PREVALENCE OF BOVINE TUBERCULOSIS IN HO DISTRICT: A POTENTIAL FOR HUMAN INFECTION

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DECLARATION

I declare that this dissertation has been the result of my own field research, except where specific references have been made; and that it has not been submitted towards any degree, nor is it being submitted concurrently in candidature for any other degree.

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DEDICATION

This work is dedicated to:

MAWUNYO KWESI ANKUGAH,

KOFI BUAME AND

ELLEN ANKUGAH

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LIST OF ABBREVIATIONS

AIDS	Acquired Immuno-defeciency Syndrome
BCG	Bacilli Calmette Gurin
DHMT	District Health Management Team
DOTS	Direct Observed Treatment Short Course
FAO	Food and Agricultural Organization
HIV	Human Immuno-deficiency Virus
M. bovis	*Mycobacterium bovis*
M. tuberculosis	*Mycobacterium tuberculosis*
MOFA	Ministry of Food and Agriculture
NTP	National Tuberculosis control Programme
PPD	Purified Protein Derivative
SPH	School of Public Health
SPSS	Statistical Package for Social Sciences
TB	Tuberculosis
TBA	Traditional Birth Attendants
WHO	World Health Organization

ABSTRACT

Tuberculosis continues to be an important public health problem worldwide. The World Health Organization estimated that human TB incidence and death for the 1990 to 1999 period would be 88 million and 30 million respectively, with most cases in developing countries.

Zoonotic TB caused by *M. bovis* is present in animals in most developing countries (including Ghana) where surveillance and control activities are often inadequate or unavailable. Consequently, many epidemiological and public health aspects of infection remain largely unknown.

This study was, therefore, undertaken to determine the prevalence of bovine TB in Ho district, and to serve as an indicator to the probability of human infection with bovine TB. The standard single intradermal comparative tuberculin test (using purified protein derivative of *M. bovis* and *M. avian*) was used. The study also reviewed data on TB diagnosed at the slaughter house/slabs between 1996 to 1999. The study furthermore, used an interview checklist to identify risk factors that might play a role in the infection of humans with bovine TB.

The study results revealed a prevalence of 3.1% and 1.1% of bovine TB in live animals and slaughtered cattle respectively.

Consumption of unpasteurized milk, eating of uncertified meat as well as living in close proximity to cattle were some of the risk factors identified during the study.

Measures to prevent transmission of bovine TB infection should be the primary objective of the Ho district and it is to be achieved with trained public health personnel, public education and proper hygienic practices such as consumption of pasteurized milk and uncontaminated meat. The test-and-slaughter programme is considered feasible and economical where bovine TB is less or equal to 5%. In line with this and the findings of the study, it is suggested the Ho district undertake the test-and-slaughter programme to control bovine tuberculosis as well as to avoid its transmission to humans.

CHAPTER ONE

1.0 INTRODUCTION

Tuberculosis (TB), an infectious disease caused by species of mycobacterium is most commonly associated with the lungs but can affect almost any tissue or organ in the body. Archaeological evidence indicates that TB afflicted prehistoric men and women and in the medieval period, Europeans, Asians and Africans suffered from it. So also was it in the 16th through the 18th century, 19th through 20th and into the 21st century.[1]

About 8-10 million new TB cases are diagnosed in the world each year and the disease is responsible for the death of 2-3million people annually. The bulk of this morbidity and mortality occurs in tropical and subtropical regions, where infection rates approaches 2-3% per year. The incidence of TB is actually increasing, so that there are more new cases now than 20 years ago.[2] The World Health Organization (WHO) estimates that human TB incidence and deaths for 1990 to 1999 will be 88 million and 33 million respectively with most cases in developing countries.[3]

TB is a major opportunistic infection in HIV-infected persons and the vast majority of persons carrying this dual infection live in developing countries. As a result of the HIV epidemic, the crude incidence rate of TB is expected to increase in Sub-Sahara Africa from 191 cases per 100,000 in 1990 to 293 in the year 2000.[4] The world-wide incidence of HIV-attributable TB is estimated to increase from 315,000 (4% of the total TB cases) in 1990 to 1.4 million (14 % of the TB cases) by the year 2000 and 40% of these HIV cases will occur in Sub-Sahara Africa.[5]

In Ghana it is estimated that, every year there are over 30,000 new TB cases and 15,000 deaths annually. The statistics for Ho district is around 93 cases per year with 30 deaths[6]. Tuberculosis in humans is principally caused by *M. tuberculosis*. However, *M. bovis* which causes bovine tuberculosis, can also cause TB in humans through consumption of unpasteurized milk and inadequately prepared meat[7].

The public health importance of animal TB was recognised early by WHO, which in its 1950 report of expert committee on TB stated: " The committee recognised the seriousness of human infection with bovine TB in countries where the disease in cattle is prevalent. There is the danger of transmission of the disease by direct contact between diseased cattle and farm workers and their families, as well as from infected food products".[8] Since then, TB in animals has been on the centre stage of all veterinary public health activities.

In Africa 90% of the population live in countries that do not undertake any form of TB control programme in livestock, additionally the close contact between man and animals and the consumption of milk and meat products under unhygienic conditions make the infection of humans with bovine tuberculosis a possibility[9]. Studies around the globe estimated that the proportion of human cases due to *M. bovis* was 3.1% of all forms of TB in 1960[10].

In Ho district, the prevalence of bovine TB is unknown, neither is the proportion of human TB due to *M. bovis* known. Prevention of zoonotic TB is achievable only through the control of TB in cattle[11].

As a step towards the achievement of the above aim, this study was designed to:

- Determine the prevalent of bovine TB in Ho district
- Identify risk factors for human infection with *M. bovis* in Ho district and suggest possible ways for the control of bovine TB.

1.1 THE STUDY LOCATION

The study was located in the Volta Region of Ghana.

The Volta Region is long, stretching along three –fifths of the length of the eastern boarder of the country–from the coast to the north. It is bounded in the north by the Northern Region, south by the Gulf of Guinea, west by the Volta Lake and east by the Republic of Togo. It covers a land area of 20,570 square kilometres with a population of 1.8 million[12]. It has twelve administrative districts of which the Ho district is the study location.

1.1.1 HO DISTRICT

It is located in the middle zone of the Volta Region and covers a landmass of 2,564 square kilometres. Hohoe District borders it to the north, south by North Tongu District, west by Kpando District and to the east by The Republic of Togo. Ho is both the regional and district capital. It has a projected population of 260,663. The main language is Ewe. The population is mainly rural .The vegetation is savanna, with some parts flat and others mountainous. It has two main rainy seasons (May –July) and (August-October). Farming though subsistence is the predominant occupation of the people. Crops normally grown are maize, cassava, yam, and vegetables. They also rear animals like, sheep, goats, pigs, cattle and poultry. Others engage in kente weaving and petty trading, the rest are civil and public sertvants[13].

1.1.2 DISTRICT HEALTH SERVICES

The Ho District is divided into 6 sub-districts namely;

Ho-Shia

Tsito

Kpetoe-Ziope

Adaklu

Abutia

Kpedze-Vane.

There are 49 health facilities in the district, one district hospital, one polyclinic, 30 health centers, four maternal and child health centers, 3 mission clinics, 5 private medical praticitioners and 5 private maternity homes. At the community level there are 61 trained and 84 untrained Traditional Birth Attendants (TBA). Health services are provided from the above institutions as static facilities comprising a comprehensive integrated package of services[13].

1.1.3 VETERINARY SERVICES

A district clinic and 15 sub –operational areas, provide veterinary services in the district. There is also a regional laboratory, which provides diagnostic support for the district's investigation needs[14]

1.2 THE PROBLEM STATEMENT AND JUSTIFICATION

The World Health Organization (WHO) estimates that by the year 2000, 3.5 million persons will be dying of TB annually, and has therefore declared TB as re-emerging disease[2]. In Ghana even though statistics on the disease is incomplete, estimates reckon that over half the adult population is affected but without clinical symptoms. An expected 30,000 cases occur every year with 15,000 deaths[6]. It is in response to this situation that the National Tuberculosis Control Programme (NTP) was launched to, among others, reduce mortality, morbidity and transmission of the disease until it no longer poses a threat to public health.

This measure is only one approach to solving the problem. On the other side of the coin is the zoonotic TB caused by *Mycobacterium bovis*, which is an isolate of the *Mycobacterium tuberculosis* complex[8]. In the Ho District there is a cattle population of 4,695 of which there is little information on the prevalence of bovine TB[13]. Also, as a requirement for the establishment of the peri-urban dairy project, (which seeks to encourage the use of milk from local cows and yet to be undertaken in the district) the Ministry of Food and Agriculture in collaboration with the District Health Administration have decided to conduct a tuberculin test on the cattle population. As a field resident in the district it was agreed I conduct the study to estimate the proportion of the herd infected with *M. bovis* and identify risk factors for human infection with *M. bovis*. It is hoped, this study will influence planning and decision making on the control of bovine tuberculosis.

1.3 GENERAL OBJECTIVE

The general objective was to determine the prevalence of bovine tuberculosis and identify risk factors for human infection with *M. bovis*.

1.4 SPECIFIC OBJECTIVES:

1. To estimate the prevalence of bovine TB in Ho district based on reaction to the tuberculin test.
2. To determine the trend of bovine TB diagnosed at the slaughter house/ slabs in Ho district
3. To identify risk factors for human infection with *M. bovis*.
4. To make recommendations to policy makers on the control of bovine TB in the district.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HUMAN TUBERCULOSIS

2.1.1 GLOBAL SITUATION AND TRENDS

The global incidence of TB is greatly under estimated. In 1995, 3.3 million cases were reported to the Global Tuberculosis Programme of WHO,whereas a more likely number is 8.8 million. Of the reported cases, 62% occurred in the Southeastern Asian and Western Pacific regions,16% in sub-Saharan African, and 7% to 8% in each of the regions of the Americas, Eastern Meritarranean, and Europe. Many countries, especially those with few resources, are unable to report all TB cases because of difficulties in identifying suspected cases, establishing a diagnosis, recording and reporting cases[15].

The annual global incidence is predicted to increase to 10.2 million by the year 2000, an increase of 36% from 1990. Southeast Asia,Western Pacific regions, and sub-Saharan Africa will account for 81% of these new cases (Appendix 3). For 1990 to 1999, in the absence of effective control, the global TB incidence and deaths will reach 88 million and 30 million, respectively,70% of the new cases will occure in patients 15 to 59 years of age, the most economically productive segment of the population[15].

2.1.2 RESURGENCE OF TUBERCULOSIS

TB is still rampant in tropical countries and although the disease has receded in the technologically advanced countries of Europe and North America over the years, the absolute number of tuberculous patients throughout the world is still increasing.[2]

Particularly in Africa, TB is a well-recognized problem in homeless people whose numbers have increased in recent years. Patients who are immuno-compromised are also at an increased risk of primary infection and exogenous re-infection, especially those in confined settings, such as nursing homes and prisons. TB is an opportunistic infection and tends to affect those who already have reduced resistance, as in HIV/AIDS patients. Malnutrition, cigarette smoking, uncontrolled diabetes millitus and post gastrectomy state may diminish host immunity and lead to infection of the patient with tuberculosis or re-activation of a latent or healed focus of tuberculosis. It has been observed that poverty and tuberculosis go hand in hand, hence with increased unemployment and its attendant reduction in the standard of living, poor housing and malnutrition, the conditions are ripe for the resurgence of tuberculosis.[16]

2.1.3 AETIOLOGY, TRANSMISSION AND CLINICAL OUTCOME

Basically, there are five types of bacilli recognized. Each is adapted to a different range of animal host: human, bovine, murine, avian and the cold-blooded. In the pathology of human TB only the human type (*M. tuberculosis*) and the bovine type (*M. bovis*) play an important role.[17]

The source of infection is the diseased man, in particular the patient with pulmonary disease. The infectiousness of a patient is determined by his bacillary status. Patients in whom tubercle bacilli can be demonstrated in the sputum by direct smear examination are highly infectious. In contrast, patients in whom tubercle bacilli can be demonstrated in the sputum by culture only, or whom are culture negative are relatively non – infectious.

The bacilli are transmitted through infectious aerosol droplets discharged by the patient when coughing, sneezing, or talking. Transmission is more intense among close relatives, since they are in close contact with the patient several hours per day; in practice those who live under the same roof and sleep in the same room with the infectious patient are at higher risk.[18]

Bacilli penetrate the bronchi and the lungs of a healthy subject when the latter inhales the droplets. This initial penetration causes a primary infection usually asymptomatic but sometimes accompanied by clinical signs such as fever, skin or mucous reactions and/or radiological signs as primary focus and hilar lymphadenopahty. Primary infection may be followed by early post-primary disease (meningitis, milliary TB, pleurisy) or by late manifestations such as extrapulmonary localization in lymph nodes, bones, joints and abdomen. TB will maintain itself in a human community under natural conditions provided that;

1. one tuberculous person infects approximately twenty others
2. at least two of the twenty infected persons come down with the disease and
3. of those two at least one becomes a source of infection.

This process will continue until there are changes in the environmental conditions to alter the reproductive rate.[16]

2.1.4 CLINICAL AND LABORATORY DIAGNOSIS

Diagnosis of the disease depends upon the site and intensity of the inflammatory process and amount of tissue involved. Usually the onset of pulmonary TB is insidious. Coughs haemoptysis and breathlessness develop only as the disease progresses. Systemic symptoms such as weight loss, fever, and sweating also reflects advanced stage of the disease.

Suspect pulmonary tuberculosis if a patient has these symptoms:

1. Cough with or without expectoration (blood stained sputum) for three weeks or more.
2. Chest pain
3. Shortness of breath
4. Fever
5. Night sweats
6. Weight loss
7. Poor appetite.[17]

TB diagnnosis depends mainly on identifying tubercule bacilli by sputum-smear microscopy. A patient suspected to have pulmonary TB should have three sputum specimens, (spot, early morning, spot) examined by direct smear microscopy. A definite diagnosis is made with two positive smear results out of the three.

The Mantoux test is particularly helpful in children under 5 years who have not had BCG and are suspected of having TB.[6]

2.1.5 TREATMENT AND CONTROL

Under the NTP, it is WHO's recommended TB control strategy that provides the most effective medicines to TB patients using the DOTS (Direct Observed Treatment, Short Course) approach. DOTS uses a specific combination of anti-TB medicines, featuring the drugs isoniazid, rifampicin, pyrazinamid and ethabutol (streptomycin). This standardized regime, known as the short–course chemotherapy is nearly 100% effective.[19]

2.1.6 VACCINATION

BCG vaccine produced by a French scientist Calmette Guerin, is a live attenuated strain of bovine bacilli. It is given intradermally to a non-infected population, usually children, to protect them from developing TB. The accepted vaccine dosage for children under one year is 0.05ml, and over a year 0.1ml.[18]

By the year 2000, 3.5 million people will be dying of TB annually an increase of 39% from 1990. *M.* tuberculosis will be largely responsible for the new cases and deaths, but an unknown, and potentially important, proportion will be caused by *M. bovis.*[15]

2.2 BOVINE TB IN DEVELOPING COUNTRIES

2.2.1 AFRICA

Although prevalence data on animal TB in developing countries are generally scarce, information on bovine TB occurrence and control measures exists.[20] Of 55 African countries, 25 reported sporadic/low occurrence of bovine TB, six reported enzootic disease, two , Malawi and Mali, were described as having a high occurrence , four did not report the disease, and the remaining 18 countries did not have data.[21]

Of all nations in Africa, only seven apply disease control measures as part of a test-and – slaughter policy and consider bovine TB a notifiable disease, the remaining 48 control the disease inadequately or not at all[20]. Almost 15% of the cattle population are found in countries where bovine TB is notifiable and test-and-slaughter policy is used.Thus, approximatelly 85% of the cattle and 82% of the human population of Africa are in areas where bovine TB is either parly controlled or not controlled at all.[22]

In Ghana, test- and-slaughter policy is in place and tuberculin test carried out in some kraals in the Tema district and Kasoa in the Ewutu Senya districts showed a 2% prevalence. Another work done at Aveyime in the Dangme- East district showed a 4% prevalence and as high as 50% positive reactors were recorded in a kraal with a total stock of 75 at Adidome in the Volta region[29].

2.2.2 ASIA

Of 36 Asian nations, 16 reported a sporadic/low occurrence of bovine TB, and one (Bahrain) described the disease as enzootic, ten did not report bovine TB, and the remaining nine did not have data.[23] Within the Asian regions, seven countries apply disease control measures as part of a test-and –slaughter policy and consider bovine TB notifiable. In the remaining 29 countries, bovine TB is partly controlled or not controlled at all.[20]

Of the total Asian cattle and buffalo populations, 6% and less than 1%, respectively, are found in countries where bovine TB is notifiable and a test-and- slaughter policy is used, 94% of the cattle and more than 99% of the buffalo populations in Asia are either only partly controlled for bovine TB or not controlled at all. Thus, 94% of the human population lives in countries where cattle and buffaloes undergo no control or only limited control for bovine TB. [23]

2.2.3 LATIN AMERICA AND CARIBBEAN COUNTRIES

Of 34 Latin American and Caribbean countries, 12 reported bovine TB as sporadic/low occurrence, seven reported it as enzootic and one (Dominican Republic) described occurrence as high. Twelve countries did not report bovine TB. No data were available for the remaining two countries.[21]

Of the total Latin American and Caribbean cattle populations, almost 76% is in countries where bovine TB is notifiable and a test-and–slaughter policy is used. Thus, approximately 24% of the cattle population in this region is either only partly controlled or not controlled for bovine TB. It is also estimated that 60% of the human population live in countries where cattle undergo no control or only limited control for bovine TB.[21]

2.3 ZOONOTIC TUBERCULOSIS

TB caused by *M. bovis* is clinically indistinguishable from TB caused by *M.tuberculosis.* In counties where bovine TB is uncontrolled, most human cases occur as a result of drinking or handling contaminated milk. Little is also known of the relative frequency with which *M. bovis* causes TB in developing countries because of limited laboratory facilities for the culture and typing of tubercle bacilli.[8]

Agricultural workers may acquire the disease by inhaling cough spray from infected cattle, and develop typical pulmonary TB. Such patient may infect cattle, but evidence for human –to-human transmission is limited and anecdotal. From a review of a number of zoonotic tuberculosis studies, published between 1954 and carried out in various countries around the world, it was estimated that the proportion of human cases due to *M. bovis* accounted for 3,1% of all forms of tuberculosis: 2.1% of pulmonary forms and 9.4% of extra pulmonary forms.[24] (appendix 4 summarizes the findings of more recent reports of TB caused by *M. bovis* in industrialized countries).

Human disease caused by *M. bovis* has been confirmed in African countries. In an investigation in two Egyptian health centers, the proportions of sputum positive TB patients infected with *M. bovis,* recorded during three observations, were 0.4%, 6.4% and 5.4% [25]. Isolation of *M. bovis* from sputum samples of patients with pulmonary TB has been reported from Nigeria. Of 102 *M. tuberculosis* complex isolates, 3.9% were *M. bovis.*[24] In a recent investigation in Tanzania, seven of 19 lymph node biopsies from suspected extrapulmonary TB patients were infected with *M. tuberculosis,* and four with *M. bovis* (appendix 5) [24]

In an epidemiological study in Zambia, an association between tuberculin- positive cattle and human disease was found. Households that reported a TB case within the previous 12 months were approximately seven times more likely to own herds containing tuberculin – positive cattle. Although this could be explained by zoonotic TB transmission, other factors such as transient sensitivity to tuberculin of cattle exposed to TB patients and coincidental environmental factors favouring both human clinical TB and sensitivity to bovine tuberculin should also be considered. [7]

In Latin America, a conservative estimate would be that 2% of the total pulmonary TB cases and 8% of the extra pulmonary TB cases are caused by *M. bovis.* These cases would therefore account for 7,000 cases per year, a rate of nearly 2 per 100,000 inhabitants[26]. From a nationwide study in Argentina during 1982 to 1984, 36 (0.4%) of 7,672 mycobacteria cultured from sputum sample were *M bovis.*[6]

2.3.1 ECONOMIC IMPACT OF ZOONOTIC TB

The full economic implications of zoonotic TB are, however, overlooked in many developing countries, where the overall impact of the disease on human health and animal production needs to be assessed.[9] According to recent estimates, annual economic loss to bovine TB in Argentina was approximately $63 million.[10]

In a study recently conducted in Turkey, the estimated socioeconomic impact of bovine TB on both the agriculture and health sectors was approximately $15-59 million per year.[24]

2.3.2 RISK FACTORS: ANIMAL POPULATION

2.3.2.1 Animal reservoir: The widespread distribution of *M. bovis* in farm and wild animal populations represents a large reservoir of this microorganism. The spread of the infection from affected to susceptible animals both in industrialized and developing countries is most likely to occur when wild and domesticated animals share pasture or teritory.[25] Well–documented examples of such spread include infection in badgers (*Meles meles)* in the United Kingdom and possums (Trichosurus vulpecula) in New Zealand. Wild animal TB represents a permanent reservoir of infection and poses a serious threat to control and elimination programs.[27]

2.3.2.2 Milk production and animal husbandry

Milk production has increased in many developing countries as a consequence of greater demand for milk for human consumption. This increased demand for milk estimated at 2.5% per year for 1970-1988 for sub –Saharan Africa led to increases in the number of productive animals and milk imports and intensification of animal production through the introduction of exotic breeds.[27]

Although the prevalence of the disease within a country varies from area to area, the highest incidence of bovine TB is generally observed where intensive dairy production is most common. This problem is exacerbated where there is inadequate veterinary supervision, as is the case in most developing countries. In addition in some industrialized countries such as the United States of America, where large dairy herds (5,000 or more cows) are crowded together represent the main source of infection.[8]

In developing countries, bovine TB infects a higher proportion of exotic dairy breeds *(Bos taurus)* than indigenous zebu cattle (*Bos indicus)*. However, under intensive feedlot conditions, a death rate of 60% and depression of growth have been found in tuberculous zebu cattle. In those areas where extensive management is more common, animal crowding (e.g., near watering ponds, dip tanks, markets.) still plays a major role in the spread of the disease.[28]

2.3.3 RISK FACTORS FOR HUMAN POPULATIONS

2.3.3.1 Close physical contact

Close physical contact between humans and potentially infected animals is present in some communities, especially in developing regions. For example, in many African countries cattle are an integral part of human social life, they represent wealth and are at the center of many events and, therefore, gatherings. In addition, with 65% of African, 70% of Asian, and 26% of Latin American and Caribbean populations working in agriculture, a significant proportion of the population of these regions may be at risk for bovine TB infection.[25]

2.3.3.2 Food hygiene practices: Consumption of milk contaminated by *M. bovis* has long been regarded as the principal mode of TB transmission from animals to humans.[8] In regions where bovine TB is common and uncontrolled, milk borne infection is the principal cause of cervical lymphadenopathy (scrofula) and abdominal and other forms of nonpulmonary TB.[3] Although proper food hygiene practises could play a major role in controlling these forms of TB, such practices are often difficult to institute in developing countries.

In all countries of sub-Saharan Africa, there is active competition between large scale, often state run, processing and marketing enterprises and the informal sector. The informal sector can ignore standards of hygiene and quality, and producers often sells directly to the final consumers. In addition, an estimated 90% of the total milk produced is consumed fresh or soured.[8] Although it has been stated that Africans generally boil their milk and that the souring process destroys *M. bovis,*[10] other sources strongly contradict this statement[11]. *M. bovis* was isolated from seven (2.9%) of 241 samples of raw milk in Ethiopia. Both *M. bovis* and *M. tuberculosis* have also been found in milk samples in Nigeria and Egypt[24]. Thus, serious public health implications of potentially contaminated milk and milk products should not be underestimated.

2.4 Bovine TB and HIV/AIDS

In many developing countries, TB is the most frequent opportunistic disease associated with HIV infection. HIV seroprevalence rates greater than 60% have been found in TB patients in various African countries.[4] TB cases due to *M. bovis* in HIV–positive persons also resemble disease caused by *M. tuberculosis.* Thus they manifest as pulmonary disease, lymphadenopathy, or, in the more profoundly immunosupressed, disseminated disease.[25]

M. bovis has been isolated from HIV-infected persons in industrialized countries. In France, this infection accounted for 1.6% of TB cases in HIV-positive patients. All isolated strains were resistant to isoniazid and pyrazinamide and in situations of high primary resistance to isoniazid and streptomycin, the intrinsic resistance of *M. bovis* to pyrazinamide may severely limit the efficacy of treatment of TB caused by *M. bovis* .[25]

In Paris hospital, a source patient with pulmonary TB due to multidrug –resistant stain of *M. bovis* led to active disease in five patients. This observation led to three concerns:

- Human-human *M. bovis* transmission leading to overt disease,
- A short interval between infection and overt disease,
- Disseminated multidrug- resistant *M. bovis*.[4]

In another study conducted in San Diego, in California one of 24 adults with pulmonary TB and 11 of the 24 adults with nonpulmonary TB due to *M. bovis* had AIDS.[24]

It is commonly believed that *M. bovis* is less virulent than *M. tuberculosis* in human and therefore less likely to lead to overt post primary disease and that human to human transmission leading to infectious disease is rare. However, if the apparent difference in virulence is the result of differences in responsiveness of the host mechanism, HIV-induced immunosuppression could well lower host defences leading to overt disease after infection.[4]

2.5 SURVEILLANCE OF TB DUE TO *M. bovis*

The use of direct microscopy as the only method for diagnosis of suspected TB, could partly explain the relatively low notification rate of disease caused by *M. bovis* in developing countries. Direct smear microscopy does not permit differentiation between species of the *M. tuberculosis* complex. In addition, culture and speciation are often not carried out, and even when culture facilities are available, *M. bovis* grows poorly in standard Lowenstein-Jensen medium one of the most widely used cultural media.[24]

The collection of representative data on the incidence of TB due to *M. bovis* from most laboratories in developing countries has additional problem. For example, the location of and coverage of laboratories are often biased towards city populations, sputum specimen may predominate, with relatively few specimen from extra pulmonary lesions, particularly among children.[24] Recent outbreaks of multidrug-resistant in some parts of the world underscore the need for surveillance through a wider application of reliable culture and drug susceptibility[23].

2.6 CONTROL MEASURES AND PROGRAMMES

Bovine TB can be eliminated from a country or region by implementing a test-and-slaughter policy.[9] However, because of financial constrains, scarcity of trained professionals, lack of political will, as well as the underestimation of the importance of zoonotic TB in both the animal and public health sectors by national governments and donor agencies, control measures are not applied or are applied inadequately in most developing countries. In addition, bovine TB does not often justify the emergency measures required for other zoonotic diseases (e.g., Rinderpest, East Coast Fever and Foot and mouth disease.). [10]

Similarly, successful conduct of a test policy requires sustained co-operation of national and private Veterinarians, meat inspectors and farmers, as well as adequate compensation for services rendered which most often is lacking in these countries.[8]

Nevertheless, control of bovine TB, can be carried out either on herd basis or on area basis.

Herd basis control relies on the:

- Removal of infected animals (using tuberculin test to detect infected animals).
- Prevention of spread of infection (feeding calves with only tubercles free products.)
- Avoidance of further introduction of the disease (avoiding common grazing and drinking grounds.)

The method used to eradicate bovine TB from large areas depends on the incidence of the disease, methods of husbandry and attitude of the farming community. It is essential at the beginning of a test- and -slaughter programme to determine the incidence and distribution of the disease. Based on the information gathered the disease can easily be eradicated from low incidence areas. However, in a high incidence area the test-and-slaughter programme may be economically impossible. Similarly livestock owners must be appraised of the economic and public health significance of the disease in order to facilitate a smooth program implementation[30].

2.7 ANIMAL VACCINATION AND RESEARCH DEVELOPMENTS

Although not usually considered relevant to elimination programmes in livestock, vaccination of animals against TB will be a viable strategy in two disease control situation: in domesticated animals in developing countries and in wildlife and feral reservoirs of disease in industrialised countries where test-and- slaughter programmes have failed to achieve elimination of the disease[24].

Many issues need to be addressed before vaccination becomes a realistic option for control of disease in cattle and other animals. First, a highly effective vaccine needs to be developed. The results obtained globally with bacillus Calmette-GuErin (BCG) have been sub-optimal, and efficacy has varied considerable from region to region[11]. Secondly, the delivery of the vaccine poses few problems in domesticated animals, but it is fraught with difficulties in wild animals. Thirdly, vaccination may compromise diagnostic tests. A vaccine that induces tuberculin reactivity would invalidate the key diagnostic tool used in control programmes. Fourthly, short of performing lengthy and expensive field studies, evaluation of the protective efficacy of a new vaccine will pose serious difficulties. Traditionally, the guinea pig and mouse have been used for this purpose, but recent work indicates that the deer may well prove a suitable mammal for evaluating new vaccines and optimal delivery system[11]. Enzyme-linked immunosorbent assay, gamma interferon test, and polymerase chain reaction, are future diagnostic tools in epidemiological studies that trace the spread of the disease between cattle, other animals, and humans or in the differentiation of *M. bovis* within *M. tuberculosis* complex.[24]

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study type

The study was a descriptive cross-sectional one, and the study population was cattle in the Banforu, Kalakpa, Tevikpo and Dawanu clusters, aged 3 months and above, including all sexes and breeds.

3.2 Sampling method

A multi-stage, sampling method was used. The cattle rearing areas were divided into 5 clusters (appendix 6). Four (4) were purposefully chosen and quotas assigned to them according to their cattle population (based on 1997 Rinderpest census). In each cluster, the index kraal was balloted for (from a sample frame appendix 7) and animals randomly sampled from the kraal according to a pre-determined number. After the index kraal animals in the next available kraal are similarly sampled until the quota was met for the cluster. This procedure was repeated in each cluster until the quota was met.

3.3 Sample Size

Where N= sample size, z = confidence limit 95 % (1.96), p = assumed prevalence of bovine TB in the district 10% (0.1), q = 1-p =0.9, d = 3% (0.03) the acceptable deviation from the true value (desired precision) .The sample size therefore was 384.

3.4 Test method

A single intra-dermal comparative tuberculin test using purified protein derivative (PPD) antigen (*M. bovis and M. avium*) [30] were used.

3.5 Site preparation and test administration

The injection site was shaved and measurement of the skin thickness was taken. A dose rate of 0.1ml solution of tuberculin solution containing 2mg bovine PPD and avian tuberculin was injected simultaneously into two separates sites on the same side of the neck (at least 12 cm apart, with the avian above the bovine tuberculin)[10].

3.6 Reading and interpreting of results

The test was read after 72 hours. Positive reactors had induration at the site of injection. The diameter was measured and compared with the initial measurement. A positive test had induration equal or more than 5 cm of the initial measurement.[10]

Apart from the tuberculin test, records on cattle TB diagnosed at the slaughter house/slabs from 1996 to 1999 were reviewed.

3.7 Quality control

Spot checks were carried out on research assistants administering the test. Instruments were also frequently checked for correctness of dosage delivery.

3.8 Data analysis

Data collected was analysed using EPI INFO (version 6) program to calculate frequencies and percentages.

3.9 Ethical issues

Permission from the district assembly, chiefs, opinion leaders and cattle owners was sought, before the test was conducted.

3.10 Limitations

Even though simple random sampling is the best method that approaches the true value, due to distance, logistics and mobility of herdsmen a multi-stage sampling method was used. Herdsmen might be biased in the animal they restrained for the test. Aggressive animals might always be ignored. The test kit might also not deliver the correct dosage. Human error in reading the results might also bias the study. Spot checks were however conducted on research assistants administering the test and instruments were also frequently checked for correctness of dosage delivery. False negative reactions may result from:

- Advanced cases of tuberculosis due to desensitization.
- Old cattle.
- Early cases (until 6 weeks after infection).

CHAPTER FOUR

4.0 RESULTS

The results of the tuberculin test, review of data on TB diagnosed at slaughter houses/slabs and interview of herdsmen using a checklist are presented in Tables 1 - 7.

4.1 RESULTS OF TUBERCULIN TEST

Table 1: **Distribution of Bovine Tuberculin Reactors by Cluster**

Cluster	No. of Cattle Tested	No. Positive	Prevalence (%)
Kalakpa	34	2	5.9
Dawanu	286	9	3.1
Tevikpo	50	1	2.0
Banfuru	14	0	0.0
Total	**384**	**12**	**3.1**

Table 1 shows that Kalakpa cluster had the highest prevalence of 5.9%, followed by Dawanu cluster with 3.1% and Tevikpo cluster with 2.0%. Banfuru cluster had no positive reactors. In all 384 animals were tested. Out of which 12 were positive, given a prevalence of 3.1% (table 1).

Table 2: **Bovine Tuberculin Reactors by Sex and Age**

Sex	Age	No. of Cattle Tested	No. Positive	Prevalence (%)
Male:				
Young bulls	Less than 2 years	22	-	-
Bulls	Over 2 years	60	2	3.3
Female:				
Heifers	Less than 3 years	50	1	2.0
Cows	Over 3 years	252	9	3.6

Out of the 60 bulls tested, (Table 2), 2 (3.3%) positive reactors were observed. Nine out of the 252 cows tested were also positive. This represents 3.6%. No positive reactors were observed in young bulls tested. Two percent (2.0%) of heifers tested reacted positively.

Table 3: **Bovine Tuberculin Reactors by Breed**

Breed	No. of Cattle Tested	No. Positive	Prevalence (%)
West Africa Short horn	60	2	3.3
Sanga	303	8	2.6
Ndama	21	1	4.8
Zebu	-	-	-

The data cited above (table 3) indicate that 4.8% (1 out of 21) of the Ndama tested were positive. The prevalence was 3.3% in the West African Short Horn, while 2.6% positive reactors was found in the Sanga breed.

4.2 REVIEW OF SLAUGHTER RECORD

Table 4:**Number of Cattle slaughtered at slaughter houses/slabs between 1996 – 1999**

Name of Slaughter House/Slabs	Number of cattle slaughtered per year			
	1996	**1997**	**1998**	**1999**
Ho	937 (88.8)*	993 (89.1)	1303 (90.9)	1434 (93.5)
Kpedze	103 (9.8)	91 (8.2)	93 (6.5)	86 (5.6)
Ahunda	4 (0.4)	2 (0.2)	0 (0.0)	0 (0.0)
Kpetoe	10 (0.9)	11 (1.0)	20 (14.0)	12 (0.8)
Nyive	1 (0.1)	0 (0.0)	11 (0.8)	2 (0.1)
Tsito	0 (0.0)	17 (1.5)	7 (0.4)	0 (0.0)
Total	1055 (100)	1114 (100)	1434 (100)	1537 (100)

* Figures in parenthesis represent percentages

Table 4 illustrates cattle slaughtered over the period of 1996 – 1999. In general, the number of animals slaughtered increased over the period, from 1055 in 1996 to 1537 in 1999, an increase of about 45.7%.

The Ho slaughter house made the highest slaughter during the period. It ranged between 937 – 1437, forming more than 90% of all the animals slaughtered. The other slaughter slabs made slaughters less than 10% during the same period.

Table 5: **Laboratory confirmed Bovine TB detected at slaughter house/slabs between 1996 – 1999**

Year	No. of Cattle Slaughtered	No. TB Cases Diagnosed[a]	Prevalence (%)
1996	1055	9	0.9
1997	1114	10	0.9
1998	1434	13	0.9
1999	1537	23	1.5
Total	**5140**	**55**	**1.1**

a = TB cases originated from all clusters studied.

A glance at table 5 shows that, whilst the absolute number of diagnosed bovine TB increased over the years, the prevalence was constant (0.9%) between 1996 – 1998. It went up to 1.5% in 1999. The overall prevalence for the period (1996 – 1999), however, was 1.1% (table 5)

Table 6 : Comparison of TB in live cattle and that in slaughtered cattle

Method of diagnosis	No. of cattle	No. of TB cases	Prevalence %
Tuberculin test	384	12	3.1
Confirmed slaughter house cases	5140	55	1.1

As can be seen from table six, 12 (3.1%) out of 384 cattle tested were positive. Out of 5140 cattle slaughtered 55 were positive.

4.3 RISK FACTORS FOR ZOONOTIC TB

From the interview of twenty (20) herdsmen using a checklist, the following information was gathered.

Table 7: **Risk factors for bovine TB infection**

Question/Statement	No. interviewed	Response: yes		Response: no	
		no.	%	no.	%
1. Do you milk your cows?	20	20	100	-	-
2. Do you consume unpasteurized /untreated milk?	20	18	90	2	10
3. Do you live on the same compound with your cattle?	20	20	100	-	
4. Do the cattle you slaughter for consumption undergo ante mortem and post mortem inspection?	20	-	-	20	100

The table above (table 6) indicates that 100% of the respondents milk their cows, live in close proximity to the animals and also consume uncertified meat. Majority (90%) of the respondents consumes unpasteurized milk, while only 10% consume pasteurized milk.

CHAPTER FIVE

5.0 DICUSSION

5.1 Tuberculin test

Analysis of the data gathered show the existence of bovine TB in the Ho district, as evidenced by the tuberculin test and the slaughter records reviewed. The findings conform to expectations for developing countries, where surveillance and control of bovine TB are often inadequate or unavailable. [11]

In the study, Kalakpa cluster registered the highest prevalence of 5.9% (Table 1). Possible reasons for this observation are that:

Kalakpa cluster was where cattle rearing started in the Ho district. However, the cattle population here is not as high as in other clusters. So during the dry season when there is scarcity of grass and water in the other clusters, most cattle are brought to the Kalakpa cluster for grazing and watering. This situation is likely to provide a common ground for disease transmission, some of which is TB. This could therefore account for the high prevalence observed.

The difference in prevalence between Dawanu (3.1%) and Tevikpo (2.0%) may be due to the high stocking density in the Dawanu cluster, making it more likely to have more TB cases than Tevikpo.

Data from 384 cattle tested revealed a prevalence of 3.1%. This finding was however, lower than findings from Dangme West District which had a prevalence of 13.8% (166 positives out of 1200 cattle tested) [29]. However, the finding was more consistent with the study done at Aveyime in the Dangme East District that showed a 4% prevalence[29].

Young bulls of less than 2 years of age passed the test, while bulls, heifer and cows reacted positively to the test. The prevalence in cows was almost the same as in bulls (3.0% and 3.3%) and about 2 times higher than in heifers (3.6% and 2.0%). The prevalence was however higher in bulls than heifers about 2 times (3.3% and 2.0%). The breeds of cattle screened were West African School horn (WASH), Sanga and Ndama. Only subtle difference in prevalence was observed among them (3.3% for WASH, 2.6% Sanga, 4.8% for Ndama).

5.2 Review of slaughter record

The results of the slaughter records reviewed show an upward trend in the prevalence of TB. For the period of 1996 to 1998 the prevalence was 0.9%, and rose to 1.5% in 1999. The increase in prevalence could be due to improvement in the surveillance system for TB, availability of qualified meat inspectors leading to better diagnosis and/or better record keeping. This trend of events suggests that more cattle are being infected over time assuming that the reasons for the increase in trend remains constant. An overall prevalence of 1.1% was, however, observed for the period under review.

The study also observed that only Ho slaughter house was recording TB cases. This could mean that the personnel at the other slaughter slabs are not familiar with TB lesions, or the surveillance system does not extend to those slabs and it is also possible that the personnel are aware of the lesions and the surveillance covers those slabs yet no TB cases were observed.

Data on Kumasi slaughter house between 1996 to 1998 (a period of 3 years) showed 184 cases as being diagnosed for bovine TB out of 90,000 cattle slaughtered. This represents a prevalence of 0.2%[31]. For a period of 4 years (1996 – 1999), Ho district slaughtered 5,140 animals and diagnosed 55 TB cases, a prevalence of 1.1%[14].

Comparing the number of cattle slaughtered to the number of TB cases diagnosed at Ho and Kumasi slaughter houses, the prevalence of 1.1% for Ho district is quite high. More so, when Kumasi slaughter house slaughters cattle from the northern part of the country as well as from neighbouring countries, where TB cases have been reported to be high[31] yet it records low prevalence. This observation, however, raises an important question as to whether there is a discrepancy in diagnosis of bovine TB among these two slaughter houses or it is a true reflection for the slaughter houses?

Comparing the prevalence of TB in cattle tested to that in slaughtered cattle, then the prevalence is high for the live animals and it is in a ratio of about 3:1 to the slaughtered cattle. This difference could be due to the fact that only animals at the terminal stage of the disease which are clinically wasted are culled for slaughter, hence, the low prevalence for the slaughtered animals. On the other hand the tuberculin test detected animals which had exposure to the mycobacterium and therefore reacted positively without necessarily developing an overt disease (making it difficult to be detected by the owners for slaughter). This might probably account for the high prevalence in the tested animals to the slaughtered ones.

5.3 **Risk factor analysis**

Consumption of untreated milk, living in close proximity to the animals and eating of un-inspected meat were risk factors identified among cattle herdsmen.

Although it has been stated that Africans generally boil their milk and that the souring process destroys *M bovis*[10], other sources strongly contradicts this statement[11].

Close physical contact between humans and potentially infected animal was present in some communities in developing regions[10]. Cattle in many African countries are an integral part of human social life, they represent wealth, and are at the centre of many events and therefore gatherings[26]. Public health effects remains alarming with the inseparable association of human's life with animal husbandry.

CHAPTER SIX

6.0 CONCLUSION

The study gives an important clue to the prevalence and distribution of bovine TB in Ho district. A prevalence of 3.1% for the tuberculin test and 1.1% for slaughtered cattle.

Risk factors for human infection with *M. bovis* were shown to include:

- Consumption of unpasteurized milk.
- Living in close proximity to cattle.
- Consumption of contaminated meat.

In view of these risk factors, its likely *M. bovis* might be implicated in some human TB cases.

In general, TB in cattle is said to be low when the prevalence is less or equal to 5%[30]. Prevalence of bovine TB in Ho district as observed by the study is therefore low.

No matter how small the prevalence is, it is an indicator for the existence of bovine TB. The potential importance of these findings for public health suggests that high priority should be given to studies on zoonotic TB.

6.1 RECOMMENDATIONS

The District Agricultural Development Unit (DADU) should:

- Implement the test -and -slaughter policy to control the disease in the district.

- In addition, slaughterhouse surveillance and trace back programme of tuberculous animals to herds of origin could be undertaken.
- Prevention of spread of infection (feeding calves with only tubercles free products) and avoidance of further introduction of the disease (avoiding common grazing and drinking grounds) could be used to prevent new infections in cattle.
- Efforts should be made to identify widelife reservoir of infection in the district.
- Collaborate with stakeholders in the industry to control bovine TB.
- Educate herdsmen and the general public on the need to pasteurize milk before consumption and always consume certified meat.
- Intensify its meat inspection activities.

The National headquarters of the Ministry of Food and Agriculture should:

- Make tuberculin testing a national affair and compulsory.
- Procure antigens for the test.
- Provide incentives for cattle owners who would participate in such programmes.
- Collaborate with the Ministry of Health to undertake a study into zoonotic tuberculosis.

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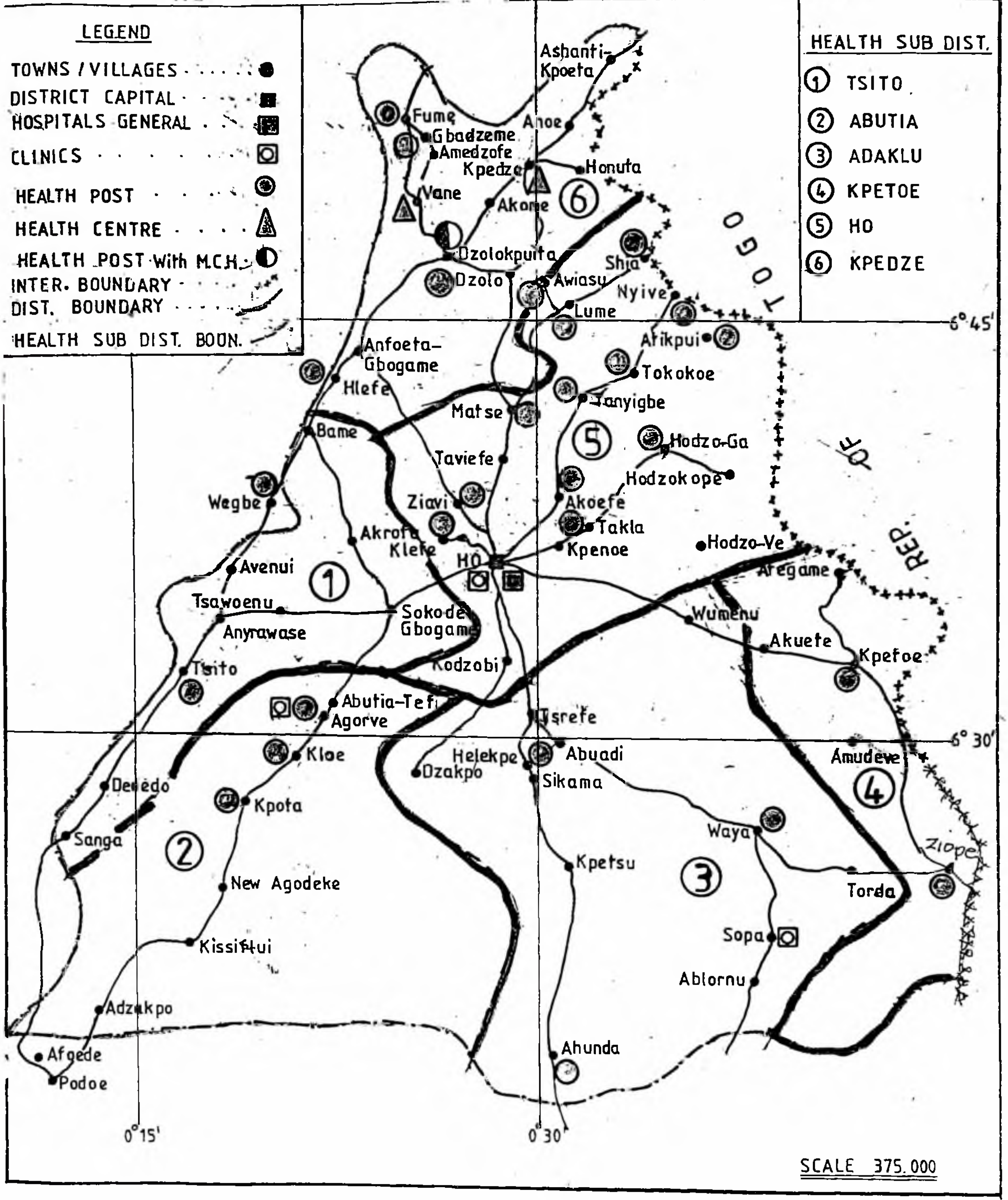
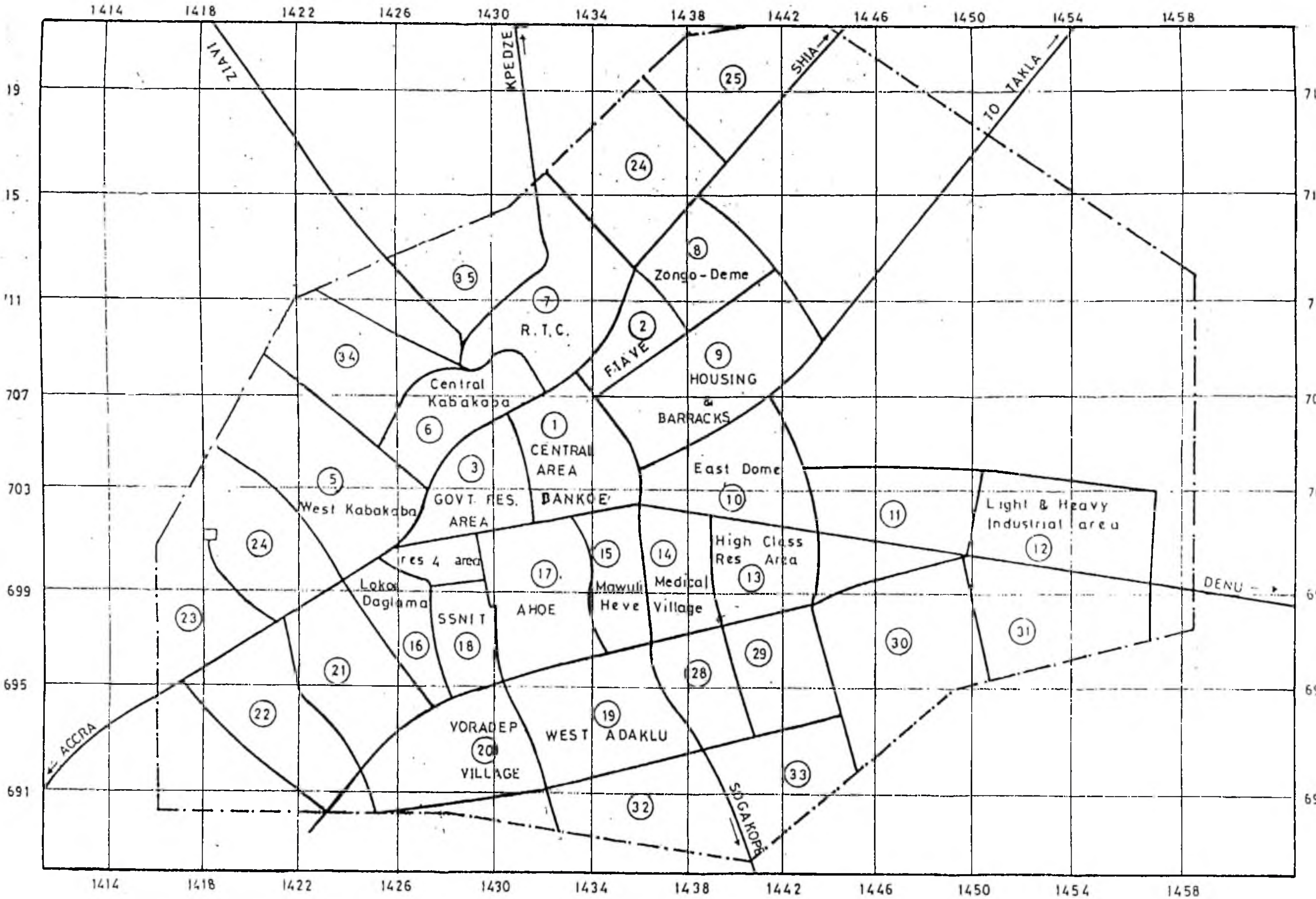
HO DISTRICT HEALTH FACILITIES V/R





Source: Town & Country Planning Department Volta Region

Appendix 3

ESTIMATED HUMAN TUBERCULOUSIS AND HIV-ATTRIBUTABLE TUBERCULOUSIS CASES IN 1990,1995, AND 2000 BY REGION									
REGION	[redacted]	[redacted]	[redacted]	1995			2000		
	TB Cases	Rate[a]	HIV-attributed	TB Cases	Rate	HIV-attributed	TB Cases	Rate	HIV-attributed
Southeast Asia	3,106,000	237	66,000	3,499,000	241	251,000	3,952,000	247	571,000
Western Pacific[b]	1,839,000	136	19,000	2,045,000	140	31,000	225,5000	144	68000
Africa	992,000	191	194,000	1,467,000	242	380,000	2,079,000	293	604000
Eastern Mediterranean	641,000	165	9,000	745,000	168	16,000	870,000	168	38000
Americas[c]	569,000	127	20,000	606,000	123	45,000	645,000	120	97000
Eastern Europe[d]	194,000	47	1,000	202,000	47	2,000	210,000	48	6000
Industrialised Countries[e]	196,000	23	6,000	204,000	23	13,000	211,000	24	26000
Total TB Cases	7,537,000	143	315,000	8,768,000	152	738,000	10,222,000	163	1410000
Attributed to HIV			4.20%			8.40%			13.80%
Increase since 1990				16.30%			35.60%		

a Rate: incidence of new cases per 100,000 population.

b Western Pacific Region of WHO except Japan, Australia and New Zealand.

c America Region of WHO, except USA and Canada.

d Eastern European countries and independent states of the former USSR.

e Western Europe, USA, Canada, Japan, Australia and New Zealand.

Appendix 4

Human tuberculosis due to *Mycobacterium bovis* in industrialised Countries

	CASES			
COUNTRY	**YEARS**	**No.**	**% Of Total TB**	**Pulmonary (%of total *M. bovis*)**
Australia	1970-1994	240	0.43-3.1	71.6[a]
England	1977-1990	232	1.2	40.0
Germany	1975-1980	236	4.5	73.7
Ireland:				
Rural	1986-1990	17	6.4	70.6
Urban	1982-1985	9	0.9	88.8
New Zealand	1983-1990	22	7.2	31.8
Spain	1986-1990	10	0.9	50.0
Sweden	1983-1992	96	2.0	0
Switzerland	1994	18	2.6	0
US	1954-1968	6	0.3	33.3
US	1980-1991	73	3.0	52[b] 12[c]

a Overall percentage includes 80.6% males and 51.2% females

b Adults

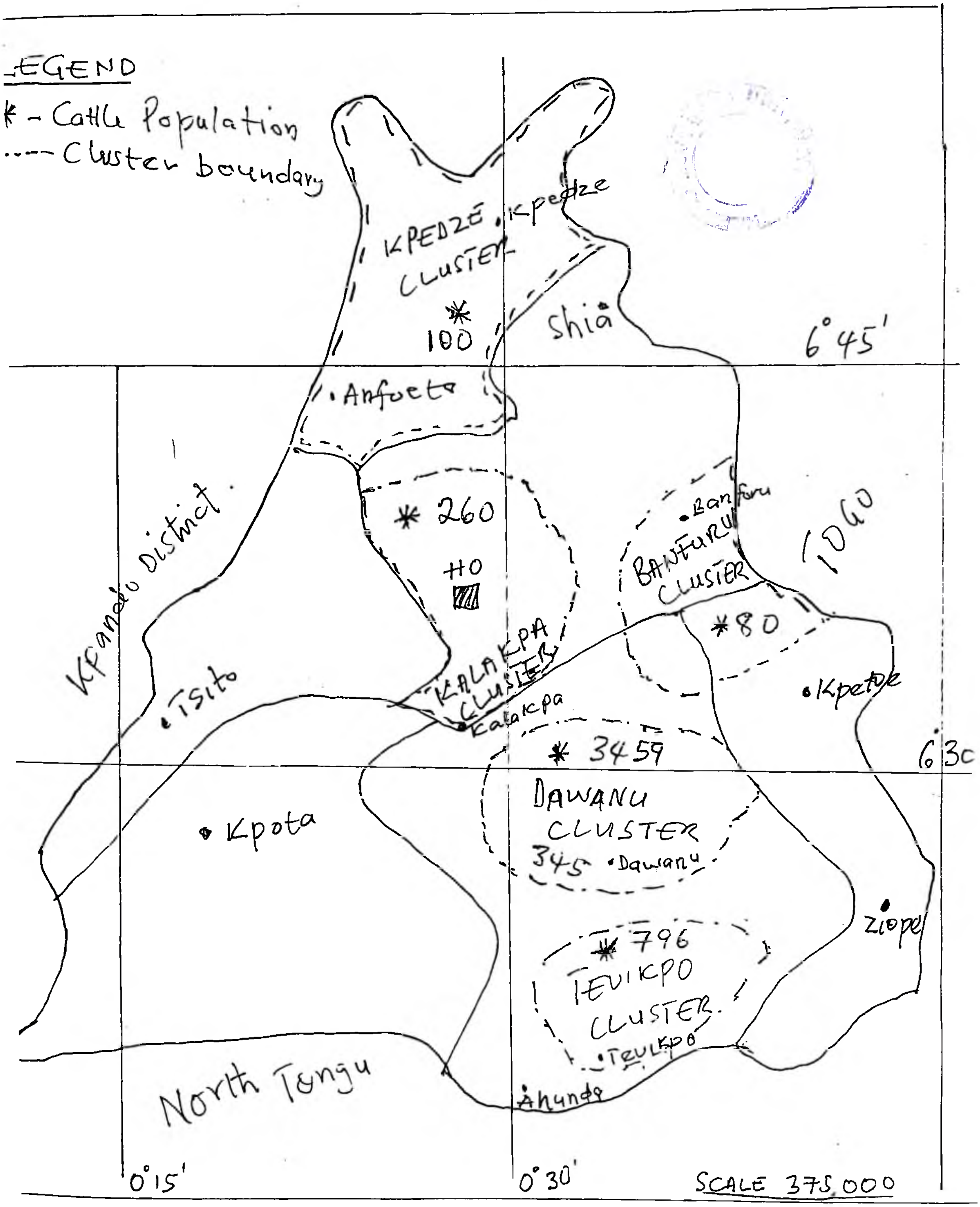
c Children

Appendix 5

Isolates from suspected extrapulmonary tuberculosis patients, Tanzania 1994

Occupation	**No of samples**	***M. tuberculosis***	***M. bovis***	**negative**
Livestock keeper	4	0	2	2
Farmers	6	2	1	3
Children	3	2	1	0
Unknown	6	3	0	3
Total	19	7	4	8

MAP SHOWING THE CLUSTERS AND CATTLE POPULATION



Appendix 7

Sample frame (based on 1997 Rinderpest census)

Village	Cluster	Name of cattle owner	Number of cattle
Kalakpa	Kalakpa	Alhaji Ali	156
Kalakpa	Kalakpa	Samfo Fuseini	22
Sokode	Kalakpa	Dr Sonu	82
Total			260
Agbokofe	Bafuru	M. Mamudu	19
Banfuru	Banfuru	I. Sambo	53
Afegame	Banfuru	O. Gali	8
Total			80
Bangel	Dawanu	Issa Mukaila	120
Bangel	Dawanu	Alhaji Kure	537
Bangel	Dawanu	Issa Gbadegbe	107
Bangel	Dawanu	Alhaji Ali	413
Dawanu	Dawanu	Abudulai Immoro	475
Dawanu	Dawanu	Ibrahim Boye	175
Dawanu	Dawanu	Alhaji Amadu	475
Dawanu	Dawanu	Alhaji Kure	142
Dawanu	Dawanu	Anani Amenya	77

Dawanu	Dawanu	Hamani Fulani	207
Dawanu	Dawanu	Gariba Immoru	383
Dawanu	Dawanu	Braima Nyako	95
Dawanu	Dawanu	Sambo Fulani	84
Dawanu	Dawanu	Henry Agrikpa	103
Dawanu	Dawanu	Alhaji Musa	66
Total			3459
Tevikpo	Tevikpo	Nukpese Anani	67
Tevikpo	Tevikpo	Besa Avordi	57
Tevikpo	Tevikpo	Richard Agbeli	4
Tevikpo	Tevikpo	Sumana Fulani	53
Tevikpo	Trevikpo	Ezhlor Adzakli	44
Tevikpo	Tevikpo	Dawudu Amadu	28
Tevikpo	Tevikpo	Braima Dzerigo	6
Tevikpo	Tevikpo	Kwasi Hotor	62
Tevikpo	Tevikpo	Adamu Amadu	63
Tevikpo	Tevikpo	Anai Agbetey	10
Tevikpo	Tevikpo	Hogo Amadu	402
Total			796
GRAND TOTAL			4595

Appendix 8

Results of the tuberculin test

Village	Cattle owner	No. tested	Positive reactors	False positives	cluster
Kalakpa	Alhaji Ali	34	2	0	Kalakpa
Agbokofe	M . Amadu	14	0	1	Agbokofe
Bangel	A Kure	80	3	0	Bangel
Bangel	A .Ali	47	1	0	Bangel
Dawanu	A.Imoro	64	2	0	Dawanu
Dawanu	H Fulani	20	0	0	Dawanu
Dawanu	G . Imoro	33	1	0	Dawanu
Dawanu	I .Boye	15	1	0	Dawanu
Dawanu	H .Agrikpa	18	1	0	Dawanu
Dawanu	A .Musa	9	0	0	Dawanu
Tevikpo	B.Avordi	8	0	0	Tevikpo
Tevikpo	A. Amadu	12	0	0	Tevikpo
Tevikpo	H. Amadu	30	1	0	Tevikpo
Total		384	12	1	

Appendix 9

Checklist of risk factors for zoonotic TB

Question	yes	No
Do you milk your cows?		
Do you consume unpasteurized milk?		
Do you live on the same compound with your cattle?		
Do the cattle you slaughter undergo ante mortem and post mortem inspection?		

Appendix 10

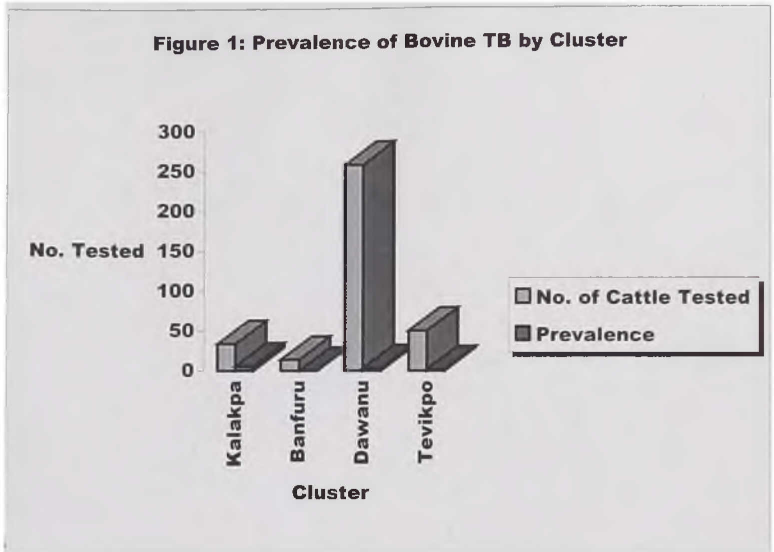


Figure 1: Prevalence of Bovine TB by Cluster
No. Tested
300
250
200
150
100
50
0
Kalakpa
Banfuru
Dawanu
Tevikpo
Cluster
No. of Cattle Tested
Prevalence

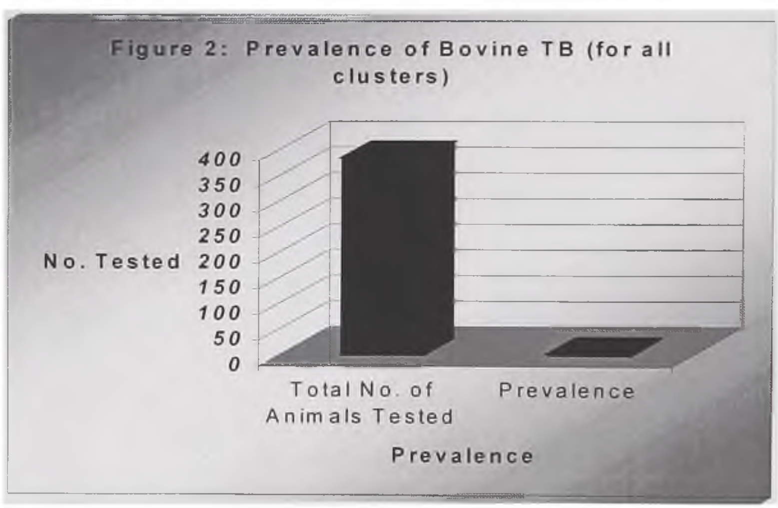


Figure 2: Prevalence of Bovine TB (for all clusters)
No. Tested
400
350
300
250
200
150
100
50
0
Total No. of Animals Tested
Prevalence
Prevalence