THE CONTROL OF BOVINE TUBERCULOSIS IN EAST AFRICA WITH SPECIAL REFERENCE TO UGANDA

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SUMMARY

The control of bovine tuberculosis in East Africa and particularly in Uganda has received very little attention although the presence of the disease was already known in the early part of the century. Literature on the history, and the present world tuberculosis situation is discussed. The epidemiology of tuberculosis and the role played by the wildlife and species other than cattle are reviewed. The literature on the incidence and prevalence of bovine tuberculosis in East Africa and Africa is reviewed with particular emphasis on bovine tuberculosis in Uganda. The literature on the control measures which have been applied to reduce the prevalence of tuberculosis infection is discussed. Discussions and recommendations are made with regard to the control of the disease, with special reference to Uganda.

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CHAPTER I

INTRODUCTION

Tuberculosis is an ancient disease and has been recognized to affect both man and animals. For centuries, efforts have been made all over the world to improve the situation and research to find better ways to control the disease continues. Success has been achieved in only a small number of countries and the whole world is still at risk of the disease. The process is slow and tuberculosis is still a major unsolved health problem of worldwide dimension (IUAT/WHO, 1982). Tuberculosis is an insidious, chronic and highly contagious disease. It is characterized by long incubation period varying from months to years before its destructive effects can be appreciated. Early diagnosis of tuberculosis has been impossible because of its lack of clinical symptoms and the lack of an immediate devestating impact on the animal population.

The infection remains inapparent and during the same period, the animal is disseminating the organisms in their secretions and excretions infecting the healthy incontacts.

The tubercle bacillus has ability to infect a wide range of hosts, including man, wild animals, birds, amphibians and domestic livestock. The organisms are widely disseminating in nature and can be found in soil, pastures and water. The effective control of the disease needs collective efforts by both human and animal health authorities.

Early in the century, the incidence of bovine tuberculosis was very high in Europe and North America and was a major problem in human health and animal economy. In the rest of the world, and Africa in particular, it was believed that the disease was no appreciable human hazard and hardly had any consequences on the economy of the livestock.

The reverse is true now, the disease has proved a major public health problem and difficult to control, or even quantify, given the present social and economic problems existing in most developing countries.

It was felt that the disease could reach explosive magnitude if left uncontrolled especially with livestock development schemes starting in many countries at that time, although the incidence was low. Unfortunately the control measures which had been effective in other parts of the world could not be applied. This was due to a number of problems, which included a) cattle husbandry systems practised at that time, b) there were more devastating diseases in the continent and East Africa, which attracted more attention and had to be controlled before they got out of hand, c) the outbreak of the first and second world wars disrupted plans to tackle the tuberculosis problem.

Hardly any measures were taken although the disease was recognized and since then very sporadic control measures have been applied in several countries but with little effect.

It is against this background that the literature on the bovine tuberculosis situation in East Africa has been examined with particular regard to control and eradication. A special reference is made to Uganda. The literature on the past and present world tuberculosis situation in both human and animals is reviewed, since tuberculosis is a major zoonosis as a food-borne infection and occupational hazard. Also it has long been known that the infected human being can infect the animals. The literature on the prevalence and incidence of tuberculosis in East Africa and Africa is reviewed to assess the extent of the disease in the continent.

In Africa, modern animal husbandry systems of livestock production are still limited and only involve a small sector of the population in each country. Nomadism is still being practised in many parts of the continent. The Fulani nomads traverse the northern plains of West Africa. In Somalia and Ethiopia cattle keepers still wander with their livestock from one part of the country to another in search of water and pastures. The Karamojong in Uganda, Turkanas in Kenya and Masai in Tanzania still live with their livestock in the open countrysides although attempts to settle them have proved a very slow process. Cattle rustling is still a common practice, for example between the Karamojong in the North East of Uganda and the Turkana on the opposite side in Kenya. The major problem of these ways of life is the uncontrolled movement of livestock and in consequence the spread of diseases.

For the past twenty years or so, there has been political turmoil in nearly every country in Africa. With such troubles come the flocking of refugees and their livestock on every frontier, and the introduction and spread of diseases from one country to another. This alters the whole outlook on the incidence and prevalence of the disease in a given particular area. Literature on tuberculosis in wildlife is reviewed as they recognise no frontier or boundary. There is an abundance of wildlife in East Africa, it could play a major role in the epidemiology of tuberculosis, especially as no effective control measures could be devised or applied.

Literature on the control measures which have been effectively adapted and applied in many parts of the world to reduce tuberculosis is discussed. Finally a discussion of the above observations is made and attempts to draw conclusions as to why bovine tuberculosis has remained a problem in East Africa and Uganda in particular. Considerable progress has been made in the control and eradication of tuberculosis in many parts of the world. Suggestions are made as to what could be done to tackle the problem, given the control measures that are available and the socio-economic and financial situations existing in the country today.

CHAPTER 2

BACKGROUND OF TUBERCULOSIS

2.1 HISTORY

Tuberculosis is a disease of great antiquity in both humans and animals. The Mosaic law prohibited the eating of tuberculous meat. Tuberculosis has been found in Egyptian mummies, and phthisis was already recognized in the Mediterranian littoral in classical times. During the middle ages, bovine tuberculosis spread in Europe with increased cattle trade. In Britain it was recognized as early as the 13th century and by the 18th century, the disease was well established in cattle kept under unhygienic conditions in town dairies which supplied milk to the industrial population. The spread to the rest of the world continued with attempts to improve cattle by crossing with European breeds (Francis 1957, Henning 1965).

2.2 THE PRESENT WORLD SITUATION

During the IUAT/WHO (1982), it was observed that the present situation of tuberculosis in the world represented the prototype of a disease of which the natural history was known and subsequently quantified and against which an effective simplified, standardized technology has been developed and organized into the national tuberculosis programme. Despite these observations, there has been a continuing gap between expectations and achievements which is of great concern. The global tuberculosis prevalence is difficult to measure in both humans and animals. This is due to the fact that there is inadequacy in the detecting, reporting and notification of new cases. The human tuberculosis incidence in the world is still raising concern. It has been estimated that 1% of the population is at risk of infection annually, which is equivalent to 50 new cases of smear positive pulmonary tuberculosis per year for every 100,000 of the general population. Each year, there are 4 to 5 million new cases of smear positive cases. The figure rises to 10 million new cases if culture positive, pulmonary and extra-pulmonary forms of tuberculosis are considered. About 3 million people die from the infection each year (IUAT/WHO 1982). The incidence varies from one part of the world to another. For example in developed countries the disease is on the decline, whereas in the developing countries is increasing. In these countries, morbidity and mortality statistics are inadequate because many cases go undetected and unnotified. Tables 2a, 2b and 2c show the tuberculosis situation in the world between 1965-1979 (WHO. Weekly epidemiological Review 1981, WHO/FAO 1982).

TABLE 2a. NEWLY REGISTERED CASES BY WHO REGIONS BETWEEN 1965-1979. A WORLD REVIEW. HUMAN TUBERCULOSIS

Year	Reporting countries	Population of thousands	Newly Registered Cases*
1965	126	1,192,277	1,252,007
1970	137	1,553,069	1,316,686
1975	140	2,436,148	1,470,410
1979	108	2,319,019	1,169,518

(Source: WHO. Weekly Epidemiological Record. 1981 56)

*The number of registered cases increases as more countries report the disease. The figures represent only a fraction of estimated number of new cases. There is lack of continuity in the reporting of new cases in almost all WHO regions, so that no meaningful comparison can be made.

*9% of all cases were reported in children under 15 years of age, 58% Males and 42% females.

TABLE 2b. HUMAN DEATHS FROM TUBERCULOSIS IN THE WORLD 1965-1979

Year	Reporting countries	Population in thousands, % of world population	Officially reported deaths
1965	116	1,223,808 36.6%	178,213
1970	136	1,488,900 40.5%	156,880
1975	112	1,426,246 35.5%	121,634
1979	61	1,001,894 23.1%	53,545*

(Source: WHO. Weekly Epidemiological Record. 1981, 56)

*The apparent decrease is largely explained by a predominance of reports from developed countries. In the developing centuries, the death toll from tuberculosis must be many times higher than suggested by the figures presented.

TABLE 2c. NEWLY REGISTERED TUBERCULOSIS CASES BY WHO REGIONS IN AFRICA BETWEEN 1965-1979. HUMAN CASES

Year	Reporting countries	Population in thousands	Newly Registered Cases
1965	33	141,283	157,822
1970	36	222,672	196,316
1975	30	170,658	68,044
1979	17	150,253	54,046

(Source: WHO. Weekly Epidemiological Record 1981, 56)

There is a lack of continuity in the reporting of new cases in almost all the countries, so that no meaningful comparison can be made.

In East Africa, tuberculosis has long been shown to infect an alarmingly high proportion of the population. From the East African Medical Research Council report of 1966, 10 million people were exposed to tuberculosis from a total population of 25 million, that is 40% of the population. 300,000 people were suffering from the disease and 60,000 contracted the disease. Only 20,000 cases had been diagnosed and only 10,000 patients successfully treated. From the

WHO report (1967), East Africa had a human incidence of tuberculosis varying from 1.6-2.2%, based on X-ray examinations. In 1969/1970 a random sample of 15 out of 61 administrative districts in Tanzania was carried out. A total of 1,884 patients were involved and 87.4% had pulmonary tuberculosis, 2.5% pulmonary and extra pulmonary tuberculosis, and 10.1% extra pulmonary tuberculosis. The results were based on smears, cultures and X-ray examinations (Tubercle, 1975). In Kenya a similar exercise was carried out. A survey was conducted on a random sample of 11 out of 30 administrative districts. Of a total of 1,296 patients, 1,164 (89.8%) were infected. Of those infected, 29.5% were children between the ages of 5 and 14 years. In all the above cases, no Mycobacterium bovis organisms were isolated, indicating the little role bovine tuberculosis played (Tubercle, 1968). The disease hardly exists in cattle.

Control of human tuberculosis has been achieved by the combination of case finding, chemotherapy and B.C.G. vaccination in children and the results are very promising especially in countries with minimal socio-economic problems (IUAT/WHO, 1982).

Tuberculosis in animals has received equal attention since early in the century. The disease has been brought under control and eradicated in most of the western European countries, Canada and the United States of America. A concerted effort of both man power and finances for many years was needed to bring the disease to negligible levels in these countries, although occasional cases do still occur. An imbalance is observed in the incidence and prevalence of the disease in developed and developing countries. In developing countries, the incidence of tuberculosis is very obscure, because of poor reporting systems, lack of organized surveys, poor understanding of the disease and lack of facilities like laboratories to quantify the problem. It has been observed by WHO/FAO (1982), that one major difficulty is poor epidemiological knowledge of tuberculosis in the world, due to the lack of accuracy and continuity in the reporting of the disease in almost all the WHO regions.

2.3 WHY CONTROL TUBERCULOSIS ?

2.3.a Zoonosis

Control of bovine tuberculosis began as a public health measure, but in its later stages became a means of improving animal health and productivity (Kleeberg, 1963). Animal tuberculosis has been recognized as a zoonosis for a long time. *M. bovis* infection in man in the whole world varied from 0-53% in various parts between 1901-1970 (Kleeberg, 1975). The main source of infection was milk from tuberculosis cows affecting children especially, and the hazard to adult people involved in handling infected animals. It has been noticed by many authorities, and there have been several reports, that the apparent healthy animal is capable of excreting mycobacteria organisms in milk. Nassal (1957) in Germany reported isolation of tubercle bacilli in 1161 of 103,324 samples of milk from tuberculin reacting cows. In 50% of the affected cows there was no noticeable change in the clinical appearance of the udder, and the milk looked normal. Richardson (1970) isolated atypical mycobacteria from 11 cows in 5 herds. All the animals were 'normal' with exception of one which had a teat injury. Keyhani in Iran (1970) experimentally infected sheep with tubercle bacilli and was able to isolate the organism from their milk. In Cairo, Kamel *et al* (1975) isolated tubercle bacilli from 13 of 85 milk samples collected from dairy shops and street vendors. In conditions where marketing systems for dairy products are not centrally controlled and supervised, especially in most of the developing countries of the world, there is a potential danger. The risk could be reduced in most cases by pasteurization of milk, and boiling of milk where access to pasteurized milk is difficult for example in rural areas (WHO/FAO 1981).

Meat-borne tuberculosis has not been clearly established, although mycobacteria have been isolated from meat. Kleeberg (1975) made an observation that in cases of generalized tuberculosis, meat from these animals could contain tubercle bacilli. He cited an example were 50-80% of the samples examined were positive. He reported that a group of 650 slaughter cattle were found to harbour tubercle bacilli in 45% of fresh primary complex, 13% in chronic lung tuberculosis and 18.4% in chronic generalized form. Therefore partial condemnation of infected carcasses, should be discouraged whenever possible. Uncontrolled bush slaughter of domestic and game animals could be regarded as a possible source of the spread of tuberculosis (Mitchell 1968).

Lack of proper hygienic precautions could lead to extensive contamination of the surface of meat during slaughtering processes, therefore vigilance is essential (Francis, 1973). Habits of eating raw meat as a delicacy in certain parts of the world, for example in Sudan and Ethiopia as "Marara" (Tag el Din et al, 1980), could present a risk of infection. For protection of man from food-borne tuberculosis of animal origin, eradication and control of the disease in the animal by test and slaughter programmes has proved most efficient. In countries where animal tuberculosis still exists, pasteurization or boiling of milk and adequate cooking of meat before consumption has proved effective (WHO/FAO 1967, 1976, 1981, IUTA/WHO 1982).

2.3.b Occupational Hazard

Cases of infection of man from infected animals and vice versa have been well documented. It has been observed that there was correlation between prevalence of tuberculosis in cattle and the prevalence of tuberculosis in humans with close association of animals (WHO 1967, Lesslie *et al* 1972). Although contact with animal products like meat is not an important source of human infections, they pose a great danger as an occupational hazard to abattoir workers and veterinarians (Meyer 1969, Atwater 1968). Tuberculin testing was carried out on 317 volunteers in Sudan. 206 (65%) gave specific reactions to tuberculin. The highest occurrence rate of positive reactivity (93.2%) was among abattoir workers and 8.7% in veterinary attendants. Of infected children under 14 years of age, 60% were living in the same surroundings as the adult reactors (Omer *et al* 1980). Humans working in close proximity with tuberculous cattle can become infected. Bladodarnyi *et al* (1975) reported the isolation of *M. bovis* in 9.5 - 25% of agricultural workers suffering from tuberculosis in Kazakhastan in Russia. Among those in actual contact with cattle, urogenital infection was common. Averina *et al* (1975) reported that 54% of 1,282 workers on poultry farms in Russia gave positive tuberculin test reactions. They were possibly getting infected from chickens with *M. avium* infection. Laboratory workers have been infected on several occasions. Dogs and cats can easily transmit tuberculosis to humans. Kleeberg (1975) cited reports from Glasgow which showed that 14.5% of the dogs and cats living in contact with tuberculous men harboured tubercle bacilli in their throats and faeces.

CHAPTER 3

EPIDEMIOLOGY

3.1 AETIOLOGY

Tuberculosis in both humans and animals is caused by a variety of species of the genus Mycobacterium. The tubercle bacillus was first identified by Koch in 1882. The mycobacteria are Gram-positive, non motile, non spore forming pleomorphic rods. They are fastidious in that they need specially enriched media with serum, eggs, pyruvic acid, antibiotics and detergents like Tween 80. They are slow growers except the saprophytes which grow more rapidly. They are primarily intracellular and obligate aerobes. The tubercle bacillus is made of a high percentage of lipids and tubercle proteins. The lipids consist of waxes and glycolipids which give the bacteria its acid-fastness and only stain by Ziehl Neelsen method, and protect it against digestion following phagocytosis. These lipids are also responsible for the 'cord factor' which determine the virulence.

These lipids have deleterious effects on neutrophils, transform histocytes and monocytes into epitheloid giant cells. This helps the organism to be resistant and enhances its virulence. The tuberculo proteins are extracted and used as tuberculin in testing for infection in humans and animals (Paterson et al 1959, Jubb et al 1970, Soltys 1979, and Wolinsky 1980).

Bovine tuberculosis is caused mainly by M. bovis. It was differentiated from other tubercle bacilli by Theobald Smith in 1898 (Wolinsky, 1980). Other mycobacteria namely M. tuberculosis causing human tuberculosis and M. avium causing infection in birds, both domestic and wild, can infect cattle. Many species of mycobacteria are widely distributed in nature as saprophytes in soil, dust and water, and in tissues of both warm and cold blooded animals. Occasionally they become pathogenic under certain conditions and cause disease in animals.

M. bovis is fastidious, a slow grower, and the growth is scanty compared to the rest. It cannot be isolated in several media and hardly reacts with several biochemical agents. The organisms are very virulent to rabbits and guinea pigs. It is these characteristics which are used to identify it from other species and also it is a basis of laboratory diagnosis of tuberculosis. M. bovis causes progressive disease in bovine animals and is virulent to other species of animals. It can affect man, horses, swine, goats, sheep, dogs and cats and a host of wild animals (McDiarmid 1960, Paine et al 1928, Woodford 1982).

Atypical mycobacteria unlike the other mycobacteria are fast growers and can be cultured on simple media and varying temperatures. They are less virulent and produce non progressive lesions in the affected animals.

Macroscopically these tuberculoid lesions are indistinguishable from those caused by other tubercle bacilli. They can only be differentiated from each other by laboratory procedures. Most of them are resistant to chemotherapeutics. Others which cause skin infections in cattle have not been cultured. These organisms promote cross sensitivity which cause confusion in the interpretation of tuberculin test allergic reactions and undermine the value of the test in diagnosis of tuberculosis. Atypical mycobacteria were classified by Runyon in groups by their ability to produce pigment in the dark or light (Runyon 1959, 1970, Schaefer 1965, Soltys 1979).

With the development of new biochemical tests, serotypes and sub-groups are recognized within the original Runyon groups (Soltys, 1979).

Some of the pathogenic atypical mycobacteria commonly isolated from animal tissues and excretions include, M.intracellulare (part of M. avium complex), M. kansasii, M. szulgai, M. xenopi, M. fortuitum and M. simiae (Jubb et al 1970, Wolinsky 1980). Jones et al (1966) in America isolated 83 strains of atypical mycobacteria in 123 pooled milk samples. When typed they found that 45 were M. phlei, 14 M. fortuitum, 1 M. smegmatis and 23 slow growers comprising scotochromogens and non-chromogens. Similarly Polkhonskii (1973) in Russia isolated 25 strains of atypical mycobacteria from milk samples of cows showing positive tuberculin test. Waddington (1967) in Kenya isolated atypical mycobacteria from a frog which proved to be infective to warm blooded animals. Woodford (1982) and Guilbride (1963) isolated atypical mycobacteria from wild animals. These organisms can confuse the true picture of tuberculosis infection in a given herd or in a given area.

3.2 SOURCE OF INFECTION

The original source of bovine tuberculosis has been difficult to trace although the disease has been known to exist for centuries. The tuberculous bovine animal has been the main source of infection. The insidious nature of tuberculosis, the long incubation period varying from months to years before the clinical signs were manifested, makes early detection of infection difficult. These are usually apparently healthy animals and negative reactors in tuberculin tested herds. They continue excreting the tubercle bacilli into the environment infecting the incontacts. The infection is protracted and more and more get exposed. The organisms are disseminated into expired air during respiration and in the sputum when the animals start coughing. When the infection is generalized the tubercle bacilli are excreted in urine, milk and faeces. Kleeberg (1975) found and 4-5% of infected animals with generalized tuberculosis excrete M. bovis in urine. Dekker et al (1962) isolated M. bovis bacilli from the urine of an emaciated circus camel. When the animal was slaughtered, tuberculous lesions were found in the kidneys and other organs on post mortem. There are several reports of outbreaks of tuberculosis from faecal contamination. Lesslie (1960) reported avian tuberculosis in 3 goats given feeds contaminated by faeces from wild birds. Most of avian tuberculosis is acquired through organisms being excreted in faeces. Animals with tuberculous udders and generalized infection excrete organisms in milk, thus infecting suckling calves and humans consuming raw milk. Jones et al (1966) isolated mycobacteria from 77 of 123 pooled milk samples. Nassal (1957) in Germany reported isolation of tubercle bacilli from 1161 of 103,324 samples of milk from cattle showing positive tuberculin test reactions.

Cattle owners, handlers and milkers suffering from active tuberculosis can infect cattle and vice versa. The human tubercle bacilli strains seldom cause progressive lesions in bovines, but play a major role in sensitising cattle. When they are tuberculin tested they give false positive reactions. These make it difficult to interpret the results during surveys. Lesslie (1960) reported reinfection of 5 attested herds from handlers and owners who were suffering from pulmonary tuberculosis. A milker with pulmonary tuberculosis infected a herd of 60 cattle which were free from tuberculosis. 5 of 22 cows which gave positive tuberculin reaction were excreting human type bacilli in milk. Post mortem examination was carried out on two of the cows and human tubercle bacilli were isolated from the lesions (Schmittdiel et al 1966). Szelenyi (1968) in Russia reported appearance of tuberculin reactions in 87.3% of cattle in 2 herds where tuberculosis has been eradicated. The infection was traced to several farm workers who were suffering from tuberculosis. Baldwin (1968) reported the case of a farmer who previously had lost a herd of cattle through tuberculosis. He contracted tuberculosis and reinfected his newly acquired herd. In Poland a man with active pulmonary tuberculosis infected a herd of 700 swine which he was looking after (Zorawski et al 1974). Englert and Milbradt (1977) reported a case of a farmer in Germany who was suffering from renal tuberculosis, resulting in a herd which was 100% tuberculin positive. He acquired a new herd which remained clean for 5 years and then became reinfected through unhygienic conditions i.e. the contamination of straw and hay with infected human urine. Waddington (1967) in Kenya found that most of the cattle reacting to tuberculin test were sensitized by exposure to human infection. Therefore when carrying out eradication and control schemes of tuberculosis, it has to be kept in mind that people suffering from tuberculosis are a potential danger to the animals.

Other species of animals for example sheep, goats, dogs and cats suffer from tuberculosis. They could act as a source of infection to cattle when in contact with them. The reverse is also true. Wildlife act as a reservoir and foci of infection in maintaining and spreading the disease (Woodford 1982, Gallagher 1972, Guilbride 1963, McDiarmid 1960 and Paine et al 1928).

3.3 RESISTANCE

The bovine bacillus is very resistant and remains viable for a long time in contaminated environment. Farm buildings equipment, food and pasture get contaminated from tuberculous animal excretions, namely urine, faeces and sputum. They remain infective for a long time (FAO/WHO). Kleeberg (1975) reported that M. bovis remained virulent for 104 days in faeces on the fields. In stables and sewage, the organisms can survive up to 160 days. In temperatures below 50°C, the organisms can be viable for 4 weeks in a concrete watering trough. In cold climates, for example in Europe, the tubercle bacilli may survive up to 6 months. If manure is heaped one metre deep and temperatures rise between 50-60°C, M. bovis will be destroyed in 14 days. Unhygienic conditions perpetuate the foci of infection. The viability of M. bovis is demonstrated by infection in wildlife (Paine et al 1928, Gallagher 1972, Woodford 1982), grazing in areas which were previously inhabited by infected cattle. Scavengers eating wild animals dying from tuberculosis scatter infected remains over the land thus contaminating the environment.

3.4 ROUTE OF INFECTION

The main route of infection in bovine tuberculosis is via the respiratory tract. This is based on the findings of several workers who showed that the main tuberculous lesions were confined to the thoracic cavity. Meat inspection reports and post mortem examinations carried out on slaughtered carcasses of tuberculous animals showed that 87%-94% of the lesions were confined to the thorax (Francis 1957, Mackay 1959, Stamp 1959, Jubb et al 1970). The lungs and mediastinal lymph nodes were most affected. When an infected animal coughs, it generates an aerosol. The drops formed are as small as 10μ in size. When the incontacts inhale air during respiration these droplets get into the lungs. Dust particles from contaminated beddings, buildings and feeds find their way to the lungs in similar manner. Francis (1957) showed that animals under 6 months of age had a tuberculosis incidence of 0.4% compared with 43.3% in animals above 6 years of age. This supports the above evidence that the respiratory tract is the main route of infection.

The alimentary tract is a site of infection when the animal ingests tubercle bacilli. The percentages of lesions in the alimentary tract vary from 12 to 36% in cattle. In pigs most of the lesions involve the sub-maxillary and mesenteric lymph nodes. Ingestion is the main route of infection in this species, as in birds and horses. About 1-2% of tuberculous cows have tuberculosis of the udder (Francis 1958). Calves suckling tuberculous dams become infected. The contaminated milk is a potential danger to other animals for example pigs fed on skimmed milk and whey. Nabholz and Graf (1960) in Switzerland reported an outbreak of tuberculosis in 103 cattle and 112 pigs in 57 attested herds. These animals had been fed on infected skimmed milk. Soliman (1953) in Britain reported an outbreak of tuberculosis in a herd of goats. The kids had been reared on infected goat milk. There is autoinfection when the animal coughs up and swallows the sputum. There have been numerous reports of children being infected by drinking tuberculous milk without pasteurization.

Congenital tuberculosis does occur in cattle. Five per cent of tuberculous cows have tuberculous metritis. The infection in a cow spreads haematogenously and through tuberculous peritonitis, to the fallopian tubes and uterus in generalized cases. The calf becomes infected through the umbilical vessels. Hermasson (1941) examined 42 foetuses from pregnant cows which had tuberculosis. He found that 33 of 42 (78.5%) of the foetuses had tuberculous lesions. Fifty five per cent of the cows had tuberculous caruncles. This showed that calves could get infected in utero. Mackay (1959) examined 543 tuberculous animals. He found that 50% had lesions in the spleen. He was of the opinion that in congenital tuberculosis infection, the organisms get established in the spleen because the lungs are non-functional in the foetus.

Other routes of infection have been reported. Infection of the mammary gland has been reported in cases of chronic tuberculosis. Saprophyte mycobacteria have been introduced into the mammary gland by intramammary infusion during mastitis treatment. Roumy (1966) reported diagnosis of tuberculosis in cows from tuberculosis-free herds. The source was traced to an infected bull which had donated the semen. The cows became infected through artificial insemination with tuberculous semen.

Skin tuberculosis has been reported in cattle (Guilbride, 1963). There are several reports on human tuberculosis. These infections are usually due to atypical mycobacteria, which enter the skin through abrasions and spread to local lymph nodes. Another example is where people washing in rivers and lakes can get infected by _M. marinum_ (Kleeberg, 1975).

The tubercle bacilli get disseminated through the animal's tissues haematogenously and through the lymphatics. All the secretions and excretions of the animal in turn disseminate the organisms into the environment. Several predisposing factors favour the spread of bovine tuberculosis. These include crowding, period of exposure, type of management, climatic and environmental conditions.

Crowding occurs in housed animals. Several workers in Europe had observed earlier in the century that tuberculosis incidence was highest in cows kept in town dairies. They also observed that cattle kept on pastures in the same area had a low incidence of tuberculosis. This was due to the fact that the stalls were usually crowded. This promoted the aerogenous infection because the air was heavily contaminated. Housed animals in temperate climates had the highest tuberculosis incidence in the world. Tuberculosis was rare in countries where the animals constantly lived out in the open (Henning, 1959). Carmichael (1937) pointed out that the Ankole cattle in Uganda had the highest incidence of tuberculosis in Uganda. He attributed it to the crowding of animals around the smudge fires lit as fly repellents. The spread of tuberculosis infection in buffalo is enhanced by their wallowing habit. The buffalos are in intimate contact in communal wallows for an average of 4 hours daily (Guilbride, 1963; Woodford, 1982). Similar reports from India support the above observation. Watering places and points are areas where animals crowd when they go to drink water. The chances of contact with infected animals are high. The above observations would support the aerogenous infection of tuberculosis.

The period of exposure is vital to the infection by tuberculosis. Francis (1957) and Henning (1956) observed that dairy cows were housed more than others. They also lived longer than the beef cattle. Another influence was the fact that they have to be milked, brought animals into contact with each other more often. They concluded that these cows were exposed more often to the infection and therefore showed a higher incidence of tuberculosis. It also had to be kept in mind that they are stressed more often than other types of animal especially during pregnancy and lactation. Another factor supporting the high incidence in dairy animals is the management procedures which are conducive to the dissemination of organisms on pastures, supplementary feeds and equipment in the milking parlours.

It has been observed by several writers that due to climatic and environmental conditions existing in different countries, there were fluctuations in tuberculosis incidence. This varied from one continent to another and from one part of the country to another. For example temperate Europe had the highest incidence of tuberculosis earlier in the century compared to the tropical Africa. In Tanzania, the southern highlands had a tuberculosis incidence of 10-84% compared to 1.8% in the northern area (Annual Report, 1947-1966; Macaulay, 1957). Rumeau (1957) showed that in Cameroon the incidence was 0.1% in the northern area which is dry, where as the central wet area had an incidence of 7.7%. In Nigeria the tuberculosis incidence varied from 0.02% in the north to 7.8% in the south (Lindley, 1957). Lepper and Pearson (1973) in Australia showed that the incidence is higher in dairy animals kept on better pastures than the ones kept on range conditions. The climate and environmental conditions play a major role in survival of the tubercle bacilli. Wet warm conditions promote the survival of the organisms for months on pastures and water, whereas the dry and hot conditions are unfavourable for the survival of the organism.

3.5 SUSCEPTIBILITY OF OTHER SPECIES

Mycobacteria cause infection in many species of animals. When we consider the epidemiology of bovine tuberculosis, we have to bear in mind that these animals constitute a potential reservoir and source of infection. The disease has been regarded as rare in some species and others considered resistant.

Horses rarely suffer from tuberculosis and reports are scanty. Griffith (1928) in England reported 25 cases of equine tuberculosis. Bovine tubercle bacilli were isolated in 24 of these cases. Luke (1958) in England estimated an incidence of 0.1%-1.5% in horses. The lesions in horses are mostly confined to the alimentary tract. They are neoplastic in appearance and have the tendency to liquify giving a thick viscid pus. In other animals, lesions are usually caseous and calcified tubercles. Infection in horses has been associated with bovine and human cases.

Tuberculosis in sheep and goats is of low incidence but they are susceptible. Griffith (1928) reported 2 cases of tuberculosis in sheep. Francis (1957) gave details of 44 cases in sheep. Cordes *et al* (1981) reported an outbreak of tuberculosis in a flock of 15,000 sheep in New Zealand. On *post mortem* examinations 43 had tuberculous lesions and from 33 of them *M. bovis* was isolated.

The disease in goats is uncommon. One case was reported by

Griffith (1928) in England. Soliman et al (1953) reported an outbreak of tuberculosis in 78 goats of which 32 had lesions on post mortem examinations. Milne (1953) reported 5 out of 109 goats infected in Tanzania. Lesslie (1960) in England reported tuberculosis in 3 goats. The incidence of tuberculosis in goats was 0.71%-1.02% between 1904-1978 in Germany (Luke, 1958). Between 1950-1966, the incidence was 0.1%-2.5% in Germany (Kleeberg, 1975).

Swine are susceptible to mycobacteria and become infected through ingestion of contaminated feed, 118 out of 168 cases of swine tuberculosis was M. bovis. In Australia Clapp (1957) isolated mycobacteria from 271 of 420 lymph node samples examined. In 1969, 980,000 of 72 million swine (1.35%) slaughtered in U.S.A. had tuberculosis. In Germany 120,000 of 28 million swine (0.4%) had tuberculosis. In Argentina 7% of pigs slaughtered had tuberculosis. In Britain the incidence of swine tuberculosis fell from 11% to 1% by 1968 (Kleeberg, 1975).

Camels in arid places play a vital role as a source of meat and milk. Although tuberculosis is rare in this species, when kept in close contact with cattle camels may be infected. Kleeberg (1975) cited cases in Cairo: of camels slaughtered in 1962, 12.2% (107) of 874 had tuberculosis. In Russia 12.9% of camels in 1964 had tuberculosis and 13.5% of 912 camels slaughtered had tuberculosis lesions. Abramanov (1964) in Russia reported 108 of 831 camel carcasses at Semipalatish abattoir had tuberculosis. More cases of tuberculosis have been reported by Elmossalani et al (1977) where 6 of 1809 carcasses in Cairo abattoir were infected.

Domestic buffalo tuberculosis is a problem with incidences varying from 0.2% to 23.6% in some parts of India. Poultry get infected and in America 50% of poultry are infected with incidences varying from 5%-95%. With modern intensive poultry keeping systems the infection has been kept low.

Dogs and cats are regarded as resistant although they get infected. There are hardly any reports of tuberculosis in U.S.A. (Snider _et al_, 1971). In Europe clinical examinations have revealed an incidence of 0.04%-1% and from _post mortem_ lesions, the incidence is 0.83%-5.6% (Kleeberg, 1975). The above reports emphasise the importance the different species may play in the spread of bovine tuberculosis.

3.6 WILDLIFE

Wild animals get infected by various diseases and tuberculosis is one of them. Wild animals recognise few boundaries in their daily movements and seasonal migrations. There is cause for alarm especially as practical methods to control diseases in wildlife are yet to be found. There are several reports of tuberculosis in wildlife mammals, amphibians and birds both in the wild and in captivity.

Guilbride (1963) and Woodford (1982) reported tuberculosis infection in African buffalo in Uganda. McCool (1979) reported 8% of 33,758 feral buffalo slaughtered between 1966-1974 in Australia had tuberculosis. Paine _et al_ (1928) reported tuberculosis in 4 of 6 kudus killed in Albany, Cape Province in South Africa. One duiker shot in the same area had generalized tuberculosis. In Zambia Gallagher _et al_ (1972) reported an outbreak of tuberculosis in lechwe antelope in Kafue park. Tuberculosis in other wildlife species have been reviewed by McDiarmid (1960). The Dublin zoo in 1981 had to destroy their cats due to an outbreak of tuberculosis. The badgers in Britain have proved a menace as reservoirs of tuberculosis after the country had all but eradicated tuberculosis from cattle by 1960.

Muirhead *et al* (1974) reported tuberculosis in 36 of 105 badger cases and 12 of 112 faecal samples examined between 1971-1973. Between 1976-1980, 2926 badger cases had been examined. 57 of them had tuberculosis and *M. bovis* was isolated (M.A.F.F. Report 1981). There are several reports of elephants succumbing to tuberculosis from ancient Indian history. Pinto *et al* (1973) reported isolation of tuberculosis from a 24 year old elephant and reported an incidence of 1.5 per 1000 in domesticated elephants.

These animals get infected at watering places, during wallowing in the case of buffalo, and eating and being fed carcasses from infected animals. In several parts of Africa, cattle are still being grazed in wildlife parks and both share watering holes and grazing during drought conditions, therefore there are chances of spreading infection to each other.

CHAPTER 4

TUBERCULOSIS INCIDENCE IN EAST AFRICA

4.1 TANZANIA

The existence of tuberculosis in animals had been known in Tanzania early in the century when 4 cases were reported. In 1928, during meat inspection, 2 lungs were found to be tuberculous in Iringa abattoir. In the same year, the medical officers reported an increase of human tuberculosis in the high wet areas in Kilimanjaro, Wachagga country and in Wasukuma in the southern highlands (Macaulay, 1957). In 1930, cases of tuberculosis were reported in one dog and 3 pig carcasses in Iringa. With the alarming situation of tuberculosis in humans, studies were started in 1930, to assess the prevalence of the disease in cattle. Connell in Tanzania carried out tuberculin testing in 441 Chagga cattle and found 1.8% reactors. Half of the reactors were "non visible lesion" cases on slaughter. He concluded that bovine infection played little role in the epidemiology of human infections. From abattoir reports between 1933-1948 tuberculosis incidence in cattle varied from 12% - 25% in the southern highlands. Pigs slaughtered in 1948, showed 40 of 1048 (3.8%) of tuberculosis infection. Another survey when carried out during the 1941 rinderpest campaigns, showed that the incidence of 48% in cattle existed in the area. Tuberculin tests carried out on dairy herds in the southern highlands and eastern provinces showed a variation of 10%-84% of reactors. The number of animals tested was small, therefore the results did not present the true picture of the disease.

The Tanzania (Tanganyika) government requested the East Africa

Veterinary Research Organisation to help in establishing the true picture of bovine tuberculosis in the country.

In 1949-1951, Makham carried out a survey on behalf of the E.A.V.R.O. The exercise was done in 5 areas of southern Tanzania involving 7%-8% of the total cattle population. He used the single intradermal comparative test (Weybridge standards) on 39,000 head of cattle. The results varied from 7% reactors in Rungwe area to 26% in Usungwe area of Mbeya district. He established that there were more than 86,000 infected cattle in southern Tanzania. He carried out tests on 110 milk samples from 600 milk cows and found no evidence of tuberculosis. This finding was supported by the low incidence of .75% tuberculosis in calves under 6 months of age, whereas the incidence was 38% in 4 year old and above. During the same period, 94% of 1,500 carcasses examined had tuberculosis. The lesions were confined to the head and thoracic lymph nodes in 93%, indicating that infection was acquired through inhalation. 30 of 208 pig carcasses examined in the same area had tuberculous lesions. The disease picture in these animals was similar to those observed in pigs in Europe. He was of the opinion that the disease could have been imported into the country with importation of pigs. From the samples submitted for laboratory examination, 52 strains of mycobacteria were isolated. 24 of them were _M. bovis_. Of those isolated from the pigs, 3 of 9 were _M. bovis_ and 3 were _M. tuberculosis_ indicating a possible human source of infection (Macaulay 1957, Annual Report of E.A.V.R.O. 1950/1951).

Further work to assess the prevalence and incidence of bovine tuberculosis was reported by Rumaeu (1957). At a government livestock station 635 cattle were tested in 1951, and 19 head of cattle (3%) reacted and 13.6% gave non specific reactions. In 1954, 70 of 979 (7%) of cattle tuberculin tested were reactors and 44 (4.5%) were doubtful. Of the 70 reactors which were slaughtered, 67 (94.4%) had lesions on post mortem examination. In the total of 101 reactors and doubtful reactors, 46 were calves under 6 months of age. 30 of 46 (65.2%) had lesions on post mortem examination. A discovery of a goat with generalized tuberculosis led to the testing of 192 goats in the same station. 5 of 192 were reactors and tuberculous lesions were found in all of them on post mortem examination. *M. bovis* was isolated.

Reports from abattoirs between 1945-1966 indicated that the disease was still rampant in the country. In 1959, 7% of the ox plucks in Iringa abattoir were condemned because of tuberculosis. The tuberculosis incidence fluctuated between 12-15% in the southern highlands.

In 1966, 3 cases of tuberculosis were reported in Dar es Salaam area and 7 cases in Masai cattle. 42 cases of tuberculosis were reported in slaughtered cattle from Tanganyika Packer's meat factory, and their origin traced to southern Tanzania (Annual Reports 1948-1966).

Bovine tuberculosis was prevalent in Tanzania with highest incidence in the southern highlands. The tuberculosis problem was appreciated, and that it could spread and would become serious unless it was checked. It had little significance to human health or the health and economy of the livestock (Macaulay, 1957). Attempts to eradicate it from government owned farms using test and slaughter methods were made. More and more infections were revealed as the testing continued. This was due to the fact that calves were never tested previously thus increasing the number of reactors on subsequent tests.

No eradication methods available at that time were entirely suitable for Tanzania. Efforts to contain the disease and prevent it from spreading to other areas were made. Legislation was introduced where quarantine was imposed in the southern highlands and by 1973 was still in force. The animals leaving the area were subjected to tuberculin testing and reactors disposed of. Only cattle for slaughter were allowed to leave the area. Routine annual tuberculin testing was carried out on all departmental farms and reactors removed. All animals imported into the country especially the breeding stock were required to pass the tuberculin test. Suggestions were made to encourage individuals to co-operate in the surveys and to slaughter their reacting animals (Annual Reports 1948 - 1966, 1973).

4.2 KENYA

Kenya was at one time regarded as free from bovine tuberculosis and the disease was virtually non-existant in cattle. The situation in cattle of her two neighbours Uganda and Tanzania was different. There was a high incidence of tuberculosis in cattle in these countries. The first case of bovine tuberculosis was reported in 1917 when 2 oxen originating from Uganda were found to be tuberculous (Macaulay, 1957). More reports started to be received of bovine tuberculosis in the country. In 1920, 167 cattle originating from Uganda were subjected to tuberculin test. 27 reactors were found, of which 23 had lesions on *post mortem* examination. The cattle which were in contact with this herd were tested. Among the incontact, 4 of 143 indigenous Kenya cattle, and 3 of 52 grade cattle reacted to the test. These results indicated that cattle from Uganda where tuberculosis was known to be present, must have brought in the infection. A herd of 249 cattle in Koru was tuberculin tested. There were 8 reactors of which 4 had positive tuberculous lesions on post mortem examination. These animals had never been in contact with cattle from outside the country. This was the first report of tuberculosis having been in Kenya before importation of cattle from Uganda. In 1923 a second herd in Nakuru had 4 reactors out of 268 cattle examined. Acid-fast and alcohol fast organisms were isolated from tuberculous lesions obtained from Masai cattle in an abattoir. With improvement in meat inspection facilities, cases of tuberculosis were reported from other areas in the country. There were reports of tuberculosis in swine and poultry around 1930.

With improvement in the bacteriology, it was demonstrated that the several cases diagnosed as tuberculosis were not due to mycobacteria. Several cases of lymphadenitis in a Friesian herd were found to be actinobacillosis. Two years later a herd of 35 cattle in Kedong valley were found to be infected with Nocardia spp. bacilli causing localized lymphadenitis.

Routine tuberculin testing carried out in high grade cattle in 1946, showed non specific infections. Between 1946-1947, 6000 pigs were slaughtered in Upland Bacon Factory. Macroscopic lesions similar to tuberculosis were found in 171 of them. Laboratory results showed that the infection was caused by Corynebacterium ovis and C. equi respectively. In 1950 there was an outbreak of tuberculosis in a herd of swine in Eldoret area and had to be slaughtered. In 1954 tuberculosis was diagnosed in an old cow in Nanyuki abattoir. Tuberculin testing was carried out on the whole herd and 11 of 169 were reactors. When they were slaughtered, no lesions could be found. This problem of non-visible lesion reactors continued in the herd. A pedigree bull in the same herd was found to have generalized tuberculosis. The suggestion that bovine tuberculosis was non-existent in Kenya was no longer holding (Macaulay, 1957).

From abattoir reports, the incidence was low. Rumaeu (1957) reported that 10 of 2294 (0.43%) cattle slaughtered at Athi-River abattoir had tuberculosis in 1953. The incidence was 13 of 12,557 (0.10%) in 1954: in 1955, 5 of 32,256 (0.012%) showed tuberculosis on meat inspection examination. Of the total of animals slaughtered $\frac{2}{3}$ to $\frac{3}{4}$ were from local cattle owners. In 1958, tuberculosis was found in 14 of 50 government owned work oxen. These animals had been used on a rice-growing scheme. The remaining oxen were tested. The reactors were slaughtered but no lesions could be found. It was realized that the disease could be spreading, although abattoir reports indicated a low incidence. For example 14 of 72, 782 cattle slaughtered in 1961 showed 0.019% incidence (Waddington, 1965).

Early attempts to control the disease have been made by establishing a reporting system. When cases of tuberculosis were diagnosed at Athi-River abattoir, the veterinary headquarters were notified. The District Veterinary Officer of the area where the animals had come from was informed. Tuberculin tests were carried out on the animals on the farm and adjacent areas. Cattle imports were subjected to tuberculin testing prior to entry into the country and another test done 60 days after the animal entered the country (Macaulay, 1957; Annual Report, 1962-1973).

Although tuberculin testing had been going on in Kenya, it was unsystematic. Tuberculin test reactions were inconsistent. The

Government of Kenya requested the F.A.O. for assistance in assessing the tuberculosis incidence in the country especially in local cattle, and the value of the tuberculin test as a method of diagnosis. The incidence of human tuberculosis was quite high. Since cattle owners were always in intimate contact with their stock, the true facts about tuberculosis had to be established, even though no *M. bovis* had been isolated.

Between 1961 and 1968 Waddington carried out several surveys. A sample of 5,896 cattle from 14 districts throughout the country were tested. This represented a random sample of 0.22% of total cattle population. A single intradermal comparative tuberculin test was used and interpretations based on Weybridge standards. He found that 3.15% were failures and 7.2% were inconclusive reactors.

The reactors were slaughtered, but there was no correlation between the reactions and meat inspection findings. During the same period tuberculosis was diagnosed in 5 cattle and 1 goat. Laboratory results showed that the infection was due to atypical mycobacteria in one case and the rest were *M. tuberculosis*. With the human tuberculosis incidence being high, there was a possibility of animals being sensitized by *M. tuberculosis*. Waddington carried out a test on 1,273 head of cattle and 315 people who were in close contact. The results showed that there was a high correlation between the cattle showing non-specific infection and the infected human beings. He concluded that this was due to sensitization of cattle with human tuberculosis. Five of 96 cattle tested were failures. *Post mortem* examination revealed that 3 had lesions and cultures yielded one human type tubercle bacilli and two atypical mycobacteria which grew at 20°C.

A second group of 247 animals was tested and 4 were failures. No lesions could be found and samples from lymph nodes were cultured and yielded atypical mycobacteria. He concluded that these organisms were saprophytes and may be of cold blood origin. He showed that the animals showing the highest incidence were from swampy and permanent water areas.

Another test was carried out on 96 head of cattle from Masailand which were awaiting slaughter. Reaction fluctuations were observed in the period of 10 weeks. The animals were in an abattoir holding area near the permanent waters of the Athi River. The results would indicate that the animals picked up non-specific infection during their stay in the area. He concluded that interference in tuberculin test sensitivity was due to human infection and atypical mycobacteria.

In order to assess the infectivity of atypical mycobacteria in cattle, Waddington (1967, 1968) infected a group of guinea pigs, fowls and cattle using 3 strains of atypical mycobacteria isolated from cattle and one from a frog. From the results he showed that atypical mycobacteria from the frog could establish infection in mammalian tissue and result in sensitivity to the tuberculin test. He also observed that the mammalian reactions disappeared after 72 hours, which could help in differentiating infections from different strains of mycobacteria.

From the results it could be established that atypical mycobacteria were of low pathogenicity but capable of causing infection under suitable conditions especially of stress, like tick-borne diseases, worm burdens and malnutrition during drought conditions.

The lesions were localised in most cases and showed few organisms, indicating that the animal could overcome the infection. Body excretions like urine, mucous and faeces were also infective to the guinea pigs. This indicated that infected animals contaminated the environment. The control animals during the experiments showed no reactions to tuberculin. He concluded that the atypical mycobacteria were acquired through ingestion of contaminated feeds and water and no infection from animal to animal occurred. These results were in accordance with those obtained in Uganda (Waddington, 1967; Prichard, 1976) and in Malawi (Berggren, 1977).

From the above results, it was established that true bovine tuberculosis hardly existed in Kenya. This supported the observations made by earlier workers. Therefore, there was no real threat to the cattle economy in the country and no elaborate control measures were necessary. Meat inspection standards should be maintained so that the occasional case of tuberculosis could be recognized. The threat to human health would thus be reduced. Good management to reduce the stress factors would reduce the significance of atypical mycobacteria (Waddington, 1968).

4.3 INCIDENCE OF BOVINE TUBERCULOSIS IN OTHER COUNTRIES IN AFRICA

Bovine tuberculosis had been regarded as of very little importance in most parts of Africa. Rumaeu (1957) reviewed the animal tuberculosis in Africa, south of the Sahara. He observed that the importance of tuberculosis varied between territories and areas in some particular countries. The disease was rare in countries like Somalia, Equator and Kasai province in the Central Region. In the South Region, Basutoland (Lesotho) and Swaziland rarely recorded any cases. In West Africa, Sierra Leone had no tuberculosis. Other areas like Reunion, Maritius, South West Africa had low incidence.

SUDAN

In Sudan one case was reported in 1913. Between 1953-1954 only 5 cases of bovine tuberculosis were recorded from controlled abattoirs and during the same period one horse and one cheetah were found to be infected. A tuberculin test survey carried out in 1956, a herd of 47 animals in Bahr el Ghazal Province was tested and two animals were reactors and had generalized tuberculosis. Five of 116 cattle in the same area gave positive tuberculin reaction. Awad et al (1959) reported an incidence of 2.4% of cattle in the north and 16% in the south of the country in 14 herds comprising of 1,774 dairy cattle tuberculin tested. Tag el Din et al (1980) reported one case of tuberculosis in a ewe slaughtered at Nyala abattoir. He drew attention to the fact that thousands of sheep are slaughtered during the religious celebration of Eid Eladha and no meat inspection is carried out, even though the viscera were eaten raw. Among the tuberculous lesions encountered in Sudan 15%-16% were due to Nocardia spp. (Alhaji, 1974).

EGYPT

Very few reports of tuberculosis come from Egypt. Elmossalani et al (1971) reported 6 of 1,809 camel carcasses slaughtered at Cairo abattoir were infected with tuberculosis. Kamel et al (1975) isolated mycobacteria from 13 of 85 samples examined. There was evidence of tuberculosis although the incidence is low.

ETHIOPIA

Between 1963-1968, 16 of 9,860 cattle slaughtered in South East Ethiopia, Harara Province, had tuberculosis on meat inspection, and 1 in 60 pigs examined in the period was infected (Didierjean, 1968). In a period covering 1967-1971, 25,850 male cattle aged 2-14 years were slaughtered at Chandris African Ltd. abattoir in Dire Dawa, Harar Province. One hundred and seventy two of them had tuberculous lesions, 24 of which were generalized (Owen, personal communcation).

RWANDA BURUNDI

In the Central Africa, Rumaeu (1957) reported 43% incidence of tuberculosis in Rwanda Burundi in 1955, 2.08% in Kivu Province, and in adjoining areas only 3 cases were reported in 1954 and one in 1956. The area had a high incidence of avian tuberculosis; reported in 50 instances in 1954. Benhauer (1970) reported an incidence of 28% in Mali and Burundi. Chad had a low incidence of 0.3%-0.35% and the disease was confused with nocardiosis.

ANGOLA

Angola had a tuberculosis incidence of 1.68%-1.33% in cattle. In the same year, 1955, tuberculosis in pigs varied from 0.09% to 0.69% in some places in the country.

ZIMBABWE

In Northern Zimbabwe (formerly Rhodesia) bordering south Tanzania tuberculosis incidence was high in Fort Jameson district. There are reports of the infection up to 1940 in imported livestock from the Republic of South Africa (Macaulay, 1957). In the south of the country, cattle from ranches were relatively free. In 1950, 0.03% of 126,000 cattle slaughtered had tuberculosis in Salisbury abattoir.

Another abattoir, Havard, reported 16 of 44,805 (0.03%) cases of tuberculosis. On the dairy scene, the situation was different. Tuberculin tests carried out in 1950 revealed 23.6% of 1,442 dairy cows had tuberculosis. It was then that the eradication scheme was started. In 1952 voluntary tuberculin testing was started, and incidence fell from 4.48% to 2.3%. By 1954, the number of voluntary herds had risen from 92 to 149, comprising of 7,182-13,525 head of cattle. When further testing was done, only 71 (0.52%) were positive. The Government introduced compensation for slaughter of reactor schemes, to hasten the eradication campaign. If more than 5% of animals were slaughtered, the compensation was 30% of the value of the animal, with £50 for a cow and £100 for a bull. This money was independent of the amount realized from the carcasses. If there was total condemnation of the carcasses, a further 20% of the value was paid. If the reactors were under 5%, the owner had to stand the losses incurred by the compulsory slaughter. The terms were attractive. The policy was not a heavy burden on cattle economy because the incidence was low. It also prevented the sale of reactor to other stockowners not in the voluntary scheme and enforced the isolation of reactors (Rumaeu, 1957).

ZAMBIA

Zambia had sporadic reports of tuberculosis. Gallagher (1972) reported an outbreak of tuberculosis in the lechme antelope in Kafue National Park.

MALAWI

In the European owned herds in Malawi there had been tuberculin testing and elimination of reactors for a long time. The disease was reported from Blantyre abattoir chiefly in Zebu cattle from northern provinces. Tuberculosis caused more condemnation of meat than any other disease in Malawi. About 10% of all cattle slaughtered showed tuberculous lesions. 2%-3% of the total carcasses had to be condemned as unfit for human consumption. In 1968, the Government of Malawi requested the assistance of the United Nations special fund in the establishment of a livestock and dairy development scheme. A tuberculin survey was carried out to investigate the costs involved in the test and slaughter policy, reliability of tuberculin tests in finding the infected animals and immunising ability of the BCG vaccine. The control of tuberculosis by test and slaughter method and vaccinations had been going on in the country. Berggren (1976) found that 171 of 7,156 (2.4%) of cattle tested were positive reactors. Forty two of the reactors were purchased for post mortem examination. The animals had tuberculosis lesions. He was able to show that most of the reactions were due to atypical mycobacteria.

BOTSWANA

In Botswana, the tuberculosis incidence in cattle was 1/50,000 of animals between the age of 1-16 years and all of those diseased were imports from the Republic of South Africa. At the same time the human incidence was very high (Owen, personal communcation).

REPUBLIC OF SOUTH AFRICA

Tuberculosis in the Republic of South Africa was reported as early as 1880. In 1932, 39% of 2,402 cattle at Durban supplying milk to the town were infected with tuberculosis. In 1942, 2.5% of milk sampled in Johannesburg city were found to contain tubercle bacilli. In Capetown and Pretoria the incidence was 2.3%. Tuberculosis was high in the town dairy cows and low in ranching areas. One hundred cases of pigs slaughtered were found to be infected with

M. bovis. In 1950, a provisional programme for tuberculin testing was inaugurated. Private practioners could test the herds and the reactors branded for future identification. The owner could dispose of these animals as best as he could. When the infection was reduced below 5% then the farmer could apply for the Government scheme for certification basis but the cattle owner had to comply with certain rules to prevent reinfection of his herd (Rumaeu, 1957). With the discovery of isoniazid as an anti-tuberculous drug, its use in cattle has been applied since early 1960 up to now. In 1979/1980, 76 herds with an infection rate of 2.9% were being treated (Annual Report, 1979/80).

MOZAMBIQUE

In Mozambique, the incidence of tuberculosis was 1.5% in cattle and 1.17%-1.24% in pigs from abattoir reports.

MADAGASCAR

Madagascar,an island off the south coast of Africa, had the highest incidence of tuberculosis in the whole of Africa. It was realized early in the century that the infection rate was 18%-84% with the average of 36%. There has been a shift from one part of the country to another. In 1903, the incidence was 50%-60% whereas in 1954 it had fallen to 3.64%. In another area, the incidence was 71% in 1907 and by 1954 had been 5.4%, whereas in the north of the island an abattoir in Tananarive reported incidences of 5%-12% between 1907-1912, and reports in 1954 put the incidence to 50%. Rumaeu (1957) ascribed the shift to the cattle traffic northwards to the heavily populated urban areas and meat processing factories. Another factor which precipitated the high incidence was the theft of cattle, which was very common. So all the stock had to be closely confined at night, thus increasing the aerogenous spread.

CHAPTER 5

BOVINE TUBERCULOSIS IN UGANDA

5.1 BACKGROUND

Early in the century, cattle population in Uganda was estimated at 1 million and all were indigenous breeds (*Bos indicus*). They were kept under traditional systems and no improvement was practiced. The main breeds were the Ankole long horn found in the Western Province, and owned by the nomadic Bahima. The Karamojong short horn zebu was found in the Eastern Province and kept by the Karamojong. The East African short horn zebu type was distributed in the rest of the country (Annual Report, 1921-1924). These two provinces were the main cattle suppliers for the abattoirs and hence the attention paid to them.

The picture has changed since then. The livestock census of 1976 estimated the number of cattle at 5,048,719 of which 27,955 were of exotic breeds, Table 5a (Annual Report, 1976). Livestock development schemes have taken place. Modern animal husbandry systems are practiced. The country has 2,959 commercial dairy farms, 461 beef ranches and 17 Government livestock experimental and breeding farms. Most of the epizootic diseases such as rinderpest, contagious bovine pleuropneumonia, tick-borne diseases and trypanosomiasis are now under control. They attracted more attention earlier in the century because of their devastating impact on the cattle population. Bovine tuberculosis was given little attention. Because of its insidious nature, it had no obvious effect on the cattle population or the country's economy at large.

TABLE 5A. LIVESTOCK POPULATION FROM 1924—1976 (ESTIMATES**) IN UGANDA
(Source: compiled from Department of Veterinary Services Annual Reports 1924—1976

YEAR	CATTLE	SHEEP	GOATS	PIGS	DONKEYS	MULES	HORSES	CAMELS
1924	1,399,028)	—	—	—	—	—	—	—
1927	1,846,514)							
1929	1,909,558)			FIGURES NOT AVAILABLE				
1932	2,151,668)							
1935	2,197,536	1,062,139	2,335,037					
1938	2,582,342	1,444,750	2,495,874	1,328	25,257	231	31	84
1939	2,590,555	1,193,937	2,415,860	295	36,885	22	27	80
1944	2,258,900	2,103,000	FIGURES NOT AVAILABLE			—	—	—
1945	2,293,740	995,321	2,143,533	25,158)				
1946	2,394,000	—	2,202,500	—)				
1947	2,454,000	—	2,057,000	—)				
1948	2,484,614	1,037,083	2,138,153	19,337)				
1949	2,548,161	1,076,712	2,309,538	18,286)				
1950	2,533,819	1,065,822	2,324,232	17,366)				
1951	2,713,941	1,035,935	2,441,202	14,686)				
1952	2,745,499	1,051,431	2,471,749	13,198)	FIGURES NOT AVAILABLE			
1953	2,842,143	1,128,279	2,727,736	13,783)				
1954	2,854,937	1,135,809	2,746,798	12,527)				
1955	3,094,364	1,093,247	2,513,732	12,376)				
1956	3,232,115	1,120,361	2,797,468	12,286)				
1957	3,308,392	1,120,425	2,656,213	12,980)				
1958	3,427,221	1,127,266	2,727,644	11,998)				
1959	3,596,335	959,324	2,764,635	15,668)				
1960	3,618,180	865,000	2,592,000	15,594)				
1961	3,382,762	832,219	2,532,953	16,069)				
1962	3,464,603	760,016	2,339,920	14,751)				
1963	3,463,937	861,362	1,990,915	18,738	18,738	16,208		408
1964	3,496,797	754,833	2,013,597	* 37,280	1,665*			1,440
1965	3,625,643	790,933	1,997,000	* 37,280	1,665*			1,000
1966	3,682,325	773,750	1,900,426	37,358	16,603			1,200
1967	3,780,709	775,011	1,710,034	42,546	16,104			408
1968	3,854,480	766,277	1,872,598	53,260	16,759			1,500
1969	4,145,101	854,915	1,910,689	74,481	17,116			1,600
1970	4,280,455	827,444	1,801,311	65,532	17,281			1,650
1971	4,171,686	920,800	2,211,741	87,108	10,301	**Buffalo 10		1,600
1972			FIGURES NOT AVAILABLE					
1973								
1974	4,789,749	825,992	817,066	165,118				
1975	4,879,921	1.081,041	2,110,896	186,000				
1976	5,048,791	1,071,516	2,263,069	156,085	3,222	***Buffalo 27		

*Estimates: because true figure could not be obtained most of the time. This was due to the fact that some places were unaccessible and unwillingness of cattle owners to present the numbers of the animals in their possession.

** Buffalo brought in for experimental purposes.

1917-1923 No figures could be obtained but in 1921 the number of cattle was estimated to be about 1 million. It was also the period during the First World War. Years 1925, 1926, 1928, 1930, 1931, 1934, 1937 no cattle census was carried out.

1940—1943 was the period of the outbreak of the Second World War. There was acute shortage of staff, no census was done.

*** 1965: 8,658,690 birds in the country. The only time the total number of poultry in the country was estimated.

5.2 INCIDENCE OF BOVINE TUBERCULOSIS IN UGANDA

5.2.a Cattle

The existence of bovine tuberculosis in Uganda was recognised earlier than 1917, when one case was reported (Carmichael, 1939). Between 1917-1927 only 8 cases were reported, from a slaughter house in the Western Province. All the cattle involved were the Ankole long horn breed. It was not until 1930 that attention was drawn to the situation (Annual Report, 1930). In 1931, 48 of 277 (17.3%) of the cattle originating from Ankole District in Western Province showed tuberculosis on meat inspection. Three of 2,600 carcasses examined from the Eastern Province had tuberculosis, an incidence of 0.11%. The percentages were alarming. The apparent incidence was highest in the Ankole long horn in Western Province. Work was started in 1931 by the Department of Veterinary Services in conjunction with the Medical Department to ascertain the exact incidence of the disease with a view to adopting preventative measures if necessary. In 1931, tuberculin tests were carried out. The double intradermal tuberculin test method aid technique employed by the Medical Research Council (1925) was adapted. From the 140 head of cattle tested, 44 (30%) were reactors, of which 45.2% had tuberculous lesions on post mortem examination. In the same year, 131 cattle that died from rinderpest were post mortemed and 51.1% had tuberculosis. Another group of 266 head of cattle were tested in the same area. Fifty two (19.5%) gave positive reactions and on post mortem 23 of 52 (44.2%) had tuberculous lesions. A total of 7,322 carcasses from various parts of the country were examined between 1931-1933. The results showed the following tuberculosis incidence at meat inspection.

TABLE 5b

Breed	No. Carcasses examined	No. with visible lesions	Percentage
Ankole long horn (Western Province)	2,874	359	12.5
Zebu	784	28	3.5
Karamajong Zebu (Eastern Province)	3,674	3	0.08

In 1936, 33.3% of 231 carcasses from Mbarara (Ankole) abattoir had tuberculosis.

From the tuberculin test results and meat inspection figures, it was observed that the Ankole long horn cattle were more susceptible to tuberculosis. The tuberculosis incidence in the area varied from 12.5% to 51.1%, compared to 0.08% to 3.5% of the zebu breed (Carmichael 1939, Annual Report 1924-1939).

There was little reported on tuberculosis incidence between 1939-1945. This was due to the outbreak of the Second World War. There was depletion of staff as most of them were called for military services. The remaining few were engaged in the control of epizootic diseases and maintaining adequate numbers of livestock to meet the war time requirements. Only one case was reported in 1947, although tuberculin testing continued. In 1949, 50% of cattle slaughtered at Mbarara abattoir had tuberculosis on meat inspection. 58% of the tuberculin tested cattle were infected. The period between 1949-1958, there were reports of tuberculin tests being carried out. 2.88%, 14 of 485 zebu cattle tested were reactors compared to 34.5%, 18 of 55 Ankole long horn breed, emphasizing the susceptibility of the breed and the prevalence of tuberculosis in the area.

No control measures could be taken. It was stated that under the prevailing conditions namely the nomadic habits of the cattle owners, the existing systems of animal husbandry and the conservative attitudes of cattle owners, who could not be convinced that a healthy looking animal could be infected, the methods of control applied in other parts of the world, especially in Europe and America were not suitable. Any campaign to eliminate tuberculosis in the affected areas would be impracticable. The bovine tuberculosis problem was shelved.

It was not until 1963, when the Government of Uganda and the United Nations Food and Agriculture Organisation (F.A.O.) made an agreement to carry out surveys in bovine tuberculosis, that further work to determine the incidence was carried out. It had been realized that the incidence of bovine tuberculosis in Ankole long horn cattle was high and the breed susceptible to the disease. It was important therefore that bovine tuberculosis should be controlled, on account of the threat to public health due to consumption of meat and milk. The nomadic Bahima in the highest affected area lived entirely on the products of their animals namely milk, meat and blood. With plans of livestock improvement, development of commercial beef production and introduction of exotic cattle, the bovine tuberculosis could prove to be of considerable economic importance. So the accurate assessment of the incidence was essential before any plans to control and eradicate the disease could be considered. It was with these views in mind that Waddington and Ellwood in 1965 carried out their survey. It was to evaluate the use and interpretation of tuberculin testing as a method of assessing the tuberculosis incidence. It was also to help identify the types of of mycobacteria causing the infection and those which may be confused with Mycobacterium bovis. In the same survey, the value of B.C.G. vaccine in immunization of cattle against tuberculosis would be assessed. A total of 929 cattle were tested and only 56.4% retained their failure reactions on subsequent re-tests. They observed that there were fluctuations in reacting animals, in that animals negative to the tuberculin test later showed inconclusive or positive reactions. The same observations had been made by previous workers who carried out tuberculin tests between 1931-1958. Waddington and Ellwood concluded that it was due to atypical mycobacteria, a fact previously observed by the same workers in Kenya (F.A.O. 1967). The same observations were made by Berggren in Malawi (F.A.O. 1976) and Woodford (1982) in wildlife in Uganda. The atypical mycobacteria caused the same sensitivity to tuberculin tests as those produced by Myco. bovis. Carmichael (1939), Waddington and Ellwood (1967) showed that under stress of intestinal parasite burden, the irritation of smudge fires lit as fly repellant, poor nutrition and cattle drinking swampy water during the dry seasons, these atypical mycobacteria could be pathogenic and cause infection. Guilbride (1963) observed that "skin tuberculosis" prevalence varied from 0% to 80% and was highest in herds with bovine tuberculosis, which would suggest false reactions to tuberculin tests.

From the survey results, Waddington and Ellwood concluded that the reports of the high prevalence of bovine tuberculosis in Ankole District were exaggerated. The period of the survey was too short and was interrupted by financial and political problems. They suggested that further work should be carried out. Laboratory examinations should be carried out in order to support post mortem findings. The surveys should have been extended to other parts of the country in order to obtain the true picture of bovine tuberculosis in the whole country.

The last tuberculosis survey was carried out in 1975. Prichard et al (1975) observed that tuberculosis incidence in Karamoja was 27% in the cattle examined. 75 of 281 cattle examined were positive compared to 0.08% (295 of 33,627)cattle slaughtered between 1932-1937. Tuberculin testing was carried out on 1534 head of cattle. 19 (1.2%) gave positive reaction to avian tuberculin and negative to mammalian tuberculin. This indicated that the level of non-specific infections in Karamoja cattle was low. In the retested animals 110 of 171 (64%) gave consistant results similar to observations made by Waddington and Ellwood (1967). These results cast doubt as to the accuracy of the tuberculin test as a measure of assessing tuberculosis.

The main causal organism of bovine tuberculosis in Uganda was identified as Myco bovis. This was supported by the results obtained by Carmichael (1939). He isolated 19 cultures from Ankole long horn and 12 cultures from the zebu cattle all of which were Myco. bovis. Guilbride (1963) isolated 5 Myco. bovis and 3 strains of atypical mycobacteria from 6 specimens. Myco. bovis was typed from 50 specimens cultured between 1958-1970. 7% of specimens examined in 1971 in the Animal Health Research Centre in Uganda, were typed as Myco. bovis (Annual Reports 1958-1971). Mitchell (1968) observed that of the cultures obtained from abattoir specimens, 90% were Myco. bovis and 10% atypical mycobacteria. Prichard et al (1975) obtained mycobacteria organisms from 21 of 77 cultures from specimens of Karamoja cattle. 20 isolates were typed as Myco. bovis and one atypical mycobacteria. Woodford (1982) isolated 12 Myco. bovis and

2 atypical mycobacteria from 14 wildlife specimens. It would seem that Myco. bovis is responsible for most of the tuberculosis in cattle but that atypical mycobacteria can cause similar tuberculous lesions.

5.2.b Breed Susceptibility

From meat inspection figures, it was observed that the Ankole long horn breed cattle were more susceptible to tuberculosis than the zebu breed, 12.5% - 51.1% compared to 0.08% incidence (Annual Report, 1933). Carmichael (1941) carried out experiments between 1937-1939 to verify the susceptibility of the two breeds to Myco. bovis. He observed that of the 8 zebu and 3 Ankole calves inoculated with bovine bacilli (European strain) of standard virulence, the zebu calves showed marked resistance on the basis of weight gain and lesion distribution compared to the Ankole calves.

Rumeau (1957) reported that the dwarf humpless zebu breed was very resistant to tuberculosis in West Africa. Lindley (1959) however demonstrated no difference in susceptibility between the zebu breeds of Guudali and red Bororo cattle slaughtered in Nigeria. Another factor leading to the apparent high incidence in the Ankole long horn cattle was that the owners were more observant and they disposed of the animals showing debilitation and poor condition rather than the healthy looking ones. Carmichael (1941) cited Liston and Sopakar in India who carried out similar experiments in 12 buffalo and 12 zebu calves. From the weight gain and lesion distribution it was shown that the indigenous zebu were more resistant than the buffalo.

5.3 OTHER SPECIES

Tuberculosis in sheep and goats has been recognized as a rare condition. Very few cases have been reported. Between 1934-1935, Carmichael (1938) identified 10 cases of tuberculosis in goats in Uganda. In all the cases M. bovis was isolated. During the same period, 12 sheep from a herd of 15 were found to be tuberculous, and 11 yielded M. bovis and one M. tuberculosis (Carmichael, 1938). These animals had shared the same hut with the owner, a common practice and could have acquired the infection from a human. In 1936 one sheep had tuberculosis in 324 carcasses examined. The low incidence was attributed to the fact that most of the goats and sheep are privately slaughtered. No post mortem is done so cases go unnoticed. This is a hazard from the public health point of view especially in areas where raw offals are eaten as a delicacy for example "Marara" in Sudan (Tag el Din, 1980) and in Ethiopia.

No tuberculosis in pigs had been recorded in Uganda. No tuberculosis in other animals like camels, mules and dogs had been reported.

5.4 HUMAN INVOLVEMENT

The discovery of the high incidence of tuberculosis in the Ankole District, prompted surveys to determine its relationship to human tuberculosis. It was well known that the Bahima in the Western Province lived in close intimacy with their animals. All their livelihood depended on them. A sick animal was nursed inside the hut of the owner which was shared by other humans and the small ruminants. Between 1932 and 1940 Carmichael (1941) stated that Dr. Scott Brown from the Medical Department examined 30 adult Bahima males and 76.6% had tuberculosis. Carmichael (1940) carried out a bacteriological survey to determine the incidence of pulmonary tuberculosis in Uganda. Of 283 human sputums examined, 279 contained M. tuberculosis and 4 yielded M. bovis. It was interesting to note that the 4 cases of M. bovis were those of people who had close association with Ankole cattle in the Western Province. Batches of 140 and 50 human sputums examined yielded 4 and 2 cases of M. bovis. The incidence of bovine tuberculosis involvement was not high, but it played a part in the epidemiology of human tuberculosis. Human tuberculosis was common in the people in the area.

5.5 WILDLIFE

There is an abundance of wildlife in Uganda. One of the largest, the Rwenzori National Park (formerly the Queen Elizabeth National Park) is situated in the Western Province. It has parts of Ankole, Toro and Kigezi District, the area renowned for high incidence of bovine tuberculosis. In 1963, 13 buffalo were shot and 8 had tuberculosis lesions on post mortem examination Six were typed and 5 M. bovis and 3 strains of atypical mycobacteria were isolated (Guilbride et al, 1963). In 1969, 13 specimens of buffalo were examined and 11 were positive for tuberculosis. In 1970, 79 specimens from different species of wild animals were sent to the laboratory. Twelve of them were positive for M. bovis: six were typed as atypical mycobacteria, 5 from frogs and 1 from a warthog. Refer to the Table 5c for the breakdown of the species.

Woodford (1982) found that random sampling of buffalo in the Rwenzori National Park showed a 10% prevalence of tuberculosis, but where animals in poor condition were sampled the prevalence was 38%. Of the organisms isolated from 14 cases, 12 were M. bovis strains and 2 atypical mycobacteria. He concluded that an annual mortality from tuberculosis was about 1%. Lesion distri-

TABLE 5c

Species	No. of Specimen	Positive
*Frogs	22	8
Fish	26	3
Birds (feral)	14	3
*Warthog	8	1
Reed buck	8	1
Kob (antelope)	11	2

*atypical mycobacteria 5 frogs 1 warthog.

(Source: Annual Report of Department of Veterinary Services 1970. Animal Health Research Centre.)

bution in the cases examined showed that 96.5% were confined to the thoracic cavity indicating the infection to be spread by inhalation. This supported Guilbride *et al* (1963) observations.

Carcasses of 90 warthogs were examined and 9% showed gross lesions of tuberculosis on *post mortem* examination. *M. bovis* was isolated from 2 of 6 cases, and 5 atypical mycobacteria and one of which had characteristics of *M. intracellulare* (Woodford, 1982). Distribution of the lesions showed that route of entry was alimentary. Different species of wildlife were examined by Woodford (1982) and the results are shown in Table 5d.

The isolation of *M. bovis* from the buffalo and warthog by Woodford (1982) raised the possibility that cattle were a source of infection. It had been recorded that the area of the Rwenzori National Park was inhabited by humans and their livestock in the early part of the century. Both populations were affected by smallpox and rinderpest epidemics respectively, which also reduced the wildlife population in the panendemics between 1890-1952. In 1924, when

TABLE 5d

Species	No. sample	P/M Lesions Results. Positive	Laboratory Results
Elephants	2	1	-ve
Bushbucks	2	2	1*
Reedbuck	3	3	1*
Waterbuck	2	2	-
Uganda Kob	7	7	2*
Hyena	1	1	-
BIRDS			
White-backed vultures	3	3	1*
Yellow-billed stork	1	1	1*
Pink-backed pelicans	2	2	1*
FISH			
Tilapia	1	1	1*
Barbus	2	2	1*
Bargus	4	4	-
Protepteris	1	1	1*
Clarius	1	1	-
AMPHIBIA			
Frog	3	3	2*

*atypical mycobacteria.
Source: Animal Health and Repn. Vol 14 1982

trypanosomiasis control measures failed, the area was closed for humans and the remnants of humans and cattle removed, the wildlife flourished (Morris, 1960).

The wildlife have a vital role to play in the epidemiology of tuberculosis in cases where livestock is grazed on the fringes of the game parks. Cattle involvement in the origin of tuberculosis in wildlife is supported by the evidence showed by Gallagher _et al_ (1972) In attempts to control and eradicate tuberculosis in farm animals, wildlife have to be kept in mind as reservoirs and foci of infection.

In summary, the prevalence of tuberculosis in Uganda cattle is still unclear. From the above observations it would seem highest in the Western Province 12.5% - 51.1% and low in the Eastern Province 0.08% - 3.5% incidence respectively. The surveys carried out so far had been confined to one part of the country and a limited number of animals examined. The tuberculin tests have been unsystematic in most instances. Meat inspection reports had been scanty and limited to a few slaughter houses and abattoirs. Therefore the evidence drawn from the tuberculin test results and abattoirs as regards the incidence of tuberculosis must be and have been interpreted with caution. The picture of bovine tuberculosis must have changed in the last twenty years, with livestock improvement programmes, introduction of exotic breeds of cattle and other species appearing on the scene of animal husbandry, namely the pigs and poultry.

CHAPTER 6

CONTROL OF BOVINE TUBERCULOSIS

The control of bovine tuberculosis over the past fifty years has been and still is a subject of many studies and continued efforts by many countries and international organisations. Measures against bovine tuberculosis have always been considered from the public health and economic point of view. Considerable progress has been made in the eradication of tuberculosis in cattle in many parts of the world. The disease has been reduced to negligible levels in countries like United States of America, Canada and in Western Europe, although occasional cases do occur and the niche is being occupied by atypical mycobacteria and infected wildlife act as a nidus of infection. This has been achieved by systematic application of the tuberculin test and the slaughter of reactors.

The economic losses to the cattle industry due to tuberculosis are difficult to estimate. No figures could be put on the losses through reduced productivity and efficiency. Losses result from meat and milk condemnation, loss of off-springs, decrease in life span of the animal, inefficient utilization of food, infertility, poor body condition, interference with herd improvement programmes and low market value. High costs are involved in preventing reintroduction of the disease in clean herds. Examples of amount of time and cost involved in the control of bovine tuberculosis in some countries is shown in Table 6.

Many developing countries have failed to tackle the tuberculosis problems efficiently. The disease had been regarded as of insufficient importance to warrant stringent measures of control. In most African

Table 6 Losses incurred through bovine tuberculosis eradication campaigns.

Country	Year Declared Free	Duration of Eradication Campaign in Years	Annual Financial Losses Before Eradication Began in Millions	Total Cost of Eradication Campaign in Millions
Austria	1962	12		60 Austrian shillings
Australia	Not yet free		1 Australian dollar	$1,05 to date
Belgium	1961	10		150 Belgian francs
Canada	1952	30		
Denmark	1950	60		48 Danish crowns
Finland	1930	35		
France	1965	12	200 French francs	
Great Britain	1960	25		£130 - £162
Netherlands	1956	6		70 Guilders
Sweden	1951	40	30 Swedish crowns	40 Swedish crowns
Switzerland	1959	19	50 Swiss francs	400 Swiss francs
U.S.A.	1947	30		326 American dollars
West Germany	1962	10	300-350 German marks	2,000 German marks

Source: Compiled from J.S.A.V.A. 1963 and Hubbert, 1975.

countries, cattle were kept for a variety of reasons. Cattle were kept as mobile banks, for religious and cultural customs, for barter, for food as milk and meat, for draught purposes in agriculture and for transport. The tendency was towards quantity rather than quality (Macaulay, 1958). With exception of a few countries, hardly any control measures had been taken.

In Uganda, although the disease was recognized very early, no systematic control measures were implimented. Tuberculin testing and slaughtering of reactors had been occasionally done. The main hinderances were the outbreak of the world wars, the cattle keeping systems at that time and most of all the disease was not considered important compared to other devastating enzootic diseases. In Tanzania the same situation was existing except quarantine measures were introduced to keep the disease from spreading to the rest of the country (Macaulay, 1958). In the neighbouring Kenya, bovine tuberculosis was non-existant, no measures therefore were necessary, except to be vigilant, by improving the meat inspection services and testing of the animals entering the country to avoid introduction of the infection (Waddington, 1968). The rest of the developing countries follow the same trend.

6.1 DIAGNOSIS

In order for effective control measures to be applied, the prevalence and incidence of the disease have to be correctly gauged. Unlike other diseases, clinical diagnosis is rarely possible because of lack of symptoms while the infected animal appears healthy and the disease being disseminated out of proportion (Ritchie, 1959). Diagnosis is based on efficient meat inspection and tuberculin testing backed-up by laboratory examination of the suspected specimens.

6.1.a <u>Tuberculin test</u>

Tuberculin testing is the oldest and most efficient method used to detect the incidence and distribution of bovine tuberculosis. It is used as a herd test. Its action was first demonstrated by Koch in 1890 (Francis, 1947). It is now known to be a cell mediated immune response unrelated to humoral antibodies. The sensitized cells accumulate at the injection site in the skin, liberate a histamine-like substance and the ensuing inflammation recognized as oedema, erythema and induration which consitutes the tuberculin reaction. It is read in 72-96 hours after the inoculation (Jubb et al, 1970; Kleeberg, 1975).

Several types of tuberculin has been used and tried for a long time. These include the mammalian tuberculin from M. tuberculosis, the avian tuberculin from M. avium and now bovine tuberculin from M. bovis and other sensitins from atypical mycobacteria have been used.

The first to be used was Koch's old tuberculin. It was prepared from tubercle bacilli grown on gycerated broth media. The proteins were extracted by steaming and evaporating the mixture to one tenth of its bulk. It was easy to make, but the main disadvantage was that the content of active principles was low and destroyed during the extraction process. It was difficult to standardize and also contained a lot of impurities. It is no longer in use (Francis, 1947; Paterson et al, 1959).

In order to find a better product, a heat concentrated synthetic media tuberculin (HCSM) was introduced. This was prepared in open pans and concentrated under vacuum. Phenol was added as a preservative. Its main disadvantage was that it also contained a lot of impurities. It is still in use in America and Australia (Francis et al, 1973).

The third and most used is the Purified Protein Derivative (PPD) tuberculin. Unlike the last two, the tubercle proteins are extracted from the steamed culture filtrate by using trichloroacetic acid. It has advantages in that it is pure and can be easily standardized and is more stable (Paterson et al. 1959).

The standard dosage adopted is 0.1 ml of mammalian at 10,000 I.U/g and 0.1 ml of avian tuberculin 2,500 I.U/g (WHO/Weybridge standard 1959). Other tuberculins namely the bovine and sensitins are prepared in the same way. Bovine tuberculin is in use in Europe as a single intradermal test (Francis et al, 1973).

Different methods administering tuberculin have been adopted and the most-used one is the single intradermal comparative test. Different sites have been used in different animals. In cattle the test is done on the side of the neck, caudal fold or the conjunctiva. The skin fold at the base of the ear is the site used in pigs, the wattle in poultry and in dogs and cats the flank is used. The reactions are read in 72-96 hours adopting the standards laid down by the Medical Research Council and Weybridge, using the discriminate formula. When the swelling is less than 3 mm it is regarded as negative. When it is more than 5 mm it is regarded as positive and anything in between as inconclusive. When the mammalian tuberculin reaction is negative and the avian tuberculin reaction positive, the reaction is regarded as non-specific.

Other methods like Von Pirquet has been used where the tuberculin is applied on scarified skin. In the Stormont method the injection of PPD tuberculin is administered then after 7 days the animal is re-injected and the reaction read in 24 hours. It is time consuming and rarely used these days.

Although tuberculin testing proved invaluable as a means of detecting tuberculous cattle, it had a disadvantage in that the reaction could be elicited by different acid fast organisms, thus interfering with its sensitivity (Francis, 1947). It became more noticeable as the incidence of tuberculosis in animals was reduced. The animals showed non-specific reactions. It was found out that these were due to non-progressive infections caused by mycobacteria other than M. bovis, making the interpretation of the test difficult. These include M. tuberculosis, M. avium and atypical mycobacteria which are mainly saprophytes and soil contaminants (Waddington, 1967; Berggren, 1976; Kleeberg, 1975; Prichard et al, 1975). M. paratuberculosis causing Johne's disease also interferes with tuberculin sensitivity. Mycobacteria causing skin infections in cattle were shown to behave in a similar manner (Guilbride, 1963; Lindley, 1958). Norcardiosis and B.C.G. vaccine interfere with tuberculin reaction. The problem may soon be overcome by using sensitins derived from atypical mycobacteria to detect infections other than those caused by M. bovis.

Once the infected animal is identified by the tuberculin test, the infection is confirmed by a) macroscopic demonstration of the lesions through post mortem examination and b) laboratory methods for microscopic demonstration of the causal organism, culture and biological tests for identification and typing of the mycobacteria species.

6.2 METHODS OF CONTROL

Several methods of controlling bovine tuberculosis have been used once the infection is diagnosed and confirmed. These include:

a) OSTERTAG'S METHOD, where it was recommended that bacteriological testing and slaughter of animals with 'open' tuberculosis would decrease the infection. It was the first step in an attempt to eradicate the disease. Such a method had little effect on the incidence of tuberculosis.

b) BANG'S METHOD was first introduced in 1892. It was based on the fact that the incidence was low in new born calves. These calves would be raised separately on milk. The herd should be tested and separated into clean and infected groups and the calves added to the clean herd. The method was used in Denmark and it was found impracticable especially in one farm system and the incidence of tuberculosis was not reduced (Francis, 1947).

6.3 B.C.G. VACCINATION

The discovery of attenuated M. bovis by Calmette and Guerin in 1908 (Rees, 1969), raised new hopes of combating tuberculosis. It was felt that the organism could be used as a vaccine. It was first tested in humans with the aim that artificial infection could enhance resistance to subsequent infection with M. tuberculosis. At that time infections in humans ranged from 15-20 million of the world's population at risk. Deaths were estimated at 2-3 million per year (WHO, 1967). So the Bacille Calmette Guerin (B.C.G.) came into being. With the recommendation of the World Health Organisation, B.C.G. has been widely used since, with efficacy of 80%-100%. It has been declared that a vaccinated child is protected up to 10 years (Kleeberg, 1975).

With such successful results in humans, it was thought that B.C.G. vaccine could prove to be of value in controlling bovine tuberculosis. It was thought that it could be put to use in countries with high prevalence of the disease and in which economic conditions made it difficult or impossible to employ on a test and slaughter eradication programme. Vaccinations could be carried out in calves early in life and in older animals showing negative reactions after a tuberculin test.

Several workers carried out experiments to assess the use of B.C.G. vaccine, but results were conflicting. The vole bacilli was tried in Britain in an attempt to find a better vaccine. It did not produce satisfactory immunity and some strains were very virulent (Francis, 1958). Between 1909-1953, several countries in Western Europe carried out vaccinations using B.C.G. vaccine. The results were not encouraging, although in some cases the vaccine conferred a temporary immunity, but did not prevent animals from getting infected (Henning, 1956; Francis, 1958; Stamp, 1959; Bibby's book on Milk Section IV).

Other countries in the developing world used the vaccine with unsatisfactory results. In Malawi the incidence of bovine tuberculosis was high varying from 30%-40% in some areas. About 10% of cattle slaughtered showed tuberculosis lesions and 2-3% were condemned as unfit for human consumption. As the test and slaughter method was impracticable, B.C.G. vaccine was used from 1963-1971 with the aim of reducing the incidence levels. By 1971 a large scale vaccination campaign was involving the whole country. A total of 347,485 head of cattle were vaccinated in a population of 400,000 head. The results showed that there was some reduction in the incidence, but when other factors especially age were taken into consideration, there was no reduction in the actual rate of carcass condemnation under field conditions. Temporary immunity was conferred but did not prevent animals getting infected (Ellwood, 1975; Berggren, 1976). The project had to be given up as it had no significant effect on the control of tuberculosis.

In Iran 15% of 30,000 cattle were affected in Teheran district, B.C.G. vaccination was carried out with unsatisfactory results (F.A.O., 1957). In Australia a trial using B.C.G. vaccine in pigs was carried out. Tammemagi (1970) showed that the vaccine did not prevent the infection, although the lesions were small and non-progressive in the test animals. Vaccination trials carried out in Brazil, showed that the vaccine was ineffective. Post mortem examinations showed no difference in the number and severity of lesions between vaccinated and control animals (Oliviera and Ramos, 1978).

The main disadvantage besides the temporary immunity, the B.C.G. vaccine interfered with the tuberculin test and Johne's test. The vaccine had no place in the control or eradication of tuberculosis as tuberculin testing is the only basis of detecting infections. Both B.C.G. and vole strain vaccine interfered with sensitivity to tuberculin test the main base of control and eradication programme (WHO/FAO, 1967).

6.4 CHEMOPROPHYLAXIS AND CHEMOTHERAPY

Isoniazid was discovered in Prague in 1912. Its activity was subsequently discovered in 1951 by three investigating laboratories, namely Hoffman La Roche and Swibb in America and Bayer Leverhausen in Germany (McDemott, 1969). Other drugs like streptomycin and paramino salicylic acid (PAS) were already in use, but the organisms showed resistance leading to fatal flare-up of infection in humans. Other drugs like pyrazinamide, ethionamide, cycloserine, thiacetazone, viomycin and capremycin were used in resistant cases, they proved to be very toxic and expensive. The joint WHO/FAO expert's committee on zoonoses (1967) felt that the chemotherapeutic agents found to be effective against tuberculosis, may also be of value against bovine tuberculosis. Chemotherapeutics could be employed in developing countries where it was difficult to undertake control and eradication programmes based solely on test and slaughter methods. They could be used where there was difficulty in obtaining replacement animals.

Many countries in Europe carried out extensive studies to evaluate the use of isoniazid in controlling bovine tuberculosis. Among others was South Africa where extensive and controlled series of trials took place. Kleeberg (1959, 1961, 1963) and Kleeberg _et al_ (1966) showed that the optimal dosage was 10 mg/kg body weight. The drug could be administered orally and for a reasonable period, up to 9 months, and it was effective and also produced low toxicity. They also showed that the drug had little effect on the tuberculin test sensitivity, that there was minimal drug hazard to the human as its excretion in milk was low and that it was denatured and disappeared during the process of milk pasteurization. In South Africa the drug was extensively used and up to 1979/80, 76 herds which had an infection rate of 2.9% were being treated (Annual Report 1979/80). Towar (1968) reported the use of isoniazid to control an outbreak of bovine tuberculosis in a herd of deer where 50% were infected. They could not dispose of the animals for economic reasons. The animals were treated at a dosage of 15 mg/kg body weight, daily in the drinking water for 12 months. The herd which had dwindled grew from 160 to 250 after 3½ years.

There are several reports where similar treatment was successfully carried out in tuberculosis outbreaks in laboratory animals. The dosages used were lower than that in cattle, 2 mg/kg body weight for a period of 6 months.

Isoniazid could best be used in conjunction with other control methods to reduce the level of infection so that eradication measures could be implemented. There were disadvantages in the use of isoniazid therapy, they include:

1) Prolonged period of treatment necessary for an effective response.
2) Drug resistance leading to flare-up of infection where therapy was stopped, especially after a short period.
3) Only useful in conditions where careful supervision could be maintained for example large government farms.
4) Veterinary supervision was necessary for proper administration of the drug, identification of animals and maintenance of accurate records.
5) Follow-up tests, using tuberculin test and laboratory tests namely bacteriological and biological were necessary to monitor the disease.
6) Control of cattle movement into and out of the infected herds.
7) Never to be used in small private herds where supervision is difficult.
8) Never to be used in areas where test and slaughter methods are feasible and already in progress.

6.5 ERADICATION/TEST AND SLAUGHTER

The basis of eradication programme depends on a) the systematic application of tuberculin test and b) removal of reactors either by slaughter or by establishing separate herds. The only proven effective method of eradicating tuberculosis is test and slaughter. It has been widely adopted by very many countries. It was successfully used in the eradication campaigns by the U.S.A. federal programme since 1917. The overall incidence was 5% although it varied from 2-50% in some areas (WHO/FAO, 1967). The main disadvantage is that it cannot be applied in most of the developing countries because of (a) the high cost of facilities, trained manpower and compensation, (b) reluctance of cattle owners to surrender reacting animals and (c) difficulty of obtaining replacement animals.

6.5.a Modified test and slaughter

Procedures could be applied where slaughtering of reactors is economically impossible. The system was adapted in Scandanavian countries and also in Great Britain. The implimentation had to be done in steps:

1. Voluntary schemes: by encouraging owners with offer of bonuses on milk and meat from free herds and paying compensation.
2. Disposal of reactors: the animals are sold for slaughter where some of the them are salvaged thus reducing the total loss to the owner, or the reactors can be put into special herds, so that other animals are no longer exposed to the risk of infection.
3. Tuberculosis in young stock is usually low, therefore, animals should be tested regularly and removed, especially in cases with pulmonary, uterine and mammary tuberculosis.
4. Early steps of eradication, the herds should be tested at intervals of 2-3 months, then annually and then 3 years, that is building up attested herds.

5. Protection of free herds, by raising calves on milk from tuberculosis free herds or sufficiently pasteurized. Doubtful animals should not be mixed with healthy ones for example in markets and pastures. Introduction of animals from other sources outside the herd should be discouraged.

6.5.b Area Eradication Plan

As more and more herds are free from the infection, area eradication plans should be adopted until the entire country is freed. Time for compulsory eradication would depend on a) the prevalence of tuberculosis and b) the economical conditions. In high prevalence areas, at least 70-90% of the herds should be free and where the prevalence is low, 10-50% of the herds should be free.

6.5.c Long term measures

These should be adopted to avoid reintroduction of infection. As the incidence and prevalence of infection in the population decreases, the importance of epidemiological tracing and testing procedures increases. This can be achieved by:

a) Routine meat inspection and trace back of affected animals to the herds of origin. When the herd is located, tuberculin test is carried out, reactors removed and the infection can be contained. Adequate meat inspection services and case finding programme can reduce the need of testing the whole area or the entire country.

b) Meat inspection services would also help in the control of zoonosis. Further steps to control the zoonosis should include proper milk hygiene programmes, health control of milk handlers and health programmes should be conducted to make the population be aware of the danger of tuberculosis from milk.

c) Quarantine. International regulations concerning livestock movement should be observed and health certificates issued by authorised veterinarians. Quarantine measures should be applied from herd level to whole country whenever necessary.

6.6 PROBLEMS IN CONTROLLING TUBERCULOSIS

The tuberculosis situation has changed. Early in the century tuberculosis incidence was high in housed animals especially in Europe. Now the reverse is true. The disease is proving to be a major problem in undeveloped countries. Kleeberg (1975) observed that modern farming methods introduced in less developed countries with no tuberculosis control and eradication programme, could increase the level of bovine tuberculosis. He stated that control programmes could be achieved in a short period before the situation gets out of proportion. The problem lies in launching a feasible programme for a given particular country.

In order to achieve optimal aims, a national programme must satisfy four basic requirements. These should be:

1) On a country wide basis and continuous. That efforts should be centralized because of the complexity of the disease in both humans and animals.
2) Adapted to the existing agricultural situation and be acceptable to the population.
3) The specialized services of a tuberculosis campaign should be integrated into the animal health services.
4) Economically it must fit the available resources.

This means that the costs of the necessary actions leading to the systematic reduction of tuberculosis must be within the resources available. It should aim at optimal results with expenditure. All that it amounts to is the employment of modern principles of rationalization and management for the planning, implementation, operation and evaluation of eradication schemes.

The programme should start with:

1) Collection of epidemiological data, for quantification of the disease problem.
2) Formulation according to the relevant agricultural, social and professional structure and infrastructure of the country.
3) Must study the accessibility of the animals, size of the population at risk and acceptability of the control measures.

Plans for eradication must be long term, that is covering decades, because tuberculosis has a very long incubation period and is a chronic disease. A large number of animals are affected and have long periods of infectivity. There must be continual surveillance compared to other diseases. The social and economic conditions in humans and cattle have to be taken into consideration. Kleeberg (1975), suggested that a single team of experts with special training was necessary to carry out the job. It should consist of an epidemiologist, bacteriologist, public health expert in meat hygiene and an administrator. For effective results, adequate motivation of personnel and education of animal owners is necessary.

DRAWBACKS:

1. In certain countries no concerted effort is made to gauge the extent of the disease in cattle.
2. Few laboratories exist which can isolate or type acid fast bacilli from tuberculous like lesions, to back up meat inspection and *post mortem* results.

3. The prevalence of the disease usually depends on the intensification of farming. There could be pockets of high density milk farming community in the country.

4. Religious beliefs for example in India, effective measures could not be carried out because infected cows may not be slaughtered. So that there is always a constant danger.

5. Financial constraints to carry out eradication campaigns.

CHAPTER 7

DISCUSSION AND RECOMMENDATIONS

The present situation of bovine tuberculosis in Uganda and the entire world at large is still unclear. The prevalence of tuberculosis is high in some parts of the country, but no true picture could be obtained, as no systematic survey has been done to assess the situation.

The bovine tuberculous incidence and prevalence in East Africa is of interest. We have on one hand the absence of the disease in cattle in Kenya, whereas on the other hand both her neighbours, namely Uganda and Tanzania, the incidence is high in some areas of the country and the disease is prevalent in both domestic and wild animals.

Hardly any effective measures to control the disease and to assess its dimensions in livestock have been tried, although sporadic tuberculin testing surveys and slaughtering of reactors have been carried out.

Early attempts to tackle the problem have been hindered by the outbreak of the first and second world wars and cattle keeping systems in the country practiced at the particular time. The existing control and eradication measures cannot be effectively implemented because of the socio-economic conditions existing in many countries. These include lack of manpower, lack of financial resources and diagnostic facilities to quantify the disease situation.

The IUAT/WHO study group (1982) on tuberculosis, recommended that all efforts must be made to co-ordinate tuberculosis control measures. No country could claim freedom from the disease. With the improvement of modern transport facilities, it is a matter of hours from one country to another. Unsatisfactory tuberculosis control programmes especially in most developing countries have a direct effect on the global tuberculosis situation. This is due to the fact that the number of refugees is increasing in the world, the rapid expansion of tourism to the countries of the third world, and immigrants from high prevalence countries, facilitate the spread of tuberculosis.

The increasing world population, and the need to be fed, had led to the thoughts to supplement and replace the conventional live-stock with the wild animals which are in abundance especially in Africa. The wild animals, especially the ruminants, are more adapted to the natural and usually harsh environment than the domestic ruminants. This adaption and resistance to diseases would allow more effective exploitation of the existing vast poor vegetation (Hammond and Branagan, 1973). Such changes would alter the epidemiological outlook of the diseases especially tuberculosis.

RECOMMENDATIONS

Many countries, especially in Europe and U.S.A., after long years of patience, extensive financial resources and collective efforts by everybody concerned, have managed to reduce the tuberculosis menance to negligible levels in both human and animal population. With the existing well tested, established diagnostic and control measures, there is no reason why countries in Africa and Uganda in particular cannot control tuberculosis. From the above literature review, hardly any systematic survey to assess the incidence of tuberculosis in the whole country has been made. Similarly no control measures apart from tuberculin testing and removal of reactors have been done regularly. Therefore the existing infrastructures of the established veterinary, agricultural and medical services should be brought into play to establish the accurate bovine tuberculosis situation in the country. Surveys should start by:

1. Stepping up abattoir surveys, by improving the existing meat inspection facilities from a village slaughterhouse to town abattoirs. The meat inspectors should be vigilant and report any suspicious lesions found during routine meat inspection examinations. The suspected samples should be submitted to the Animal Research Centre for laboratory examination. Laboratory facilities should be extended to district level for ease of handling the materials.

2. Tuberculin testing should be carried out on a) the departmental farms because the management is of a relatively high standard and the cattle population stable; b) the individual dairy farms and commercial ranches should be tested next, and (c) the rest of the cattle population could be tested by taking advantage of dipping facilities available to have access to a large population of the animals and ease of handling.

3. Once the true incidence has been established, a centrally organised tuberculosis control programme should be planned to fit in the social economic situation with maximum results utilizing the scanty financial resources available.

4. The programme should be gradually implemented in order to avoid massive depletion of the animal products if large numbers of animals have to be disposed of.

5. There should be a systematic disposal of reactors by slaughtering, backed up by legislation to discourage keeping of reactors.

6. Vaccination and chemotherapy should discourage as they do not eliminate infection and would prove expensive to be effectively carried out.

7. Compensation should be paid to farmers who may have to lose large numbers of animals and to encourage them to get rid of the reactors.

8. Motivation of farmers and individuals by educating them on the dangers of keeping tuberculous animals. This could be achieved by using mass media, like radio, newspapers and by paying attractive bonuses for milk from clean herds.

9. There should be co-operation between the ministries of animal resources and the ministry of health to establish the relationship between the human incidence and bovine tuberculosis especially in areas of high incidence.

10. There should be gradual expansion of tuberculosis-free zones until the entire country is free.

11. When the incidence has fallen to very low levels, compulsory test and slaughter method should be introduced.

12. Legislation should be sought to carry out quarantine measures at the country's frontiers and movement of animals from one part of the country to another.

13. The disease situation should be monitored and for this a good meat inspection service is invaluable as a tool in epidemiological surveys of tuberculosis in animals. Schilf (1974) observed that a good trained meat inspector had an accuracy of 93% in diagnosis of bovine tuberculosis, and that the information could provide very low cost support in eradication programmes.

14. Every effort must be made to improve the hygiene of milk production, and to increase, as rapidly as finances allow, the proportion pasteurized before sale.

Given the good will of everybody concerned, participation of the population and endurance for the long term,the control measures have to be implemented for visible results, bovine tuberculosis could be controlled and eventually eradicated from the world population.

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