-emergence of the disease.

i) Strengthening of national emergency response capacity, including the provision of manpower and financial resources for immediate action in case of the re-emergence of the disease.

ii) Maintaining of strategic vaccine reserves for immediate access in case of the re-emergence of the disease, and maintaining of vaccine seed virus in a level 3 bio-safety laboratory (PANVAC).

iii) Emergency funds that can be easily accessible as and when required.

iv) Continuous surveillance of both livestock and wildlife for epidemiologically significant disease events and timely confirmation of the aetiology.

v) Destruction of rinderpest virus strains maintained in African laboratories or securing them in level 3 bio-safety laboratories.

vi) Sustained dissemination of relevant information to stakeholders via a strong extension system embedded within veterinary services' delivery systems.

vii) Consolidating and sustaining the gains from rinderpest eradication by implementing other specific regional programmes for surveillance and control supporting the eradication of other trade sensitive TADs.

viii) The AU should continue playing its coordinating role, including resource mobilisation.

7. REASONS FOR SUCCESS

7.1. Political

A decision was made at the beginning of PARC to invoke the political support of governments of AU member states. This had not been the case with the JP-15 campaign. All countries listed to participate in the campaign were visited by AU-IBAR to engage the support of political leadership. One example was the initial visit to Mali, where the Prime Minister, Minister for Foreign Affairs and Minister for Rural Development, were engaged and thereafter supported the campaign. This was repeated in all participating countries.

Cross border coordination and harmonisation meetings were regularly organised, the participants being political authorities; directors of veterinary services; project coordinators; FAO; OIE; IAEA; CIRAD; reference and regional laboratory personnel, and; donors. During these meetings, the strategy and progress of the campaign were reviewed. This advocacy was extended to the political organs at the AU headquarters. In this regard, handing over of PARC and PACE vehicles, equipment and materials to the Ethiopian Government was strategically conducted at the headquarters in Addis Ababa, to create awareness and ensure support of the political organ of the AU for the campaign.

7.2 Technical Inputs

7.2.1 Pan African Rinderpest Vaccine Centre

Unlike in the JP-15 campaign, it was decided from the outset to use only quality-assured vaccines in PARC and PACE programmes. The establishment of the PANVAC is therefore one of the most important technical outputs in the eradication of rinderpest from Africa. It was mandatory for all laboratories in Africa producing the rinderpest vaccine, to submit vaccine samples for quality assurance at PANVAC before use in the field. Now PANVAC is assuring quality of vaccines for many other epidemic diseases.

7.2.2 ELISA technology

The utilisation of ELISA technology for both seromonitoring and serosurveillance was of great value to the campaign. Laboratories in Africa adapted this method for analysis of samples throughout the campaign and supported the epidemio-surveillance networks using this technology. Training of laboratory personnel in ELISA was conducted for all laboratories participating in the campaign, thus creating capacity and generating confidence in using the procedure.

7.2.3 Thermostable rinderpest vaccine (ThermoVax) and CAHWs for vaccine delivery

The introduction of the Thermostable Rinderpest Vaccine significantly reduced dependency on the field component of the cold chain system and allowed CAHWs to deliver the vaccine to the field and carry out vaccination efficiently. CAHWs penetrated civil strife and remote areas of the continent vaccinating pastoralist cattle. For example, it would not have been possible to reach cattle in strife-stricken southern Sudan or the remote areas of the Afar region in Ethiopia without this cadre of workforce.

7.3 Mild Rinderpest Strains

Several reasons contributed to the persistence of RP in East Africa despite rigorous campaigns. One feasible explanation was that the virus was maintained in a southern endemic area of East Africa in susceptible yearling cattle following waning of maternally acquired immunity (Plowright, 1963; Taylor and Watson, 1967). The state of affairs in the SES and northern Uganda, however, was different with the disease making periodic incursions, especially when the vaccination coverage was low. This northern disease outbreak was more severe in both cattle and susceptible wildlife such as buffalo, eland, warthog and giraffe (Liess and Plowright, 1964).

Although there is only one serotype of RPV, there are three genetically distinct lineages of the virus (Lineages 1, 2 and 3) reflecting their geographic distribution and evolutionary relationships. RP virus lineages do not reflect their pathogenic potential. There are mild and highly virulent viruses in each lineage. Mild strains of rinderpest virus may be of low pathogenicity in cattle, but cause severe disease in susceptible wildlife.

The mild strains of rinderpest virus have been observed in pastoral areas of Africa since the late 1950s and early 1960s, occurring in 5-6 year cycles (FAO, 2002). The detection of these strains in buffaloes and lesser kudus in Tsavo West National Park of Kenya in 1994 was timely for they would have posed a potential problem in the final eradication of the disease. Therefore, the PACE eradication campaign reaffirmed its commitment to the eradication of all mild RPV strains as it was perceived that these strains could revert to a more virulent form. To deal with them, it was agreed that the basic strategy was one of “seek, contain, eliminate and verify” – in other words, surveillance would identify the areas of endemic maintenance and, within these areas, the foci of active disease transmission. This was a participatory disease search approach that entailed the use of pastoralists, who are adept clinical diagnosticians and could readily identify livestock disease problems present in their flock and wildlife (FAO, 2002), thus facilitating the identification of mild rinderpest. It should be emphasised that the remaining foci in the SES were due to mild strains of RP and using the above strategy, they were eliminated and the three SES countries were able to join the OIE pathway.

8. LESSONS LEARNT

i) Disease eradication programmes require sustained political goodwill at national, regional and global levels, especially when disease impact diminishes with time

ii) Sustained funding by donors, notably the EU was vital in the success of the eradication of rinderpest

iii) AU-IBAR's partnership with FAO, OIE, and IAEA was critical for the for accreditation of rinderpest

iv) Focussed strategic vaccination (immuno-sterilization) based on rigorous epidemiological surveillance, not only reduced wastage of scarce public funds but also accelerated the eradication of rinderpest

v) The availability of effective and safe vaccines and reliable diagnostic and surveillance tools were critical in the eradication of RP

vi) Mild strains of rinderpest had to be dealt with to ensure total elimination of the disease

vii) Innovative approaches (including the use of CAWHs and participatory epidemiology techniques) to animal health services delivery facilitated access and elimination of the disease from remote areas affected by political instability, civil strife and insecurity

viii) The rinderpest eradication process played a very important role in building the capacity of national veterinary services in Africa, particularly in epidemiology and laboratory diagnosis, including the creation of epidemiological and laboratory networks

ix) Enabling research was critical in clarifying that wildlife are not reservoirs for rinderpest virus

x) The ecosystem approach with enhanced coordination and harmonization between veterinary services of neighboring countries proved critical for the eradication of rinderpest

9. WHAT STAKEHOLDERS SAY ABOUT RINDERPEST ERADICATION

9.1 Introduction

A survey was conducted among stakeholders seeking their perspective of the impact of eradication of rinderpest from Africa. The stakeholders were selected to cater for donors, regional and traditional livestock herders of Africa. The European Union was selected to represent donors because of having provided a large proportion of the funding for all the four RP eradication campaigns.

9.2 The European Union

The EU was the main donor for rinderpest control and eradication campaigns in Africa for over four decades. Its financial inputs sustained JP15, PARC, PACE, AWF and SERECU programmes to the total tune of approximately Euro 203 million. The donor also provided technical assistance throughout all the campaigns. In their view, the benefits accruing from this contribution may be summarised in the following manner:

i) Eradication of rinderpest resulted in a vibrant livestock industry, creation of wealth, sustenance of livelihoods and assurance of food security in Africa.

ii) The leadership provided by AU-IBAR, was outstanding and key to bringing together other stakeholders and political leaders for a focused and objective action plan.

iii) The rinderpest eradication campaigns contributed to capacity building for disease control. As a case in point, during the global outbreak of avian influenza early in the 21st century, the infrastructure put in place by PACE was invaluable for the campaigns in Africa.

iv) The EU was instrumental in the establishment and running of PARC, PACE and SERECU, at a time when JP15 had not eradicated rinderpest from Africa. The EU continued to support rinderpest eradication on the continent, notwithstanding the reluctance of other donors to stake their finances.

v) As a result of the eradication of rinderpest from the continent, Africa's bargaining power in international livestock and livestock products trade was enhanced, especially with the WTO. The eradication of the disease has started to remove trade barriers and therefore increase access to international markets for livestock and livestock products.

vi) The eradication allowed the establishment and strengthening of inter-institutional collaboration between national, regional, international organisations and laboratories across the globe. In addition, there was integration of stakeholders for a common course, which became invaluable in similar campaigns.

vii) The capacity of national and regional laboratories, for example that of PANVAC in Debra Zeit, Ethiopia and Veterinary Research Centre Muguga, Kenya; and LANADA / Laboratoire Central de Pathologie Animale - Bingerville – Côte d'Ivoire were enhanced in research, training and disease control.

viii) The promotion of African experts in laboratory techniques, epidemiology and surveillance among others, was seminal for Africa.

ix) The commitment of the donor to funding rinderpest eradication process for over four decades was unparalleled. A phased funding strategy and the ability to evolve approaches with changing of times were instrumental for this success.

x) The consistency of rinderpest seronegativity following the declaration of final eradication of the disease was lauded as a sign of no more rinderpest.

xi) The donor acclaimed the role of OIE in the execution of PARC and PACE as OIE played a balancing role with respect to other international stakeholders.

xii) They emphasised that in future, regional economic communities such as SADC, COMESA, and ECOWAS should be an integral part of the partnership to facilitate expansion of trade and market opportunities.

xiii) The bi-annual meetings of ministers responsible for livestock were a good forum for formulating policy, resource mobilisation, strategising and reviewing progress.

xiv) Their financial support for privatisation of veterinary services on the continent resulted in sustainable arrangement for delivery of veterinary services to the farmer, an example being the creation of K-LIFT in Kenya as a microfinance institution. This microfinance supports livestock service deliverers and small-scale farmers.

9.3 East African Region

9.3.1 Ethiopia

Ethiopia is the leading cattle keeping country in Africa with 51.8 million head of cattle as per the 2008 census. Historical records indicate that the pandemic that swept across the entire continent between 1889 and 1897 (Scott, 1964; Pankhurst, 1966; Plowright, 1968; Mack, 1970; Kjekshus, 1977) caused over 90 per cent mortality in the cattle populations and unquantifiable destruction in the vast free-ranging populations of susceptible wildlife. Its origin is thought to have been Ethiopia (Pankhurst, 1966; 1985; Mack, 1970). Some records indicate that the Ethiopians blamed the introduction of the disease on cattle from India, imported by invading Italian soldiers through the Port of Massawa in November 1887. The Ethiopians also believed that the Italians had spread the disease deliberately (Pankhurst, 1966). Subsequent episodes are also reported including the possible occurrence of the mild strains of the RP virus in the larger SES.

In an attempt to control rinderpest, Ethiopia initially used the "caudal inoculation" method with the hope of controlling the disease. Unfortunately, this fuelled the spread of the disease rapidly to other areas and by 1889; it had spread from Massawa across the entire northern Ethiopia and vast areas of southern Ethiopia (Spinage, 2003). Later on, a rabbit attenuated (Lapinised) vaccine, developed

Plate 2: Ethiopian Chief Veterinary Officer Dr. Berhe Gebreegziabher (left) receiving OIE certificate of rinderpest freedom from Dr. Bernard Vallat, Director General of the OIE, May 2008. The OIE President Dr. Barry O'Neil (centre) is holding the certificate.

Plate 3: Cattle for export in a feedlot at Adama, Ethiopia

in China in 1945, was introduced in Ethiopia (Cheng and Fischman, 1949) with limited efficacy. The advent of the tissue culture vaccine was the panacea to the rinderpest problem in Ethiopia. With the use of this vaccine, Ethiopia participated in all the four rinderpest eradication campaigns, with the utilization of CAHWs in the Afar region. PANVAC was initially located in the National Veterinary Institute, Debre Zeit, Ethiopia, but later its own facility was established within the Debre Zeit campus. The Ethiopian veterinary service implemented JP15, PARC, PACE and finally SERECU resulting in total eradication of rinderpest from the ecosystem. The country was accredited a “freedom from infection” status by OIE in 2008 and celebrated this “freedom” in 2009. It was therefore important to assess the experience of Ethiopian pastoralists of the disease and the impact it had on their livestock farming and livelihoods in general.

Pastoralists of the Borana/Oromo extraction from Mega, central eastern Moyale gave accounts of the outbreaks of the 1970s. The disease is known locally as “warandomisi”. In their opinion, these outbreaks caused over 80 per cent mortalities in cattle. These outbreaks occurred mostly in long rain seasons with cattle falling sick acutely and manifesting diarrhoea, dry skin and sudden deaths. On occurrence, the disease, also reported in buffalos, would spread across herds rapidly since the pastoralists did not have any means of controlling it other than by segregating sick animals. The farmers appreciated government action to vaccinate their cattle. Since the 1980s, no cases of RP have been reported or witnessed. Subsequently, they are able to export their cattle to Yemen and Saudi Arabia, thus fetching handsome income and securing their livelihood.

A visit to cattle holding yard in Nazarene (Adama) gave a vivid picture of the impact rinderpest eradication has had on cattle keeping. Cattle exporters and intermediaries were at hand with huge and healthy herds destined for export. The traders intimated that they fetch over 250 per cent profit following a month of quarantine and fattening at the holding ground. One of these traders, hailing from Diksis in eastern Oromia, witnessed the outbreaks of the 1970s and was quite elated at the blossoming cattle business following RP eradication. He stated that the prices of cattle had increased exponentially.

Pastoralists in Awash in the Afar region of Ethiopia were even more categorical in their characterisation of rinderpest. The disease is known locally as "Intefueh" or "Honchuf". The farmers expressly put it thus: "Cattle is our bank, our livelihood and our life". These farmers, aged over 70, had witnessed the disease outbreaks of 1970s and 1980s. They described the typical clinical signs especially in calves, of lacrimation, diarrhoea and subsequent mass deaths. Warthogs, thought to be the source of the disease, also manifested similar clinical signs and suffered the same fate. Nevertheless, they practised segregation/quarantine as a means of minimising the spread of the disease. Animals dying from the disease were abandoned. Since the pastoralists did not have any traditional means of treatment for the disease, all was left to fate. Government supported control and eradication programmes have enabled them to keep larger herds of cattle, a source of subsistence and livelihood. However, other concerns remain, such as scarcity of pasture, water and other diseases such as blackquater.

Summary of Information from Ethiopia:-

i) Rinderpest has been eradicated from Ethiopia.

ii) Herders expressly put it thus: "Cattle are our bank, our livelihood and our life".

iii) Cattle, the sole source of livelihood for the pastoralist farmers is secured following the eradication of rinderpest.

iv) Herders are now able to keep larger and healthier cattle.

9.3.2. Kenya

Kenya witnessed devastating outbreaks of rinderpest from 1890, claiming large populations of cattle and wildlife. In an attempt by the pastoralists to restock their herds, the disease was spread further to neighbouring countries. Early explorers travelling through Eastern Africa recorded the rapid spread and devastating effects of rinderpest in the cattle and wildlife populations, particularly buffaloes between 1890 and 1897 (Spinage, 2003). Vaccination programmes alleviated the spread of the outbreaks, but the disease remained endemic with recurrent epidemics in cattle and wildlife populations.

The Maasailand areas of southern Kenya were particularly affected and the emergence of mild forms of the disease in this area was recognised in these early years (White, 1958; Robson, 1959; Plowright, 1963). Lineage 2 of RP Virus caused disease in buffalo in Tsavo National Park in December 1994. Apparently, this virus circulation persisted until 2001 when the disease was diagnosed in buffalo in Meru National Park.

Throughout the rinderpest control and eradication campaign in East Africa, Kenya played a crucial role of provision of diagnosis and vaccines by the laboratories at Muguga and Kabete. To start with, an African Conference on Rinderpest was held in Nairobi, Kenya, in 1948, which recommended the creation of an African Rinderpest Bureau, later evolving into the present day AU-IBAR based in Nairobi.

Kenya also played a significant role in the development of new technologies that were instrumental in the rinderpest eradication campaigns. On the vaccine

Plate 4: H.E. President Mwai Kibaki of Kenya (centre) unveils the commemorative statue during celebrations to mark Kenya's freedom from rinderpest at Meru National Park in November 2010. To his left is H.E. Eric van der Linden, Head of EC delegation to Kenya and to his right Prof. Ahmed El-Sawalhy, Director of AU-IBAR.

development front, in 1936, a goat attenuated vaccine was tested in both zebu and grade cattle, although with disastrous results. On a positive note, avianised vaccine produced at Kabete was able to induce solid immunity with no side effects.

Finally, the magic tissue culture rinderpest vaccine developed at Muguga, by Plowright and Ferris (1959) was instrumental in the eradication of rinderpest from the African continent. Universal RPV specific primers that enabled detection of all field isolates of the virus were first used during the rinderpest outbreak in wildlife in Kenya in 1994 and confirmed infection to be due to Lineage 2 of the virus (Barrettt et al., 1998). From here onwards, Kenya became an integral part of the SES as the virus was also detected in Mandera, bordering Somalia. This virus had to be eliminated to ensure total elimination of the virus from SES and Africa as a whole. Kenya was accredited RP freedom in 2009 and comemorated this freedom in november 2011

9.3.2.1 Somali Pastoralists, Kenya

Somali pastoralists in north eastern Kenya have a clear knowledge of rinderpest and can recognise it easily. They have different names in Somali language for different forms of the disease. The local name for rinderpest is “Shifow”; the mild form is “Ilsar” while the acute form is “Madobeeye”. Once these pastoralists observe sudden deaths in large numbers of warthogs they know “Madobeeye” is in the area. When they observe blindness in kudu, they are certain that Ilsar is about to occur. These herders are aware of the importance of rinderpest eradication because their livelihoods, food security and international trade have improved following eradication of the disease.

In north eastern Kenya, pastoralists of the age range 30-67 years from Saka Location, Sankuri Division of Garissa District, including the area assistant chief and Chief were interviewed. They stated that cases of rinderpest were last reported more that 33 years ago in cattle, buffalo, and warthogs. Cattle of all age groups were affected; exhibiting copious lacrimation, nose drooling, ulceration of mucous membranes, and haemorrhagic diarrhoea. High mortalities occurred, and the pastoralists disposed of the carcasses by burning to avoid contamination. In addition, sick animals were isolated in their own kraals from where they were fed and watered. Government veterinarians controlled the disease through vaccination. The pastoralists believe wild animals, especially buffalo and warthogs, transmit the disease to cattle.

In one of the interactions with Somali pastoralists at the Garissa livestock market, a 60-year-old herder vividly described the rinderpest outbreaks of the 1970s. He associated them with rains after a long dry spell. According to him, there was no traditional cure or prophylaxis for rinderpest, although recovered animals never contracted the disease again. He, however, was quick to add that the disease has not been witnessed since the 1970s following government intervention. A similar description was captured from Somali pastoralists in Ijara District.

The herders, aged between 50 and 83, had witnessed rinderpest in cattle, buffalo and warthogs in the 1970s. They were of the view that once the animals developed rinderpest, vaccination was of no use. They stated that the disease had been eradicated by vaccination.

In Tana River, a region bordering the SES, Orma pastoralists, aged over 65 years, described rinderpest outbreak in the 1970s characterised by copious lacrimation, loss of hair, fetid haemorrhagic diarrhoea and subsequently high mortalities in cattle. The outbreaks, mostly associated with long rains, were acute in young heifers and bullocks, killing the animals in less than five days. According to them, cattle that survived beyond seven days recovered and acquired lifelong immunity. Wildlife, including buffalos and kudu, were also affected. The herders believed that flies and urine following contact with sick animals could transmit the disease. They were quite elated that government intervention eradicated the disease. The herders voluntarily instituted livestock movement barriers, akin to quarantine, to control the disease during outbreaks. Before the advent of vaccination, the Orma pastoralists had traditionally administered herbal medicine orally; an extract of the “Karchacha” and “Golecha” tree roots, as treatment for the disease.

The information provided by the Somali and Orma pastoralists in Kenya can be summarised as follows:
In all the communities visited, it was stated that rinderpest had been eradicated by vaccination.In the opinion of the Somali communities of N.E. Kenya, other diseases emerged after the eradication of RP. Some of the diseases are anaplasmosis, CCPP, CBPP, and RVF. The Orma pastoralists of Tana River District, Kenya expressed similar sentiments. They yearned for the government to institute measures to keep at bay other livestock diseases that bedevil them including blackquater (Garabgsya), anthrax (Bashasha), FMD (Hoyale) and CBPP and CCPP (Somba). The pastoralists found the delivery of veterinary services by CAHWs valuable and requested that more of this cadre be trained and deployed.

In neighbouring Somalia, now that rinderpest has been eradicated, the cattle population has grown and so are the profits accruing from livestock and livestock products sales. They are now able to export their livestock to the Gulf States.

The main market for cattle of Somalis of N.E. Kenya is neighbouring Eastern and Coast provinces, but the local community hopes that in future, more external markets would be sought to boost their income.

9.3.2.2 Maasai Pastoralists, Kenya

The Maasai of Kenya and Tanzania are a pastoralist community whose livelihood is dependent on livestock. The community was vastly and severely affected by rinderpest outbreaks of the 19th and the 20th centuries. Rinderpest struck East Africa in 1890, and in two years, 95 per cent of the buffalo and wildebeest had died. The disease devastated the herds of pastoral Maasai, driving them into the mountains to seek refuge. Other outbreaks were recorded between 1910 and 1960, and in the 1990s. It was, therefore, imperative to get an insight from the Maasai on the disease. Their views of the impact of rinderpest eradication, and how this contributed to their livelihoods were captured. Views were collected and collated from the Maasai of Kajiado, Kenya, bordering Tanzania, who are one of the major pastoral communities in Eastern Africa. Those interviewed were Maasai of the Illnyankusi (on average 75-90 years old) and Ilseuri (60-75 years old) age groups that witnessed rinderpest outbreaks in their cattle populations. Views of younger generations and local chiefs were also captured. Interviews were conducted with elders from Ildamat, Oldonyo-Orok and Namanga locations, Malewa Group ranch, Naron and Loitoktok/Namanga border areas. During

Plate 5: A livestock herder shares his experiences of rinderpest at Garissa market in Kenya

Plate 6: Maasai women in Kajiado, Kenya, the first line of diagnosis and key beneficiaries of rinderpest eradication, share their experiences of rinderpest

the interviews, it became apparent that the Maasai have a vivid recollection of rinderpest. The disease is known locally as “olodua”. They intimated that the disease manifests in three clinical forms; a mild form exhibiting a typical ulceration of the conjunctiva and low mortality; an acute form characterised by severe diarrhoea and a near 100 per cent mortality, and a peracute form occurring occasionally and causing sudden death in highly susceptible animals.

The Maasai elders stated that the pathognomonic clinical signs of the disease were copious tearing, severe hemorrhagic diarrhoea and general malaise.However, occasionally, they were unable to differentiate rinderpest from East Coast Fever. In their recollection, the last severe outbreak of rinderpest occurred in the 1950s when some of the respondents were young initiates (Morans). According to them, the disease affected young cattle with very high mortalities

They were quite elated that the colonial government controlled the disease outbreaks using vaccination and branding their animals with the ‘N’ brand mark after vaccination. These vaccinations were repeated annually for four consecutive years. The Maasai women also observed a similar form of the disease in game parks affecting elands, buffalos and kudu in 1980s, resulting in very high mortality of these animals although cattle were not affected this time round. According to them, the last vaccination campaign was conducted in 1996.

Before the introduction of modern vaccination by the colonial government, the Maasai had vaccinated their cattle orally against rinderpest using a concoction of blood, urine and dung from sick animals. Apparently, this procedure resulted in mild clinical signs and acquisition of solid lifelong immunity thereafter.Other control methods included avoidance of contact with wildlife and keeping their cattle away from any suspected outbreaks.

It was intriguing to learn that before the advent of modern rinderpest control methods, the Maasai controlled the disease by segregating sick animals from healthy ones. It was mandatory that healthy animals had to be taken to watering points before diseased ones. Before the return of healthy animals the next day, thorough cleaning of the area was carried out. They aseptically disposed of cow dung, urine, and the area was left to dry. In their view, after three months, the disease was deemed to have been eliminated and the restriction would then be lifted. The community punished anybody flouting this procedure. Families that incurred severe losses due to the disease had their flocks restocked by those least affected.

In summary the information from the Maasai pastoralists of Kenya was:

i) Rinderpest has been eradicated.

ii) Since the eradication of rinderpest, the cattle population has grown, their livelihoods have improved tremendously, and food security is assured.

iii) The government should strengthen disease surveillance and control systems to include tick-borne diseases such as East Coast Fever and anaplasmosis, foot and mouth disease, malignant catarrhal fever, anthrax, contagious bovine pleuropneumonia and contagious caprine pleuropneumonia

iv) An early warning system should be put in place to incorporate prediction of drought and el-Niño type precipitation.

v) Their expectation was that our mission would help in finding a solution to other livestock diseases such as CCPP, CBPP, FMD and anaplasmosis (ndigana) which still bedevil them.

9.3.3. Somalia

History has recorded rinderpest in Somalia as early as 1897, apparently originating from Ethiopia. The outbreaks caused the loss of large numbers of cattle (Pankhurst, 1985). The disease spread to southern Somalia, destroying cattle, buffalo, kudu and hartebeest populations, particularly in the Juba River region. The spread of rinderpest in Somaliland was thought to have been inhibited by the low cattle densities. Another small outbreak, the source of which was suspected to be Eritrea, was recorded among Somali cattle in north western Somalia (Somaliland) in 1918. A concerted rinderpest eradication campaign for Somalia commenced in 1968 under the JP15 campaign. Somalia also participated in PARC and PACE programmes notwithstanding the volatile socio-political situation in the country. Following the detection of the mild strain of rinderpest virus in Mandera area of Kenya near Somalia, the country was incorporated into the SES rinderpest eradication programmes. This ensured Somalia progressed through the OIE Pathway and submitted their dossier for certification of freedom from infection. Once the virus was finally eliminated from SES, rinderpest was confirmed to have been eradicated from the entire continent of Africa and indeed the world. As the call was with when the last case of small pox was diagnosed in a hospital cook in Merka, Somalia in 1977. Somalia was officially certified rinderpest "infection free" by the OIE in 2010.

Somali pastoralists knew rinderpest and were able to describe classical acute rinderpest and the mild form of the disease. Somali pastoralists in Afmadow and

Plate 7: Hon Abukar Abdi Osman, Somalia's Minister for Livestock, Forestry and Range (right) and Prof. Ahmed El-Sawalhy, Director, AU-IBAR admire the OIE certificate of freedom from rinderpest for Somalia in May 2010

Dinsor areas of southern Somalia recalled their experience with rinderpest. The disease killed large numbers of cattle and wildlife particularly buffalo, kudu and warthogs. They have different names in Somali language for different forms of the disease. The local name for rinderpest in the South of Somalia is “Shiifow”, the mild form is called “Ilsar” while the acute form of the disease is known as “Madobeeye”. Like their cousins across the border in Kenya, once they observe sudden deaths in large numbers of warthogs, the Somali know “Madobeeye” is in the area. When they observe blindness in kudu, they are certain Ilsar is about to occur. They are aware of the importance of RP eradication because their livelihoods, food security and international trade have improved following eradication of rinderpest. Now that RP has been eradicated from Somalia, the population of cattle has increased. They are now able to export their livestock to the Gulf States.

9.4 West African Region

9.4.1 Mali

The Organisation of African Unity, through JP15, facilitated the vaccination of cattle against rinderpest annually for three consecutive years until 1976. The programme that spanned over 22 countries was overall successfully implemented yet it did not eliminate rinderpest. Many countries failed to adhere to the strategy due to the expensive surveillance programmes and hence the project was terminated before total elimination of the virus from the continent. Subsequently, the disease re-established itself at the Mali-Mauritania border in the 1980s. As the largest concentrations of cattle in Mali are in the areas north of Bamako and Ségou, extending into the Niger delta, it was easy for the disease to spread northwards affecting the adjoining countries of Burkina Faso, Niger and Nigeria. Mali was the hub of operations in the eradication of rinderpest in West Africa, being the regional coordination headquarters for PARC and PACE.

In the initial stages of PARC, Mali along with Burkina Faso and Nigeria in West Africa, and Ethiopia and Sudan in Eastern Africa, were targeted for mass vaccination against rinderpest without conditionality because of massive rinderpest outbreaks that occurred at the time. These countries received the first financial allocation for the immediate action at the start of PARC. Mass vaccination campaign in Mali was carried out efficiently in accordance with the PARC strategies, achieving fast control of rinderpest throughout the country. The country also participated in the PACE programme establishing epidemio-surveillance networks throughout the country. The government of Mali has maintained the epidemio-surveillance networks established during the PACE programme to date, providing facilities, finance and other resources. The networks are being used in the management of other TADs in the country.

During a meeting with senior staff of the Veterinary Department of Mali, it was reported that the last episodes of the disease in both cattle and wildlife occurred in Yanfolila, Kita, Diandjoubera-Kayes and Timbuktu between 1982 and 1986. The department was unequivocal that the last known outbreak of the disease occurred in Yarosso-Sikasso in 1986. The Veterinary Department had conducted vaccination against rinderpest in the early 1980s before the initiation of PARC although to a smaller scale but intensified vaccination during PARC programme.

The department carried out the necessary surveillance for rinderpest until 1995 when it received the infection-free status from OIE. Nevertheless, Mali continued with sero-surveillance for rinderpest until 2004 when the exercise was incorporated into the government funded Priority Diseases Programme. It should be emphasised that sero-surveillance for rinderpest has continued up to 2010 as a precaution against any re-emergence of the disease. It is important to note that the government is carrying out former PACE activities targeting seven priority diseases for serosurveillance namely; rinderpest, CBPP, PPR, FMD, Rift Valley Fever, Avian Influenza and Newcastle Disease. The Veterinary Department and the herders were of a strong view that after the eradication of rinderpest, CBPP should be the next candidate for eradication from Africa, with the facilitation of AU-IBAR.

Interviews with pastoralists revealed that they were conversant with rinderpest clinical signs and that they knew the disease well. They described the typical clinical signs of rinderpest to be lacrimation, “shooting” diarrhoea, dry skin and mass deaths. The disease in southern Mali is known as “Peuth” in Fulani and “Berebla” in Bambara languages, while in northern Mali, it is known as “Boyi” in Fulani and “Niejibon” in Bambara languages.

The Cooperative des Eledeus, Badinko, a livestock farmers’ cooperative society, Kita in south eastern Mali, confirmed that rinderpest had been eradicated from Mali by 1986. The farmers interviewed were aged between 40-77 years and were familiar with rinderpest since they had witnessed the disease outbreaks in their areas. The disease was last witnessed in Bankasi in the north in 1984, according to the farmers, and the disease was stated to have emanated from wild pigs/warthogs and antelopes, while the herders in Kolokani believed rinderpest outbreaks in their areas originated from Mauritania. It was therefore no surprise that the Kolokani herders attributed the disappearance of the disease to its control at source in Mauritania. The Mali herders mainly comprised the Bambara, Sarakole, Malinke, Badinko, Jawambe and Fulani ethnic groups, who owned large cattle herds averaging 100 head per household. These herders had no traditional means of treatment or control of rinderpest until the advent of vaccination by government veterinarians. For this reason, they were grateful to the government for the eradication of rinderpest. It was obvious that following the eradication of the disease, cattle populations had soared with the resultant increase in income and secured livelihoods. Large herds of cattle were witnessed being shipped to markets in Bamako from both North and South Mali.

With rinderpest having been eradicated, Mali herders are now concerned with other cattle diseases. These included CBPP, dermatophilosis, FMD and pasteurellosis, the latter two known locally as "Safa" and "Kenyel", respectively. Anthrax and blackquarter were also mentioned as occurring occasionally. The herders called for urgent attention to these diseases. Their sentiments were also echoed by the Veterinary Department and the Secretary General of the Assemble Permanente des Chambres d'Agriculture du Mali (APCAM). They were also of the opinion that herders should be encouraged to form organised groups such as cooperative societies to benefit fully from information, financial and service delivery.

AU-IBAR was commended by the Veterinary Department and all the stakeholders for its role in mobilising donor funds, coordination of PARC and PACE, and for facilitating effective communication amongst stakeholders. The Veterinary Department and farmers were of the view that AU-IBAR should facilitate the control of CBPP and FMD at continental level.

Summary of information obtained from Mali:

i) Rinderpest eradication was a big milestone for livestock farmers in Mali.

ii) Mali was a kingpin in the overall rinderpest eradication campaigns in West Africa.

iii) Other diseases of importance in Mali are CBPP, FMD, PPR, Rift Valley Fever, Avian Influenza and Newcastle Disease. These diseases have been identified and classified by the Mali Government as priority.

iv) The Government of Mali has established a programme for the control of these diseases and former PACE activities are being undertaken under this programme.

v) Mali has a five-year annual vaccination programme for CBPP using the T1 vaccine produced by the Central Veterinary Laboratory, Bamako.

vi) There is need for a regional programme, in tandem with AU-IBAR, to address other TADs such as CBPP and FMD.

Plate 8: Herders of Kolokani, northern Mali recount the benefits of rinderpest eradication.

10. AFTERWORD

Rinderpest is the single most serious disease of ungulates in the world. Addressing the challenges the disease posed to the livelihoods of the peoples of the world resulted in the establishment of veterinary schools in Europe and Africa, as well as international and regional institutions such as OIE, CCTA, EMPRES and STRC/AU-IBAR. The commitment of world-renowned scientists to researching, controlling and eventually eradicating rinderpest spanned more than four decades. They worked across regional, national, and colonial boundaries and the success of the campaign was in no small part, due to their long hours of toil, quest for knowledge and development of effective vaccines and diagnostics.

Some of the names that come to mind are Gordon Scott, Walter Plowright, Alain Provost, WG Beaton, Protus Atang, H.E Lepissier, Ian Macfarlane, A.M. Dahab, Yves Cheneau, Walter Masiga, Solomon Haile Mariam and Samba Sidibe. Others are Rene Bessin, Bouna Diop, Peter Roeder, Mark Rweyemamu, Gijs van't Klooster, Ali Musa, Bill Taylor, Jimmy Thomson, Jeff Mariner, Tim Leyland, Paul Rossiter PB, Richard Kock, John Wafula, Karim Tounkara, Tom Barrett, John Anderson, Martyn Jeggo, Joseph Domenech, Adama Diallo, Genevieve Libeau, Tilahun Yilma, Henry Wamwayi and Dickens Chibeu. Of the donor community, Ian Mulder, Phillip Vialatte, Bernard Rey and Guy Freeland played a pivotal role in the financing of rinderpest eradication campaigns. Moreover, there were the National Coordinators and their teams whose contribution was invaluable in the eradication process. Scientists worked in institutions at the national, regional, and international levels. Some of the institutions that must find a place in this book are the Institute for Animal Health, Pirbright UK, CIRAD-IEMVT in Montpelier, France, the National Veterinary Institute in Vom, Nigeria, Farcha Laboratories in Chad, National Laboratories in Bamako, Mali; Dakar, Senegal; Debre Zeit, Ethiopia; Kabete, Kenya; the National Veterinary Research Centre in Muguga, Kenya; the Virology Laboratory of LANADA/Laboratoire Central de Pathologie Animale – Bingerville, Cote d'Ivoire; and the African Union Pan African Vaccine Centre (PANVAC) in Ethiopia. These institutions participated in the development of vaccines and diagnostics, disease surveillance, and provided training and capacity building for the management of rinderpest. In addition, donors, viz. the EU, Italian Cooperation, SIDA, USAID, the IAEA and DfID need special mention. Non Governmental Organisations, and UNICEF, OIE and FAO in particular, played critical roles in the eradication of rinderpest.

There is no doubt that the lessons learned from the Rinderpest Eradication

Campaign will serve as a benchmark for the control of other TADs such as PPR, CBPP, RVF, Avian Influenza and Swine Flu. In particular, the establishment of an epidemiosurveillance networks throughout Africa will remain a major tool in the management of other TADs. The campaign was successful for a number of reasons:

i) Control strategies were adjusted to accommodate prevailing conditions evolving from the use of serum from recovered animals to the goat and rabbit adapted virus vaccines and finally, to the rinderpest tissue culture vaccine, which proved, to be the silver bullet that eliminated the disease from Africa. Diagnostic procedures also advanced from the laborious CFT and virus neutralisation assays to the ELISA technology that was eventually used in seromonitoring and serosurveillance and the polymerase chain reaction and nucleotide sequence analysis that have enhanced our understanding of rinderpest virus and epidemiology of the disease in modern times. Thus, in the course of the campaign, national and regional laboratories acquired new technology and improved their capacities to manage future epidemics.

ii) The campaign harnessed resources from many partners especially FAO, OIE, national governments and donors. Particularly effective was the bringing together of national, regional, and international institutions to fight the rinderpest scourge. From colonial times, political and other differences were set aside to confront the disease with a common front. Sworn enemies laid down their arms and united in the face of the grave danger posed by the disease. Community Animal Health Workers ventured into the remotest and most dangerous of regions to vaccinate animals. The campaign went so far as to solicit the permission of indigenous leaders, where necessary, to ensure that all animals were vaccinated.

iii) The war against rinderpest was conducted across political, economic, social, and national lines uniting Africa and the world in the face of a challenge that was recognised to be greater than the often-petty differences that divide so much of the continent.

iv) The herders cooperated throughout the campaign and in the end they appreciated the eradication of rinderpest as they witnessed increased cattle populations, income and secured livelihood.

A great deal of time, resources and effort were invested in the campaign and it would be a great shame if the disease recurred for a lack of vigilance in detecting and handling any potential threat. In this regard, there must be emergency preparedness at all times with a vaccine bank, financial and logistical support on constant standby.

In conclusion, it must be mentioned that the great strength of the Rinderpest Campaign was coordination and uniformity. AU-IBAR played a pivotal role in leading the charge against the disease by mobilising resources, coordinating and harmonising the campaign and providing the political platform through which conflicting groups could put aside their differences to address a common threat. Finally, having achieved freedom from rinderpest, the initiative has contributed enormously to livestock development and provided a great opening for new livestock trade opportunities in Africa. This in return is an indispensable building block to reach the goal of lifting African livestock farmers out of poverty.

Plate 9: Minister for Animal Resources and Fisheries, Sudan, H.E Dr. Faisal Hassan Ibrahim during celebrations to mark Sudan's freedom from rinderpest in Khartoum, April 2011.


Plate 10: Thanks to rinderpest eradication, we are free at last... the joy of a Maasai elder

Plate 11: Healthy herds of livestock and wildlife following rinderpest eradication

Plate 12: Rinderpest no more - export cattle in Ethiopia

APPENDIX

Table 1: Properties of Rinderpest Vaccines

Vaccine	Attributes	
	Advantages	**Disadvantages**
Viral-Serum-Simultaneous	• Lifelong immunity • Cheap to produce	• Potential for disease and onward virus transmission • Potential to transmit other diseases • Labour intensive • Need for isolation of vaccinated from naïve animals • Cannot allow for differentiation of infected from vaccinated animals
Inactivated	• Safe	• Brief duration of immunity • Cannot allow for differentiation of infected from vaccinated animals
Egg Attenuated	• Long immunity • Unlimited capacity to modify virulence	• Potential to lose immunogenicity • Potential to increase virulence • Labour intensive • Cannot allow for differentiation of infected from vaccinated animals
Rabbit Attenuated	• Cheaper to produce than GAV • Cheaper to produce than goat-adapted vaccine	• Retains considerable pathogenicity • The need to use live animals • Cannot allow for differentiation of infected from vaccinated animals
Goat Attenuated	• Long duration of immunity • Cheap to produce • Lifelong immunity • Safe in Zebu cattle	• Not safe in improved cattle • The need to use live animals • Cannot allow for differentiation of infected from vaccinated animals
TCRV	• Cheap to produce • High efficacy/potency • Robust/easy to produce • Lifelong immunity • Safest of all	• Cannot allow for differentiation of infected from vaccinated animals
Recombinant Vaccines	• Robust and Easy to produce in bulk • High efficacy • Inexpensive • No fear of reverting to virulence • Potential for use as a marker vaccine	• Safety not clear

Table 2: Costs of JP15 ($US) in West Africa

Country	National Contributions	External Aid Contributions	Total
Benin	61,500	167,749	229,249
Burkina Faso	469,387	753,976	1,223,363
Cameroon	285,714	216,612	502,326
Chad	1,224,489	1,275,074	2,499,563
Gambia*	18,074	71,635	89,709
Ghana**	195,000	157,005	352,005
Guinea	240,734	68,611	309,345
Côte d'Ivoire	125,161	287,003	412,164
Liberia	800	8,699	9,499
Mali	637,708	1,048,825	1,686,533
Mauritania	428,571	514,446	943,017
Niger	1,020,408	1,623,652	2,644,060
Nigeria	907,000	743,556	1,650,556
Senegal	734,693	72,808	807,501
Sierra Leone*	90,653	234,509	325,162
Togo	32,653	67,400	100,053
Sub-Total	**6,472,545**	**7,311,560**	
Coordination			792,598
AVRI Vom			59,786
Miscellaneous			19,276
German Aid			107,143
Grand Total EDF/USAID			**14,762,908**
* includes contribution from British aid			
** includes contribution from Canadian aid			

Table 3: Vaccination Achievements in Phases I to III of the JP15 Campaign

Country	Total Vaccinations	Estimated Coverage of Cattle Population (%)
Benin	951,623	81.4
Burkina Faso	6,629,537	88.5
Cameroon	2,076,241	89.2
Chad	10,366,107	80.4
Gambia	678,871	94.1
Ghana	1,052,627	83.4
Guinea	1,712,035	38.1
Côte d'Ivoire	792,761	85.1
Liberia	4,100	27.5
Mali	10,932,324	78.1
Mauritania	5,993,284	79.7
Niger	12,200,944	88.4
Nigeria	21,099,147	91.9
Senegal	6,412,816	85.4
Sierra Leone	475,460	79.0
Togo	106,248	33.3

Table 4: Emergency Vaccinations against Rinderpest in West Africa in 1981

Country	Estimated Target Population	Number of Emergency Vaccinations	% coverage
Benin	524,883	453,763	86.5
Burkina Faso	2,708,000	2,623,934	87.9
Ghana	823,661	128,654	15.6
Côte d'Ivoire	612,000	380,150	62.1
Mali	5,054,000	2,427,058	48.0
Mauritania	1,900,000	542,311	28.5
Niger	3,354,710	2,738,208	81.6
Senegal	2,565,100	1,290,695	50.3
Togo	205,369	156,706	76.3

Table 5: Vaccine Banks

Location of Bank	Number of Doses held	Date of Establishment
Gaborone, Botswana	3 million	July 1987
N'Djamena, Chad	2 million	February 1988
Derbe Zeit, Ethiopia	2.27 million	July 1987
Muguga, Kenya	2.5 million	April 1988
Dakar, Senegal	1.3 million	October 1987

Table 6: Annual Vaccination Returns for PARC Participating Countries

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Benin	0	0	507730	488750	508000	573640	645220	553840	111390	507370	495130	490400	0	4881470
Burkina Faso	0	1522540	1752990	1928360	2095180	169149	1394320	1433890	1384920	1777320	1469500	0	0	14928169
Camer-oon	2507350	2521590	2530490	2313080	2474370	2175870	2268780	2325450	2435450	2376680	2385340	0	0	26314450
CAR	1044490	0	654550	348290	654340	538010	568060	507670	681150	607170	507430	448000	0	6559160
DRC	256100	306610	520300	766190	0	0	0	0	0	0	0	0	0	1849200
Ghana	741100	310810	513470	616680	636060	608550	906030	962850	430240	0	1027710	0	0	6753500
Gambia	0	240000	0	0	0	0	0	0	0	0	0	0	0	240000
Guinea Conakry	0	0	237990	325850	352960	332810	246690	79840	49630	0	0	0	0	1625770
Côte d'Ivoire	670530	666730	846640	883000	983330	630170	353830	298230	0	550810	0	0	0	5883270
Mali	1401000	2822770	1636040	2330290	2116940	1656780	1691460	1654660	1230350	854820	1482820	0	0	18877930
Maurita-nia	0	0	0	0	0	518000	521000	480000	350000	281000	596000	547000	0	3293000
Niger	1417620	1585540	1523470	1088720	1342000	931000	577000	503000	635000	344000	663400	827600	0	11438350
Nigeria	5897780	7824900	4160270	2160270	2290240	4379440	4243600	2458900	3649420	2697420	2697220	0	0	42459460
Senegal	1343580	1536720	1601680	1674010	1767380	1719460	1060730	1090820	818900	612070	0	0	0	13225350
Sierra Leone	0	0	0	283000	0	0	0	0	0	0	0	0	0	283000
Chad	1772820	2224460	2017550	1984710	2200420	2035940	3254960	3432580	1708400	2459180	2242220	2E+06	0	27554480
Togo	186500	157690	213080	220000	113680	0	0	0	0	0	0	0	0	890950
Burundi	0	0	0	0	0	0	0	394780	313930	0	0	0	0	708710
Eritrea	0	0	0	0	0	206900	362120	477140	601810	668290	842890	511650	0	3670800
Ethiopia	0	0	0	########	2.6E+07	7878580	5737690	4060000	4564080	3863570	3093590	2E+06	0	67233210

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Kenya	2432780	2724030	2153360	2253210	2983710	2112380	1849550	2756840	2461740	2768240	1938070	4E+06	3534000	33801910
Uganda	513670	1009920	1318870	316210	689540	2716320	1413030	1793920	1105730	1404170	427000	2E+06	1175220	15638640
Rwanda	0	0	0	0	0	730000	0	0	0	0	0	289190	0	1019190
Somalia	0	0	0	300000	1500000	0	0	700000	0	0	227410	136950	0	2864360
Sudan	1602610	982250	1066450	3300090	2830800	3957300	3847340	4864350	5032050	4728860	5513100	6E+06	1197130	44575500
Tanzania	8793570	8713830	8183550	3480000	1268150	1868000	5980000	3362000	631370	777800	0	4E+06	0	47336270
Egypt	4654400	5384870	5775970	5405400	5014990	4492710	5300000	4700000	0	0	0	0	0	40728340
Totals	3.5E+07	4.1E+07	3.7E+07	42735400	5.7E+07	4E+07	4.2E+07	3.9E+07	2.8E+07	2.7E+07	2.6E+07	2E+07	5906350	4.45E+08

Table 7: Costs of Rinderpest Eradication under PARC

Country	National Contributions	EDF Contributions	Total Cost (€)
Benin	193,500	430,000	623,500
Burkina Faso	1,390,050	3,090,000	4,480,050
Burundi	184,500	410,000	594,500
Cameroon	720,000	1,600,000	2,320,000
CAR	593,100	1,318,000	1,911,100
Djibouti	146,700	326,000	472,700
Ethiopia	6,317,550	14,039,000	20,356,550
Gabon	292,500	650,000	942,500
Gambia	202,500	450,000	652,500
Ghana	450,000	1,000,000	1,450,000
Guinea Bissau	202,500	450,000	652,500
Guinea Conakry	1,464,750	3,255,000	4,719,750
Côte d'Ivoire	1,818,945	4,042,100	5,861,045
Kenya	958,275	2,129,500	3,087,775
Mali	1,938,195	4,307,100	6,245,295
Mauritania	823,113	1,829,140	2,652,253
Niger	1471500	3270000	4,741,500
Nigeria	2,257,650	5,017,000	7,274,650
Rwanda	234,000	520,000	754,000
Senegal	1,190,250	2,645,000	3,835,250
Somalia	2,323,355	5,160,790	7,484,145
Sudan	1,608,750	3,575,000	5,183,750
Tanzania	1,147,500	2,550,000	3,697,500
Chad	756,900	1,682,000	2,438,900
Togo	574,650	1,277,000	1,851,650
Uganda	809,550	1,799,000	2,608,550
Research		1,606,400	160,6400
Emergency logistics		3,000,000	3,000,000
T/A IBAR		1,200,000	1,200,000
Vaccine Banks		1,012,000	1,012,000
Vaccine quality control		800,000	800,000
Epidemiology Project		1,410,000	1,410,000
Economic analysis		345000	345000
Total (€)	30,070,283	76,195,030	106,265,313

The figures for individual national contributions are indicative only as they are based on an overall average for national contributions of 45 per cent of EDF inputs

Table 8: The position of PARC countries on the OIE Pathway at the end of PARC

Country	Last rinderpest reported	Year stopped vaccination	Declared Provisional Freedom under PARC
Benin	1987	1999	No
Burkina Faso	1987	1988	Yes, 1989
Cameroon	1983	1999	No
CAR*	1983	1997	Yes, 1999 zonal
Djibouti	1975	NA	No,
Egypt	1986	1996	Yes, 1996
Eritrea*	1995	1997	Yes, 1999
Ethiopia*	1995	1997 (partial)	Yes, 1999 zonal
Gambia	1965	1990	Yes, 1990
Ghana	1988	1996	Yes, 1997
Guinea Bissau	1986	never vaccinated	No
Guinea Conakry	1968	1996	1996
Kenya*	1996 – later 2001	1998 (partial)	Yes, 1999 but zonal
Mali	1988	1997	Yes, 1997
Mauritania	1988	1998	No
Niger	1986	1997	Yes, 1997
Nigeria	1987	1996	No
Rwanda	1933	1997	No
Senegal	1968	1996	Yes, 1997
Sierra Leone		1989	No
Somalia	1999	1998	No
Sudan	1999	1997 but zonal	Yes, 1997 but zonal
Tanzania	1997	1997	Yes, 1998 but zonal
Chad	1983	1999 but vaccinating in sanitary cordon	Yes, 1989 but zonal
Togo	1986	1998	Yes 1996
Uganda	1994	1999 but still vaccinating in some parts	No

Key: * Countries that declared provisional freedom from rinderpest after the end of PARC

Table 9: PACE finance against rinderpest

National Components	
Campaign against rinderpest	14,900,000
Strengthening Vet services	24,500,000
Support for privatisation	8,600,000
Subtotal	**48,000,000**
Regional Components	
Epidemiology	5,400,000
Communications	1,800,000
Socioeconomics	540,000
Support for privatisation	540,000
Husbandry auxiliaries	450,000
Financial monitoring	950,000
Data processing	360,000
PANVAC	900,000
Research	1,300,000
Advice	270,000
Monitoring	180,000
Vet schools	270,000
M&E	800,000
Coordination	3,240,000
Subtotal	**17,000,000**
External Total	**65,000,000**
National government contribution	**29,250,000**
Grand Total	**94,250,000**

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ISBN 978-9966-7456-2-0
9 789966 745620