POTENTIAL HEALTH RISKS ASSOCIATED WITH URBAN LIVESTOCK FARMING IN NAKURU MUNICIPALITY: A CASE OF BOVINE TUBERCULOSIS AND AFLATOXICOSIS.

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

To Njehu's family

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LIST OF ABBREVIATIONS

AIDS: Acquired Immunodeficiency Syndrome

ATPPD: Avian Tuberculin Purified Protein Derivative

BTB: Bovine Tuberculosis

BTPPD: Bovine Tuberculin Purified Protein Derivative

DFID: Department for International Development.

FAO: Food and Agriculture Organization

FGD: Focus Group Discussion

GoK: Government of Kenya

HIV: Human Immunodeficiency Virus

HTB: Human Tuberculosis

ICRI: International Cancer Research Institute

LD: Lethal Dose

MTC: Mycobacterium Tuberculosis Complex

OIE: Office International des Epizooties

PCC: Population Crisis Committee

PPD: Purified Protein Derivative

rRNA: ribosomal Riboxy Nucleic Acid

SCITT: Single Comparative Intradermal Tuberculin Test

UA: Urban Agriculture

UN: United Nations

UNDP: United Nations Development Programme

UPA: Urban and Peri-urban Agriculture

USD: United States Dollar

WHO: World Health Organization

ABSTRACT

The high rate of urbanization following rural-urban migration and natural population growth has led to increased food demands, more than the rural production systems can handle. The high population has also led to an acute shortage in employment especially in the formal sector. As one of the coping strategies, the urban dwellers have opted to agriculture, which involves both crop and animal production. Despite the benefits associated with urban and peri-urban agriculture, there are risks such as zoonotic disease infection (bacterial, viral, parasitic and protozoal), associated with the practice. These endanger not only the lives of the farmers but also the public in general.

In this study, focused group discussions (FGD) and household survey were carried out to assess knowledge, attitude and farmers' perception on health hazards associated with urban livestock farming in Nakuru Municipality. The single comparative intradermal tuberculin test (SCITT) was performed on 97 heads of cattle to determine the apparent prevalence of bovine tuberculosis (BTB) and 117 milk samples collected for detection of aflatoxin M1 in milk using the Charm Sciences (USA) Aflatoxin Test kit. Cattle were the main livestock kept in majority 83 % (n=202) of the sampled households followed by poultry.

The most important benefits of rearing livestock identified included livestock as a source of employment, income, nutrition, security and provision of manure. There were gender difference in ranking and scoring of the major benefits in the various study sites.

Generally, the farmers had limited knowledge on the risks associated with livestock keeping. The only zoonotic conditions participants in the FGD could associate with livestock keeping were rabies and brucellosis. When asked to prioritize diseases in order of importance, 46.6% of the

respondents gave brucellosis the first priority, 14.7% anthrax, 8.6% intestinal worms and 4.3% bovine tuberculosis (BTB). Seven percent could not associate any disease with urban livestock keeping.

Thirty four percent of the respondents in the household survey were aware that cattle could be infected with *Mycobacterium bovis* and 67% could associate raw/inadequately cooked or boiled milk and meat with BTB. Responding to the question on the precautions taken against BTB infection, most of the farmers either did not know or did not take any.

Results from FGDs and corroborated by the household study showed that farmers were generally aware of aflatoxin poisoning in humans. None of the participants in the FGD had heard of the condition in animals while 18% from the household survey were aware animals could pass the toxin to human. Only a few participants in the FGD and 58% of the respondents in the household survey could associate the condition in human to consumption of incompletely dried/moldy maize. Sixty eight percent of the respondents in the household survey either did not take or did not know of any precautionary measure against aflatoxin poisoning.

Seventeen of the 97 heads of cattle reacted positive to the tuberculin test giving an individual animal apparent prevalence of 17.5%. Six of the 117 milk samples (5.1%) tested positive to AFM1 residues.

With the limited knowledge of the study population and with the presence of BTB reactors in the animal population and AFM1in milk, it was concluded that there is need to educate the farmers and the general public on the health hazards associated with livestock keeping. There is need to review the BTB status in the country and establish the significance of *M.bovis* in the rising incidence of human tuberculosis. Presence of AFM1 in milk warrants closer inspection of animal feeds, through surveillance and control of feed quality during feed processing and distribution.

CHAPTER ONE

1.0 INTRODUCTION

Although there are variations in scholar's definition of Urban and Peri-urban agriculture (UPA), the practice is characterized by two main features. First, it involves the production of crops and livestock and secondly, it is exercised within the city boundaries or at the periphery of urban centers. Adopting Mougeot's (1994) definition. UPA refers to the production of food and non-food plant and tree crops, and animal husbandry both within (intra-) and around (peri-) the urban areas.

The farming systems common in UPA include horticulture, floriculture, aquaculture, agro-forestry and animal husbandry. These activities are either carried out in small plots where households tend to use their land for crop production/raising animals for household consumption or entrepreneurial/commercial gardens where the goods produced are for retail as well as wholesale marketing (Muchaal, 2002). An estimated 800 million people are engaged in urban agriculture worldwide and of these, 200 million are considered to be market producers (Mougeot, 2000; UNDP, 1996).

The high global population growth rate is the key to increased agricultural production. This has impacted positively on the growth of UPA. About 50% of the world's population lives in towns and this has been projected to rise to over 60% by the year 2030 (United Nations, 2002). African cities have registered a rapid growth and the population of city dwellers is expected to double by 2025 (United Nations, 2002). Likewise in East African countries, a high rate of urbanization, 6-8 per cent, has been registered, in the last four decades. Kenya being among Africa's most rapidly urbanizing nation the urban population had been projected to rise up to 8.6 million (i.e. twenty five percent of the total population) by the year

2000 (Lee-Smith and Memon, 1994). This rapid urban growth could be attributed to the increase in both national population growth and rural to urban migration. The most affected cities include Nairobi and Mombasa, however the medium and smaller cities, including Nakuru, Kisumu, and Kakamega, have recently also become destinations for an increasing number of migrants from the rural areas (Lee-Smith and Memon, 1994).

Rural agricultural production alone cannot meet the growing urban population food demands. Importation of food, to meet the deficit, is constrained by the stagnating economy. In order to meet the ever-increasing food demands, especially vegetables and animal products (eggs, meat, milk and milk products), there are initiatives to improve food production through crop irrigation, increased level of agricultural inputs and intensive management of livestock especially dairy animals (Cosivi *et al*., 1998). Smit (1996) predicted that in the year 2005 urban agriculture would be contributing ¼ to ⅓ of world food produced i.e. ½ of vegetables, meat, fish and dairy products consumed in the cities. The population growth in urban areas thus leads to creation of market opportunities not only for agricultural but also non-agricultural goods and services. Consequently, there is increased entrepreneurism and transformation of the local economy from sleepy agrarianism to bustling, dynamic, free market economy, small-scale industry and commercialized agriculture (Maxwell *et al*., 1998).

Despite these developments, urban agriculture is likely to increase the potential exposure of human health to hazards arising from agricultural practices. Such practices include mishandling of agrochemicals, application of untreated or improperly treated solid and liquid wastes to food crops leading to possible contamination with pathogens and heavy metals. Unsafe disposal of agricultural and animal wastes increases the risk of zoonotic diseases transmission (Mougeot, 2000).

Urban and peri-urban agriculture, therefore, not only presents benefits but also challenges (risks) for environmental health, impacting urban farmers, neighbors and the consuming public.

This study was aimed at assessing the potential heath risks associated with urban livestock farming in Nakuru Municipality. The specific objectives of the study were to:

1. Identify the community perceptions on selected health risks associated with livestock farming in Nakuru Municipality.

2. Determine the presence of aflatoxin M1 in milk from dairy cattle in Nakuru Municipality.

3. Estimate the apparent prevalence of bovine tuberculosis in Nakuru Municipality.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 URBAN AGRICULTURE

Urban Agriculture (UA) has been defined as an industry located within (intra-urban) or on the fringe (peri-urban) of a town, an urban centre, a city or metropolis, aiming at growing or raising, processing and distributing a diversity of food and non-food products (Mougeot, 1999). The practice utilizes human and material resources, inputs and services found in and around urban areas, and in turn supplies human and material resources, outputs and services largely to the urban area.

Urban agriculture has for a long time been an integral part of urban household economies in many developing nations and its sustainability and viability depends largely on its integration within the urban ecosystem. Urban food production in many cases has been described as a coping strategy by the urban poor, as a response to inadequate, unreliable and irregular access to food supplies due to unavailability or lack of purchasing power, or inadequate access to formal employment (Anon. 2001). However, currently there is diversified involvement of the various socio-economic groups in both industrialized and developing countries (Smit *et al.*, 1996).

The rapid growth of urban agriculture in the past few decades has made significant contribution to the food requirements of cities (Henning, 1997). The United States recorded a growth rate of 17% between 1980 and 1990, while Japan recorded a 60% increase in the families participating in Consumer Supported Agriculture within the same time duration (Smit, 1996).

Urban food security largely depends on the rural agricultural production. However, with the rapidly increasing urban population, poor food delivery and distribution in the urban centers as result of poor infrastructure, lack of refrigeration and ineffective market chain, UPA tends to increase.

The scope of urban and peri-urban food production varies from place to place. These variations can be attributed to factors such as the country's and household's economic status, cultural aspects which dictates their need, and the kind of crops that are grown. This is further influenced by infrastructure and availability of inputs, climate, soil and water. Horticulture, staple crops and livestock farming are the main components of UA and they contribute to the improved household welfare through good nutrition and provision of revenue. Crops grown include vegetables, maize, beans, millet, sugar cane, bananas, sweet potatoes and yams (Mireri *et al.*, 2006).

In the livestock farming industry, apart from subsistence production, commercial peri-urban livestock keeping is an extremely fast-growing sector, contributing 34% of total meat and 70% of egg production worldwide (Anon. 2001). The main livestock reared include, poultry, shoats, dairy cattle, pigs and rabbits. In a study by Nasinyama and Randolph (2005), chicken were the most important livestock kept in Kampala in terms of providing food security and income generation followed by cattle, pigs, goats, rabbits and turkeys. Similar livestock trends were found in urban Kenya, however, most of the livestock kept were for sale although products such as meat, milk and eggs were consumed by the households (Lee-Smith et *al.*, 1987). In Nakuru, Kenya 75% of the population are farmers with majority practicing mixed farming. One-fifth of the population keeps livestock mainly cattle, shoats and poultry (Foeken and Owuor, 2000).

Urban farming is undertaken by two categories of people, the traditional farmers who have been engulfed by urban development following changes in urban land boundaries including areas that are predominantly rural in character, and the recent urban migrants (Lee-Smith and Memon, 1994). The farmers include both men and women but women have been shown to represent the majority of urban farmers as reported in some cities in Kenya (Lee-Smith and Memon, 1994), Zimbabwe (Hungwe, 2006), Uganda (Musiimenta, 2002), Tanzania (Mireri *et al.*, 2006; Sawio, 1994) and Lusaka (Sawio, 1994). This could be attributed to the fact that women are the key household caretakers ensuring household food security and in addition, urban food production offers opportunities to be integrated into other household activities. Generally, men are reported to be more educated than women occupying the better part of the formal sector while women take the substantially lower jobs or seek other alternatives such as the small- and micro-scale food production (Hungwe, 2006). Where men are involved, they tend to concentrate in commercial food production (Jacobi *et al.*, 2000).

The weight of UA as a factor of urban population growth has been statistically demonstrated by UNDP (1996) which has projected that over 800 million people will be involved in UA by the year 2020 globally and 200 million of the 500 million urban dwellers in Africa will be doing so in the urban centers (Ayaga *et al.*, 2005). A report by Lee-Smith and others (1987) showed that about two thirds of urban households in Kenya grow part of their food and 29% of these households do so on urban land. In Ghana, people living in and around the urban centers were reported to raise 25% of the 4.5 million small ruminants' population (Baah, 1994). The importance of UA in providing food security and non-market access to food for the urban households cannot be over emphasized and the problem of matching food supplies and food needs, especially for an urban population, is a source of social, economic and political concern.

Food insecurity grows as the share of household budget, which must be spent on food, rises and the fewer the household's alternatives to buying food the more it will be food insecure. Hunger resulting from either food insufficiency or food insecurity plagues a lot of urban slum dwellers. People's Crisis Committee (PCC, 1990) for instance, estimated that in 23 of the least developing countries metropolitan centers, 50% of their populations were spending up to 80 % of their income on food. Thirty four percent of 189 surveyed households in Bamako in 1983 spent 32-64% of their average income on food and cooking while 80% of urban families in India spent up to 70% of their income on food (Mougeot, 1994). In Kenya poor urban households spend 40-50% of their income on food and cooking fuel alone (Lee-Smith *et al.*, 1987).

Urban agriculture is estimated to engage 800 million urban residents in income generating and/or food producing activities worldwide (Mougeot, 2000). While it may be viewed as informal, UA was ranked second largest employer in Dar es Salaam, following the small trader business (Mireri *et al.*, 2006). In Kumasi (Ghana) where farming is done throughout the year, farmers are reported to earn between USD 400-800 that is twice as much the income of the rural farmers (Danso *et al.*, 2002). Ritter and Robicheau's (1988) reported that, agriculture provided the highest self-employment earnings in small-scale enterprises in Nairobi (Kenya) and the third highest earnings in all of urban Kenya. Lee- Smith *et al.*, (1987) estimated that Kenya urban farmers produce crops and livestock worth USD $ 4 and 17 million annually, respectively, Urban agriculture, therefore, not only uplifts the household's financial status, but also largely contributes towards the entire nation's economy.

In addition to aforementioned benefits, UPA provides emergency supplies of food especially in times of severe scarcity and enhances accessibility of perishable foods by the urban consumers, therefore, increasing overall variety and food nutritional value. In studies done in Harare. Kampala and Nairobi urban agriculture has been shown to improve nutritional status of household members, as measured by caloric and protein intake, meal quality, or children's growth rates (Mougeot, 2000). There is improved access to consumer markets, implying less need for packaging, storage and transportation of food. Urban farming also creates opportunities for waste recycling and re-use and contributes to preservation and improvement of biological diversity by integrating it in the ecosystem. (Henning, 1997).

Despite the benefits attributed to UA, the risks of injury to health and environmental pollution are greater than those for rural agriculture for two reasons. First, the urban farming systems are more intensive, and secondly they are practiced in close proximity to the dense human population. These risks could be attributed to (1) increased agricultural inputs and poor disposal of agricultural waste (2) hazardous agricultural practices e.g. use of raw/inadequately treated sewage and (3) close human-livestock interaction. Of importance is the danger of toxic contamination from agricultural chemicals (fertilizers and pesticides) used in both crop and livestock production, soil and water pollution, noise, odors from livestock wastes and diseases (Flynn, 1999).

A spectrum of diseases and disease agents in livestock and livestock products pose risks to human health (communicable, food borne and zoonotic diseases). Livestock provide meat and milk for urban farmers and general consuming public. However, urban livestock are important since animals are raised in close proximity to the residential houses. In addition, 90% of milk produced in sub-Saharan Africa has been reported to be consumed raw (without undergoing pasteurization) with only a small proportion following the official marketing channels (Cosivi *et al*., 1995). Tuberculosis and brucellosis are examples of zoonooses which may result from close contact with the animal/animal tissues and/or consumption of contaminated animal products, such as milk.

Poor animal husbandry practices such as negligence during milking and handling of milk can lead to contamination of milk with pathogenic organisms from the animal's immediate environment. Cryptosporidiosis, campylobacteriosis, non-typhoidal salmonellosis and *E. coli* O157:H7 are some of the important diarrhoeal conditions associated with fecal contamination of animal products such as milk and meat, and water sources (Muchaal, 2002). In addition to agricultural runoff, poor sanitation in the urban areas seen as inadequate sewerage system and leaking septic tanks increases the risk of contaminating drinking water. Use of raw or inadequately treated sewage in agriculture could also act as a source of enteric pathogens (Viral, bacterial, protozoal and helminths).

Zoonotic parasitic conditions such as taeniasis and cysticercosis (beef and pig tapeworm), transmitted through consumption of inadequately cooked meat from animals having ingested tapeworm eggs while scavenging on human fecal material, pose a risk to the general public. These conditions are also associated with poor sanitation, a problem common in informal settlements. In addition, poor agricultural practices such as lack of protective clothes, mishandling of animal products and failure to observe the withdrawal periods following drug administration predisposes not only the animal handlers but also the public to health hazards.

Shortage of land as a result of changes in land tenure system and lack of future needs prospects during urban planning and development (Lamba, 1993) has also increased the risk of health hazards. In a study carried out in Nairobi, farming was shown to commonly occur in private residential land (32%), roadside land (29%), along the riverbanks (16%) and other publicly owned areas (16%) (Mougeot, 1994). Livestock are confined to zero grazing due to lack of grazing land while fodder is sourced from outside and are supplemented with concentrates. A few are left to roam and scavenge at the dump sites where the farmer has no control over the feed quality (Zarina, 2006). These limitations not only threaten the successful development of urban livestock keeping, but also endanger the health of the farmers living in close proximity to the animals and the general public. Increased use of concentrates, as a remedy to feed scarcity, is likely to lead to contamination of milk with mycotoxins which increases the risk of human poisoning.

2.2 HEALTH RISKS PERCEPTION

Urban agriculture has both negative and positive effects on the health and environmental conditions of the urban population. The negative effects are important and need to be addressed as they put the health of the urban farmers at risk. Some of the health risks associated with UPA include contamination of crops with pathogenic organisms or heavy metals due to irrigation with water from polluted streams or inadequately treated wastewater or organic solid waste. There is also the risk of zoonotic diseases transmission during husbandry, processing or consumption of infected animal products (Flynn, 1999). For most farmers, the perception of risks (which is the subjective assessment of the probability of a specified type of accident happening and how concerned farmers are with the consequences), and benefits of UA are centrally tied to their livelihoods (Kilelu, 2004).

While knowledge, attitude and practices in regard to health risks related to livestock keeping may play a role in the spread of zoonotic diseases (Mfinunga *et al.*, 2003a), differences in perceptions along the gender lines, socio-economic groups and cultural background may place certain groups at higher risk than others. Flynn (1999) points out the importance of gender dimension in understanding health hazards as a result of involvement at different levels in socio-economic activities. Women, for instance, have been observed to represent the majority of urban farmers in some cities and, therefore, their role as producers as well as family health care providers explains the gender disaggregation in knowledge of health hazards and preventive measures. Likewise, the division of labour in farming activities may expose men to risks that women may not encounter and vice versa. A recent study in Dagoretti,, Nairobi (Kenya) concluded that knowledge levels influenced perceptions and behaviour of men and women towards risks associated with dairy farming (Kang'ethe *et al.*, 2005). Women were found to have lower formal education than men and lacked knowledge on the hazards investigated in the study. For instance, only 32% of the women knew existence of bovine tuberculosis compared to 42% of men in the division. The study further reported that there was generally low knowledge on the health risks associated with urban livestock keeping, and less than half of the respondents perceived themselves at risk of exposure to health hazards while 63% sensed they could protect themselves from the health risks.

In Arusha, Tanzania Mfinunga and co-workers (2003b) revealed that 40% of the study population practiced habits that might expose them to bovine and human tuberculosis, for example, eating raw or inadequately cooked animal products. Although knowledge of the disease was limited in all the tribes, two out of the four sampled tribes practiced such habits more. Overall 75% of the study population had poor knowledge of tuberculosis, its transmission and prevention (Ibid).

2.3 BOVINE TUBERCULOSIS

2.3.1 Introduction

Bovine tuberculosis (BTB) is a classical direct zoonosis, potentially transmitted through contact with ruminants and consumption of improperly treated dairy products. The disease is characterized by progressive development of specific granulomatous lesions or tubercles in the lung tissue, lymph nodes or other organs. Bovine species, including bison and buffaloes, are susceptible to the disease, but nearly all warm-blooded animals can be affected. All species are not equally susceptible to the disease; some are spillover (end) hosts and others maintenance hosts (Ayele *et al.*, 2004).

In Africa BTB primarily affects cattle, but infection of other farm and domestic animals, such as sheep, goats, pigs, dogs and cats, is not uncommon. Wild ruminants and carnivores are also affected and are the natural reservoirs of the infectious agent in the wild. Man is also susceptible to the disease, the highest risk groups being individuals with concomitant HIV/AIDS infection (Ayele *et al.*, 2004).

In Africa, human tuberculosis (HTB) is widely known to be caused by *Mycobacterium tuberculosis* while an unknown proportion of cases are due to *M. bovis.* Human infection with *M. bovis* is underreported as a result of the diagnostic limitations of many laboratories in distinguishing *M. bovis* from *M. tuberculosis.* This may be due to the extensive use of microscopy in confirmation of suspected cases, a technique that does not permit differentiation between species of mycobacteria.

The HTB incidence and mortality was estimated at 88 million and 30 million respectively by the World Health Organization from 1990–1999, with most cases occurring in developing countries (Anon, 1994). The annual global incidence of HTB had been predicted to increase to 10.2 million by 2000, a 36% increase from 1990. In 1995, 3.3 million cases were reported to the WHO Global Tuberculosis Program. Of these, 62% occurred in the South-east Asian and Western Pacific regions, 16% in sub-Saharan Africa, and 7–8% in America, Eastern Mediterranean and Europe. Given the rapidly spreading global HIV pandemic in developing countries, the WHO estimated that 70% (6 million) of humans co-infected with TB and HIV would be in sub-Saharan Africa (Cosivi *et al*., 1998).

In industrialized countries, BTB is controlled on farm and as a result human infection is minimized although potential risk remains. In Africa, however, BTB represents a potential health hazard to both animals and humans, as nearly 85% of cattle and 82% of the human population live in areas where the disease is prevalent or only partially controlled (Anon. 1994a).

In Africa M.*bovis* infection remains an uninvestigated problem. For this reason, the WHO, with the participation of FAO, convened a meeting on zoonotic BTB in November 1993 in Geneva, Switzerland, where the public health significance of *M. bovis* in humans and animals worldwide was discussed. Data collected from most developing countries, mainly from sub-Saharan Africa, was insufficient to represent the true epidemiological picture of the disease. There was, therefore, the recommendation that collection of scientific data on HTB due to *M. bovis* be prioritized (Anon. 1994b).

The epidemiology of TB has been affected in recent decades by the upsurge in HIV infection. As many HIV-infected individuals are co-infected with TB, the incidence of the disease may rise in the coming years (Zumla *et al*., 1999). The correlation between the prevalence of *M.*

bovis infection in humans and that in local cattle populations highlights the potential threat of this disease for humans (Daborn *et al*., 1996).

2.3.2 Etiology

Bovine TB is caused by *M. bovis,* a member of the closely related group of mycobacteria referred to as *Mycobacterium tuberculosis* complex (MTC) which comprises of *M. tuberculosis*, *M. africanum*, *M. microti* and *M. bovis* bacilli Calmette-Guérin as well as the newly characterized bacteria *M. canetti (*Van Soolingen *et al*., 1997) and *M. caprae comb.* nov., sp. nov (Aranaz *et al*., 2003). *M.tuberculosis, M. africanum* and *M. canetti* are exclusively human pathogens while M. *microti* is a rodent pathogen. Although cattle are considered to be the primary hosts of *M. bovis*, the pathogen has an exceptionally wide mammalian host range, which includes humans (Blood and Radostits, 1989; O'Reilly and Daborn, 1995).

Mycobacteria other than MTC have been implicated in the cause of atypical or non – tuberculus TB. These include *M. avium* complex, *M. kansasii*, *M. scrofulaceum* and *M. simiae* among others (Todd *et al*., 2004). These mycobacteria are not obligate pathogens but are true inhabitants of the environment. They can be found as saprophytes, commensals and the symbionts. They are normal inhabitants of a wide variety of of environmental reservoirs, including water, soil, aerosols, protozoans, animals, and humans (Todd *et al*., 2004).

Mycobacterium tuberculosis complex bacteria are usually regarded as subspecies and are characteristically 99.9% similar at the nucleotide level and have an identical 16S rRNA sequences (Brosch *et al*., 2002). However, in addition to their varying host range and pathogenecity, there are distinct phenotypic differences between the subspecies. *M. bovis* closely resembles *M. tuberculosis*, and precise identification of and distinction between the two can be established by biochemical (Table 1), and molecular biology techniques. Isolates with biochemical characteristics intermediate between *M. tuberculosis* and *M. bovis* have also been reported (Kallenius *et al*., 1999).

Table 1: Differential biochemical characteristics of the *Mycobacterium tuberculosis* complex (Aranaz *et al*., 2003)

Characteristic	*M.tuberculosis*	*M. bovis*	*M.africanum*	*M.microti*	*M.caprae*
Niacin accumulation	+	-	V	+	-
Nitrate Reduction	+	-	-	-	-
TCH	R	S	S	S	S*
Pyrazinamide	S	R	S	S	S

Key:

S=sensitive

R= resistant

V= variable test results; +, positive test results; -, negative test results

*, Resistant to 1-2ug of 2-thiophenecarboxylic acid hydrazide TCH ml^{-1} but sensitive to 5 and 10ug of 2-thiophenecarboxylic acid hydrazide TCH ml^{-1}.

In most developing countries. Lowenstein-Jensen medium, a medium on which *M. bovis* may grow poorly or not at all under poor growth temperature (optimum temperature, 35-37°C) and time (optimum incubation period, 6-8 weeks), is commonly used for the isolation of *M.*

tuberculosis. Inoculated media are often incubated insufficiently for *M. bovis* cultures to appear. This may help to explain the low number of bovine type HTB cases reported in developing countries (Ayele *et al.*, 2004). The medium usually contains glycerol that enhances growth of *M. tuberculosis* but inhibits the growth of *M. bovis*. Thus, pyruvic acid is added to the medium as enrichment for the mycobacterium

2.3.3 Bovine tuberculosis global situation

The prevalence of *M. bovis* in the developed countries is low following the stringent control measures in place (Teklu *et al.*, 2004). The scenario, however, is different in the developing countries where BTB is present in almost all African countries, (Anon, 1994) affecting both domestic and wild animals. Daborn and Grange (1993) reported that the disease was prevalent in 33 (80%) of 43 African member countries of the regional commission of the OIE (now the World Organization for Animal Health, WOAH)

The global prevalence of HTB due to *M. bovis* has been estimated at 3.1%. This accounts for 2.1% and 9.4% of pulmonary and extra-pulmonary TB cases respectively (Cosivi *et al.*, 1998). In industrialized countries, HTB due to *M. bovis* is relatively rare as a result of TB control in cattle. Nevertheless, an estimated 1% of all TB cases in industrialized countries are reported to be caused by *M. bovis*, probably due to reactivation of dormant lesions among the elderly (Ayele *et al.*, 2004). In Australia, for instance, *M bovis* was responsible for less than 1.5% of cases of TB in the Australian population during 1970-1994, and most of these cases were apparently due to reactivation of infection acquired through occupational exposure (Cousins and Dawson, 1999). In developing countries, and Africa in particular, HTB due to M. *bovis* is rarely reported and this has been attributed to the non-specific diagnostic methods commonly used.

2.3.4. Prevalence of *Mycobacterium bovis* in sub-Saharan Africa

2.3.4.1 Livestock

Although BTB in cattle is widespread in Africa, some member states fail to report the annual prevalence and incidence of the disease to the OIE, while others tend to report the disease sporadically, at intervals of several years. Generally, there is lack of reliable field survey data on animal diseases in Africa and where such data exists, there are large variations that cannot be explained by epidemiological data only. For instance in 1993, only 5 countries reported the presence of BTB at herd level i.e South Africa, Algeria, Morocco, Ghana and Madagascar. Most of these figures originated from records of slaughtered animals mainly young bulls (Benkirane, 1998).

While *M. bovis* has been reported to be endemic in Uganda and Ethiopia (OIE, 1992; Tecklu *et al.*,, 2004), Kenya had been known to be free of BTB following official government reports from reviews by FAO/WHO/GoK experts in the 1960's (Myers and Steele, 1969). However, a recent report by Kangethe and others (2005) shows an apparent prevalence of 10% cattle reactors in Dagoretti, Nairobi. Positive cattle reactors have been reported in Burkina Faso (13%), and in the Lake Victoria area of Tanzania, (0.2%) (Vekemans *et al.*, 1999; Jiwa *et al.*, 1997).

2.3.4.2 Game animals

In countries where BTB has been eliminated, wild and feral tuberculous animals constitute a serious risk of re-infection for domestic animals (Cousins, 2001). Woodford (1982) found *M. bovis* in warthog (*Phacochoerus aethiopicus*) and buffalo (*S. caffer-sparrman*) in the Ruwenzori National Park in Uganda.

In Kenya, information on wildlife infection with *M. bovis* is scanty. Tarara and others, (1985) confirmed two cases of BTB in a wild troop of baboons in Masai Mara Game Reserve. Later, Sapolsky and Else (1987) reported an outbreak of *M. bovis* in a population of feral baboons in Mtito Andei, Kenya.

Bovine TB is now a particularly serious problem in South Africa's Kruger National Park, where the disease was diagnosed for the first time in an African buffalo in 1996 (Bengis *et al*., 1996). In the same year, Keet and co-workers (1996) reported BTB in a cheetah, two lions and a baboon (*Papio ursinus*) from the same park. They are assumed to have contracted the disease directly or indirectly from tuberculus buffaloes. Tuberculus granulomatous lesions in the lungs were extensive and constituted the predominant changes in all three animal species.

The continuing geographical spread of the disease to animal species such as kudu (*Tragelaphus strepsiceros*), baboons (*Papio* sp.), lions (*Panthera leo*), cheetah (*Acinonyx jubatus*) and leopards (*P. pardus*) living in the parks at free range is a matter of serious concern as these species may act as maintenance hosts of the infection (Zieger *et al*., 1998). From a conservation point of view, BTB should be considered a potential threat to endangered wildlife species.

2.3.4.3. Human

Although the majority of HTB infections are due to *M. tuberculosis*, largely undetermined proportions result from infection by *M. bovis*. In Africa, approximately 1-5% of positive cultures from human cases have proved to be *M. bovis* (Cosivi *et al*., 1998).

In sub-Saharan Africa, where nearly two (2) million TB cases occur each year, it is unknown what role cattle derived *M. bovis* plays in the epidemic of HTB (Daborn, 1992). However, there is substantial evidence of significant transmission of *M. bovis* in pastoral communities with close human-to-livestock contact (Mposhy *et al.*, 1983). In Sahelian countries, for example, there are large communities in which no livestock screening for BTB is conducted and people are exposed to direct contact with animals and consume unpasteurised milk and milk products.

In Nigeria, Idigbe and co-workers (1986) found *M. bovis* in 4% of patients with lower respiratory tract symptoms. Hoffner and others (1993) isolated and biochemically characterized *M. tuberculosis* and *M. bovis* in humans in Guinea-Bissau. In Burkina Faso, Vekemans and co-workers (1999) have retrospectively analysed the TB registers of Bobo Dioulasso, which correlated prevalence of cattle-related TB in ethnic groups. In Ethiopia M. *bovis* has been isolated from 17.1% cases of tuberculus lymphadenitis (Kidane *et al.*, 2002). In Madagascar, a proportion of *M. bovis* (1.25%) was observed among sputum smear-positive patients and among extra-pulmonary TB patients (1.3%) (Rasolofo-Razanamparany *et al.*, 1999). Kazwala and others (1998) emphasized that non-tuberculosis complex mycobacteria are a danger to human health in countries such as Tanzania, where the number of people with impaired immunity due to HIV/AIDS infection is growing. Most TB cases in Africa of HIV/AIDS patients are due to exogenous re-infection rather than reactivation of endogenous *M. tuberculosis* Ledru *et al.*, (1999). Considering the association of HIV/AIDS with TB in humans, similar risk may occur in individuals exposed to infection with *M. bovis* (O'Reilly and Daborn, 1995).

2.3.5 Reservoirs

Mycobacterium bovis has a wide host range affecting both wild and domestic animals. The organism has been isolated in North American bison (*Bison bison*), buffaloes (*Syncerus caffer*), elk (*Cervus elaphus*), domestic and wild pigs (*Sus scrofa*), goats (*Capra hircus*), camels (*Camelus bactrianus*), dogs (*Canis familiaris*), cats (*Felis catus*), sheep (*Ovis aries*), possums (*Trichosurus vulpecula*), badgers (*Meles meles*), mink (*Lutreola vison*), ferrets (*Putorius furo*) and non-human primates (Blood and Radostits, 1989; Keet *et al*., 1996). All species are not equally susceptible, and are often grouped into spill-over (end) hosts and maintenance hosts.

Cattle and other bovine species are considered the primary and most well known reservoirs or maintenance hosts. In countries where maintenance hosts are present endemically in the wild, infection from these populations to domestic cattle or other farm animals is difficult to avoid (Ayele *et al*., 2004).

2.3.6 Milestones in eradication of BTB

Many factors, majority of which are politico-economic, account for the failure of developing countries to control and eradicate BTB. These factors include, the high costs of sustainable testing programme, social unrest resulting from political instability and ethnic wars leading to the displacement of large numbers of both human and animal populations. Additionally, inadequate veterinary expertise and communication networks, insufficient collaboration with bordering countries, lack of quarantine and smuggling of live animals across state boundaries have heightened the problem (Ayele *et al*., 2004).

The epidemiology and public health significance of BTB in Africa remain largely unknown, often because of the above reasons. In addition, few laboratories are capable of differentiating *M. bovis* from *M. tuberculosis* and other members of the MTC. The primary source of infection for humans is the consumption of unpasteurised milk and close association between humans and animals (Yates *et al.*, 1993). *M. bovis* is generally known to be destroyed by boiling or the souring process (Walshe *et al.*, 1991),but Minja and others (1998) have shown the organism to persist in soured milk for up to 14 days. This fact puts at risk the rural inhabitants and some urban dwellers in Africa who still consume unpasteurised and soured milk which may be potentially infected with *M. bovis*. Milk-borne infection is the main cause of extra-pulmonary TB in areas where BTB is common and uncontrolled (Daborn *et al.*, 1996).

The current problem of *M. bovis* in developing countries may to some extent mimic the pre-eradication period in Europe before the 1960s, where the prevalence of BTB in the human population was relatively high (Pavlik *et al.*,, 2002). Lee and Mills (2000) underscored the urgent need to develop and build scientific capacity in developing countries to improve health worldwide and curb the global spread of infectious diseases, and cited poor governance, planning, accountability and failure to conduct research as the main obstacles to controlling this global disease

2.3.7 Occurrence

M. bovis is a robust pathogen and may survive in the environment, in buildings, on transport vehicles, on pasture and in slurry. In temperate climate, the organism has been reported to survive in cow faeces for more than 5 months in winter, 4 months in autumn, 2 months in summer, and in soil for up to 2 years (Wray, 1975). Manure fertilization of arable land is a common practice in developing countries and the survival of *M. bovis* in soil and slurry thus, may pose as a potential source of infection to animals and humans.

2.3.8 Transmission

Inhalation of *M. bovis* is the most probable and principal route to bovine infection and is facilitated by close, prolonged contact between infected and healthy animals. Ingestion of *M. bovis* directly from infected animals or from contaminated pasture, water or utensils may also be very common in some regions. While congenital infections and vertical transmission have been recorded, these routes, like genital transmission, which occurs when reproductive organs are infected (Neill *et al.*, 1994), are now rarely seen in regions that have intensive eradication programmes.

2.3.8.1 Animal-to-animal transmission

Infected animals may shed *M. bovis* in a number of ways: in faeces, milk, discharging lesions, saliva and urine (Neill *et al.*, 1991). Intensive livestock farming promotes close contact between animals, favoring the spread of *M. bovis.* Extensive livestock farming, however, especially transhumance with no housing system raises the question as to how BTB transmission can take place. Close contact between animals occurs for example at watering points such as ponds, wells and streams. In Africa, grazing animals usually group together as a coping strategy at night for protection from predators. Vaccination and artificial insemination centers, dipping tanks, auction stations, market places and transportation are the commonest animal gathering places, and again are sites where transmission could easily occur. Due to the high ambient temperature in tropical zones, animals tend to concentrate under trees or other shaded areas for parts of the day, preferring to graze early in the morning and late in the afternoon. Extensive farming is safer than zero level grazing systems to prevent disease transmission.

2.3.8.2 Animal-to-human transmission

Some epidemiological conditions for the spread of *M. bovis* infection between animals and humans are very similar in Africa today to those in Europe in the 1930s and 1940's, with the added and potent impact of the epidemic of human immunodeficiency virus infection (Cosivi *et al.*, 1995).

Pulmonary TB due to *M. bovis* is more common in rural areas as a result of inhalation of dust particles or bacteria-containing aerosols shed by infected animals, while in urban areas people acquire the infection via the gastrointestinal route and develop extra-pulmonary TB (Daborn *et al.*, 1996; Cosivi *et al.*, 1998).). However, close contact with animals due to limited space predisposes the urban farmers and non-farmers to infection by *M. bovis* via pulmonary system. In countries with a relatively high prevalence of BTB in cattle, abattoir and farm workers are the groups most exposed to infection. Current economic and social globalization has created greater opportunities for the spread of zoonotic diseases such as TB.

2.3.8.2.1 Human risk factors of *Mycobacterium bovis* infection

2.3.8.2.1.1 Close contact

Human pulmonary TB due to *M.bovis* represents 2.1% cases of human tuberculosis cases worldwide (Cosivi *et al.*, 1998). *M bovis* transmitted through aerosol/air droplets of infected animals predisposes people in close contact with the animals to the infection. About 65% of African, 70% of Asian, and 26% of Latin American and Caribbean populations are involved in the agricultural industry, and thus a significant proportion of the population in these regions may be at risk for bovine TB (Cosivi *et al*., 1998). Included in this category of risk exposure are the urban livestock farmers, who confine their animals to their residential houses, and the animal handlers.

2.3.8.2.1.2 Consumption of raw/unpasteurized animal products

About 9.4% of the global human extra pulmonary TB cases have been attributed to *M.bovis* (Cosivi *et al*., 1998). Contaminated milk and milk products are the principle mode of transmission of TB from animals to human. Approximately 90% of milk produced in sub-Saharan Africa is consumed unpasteurized (Omore *et al*., 1999). This is the population at great risk of infection. *M. bovis* has been isolated in 2.9% of 241 samples of raw milk in Ethiopia. Nigeria and Egypt have also reported presence of *M. bovis* in milk samples (Cosivi *et al.*, 1998).

Cultural practices such as consumption of raw animal products (meat, milk, or blood), traditionally fermented milk prepared from raw milk are factors that increase the risk of infection with *M. bovis.* In a study by, Mfinunga and others (2003) in Tanzania for instance, 18% of respondent interviewed ate uncooked meat/meat products and significantly high proportion drank raw milk.

2.3.8.2.1.3 Immunosuppression

Immunogenically compromised individuals due to diseases such as HIV/AIDS and aflatoxin poisoning are predisposed to infections by opportunistic pathogens. Tuberculosis is the most frequent opportunistic disease associated with HIV infection. Approximately 9 million cases of human tuberculosis occurred worldwide in 1990's and 10% of these were infected with HIV (Laval and Ameni, 2004).

The role of *M.bovis* in human tuberculosis in Africa is important because 90% of the population live in areas where neither pasteurization nor BTB control programmes occur (Laval and Ameni, 2004). Furthermore, 95% of the world's AIDS cases occur in the developing countries and 70% of all these cases are in sub-Saharan Africa (Anon, 2001). In Europe and North America, up to 0.5% and 1.0% cases of human tuberculosis, respectively, are estimated to be caused by *M. bovis*. The mycobacterium has been isolated from HIV-infected persons in industrialized countries. In France *M. bovis* infection accounted for 1.6% of TB cases in HIV-positive patients (Cosivi *et al*., 1998).

2.3.8.3 Human-to-animal transmission

Sjögren and Hillerdal (1978) cited several examples of human-to-cattle transmission, and stressed the potential danger that patients with smear-positive pulmonary TB due to *M. bovis* may pose a risk of infection to animals (Daborn and Grange, 1993). However, reports of cattle infection from human sources are rare (O'Reilly and Daborn, 1995). The genitourinary tract in humans is a site of non-pulmonary TB due to *M. bovis*. This route may appear to be of little importance to epidemiologists in studying human infection, but this route of infection from human to cattle is well documented (Ayele *et al*.,2004). In urban areas where animals are left to roam and scavenge for feed, they may be predisposed to risks of infection from pastures contaminated with *M.bovis* from urine of people infected with urogenital BTB. Grange and Yates (1994) reported that farm workers urinating in cowsheds might represent a source of infection for animals. An analogous situation is thought to occur in rural Africa, where patients with genitourinary TB may urinate on pasture and animals craving salt preferentially graze on this grass and may succumb to infection.

2.3.8.4 Human-to-human transmission

Human tuberculosis caused by *M. bovis* as a result of human -to- human transmission was reported in Netherlands in 1994 (van Soolingen *et al*., 1994). Evidence of transmission of *M. bovis* between humans is considered rare and largely anecdotal, and the rate of transmission seems insignificant compared to animal-to-animal or animal-to-human infection (O'Reilly and Daborn, 1995). Human-to-human transmission of *M. bovis* is considered less efficient than that of *M. tuberculosis* (van Soolingen, 2001), however, transmission among HIV-infected humans, where immunosuppression increases the susceptibility of the host organism to infection, may be different. *M. bovis* has been isolated from HIV-infected individuals with an additional serious complication of high primary resistance to isoniazid, streptomycin and pyrazinamide (Guerrero *et al*., 1997).

2.3.9 Pathogenesis

Although there are numerous ways in which cattle can become infected with *M. bovis*, they can be influenced by animal age and behavior, environment and climate, and prevailing farming practice (Pollock and Neill, 2002). Under natural conditions, the main route of *M. bovis* infection in cattle is by inhalation. This mode of transmission is dominant in industrialized countries, where intensive farming is practiced. In field case studies of BTB in these countries, lesion distribution and pathology show predominant involvement of the upper and lower respiratory tract and associated lymph nodes. Neill and others (1994) and Whipple and co-workers (1996) confirmed tuberculin reactors frequently appear to have an absence of lung lesions; however, lesions when present within the lung parenchyma are usually too small, less than a centimeter, to be easily detected during meat inspection (McIlroy *et al*., 1986).

A generally accepted concept is that infection with *M. bovis* can become established in cattle by inhalation of tubercle bacilli, possibly a single bacillus, in an aerosol droplet (Neill *et al*., 1991) that lodges within the respiratory tract, probably the alveolar surface of the lung (Pritchard, 1988). Bacilli are phagocytosed by macrophages, and subsequently interact with cells involved in innate and acquired immune responses in tissue or draining lymph nodes. This often results in nonvascular nodular granulomas known as 'tubercles'. Characteristic tuberculous lesions occur most frequently in lungs and retropharyngeal, bronchial and mediastinal lymph nodes. Lesions can also be found in the mesenteric lymph nodes, liver, spleen, serous membranes, pleura and other organs (Blood and Radostits, 1989; Neill *et al*., 1994).

The characteristic lesion caused by *M. bovis* in cattle is described as having a centre of caseous necrosis, usually with some calcification, with a boundary of epithelioid cells, some of which form multinucleated giant cells and few to numerous lymphocytes and neutrophils (Neill *et a*l., 1994). Primary lesions in cattle, unlike in human, are rarely contained by the immune response, and dissemination from a lesion may occur by natural ducts such as bronchi, by lymphatic spread or by haematogenous spread when massive milliary tubercles occurs.

2.4. Diagnosis

Tuberculosis can be diagnosed clinically, but usually only in the later stages of the disease. The diagnostic techniques available include:

2.4.1 The intradermal tuberculin skin test (TST)

This is a universally recognized test and is generally used for preliminary diagnosis in BTB control programmes (OIE, 2004). It involves measuring the skin thickness, injecting bovine tuberculin intradermally into the measured area and measuring any subsequent swelling at the site of injection three days later. The sensitivity and specificity of tuberculin tests range from 68-95% and 96-99% respectively (Monaghan *et al.,* (1994). The sensitivity of the test is affected by the potency and dose of tuberculin administered the interval post-infection, desensitisation, deliberate interference, post-partum immunosuppression and observer variation. Specificity is influenced by sensitization as a result of exposure to *M. avium*, *M. paratuberculosis* and environmental mycobacteria (Monaghan *et al*., (1994).

The comparative intradermal tuberculin test is used to differentiate between animals infected with *M.bovis* and those sensitized to tuberculin by other mycobacteria (OIE, 2004; Blood and Radostit, 1989). Ameni and co-workers (2000) estimated the sensitivity and specificity of this test at 90.9% and 100% respectively.

2.4.2 Identification of the agent

This involves the demonstration of acid fast bacilli by microscopic examination and the isolation of mycobacteria on selective culture media and their subsequent identification by cultural and biochemical tests or DNA probe and PCR techniques (OIE,2004). Animal inoculation is slightly more sensitive than culture, but should only be used when histopathology lesions are compatible with mycobacteriosis infection and isolation in culture is negative.

2.4.3 Blood-based laboratory tests

Diagnostic blood tests are available and they include:

2.4.3.1 The lymphocyte proliferation assay

This is an in-vitro assay that compares the reactivity of the peripheral blood lymphocytes to tuberculin PPD (PPD-B) and a PPD from *Mycobacterium avium* (PPD-A) (OIE, 2004). Results are usually analyzed as the value obtained in response to PPD-B minus the value obtained in response to PPD-A. The B-A value must then be above a cut-off point that can be altered in order to maximize either specificity or sensitivity of the diagnosis. The test is relatively expensive and time consuming and, therefore not used for routine diagnosis of BTB.

2.4.3.2 The gamma-interferon assay

The assay is based on the release of gamma-interferon from sensitized lymphocytes during a 16-24-hour incubation period with specific antigen (PPD-tuberculin). The test makes use of the comparison of gamma-interferon production following stimulation with avian and bovine PPD (Neill *et al.*, 1994). The quantitative detection of bovine gamma-interferon is carried out with a sandwich ELISA that uses two monoclonal antibodies to bovine gamma-interferon (OIE, 2004). The test is considered to have a high sensitivity compared to skin test, but it has proven to be less specific in a number of trials.

2.4.3.3 The enzyme-linked immunosorbent assay

The test can be used as a complement to other tests based on cellular immunity. The sensitivity and specificity are limited in cattle, mostly due to the late and irregular development of the humoral immune response in cattle during the course of the disease (OIE, 2004).

2.5 AFLATOXINS

2.5.1 Introduction

2.5.1.1 Mycotoxins

Mycotoxin, broadly, refers to a group of secondary metabolites produced by filamentous fungi essentially belonging to *Aspergillus, Penicillium and Fusarium* genera, which when ingested by animals or human may cause disease (Pittet, 1998). Mycotoxins can be formed on crops in the field, during harvest, or during storage, processing or feeding. Mold growth and production of mycotoxins usually, are associated with extremes in weather conditions leading to plant stress or hydration of feedstuffs, poor storage practices, low feed quality, and inadequate feeding conditions. The FAO estimates that about 25% of crops worldwide are affected annually by mycotoxins (Whitlow and Hagler, 2005).

There are over 800 different mycotoxins showing a large variety of chemical structures. These are produced by over 150 species of fungi most of which belong to the class imperfecti (Jarvis, 1989). Almost all of these mycotoxins are relatively heat stable, of low molecular weight and are capable of interfering with vital metabolic functions at very minute doses. This results in many different adverse biological effects, which include acute toxicity, mutagenicity, carcinogenicity, teratogenicity, (Rustom, 1996).

Mycotoxins that are important in causation of natural outbreaks in domestic animals are few and Table 2 summarizes the major toxigenic fungi and the mycotoxins thought to be the most prevalent and potentially toxic to dairy cattle. However, aflatoxins are the most prevalent and dangerous of these toxins (Williams, *et al.*, 2004).

Table 2: Major toxigenic fungi and mycotoxins considered be prevalent and potentially toxic to dairy cattle (Whitlow and Hagler, 2005)

Fungal Genera	Mycotoxins
Aspergillus	Aflatoxin, Ochratoxin, Sterigmatocystin, Fumitremorgens, Fumitoxins, Fumigaclavines, Cyclopiazonoic acid, Gliotoxin
Fusarium	Deoxynivalenol, Zearalenone, T-2 Toxin, Fumonisin, Moniliformin, Nivalnol, Diacetoxyscirpenol, Butenolide, Neosolaniol, Fusaric Acid, Fusarochromanone, Wortmannin, Fusarin C, Fusaproliferin
Penicillium	Ochratoxin, PR Toxin, Patulin, Penicillic Acid, Citrinin, Penetrem, Cyclopiazonic Acid, Roquefortine, Isofumigaclavines A and B, Mycophenolic Acid
Claviceps	Ergot alkaloids
Epichloe And Neotyphodium	Ergot alkaloids
Stachybotrys	Stachybotryotoxins, trichothescenes

2.5.1.2 Aflatoxins

Aflatoxins are a family of extremely toxic, mutagenic and carcinogenic compounds produced by *Aspergillus flavus* and *Aspergillus parasiticus* and occur as natural contaminants of agricultural products. Four different aflatoxin isomers, B1, B2, G1 and G2, belonging to the group of bisfurano-coumarin compounds have been identified according to their fluorescence characteristics under ultra violet light and their separation on thin layer chromatography (Bennett and Klich, 2003). The B and G aflatoxins are produced by all toxigenic *A.*

parasiticus isolates whereas most *A. flavus* produce the B1 and B2 (Anon, 1982; Bennett and Klich, 2003).

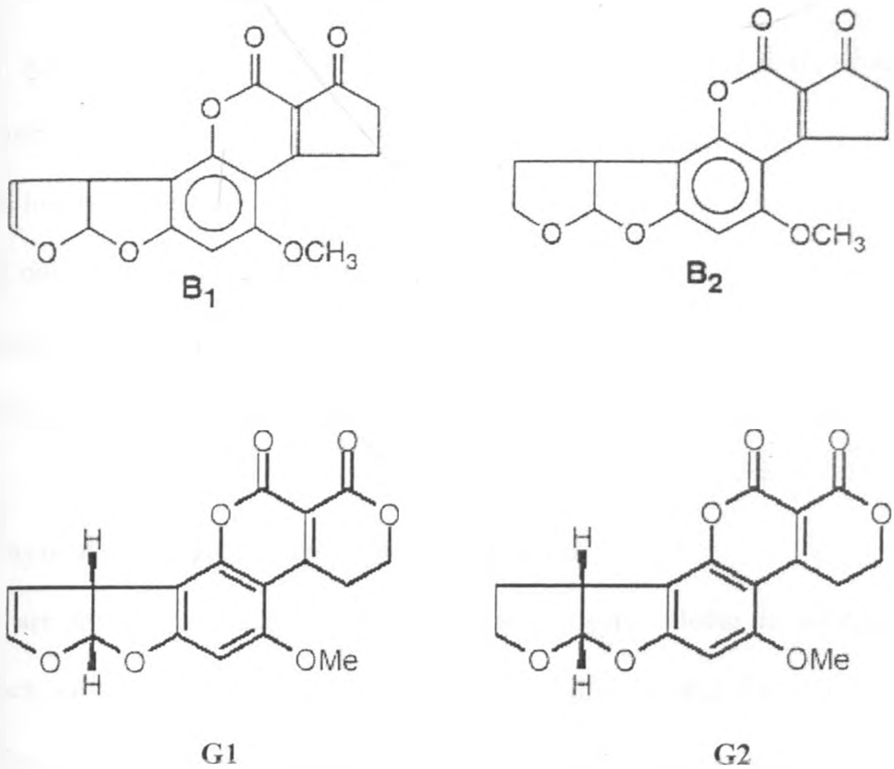


Figure 1: Structure of aflatoxin B1, B2, G1, and G2 (Reddy and Waliyar, 2000)

Aflatoxins were discovered in the 1960s following an outbreak of an acute hepatotoxic disease in animals in many areas of the world. The condition was referred to as "Turkey X disease" and was characterized by acute loss of appetite, lethargy and weakness of the wings, acute hepatic necrosis, and marked bile duct hyperplasia in affected birds (Cullen and Newbern, 1994). The disease led to the deaths of more than 100,000 young poults in England. Similar outbreaks were also reported in Kenya and Uganda (Roebuck and Maxuitenko, 1994) where birds died within a week. At autopsy, hemorrhages in the liver, necrotic hepatic lesions and frequently swollen kidneys were characteristic. Histopathological lesions included degeneration of liver parenchyma and extensive proliferation of bile duct epithelium.

Studies by Asplin and Carnaghan (1961) led to the discovery of the toxic agent that was found in both Brazilian and East African groundnuts. Ducklings used as test animals were found to be highly susceptible to the toxic agent. The toxins vary in their toxigenic potential but hepatic damage and hepatic cell carcinoma are central to injury imposed. Aflatoxin B1 has been shown to be the most toxic, carcinogenic, hepatotoxic, potentially mutagenic, and also the most prevalent of the aflatoxins (Roebuck and Maxuitenko, 1994).

2.5.1.2.1 Physical and chemical properties of aflatoxins

Aflatoxins are crystalline, slightly soluble in water, freely soluble in moderately polar solvents such as chloroform, methanol and dimethyl sulfoxide and insoluble in non-polar solvents. They are unstable when exposed to oxidizing agents, UV light, or solutions with a pH below 3 or above 10. They fluoresce under UV radiation into either blue for aflatoxin B series or yellow-green for aflatoxin G series. They decompose at their melting points (Table 3) and are not destroyed under normal cooking temperatures. They are completely destroyed by autoclaving in the presence of ammonia and bleach (Anon, 1982).

Table 3: Summary of the physical and chemical properties of aflatoxins (Reddy and Waliyar, 2000)

Aflatoxin Type	Molecular Formula	Molecular Weight	Melting Point(°C)
AFB1	$C_{17}H_{12}O_6$	312	268-269
AFB2	$C_{17}H_{14}O_6$	314	286-289
AFG1	$C_{17}H_{12}O_7$	328	244-246
AFG2	$C_{17}H_{14}O_7$	330	237-240
AFM1	$C_{17}H_{12}O_7$	328	299
AFM2	$C_{17}H_{14}O_7$	330	293

2.5.2 Occurrence

The Aflatoxigenic fungi are cosmopolitan and production of aflatoxins varies with geographical and seasonal factors depending on the conditions under which crops are grown, harvested and stored (Williams *et al.*, 2004; Gathumbi, 2001). Some differences exist in the general pattern of their occurrence. *A. flavus* is common in the temperate regions and the spores occur more in the air than in the soil, while *A. parasiticus* is more adapted to the tropical regions with the spores being found more in the soil than in air (Gathumbi, 2001).

Aflatoxins have been found in oil seeds/meals (groundnuts, cottonseed, copia, sun flower and soya beans), cereals (maize, sorghum, pearl millet, rice, wheat), treenuts (pistachio, Brazil nuts, almonds, walnuts, coconut pecans and filberts), spices (chilli, black pepper, coriander, tumeric, ginger) crude vegetable oils, fruits like figs and dairy products (CAST. 1989)

2.5.3 Growth requirements

Fungal invasion and contamination often begin before harvest and can be promoted by production and harvest conditions (Williams *et al.*, 2004). The growth of mold and the production of aflatoxins are influenced by environmental factors in the field and during storage when conditions are favorable. The crop genotypes, drought, soil types and insect activity are important in determining the likelihood of pre-harvest contamination. Studies have shown that water activity, relative humidity, temperature, light and pH affect aflatoxin production (Williams *et al.*, 2004). The aflatoxin-producing mold is traditionally considered to be a storage mold and aflatoxin contamination can, therefore, be prevented by proper storage of the cereal crops.

Diener and Davis (1969) established moisture content of 13-18% in equilibrium with a relative humidity of 85% (water activity 0.85) as the lower limit for growth of *A. flavus* and for production of aflatoxins. The temperatures favorable for aflatoxin production range between 12-42°C and the optimum is 28-30°C (Rustom, 1996). The evidence of mold on a commodity is not necessarily indicative of aflatoxin contamination, but neither does the absence of visible mold growth assure freedom from aflatoxin contamination. Thus, finding the toxigenic mold can only be a presumptive indication of aflatoxin contamination. However, analytical determination must be undertaken to establish the presence of toxins.

2.5.4 Aflatoxicosis

Aflatoxicosis appears to have existed for a considerable time prior to the epizootic outbreak in Britain in 1960. Around 1950's, cattle, pigs and dogs died in the USA from a non-infectious, hepatotoxic disease (Cullen and Newbern, 1994). The disease in swine and cattle was associated with moldy feeds and in all documented outbreaks in dogs, the peanut meal used as a protein supplement was implicated as the source of poisoning.

Outbreaks of hepatitis in human and dogs occurred in India due to aflatoxicosis, where toxic hepatitis was associated with the consumption of heavily aflatoxin-contaminated maize (Krishnamachari *et al*., 1975). In Kenya between July and October 1978, canine deaths due to aflatoxicosis were reported from Nairobi, Mombasa, Malindi, Eldoret and Nakuru (Price and Heionen, 1978). Analysis of different commercially prepared dog feed revealed high aflatoxin levels. The toxic effect of aflatoxin in animal rations, as well as in purified form, has been demonstrated in many animal species. Ducklings, rainbows trout, guinea pigs, pigs, rabbits, dogs and turkeys are highly susceptible to aflatoxins with sheep being found the most resistant of the animal species tested. In general, aflatoxin B1 is more toxic to young animals than old and more toxic to females than males (Krishnamachari *et al*., 1975; Williams *et al*., 2004). The lethal action of aflatoxin ranges from cell necrosis, cirrhosis and hepatocellular carcinoma.

2.5.4.1 Acute aflatoxicosis

Acute toxicity is caused when large doses of aflatoxins are ingested. Acute toxicity as assessed by LD_{50} values spans two orders of magnitude from highly susceptible species such as ducklings and rabbits to the very resistant species such as chickens (Roebuck and Maxuitenko, 1994). Within species, the LD_{50} values may vary with strain, sex, route of administration and age of the animal. Additionally, the nutritional status of the animal or the concurrent composition of the diet may modulate the acute toxicity. The acute toxicity of the naturally occurring aflatoxins (AFB1, AFB2, AFG1 and AFG2) has been evaluated in a limited number of species and the acute LD_{50} values are as shown in Table 4. AFB1 is the most toxic and carcinogenic of the four congeners.

Table 4: Acute toxicity of naturally occurring aflatoxins (Roebuck and Maxuitenko, 1994)

SPECIES	STRAIN	SEX	ROUTE[a]	WEIGHT (g)	AFLATOXIN	LD_{50} (mg/kg)
Duck	Pekin	M	i.p	50	AFB1	0.73
					AFB2	1.76
					AFG1	1.18
					AFG2	2.82
	Khaki-Campbell	-	p.o	50	AFB1	0.36
					AFB2	0.78
					AFG1	1.70
					AFG2	3.44
Rat	Fischer	M	p.o	200	AFB1	1.16
					AFB2	>200
					AFG1	1.5-2.0
					AFG2	>200

[a] i.p., intraperitoneal; p.o., per os

A few metabolic products have been evaluated for their acute toxicity and carcinogenicity and AFB1 and AFM1 have been shown to have similar toxicity in ducks and in rats (Roebuck and Maxuitenko, 1994). In the rat AFM1 is carcinogenic, but less so than AFB1. The other hydroxylated metabolites of AFB1 (AFP1 and AFQ1) are less toxic.

The aflatoxin metabolites react negatively with different cell proteins, which lead to inhibition of carbohydrate and lipid metabolism, and protein synthesis. Lipid infiltration of the hepatocytes leads to reduced liver function and cell death. In correlation with this, there is derangement of the blood clotting mechanism, icterus and decrease in essential serum proteins synthesized by the liver (Bommakanti and Waliyar, 2007). Other clinical signs include lack of appetite, weight loss, unthriftness, neurological disorders including convulsions and death. Pathological changes are most common in the liver whereby the liver is pale or discolored and hepatic sections show diffuse centrilobular necrosis with fat accumulation within the hepatocytes.

2.5.4.2 Chronic aflatoxicosis

This follows long-term exposure of moderate to low aflatoxin concentration. Accumulated evidence indicates that chronic exposure to aflatoxins more readily leads to cancer than does the acute exposure, thus chronic exposure almost certainly represents a more serious public health concern (Roebuck and Maxuitenko, 1994). The symptoms include decreased growth rate, lowered production and immunosuppression (Bommakanti and Waliyar, 2007). Immunosuppression is due to the reactivity of aflatoxins with T cells, decrease in vitamin K activities and phagocytic activity in macrophages. Chronic toxicity induces liver changes characterized by marked bile duct proliferation and periportal fibrosis leading to cirrhosis. The clinical picture is dominated by marked icterus (Roebuck and Maxuitenko, 1994).

2.5.4.2.1 Carcinogenicity

Besides being hepatotoxic, aflatoxins are also known to be carcinogenic. The risk of cancers due to exposure to the various forms of aflatoxin is well established (Gorelick *et al.*, 1993) and is based on the cumulative lifetime dose. The international center research institute (ICRI) identifies aflatoxin as a Class 1 carcinogen, resulting in the regulation of this toxin to very low concentrations in traded commodities (20 ppb in grains and 0.5 ppb in milk in the United States; 4 ppb in foods in some European countries (Williams *et al.*, 2004).

A long-term exposure to low concentrations of aflatoxin in diet of animal feeds causes development of hepatoma, cholangiocarcinoma and hepatocellular carcinoma (Newbern, 1973).

2.5.5 Epidemiological studies on effects of aflatoxins in human

2.5.5.1 Liver carcinogenesis

The prevalence and level of human exposure to aflatoxins on a global scale have been reviewed, with the resulting conclusion that approximately 4.5 billion persons living in developing countries are chronically exposed to largely uncontrolled amounts of the toxin (Williams *et al.*, 2004). Available epidemiological data, primarily from regions of sub-Saharan Africa and South East Asia support the correlation of aflatoxin ingestion and human cancer in population studies where estimates of aflatoxin intake and incidence of primary liver cancer were made (Sarin *et al.*, 2001; Turner *et al* 2002). Studies in Uganda (Alpert *et al.*, 1971), Swaziland (Keen *et al.*, 1971) and Thailand (Shank *et al.*, 1972) revealed positive indications between the frequency of aflatoxin contamination of foods at markets and in home stores, and the frequency of liver cancer in the study areas. Studies in Kenya (Peers and Linsel 1973), Mozambique (van Rensburg *et al.*, 1974) and Swaziland (Peers *et al.*, 1976) have shown positive relationship between the actual aflatoxin concentration in the meals about to be eaten and the incidence of the primary cancer in humans.

Hepatitis B (HBV) and C (HCV) virus infection is common in countries with high incidence of primary liver cancer (Sarin *et al.*, 2001; Turner *et al* 2002; Williams *et al.*, 2004). The hepatitis virus and chemical carcinogens (aflatoxins) are known to be potential risk factors for hepatocellular carcinoma in South-East Asia, Africa and other parts of the world where the carcinoma is prevalent. The cancer is more common in men with a male: female ratio exceeding three in high incidence area (Tuner *et al.*, 2002). Survival is poor with most people dying in less than a year after diagnosis.

To reduce the level of exposure to the toxic carcinogens, the allowable contamination levels of commodities destined for human consumption range between 4-30 ppb aflatoxin, depending on the country involved (Henry *et al.*, 1999). However, the carcinogenic aspect of the aflatoxins remains a major concern due to long-term cumulative exposure.

2.5.6 Risk of mycotoxin contamination of dairy feed and milk

In most developing countries, livestock production is an important part of the national economy and more importantly, of the subsistence and semi-commercial smallholder farming systems. In Kenya, dairy industry is increasingly becoming a smallholder farmers' domain. Currently, the farmers own over 80% of the 3 million heads of dairy cattle, producing about 56% of the total milk production and contributing 80% of the marketed milk (Peeler and Omore, 1997; Thorpe *et al.*, 2000).

A major obstacle facing the farmers is the chronic shortage of affordable feed in adequate quantity and quality particularly during the dry season (Lanyasunya *et al.*, 2005). Feed shortage is further complicated by farmer's inability to utilize them before spoilage especially in the wet season when there is peak production. This predisposes the feed to attack by mold. Though the prevalence and rate of colonization depend on environmental conditions and farm practices, growth of mold on raw materials and finished products is universal.

2.5.6.1 Aflatoxins in milk

Shortly after the discovery of aflatoxins as feed contaminants, Allcroft and Carnaghan (1963) suggested that aflatoxins residues might occur in milk and other animal products following ingestion of aflatoxins contaminated feedstuff (van Egmond, 1994). Aflatoxin-contaminated feed not only reduces animal performance and overall health, but also creates risks of residues in milk. Cows fed aflatoxin B1-contaminated feedstuff produced a toxin in milk with the same toxic effects in young ducklings, as did Aflatoxin B1. Using thin layer chromatography on silica gel, De Iongh and others (1964) showed that the toxic factor had a blue fluorescence similar to that of Aflatoxin B1, but had a much lower R_f value (van Egmond, 1994). He named it Aflatoxin M1. Holzapfel and co-workers (1966) found two components that could be separated by paper chromatography that were designated Aflatoxin M1 and M2 and identified as the 4-hydroxy derivatives of aflatoxins B1 and B2, respectively (van Egmond, 1994).

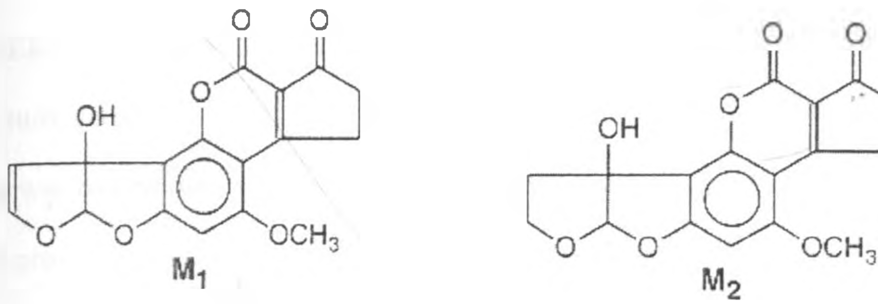


Figure 2: Structure of aflatoxin M1 and M2 (Reddy and Waliyar, 2000)

Aflatoxins are secreted in milk in the form of aflatoxin M1 with residues approximately equal to 1 to 2 percent (1.7 percent average) of the dietary level (van Egmond, 1994). The percentages vary from animal to animal, from day to day, and from one milking to the next. In addition, the quantities seem to depend on the milk yield and the lactation period. Due to risks of milk residues, dietary aflatoxin should be kept below 25 ppb. This level is conservative due to: (1) non-uniform distribution of aflatoxin in grain and feed, (2) uncertainties in sampling and analysis, and (3) the potential for having more than one source of aflatoxin in the diet. The allowable US Food and Drug Administration level of aflatoxin residues in milk is 500ppt (Henry *et al.*, 1999)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 The study area

The study was carried out in Nakuru Municipality. This is the fourth largest town in Kenya. and is the provincial headquarter of Rift Valley Province. The town is 160 km North West of Nairobi, and lies on the bed of historic geographical feature, The Great Rift Valley, and the slopes of the extinct Menengai volcano. Nakuru is situated at 2000m above sea level and at 36^0, 04′ East and at 0^0, 15′ South of the equator. Nakuru is a high potential area with a bimodal pattern of rainfall.

In 1999, Nakuru population was estimated at 239,000 with a growth rate of 4.3% (Kenya 2000). A quarter of the households grow crops and a fifth keep livestock (Foeken and Owuor 2000). Data from the local branch of Ministry of Agriculture indicates that there are about 160,000 heads of poultry, 25,000 heads of cattle, 3000 goats, 3500 sheep and 1500 pigs (Foeken and Owuor, 2000).

The Municipality is divided into 16 wards that constitute the central business district and residential areas. The living quarters fall under different ownership types (Municipal council, Government or Private companies and individuals).

3.2 Sampling procedure

The study was of cross-sectional type. The municipality was transected from North to South and East to West. and 4 wards purposively selected according to the agricultural activity, livestock population and levels of income. A list of livestock farmers in each ward was generated with the help of the extension officers and the contact farmers. The farmers added any missed names during the participatory focused group discussions.

Two hundred and two livestock keeping households were listed and out of these, 160 cattle farming households were randomly selected for tuberculin test and aflatoxin M1 detection These households were determined using the formula described by Martin and co-workers (1987) i.e. $n = 4pq/l^2$

Where n=sample size

4=the value of $Z\alpha$ required for confidence at 95%

p=prevalence

q=1-p

l^2=precision

$N=4*0.04*(1-0.04)/0.05^2$

=43

Although 43 was the calculated sample size, 40 cattle farmers were randomly selected from each ward constituting a sample size of 160 cattle farming households. From this subset, pooled milk samples from each household were collected for AFM1 testing and cattle were administered the SCITT.

3.3 Generation of participatory data

This was conducted through gender segregated focused group discussions (FGD). A two-days workshop involving the livestock farmers in each of the four wards was held in a central location and at that time, the participants were briefed on the research goal. A checklist (Appendix 8.2) was used to obtain information on the benefits and knowledge, attitude, practices (KAP) and risk pathways of health risks associated with livestock farming.

Farmers were asked to generate a list of the potential risks they perceived could emanate from livestock keeping and through group discussions and consensus, ranked them in order of impact. The ranked benefits/risks were scored individually by proportion piling using 50 pebbles and this was used to indicate individual's perceptions on perceived benefits/risks. Probing questions were asked and participant requested to explain the reason(s) behind their scoring.

The participant's perceptions of the risks posed by bovine tuberculosis and aflatoxins in milk were investigated. They discussed the risk pathways and practices they perceived could predispose them to the hazard(s), and the mitigation strategies to reduce the exposure to each of the hazard.

3.4 Household survey

A baseline questionnaire was administered to the 202 farming households with the help of research assistants to obtain more information on farmer's knowledge, attitude, practices and precautions taken against the possible health risks (Appendix 8.3). Household owners were targeted to answer the questionnaire, but where these were absent, adult relatives or workers were asked to respond to the questions. Data obtained was triangulated with the community workshop data on perceived health hazards.

3.5 Sample collection

A sample of 10ml pooled raw milk was collected from each of the randomly selected dairy households. The samples were kept in cool boxes packed with ice packs for atmost 5 hours awaiting transportation to the laboratory. On arrival, they were refrigerated for 15 minutes before testing for the presence of Aflatoxin M1.

3.5.1 Aflatoxin M1

The presence of Aflatoxins (M1) in the milk was detected using Charm Sciences (USA) Aflatoxin Test kit. The Charm SL Aflatoxin Test is a qualitative/ semi-qualitative assay utilizing ROSA® technology. The test is a lateral flow assay, which on addition of milk sample visible binding agents react with any aflatoxin in the flowing sample. The test line stops flow of unreacted binder while the control line stops the reacted binder. Visible colour intensity or comparison of Test (T) and Control (C) lines determines whether the sample is positive or negative for AFM1. The test detects AFM1 at the United States action level of 500 parts per trillion.

Procedure: The SL aflatoxin Test Strip was placed in ROSA incubator with the flat side facing up and the tape peeled back to the edge of the green label. The sample was well mixed and using a fixed micropipette, 300µl of the prepared milk sample was pipetted into either side well of the sample pad compartment. The tape was then sealed back and the cover on the incubator tightly closed, the sample was incubated for 8 minutes and results read qualitatively by visual inspection of the development and intensity of the control and test lines for the presence of aflatoxin M1.

Result Interpretation:

A sample was said to be negative when the T line had the same color intensity as, or was darker than the C line. When the T line was clearly lighter than the C line, or the T line was absent, or partially or unevenly colored, then the sample was said to be positive. If the C line was missing, smeared or uneven, or if milk was obscuring either the C or T lines, the test was regarded invalid.

3.6 Bovine tuberculin test

The Single comparative intradermal tuberculin test (SCITT) was performed according to Blood and Radostits (1989) using avian tuberculin purified protein derivative (ATPPD) and bovine tuberculin purified protein derivative (BTPPD) from Veterinary Laboratory Agency (Weybridge, UK). The test was performed on oldest animal in the herd irrespective of the sex. Ninety seven cattle were tested.

Procedure: Two areas, on the cervical fold on the left side of the neck, each measuring approximately 3 cm in diameter and 15cm apart were prepared by shaving and then cleaning with a swab moistened with 70% ethanol. These areas were then marked with an indelible marker. A fold of skin from the center of the marked area was pinched and thickness measured using a vernier's caliper and recorded against the farmer's name. With the fingertips, a fold of skin from the center of the marked area was pinched and 2,500 i.u (0.1ml) of BTPPD injected intradermally using a 23Gx1"needle. A second injection of 2,500 i.u ATPPD was administered at about 15cm below the initial one. The results were read 72 hours later by measuring the thickness of the previously marked area and results recorded. Cattle showing an increase in skin thickness of 4mm or more were considered to be positive reactors. This was arrived at by obtaining the difference between the skin thickness readings of BTB and ATB tuberculin injected sites $[(B_2- B_1) - (A_2- A_1)]$ as illustrated in the Table 5.

Table 5: Obtaining the difference in skin thickness

Site of Injection	Initial Skin Thickness (mm)	Final Skin Thickness (mm)	Difference in skin thickness (mm)
1st (BTPPD)	B_1	B_2	$B_2 - B_1$
2nd (ATPPD)	A_1	A_2	$A_2 - A_1$

3.7 Data entry and analysis

The household survey data, laboratory results and part of the participatory data (PD) i.e information on KAP and risk pathways of health risks associated with livestock farming were entered in Ms Access. The mean scores from the PD were entered in Ms Excel. The data was then exported to Instat® version 3.029 (statistical services centre, University of Reading, UK, copyright, 2005) statistical programme for both descriptive and statistical analysis.

The mean scores for benefits/ health risks in the FGD were calculated as the sum of the scores divided by the number of participants in each of the group. This was done for both men and women in the four study sites and, comparison and conclusions made accordingly. Average responses from the household survey were obtained by dividing the number of responses by the total number of respondents.

Apparent prevalence for BTB was calculated as number of positive reactor animals divided by total number of animals tested while the prevalence for aflatoxin M1 was calculated as the number of milk samples testing positive divided by the total number of samples tested.

CHAPTER FOUR

4.0 RESULTS

4.1 PARTICIPATORY DATA

In the segregated focused group discussions, participants listed, ranked and scored the benefits and health risks associated with urban livestock farming and the practices linked to animal husbandry. The ranking reflected the groups' perception of the accrued benefits and health risks while the scoring gave the individual households' perceptions of the same.

4.1.1 Benefits associated with urban livestock farming

The benefits varied by gender and across the study sites as shown in Table 6. Other benefits included poverty alleviation, education of children, improved living standards and uplifted social status.

Table 6: Gender disaggregated mean scores of benefits associated with urban livestock farming

STUDY SITE	GENDER	BENEFIT				
		INCOME GENERATI-ON	PROVISION OF EMPLOY-MENT	IMPROVED NUTRITION/ FOOD	FINANCIAL SECURITY	GENERATION OF MANURE
Kivumbini	Men (n=6)	9.2	9	10.5	0	5.2
	Women (n=6)	10.3	16.3	6.3	6.8	4.5
Kaptembwo	Men (n=9)	11.7	8.7	7.6	6.4	3.3
	Women (n=3)	10.7	16	7.7	7.3	5.3
Menengai	Men (n=8)	11.6	6.6	7.1	8.3	0
	Women (n=8)	7.3	6.4	13.6	0	4
Nakuru East	Men (n=5)	9.4	8.2	0	9.4	7.8
	Women (n=4)	7.5	11	6.8	6.8	5.3
Mean	**Men (N=28)**	**10.5**	**8.1**	**6.3**	**6.0**	**4.1**
	Women (N=21)	**9.0**	**12.4**	**8.6**	**5.2**	**4.8**
p-value		0.2	0.1	0.4	0.8	0.7

4.1.2 Health risks associated with urban livestock farming

The health risks associated with urban dairy farming were scored differently across gender and the study sites as shown in Table 7.

Table 7: Gender disaggregated mean scores of health risks associated with urban livestock farming

		HEALTH RISK				
STUDY SITE	GENDER	DISEASES	ODOUR	INJURIES	FLIES	NOISE
Kivumbini	Men (n=9)	8.1	4.8	5.0	8.9	6.0
	Women (n=6)	11.2	5.5	0	6.3	0
Kaptembwo	Men (n=9)	4.9	8.9	3.6	7.8	8.6
	Women (n=3)	14.0	8.3	11.0	8.7	0
Menengai	Men (n=7)	14.6	0	2.0	9.8	3.1
	Women (n=11)	15.0	5.3	6.5	3.1	3.6
Nakuru East	Men (n=5)	3.5	4.4	9.6	4.8	0
	Women (n=4)	10.7	7.8	9.0	7.8	4.3
Mean Score	**Men (N=30)**	**7.8**	**4.5**	**5.1**	**7.8**	**4.4**
	Women (N=24	**12.7**	**6.7**	**6.6**	**6.5**	**2.0**
p-value		0.1	0.3	0.6	0.4	0.3

Both men and women scored diseases highest although the scores were higher for women (12.7). The diseases mentioned include brucellosis, rabies and tetanus. Other risks mentioned included poisoning from acaricides, death, dirt, environmental degradation, accidents, insecurity, soil erosion, drug residues and allergy.

4.1.3 Practices in animal husbandry

The main practices perceived by farmers to be associated with urban livestock farming included milking and handling of milk, watering and feeding the animals, treatment and dipping of the animals, cleaning the shed and disposal of manure (Appendix 8.1). Involvement of household members in these activities differed across gender as summarized in Figure 3 and 4. According to both men and women, all the household members and the hired workers were involved in the activities. The female worker's contribution however, was almost insignificant.

4.1.3.1 Women perceptions

According to women, the household female, hired male worker and the boy child were more involved in attending the livestock compared to the male household head and the hired female worker. Milking and handling of milk, watering and feeding the animals, cleaning the sheds and disposal of manure were chores mostly done by the household female. The male household head played a major role in treatment and dipping of the animals. The boy child was the most likely household member to assist the household female in milking while the girl child would handle milk in the absence of the household female. The male worker was more involved in feeding, cleaning the shed and disposal of manure in the absence of household female. He also assisted in dipping, milking and treatment of the animals.

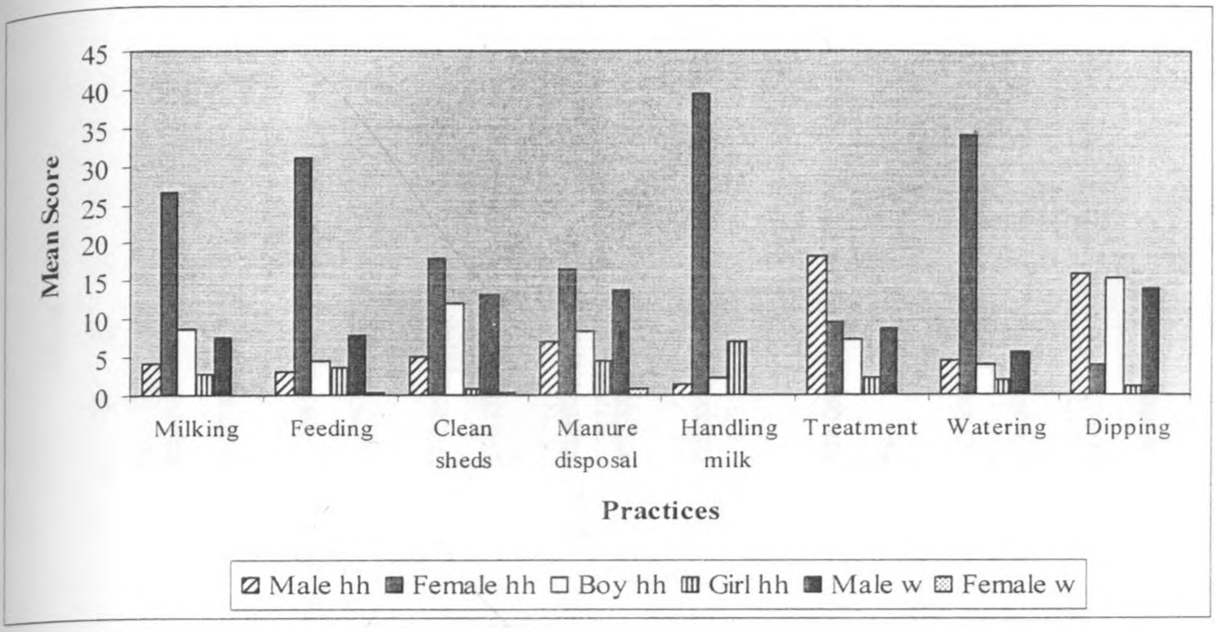


Figure 3: The perceptions of women on the involvement of household members in animal husbandry practices.

4.1.3.2 Men perception

Men's views however, differed with those of the women on involvement of household members in some activities. The scores were more distributed amongst the household members except for the hired female (Appendix 8.1). According to men, they were more involved in dairy activities than how women perceived them to be, however, they agreed with the women that handling of milk and watering the animals was more of household female's activity while they did most of the treatment and dipping of the animals. Milking which was according to women mainly done by the household female or boy child was usually done by men. The male household head also assisted the household female more in handling of milk. The boy child was more likely to assist dip the animals and dispose of manure in the absence of the male household head. The hired male worker was less involved in treatment of the animals and handling of milk.

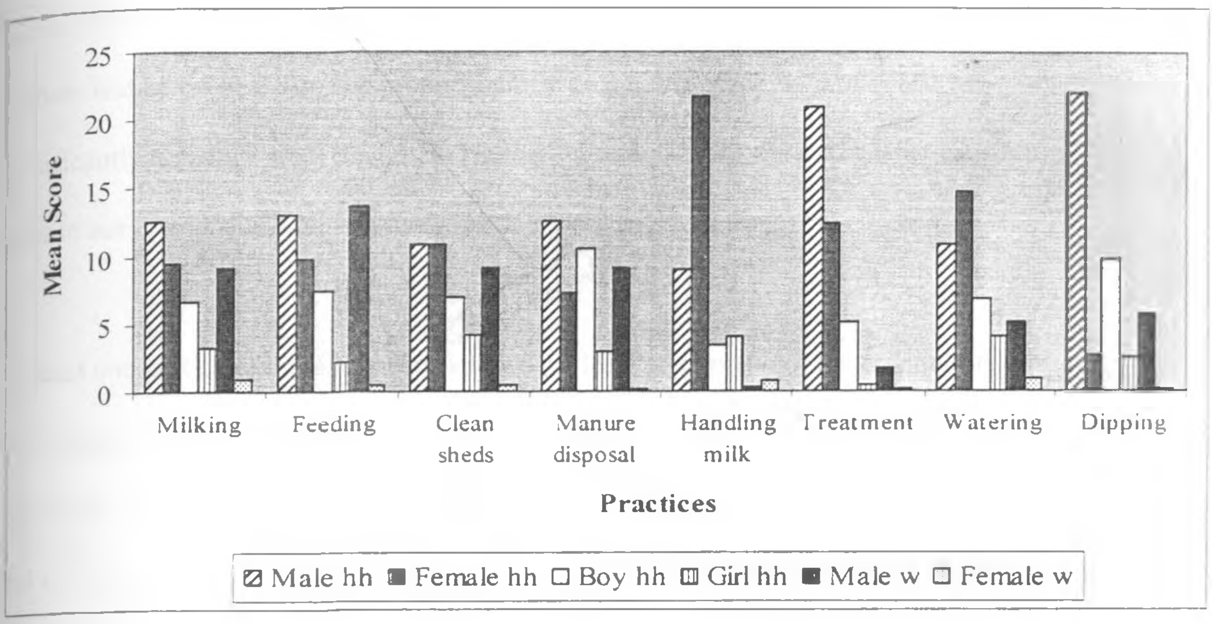


Figure 4: The perceptions of men on the involvement of household members in animal husbandry practices.

4.1.4 Knowledge, attitude and perception of selected health risks

4.1.4.1 Aflatoxin poisoning

Sixty seven percent (n=64) of all the participants in the four study sites had heard of human aflatoxicosis and most were from Menengai and Kaptembwo. Majority of these (65%) were women and the remaining were men from Kaptembwo exclusively. Only 21% of the participants (n=56), mainly men from Menengai and women from Nakuru East could associate the intoxication with the consumption of moldy grains. Participants did not know how aflatoxins could be transmitted from animals to human or how aflatoxicosis manifested itself in affected animals. Neither did the participants consider themselves at risk of intoxication nor did they know of any measures they would take to prevent exposure to the intoxication.

4.1.4.2 Bovine tuberculosis

Of the participants, 61% (n=56) had heard of HTB with 71% (n=34) being females, but none of them had heard of BTB. The proportion of women, who had heard of HTB, was significantly higher (P=0.0) than men. Neither did the participants know what causes the disease nor how the disease is transmitted from animals to humans.

At least one participant in 4/8 groups knew of at least one person in the community who had ever coughed blood. Participants in 3/8 groups could associate emaciation/wasting, coughing, weakness, light hair, sweating and chest pains with HTB. The participants in all the groups did not consider themselves at risk of BTB and were not aware of any risk factors or how they could protect themselves against infection.

4.2 HOUSEHOLD SURVEY DATA

4.2.1 Demographic characteristics of the respondents

The number of respondents involved in the household survey totalled 202 where females were the majority and constituted 55.4% (n=202) of total respondents. The female respondents dominated in all the sites except in Nakuru East where they constituted only 44% of the respondents (Figure 5).

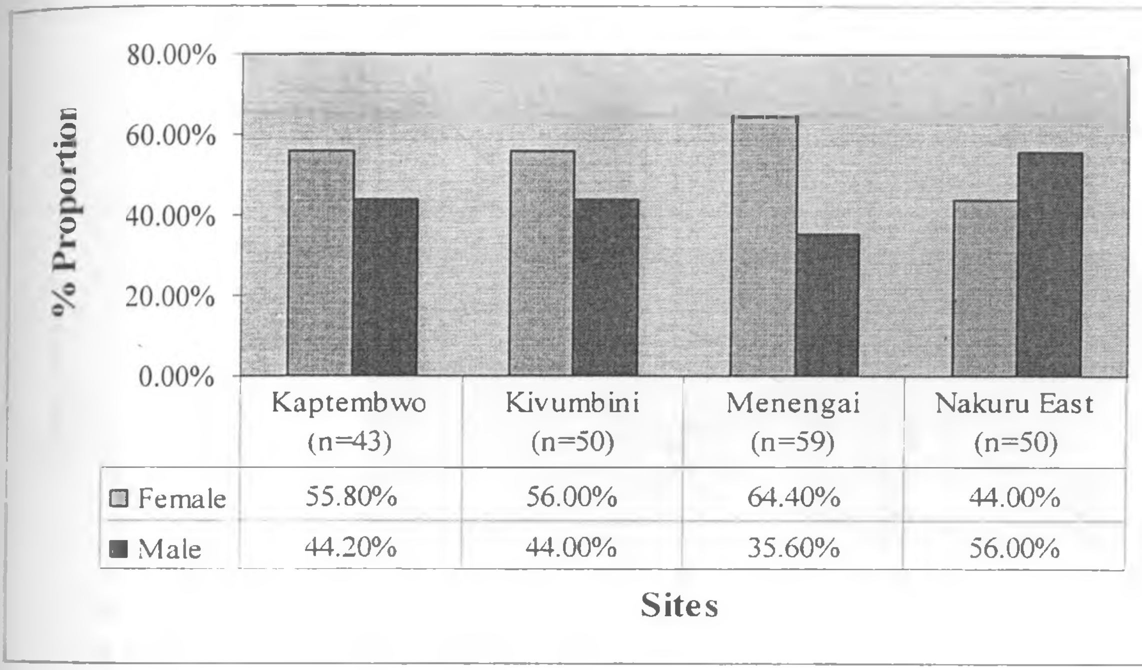
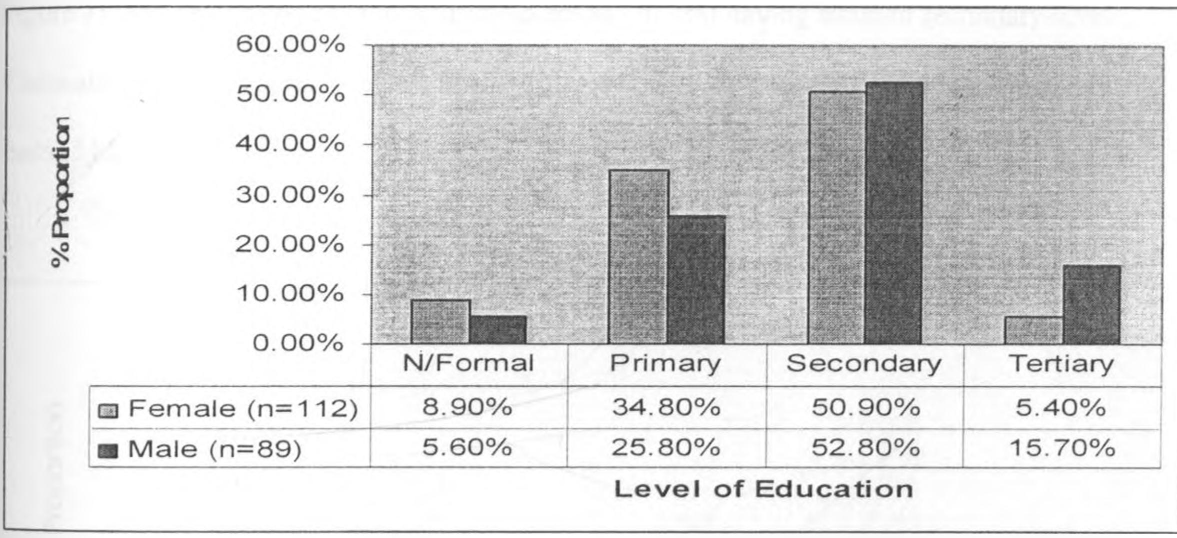


Figure 5: Proportion of the respondents by gender in the study sites

The majority of respondents (43.1%, n=202) were household heads and most of them were men (73.6%, n=87). About 40% of the respondents were female spouses while the remaining 16.8% comprised of either a relative (14.9 %) or worker (1.9%).

The average age of the respondents was 42.37 ±13.6 years with the male respondents being older (44.84±16.8 years) than female respondents (40.4±10.04 years). The difference in mean age between the male and female respondents was statistically significant (p=0.022).

About 92.5% of the respondents, majority of whom were women (55.7%), had attained at least primary education. However, a higher proportion of women (10/112) had no formal education as compared to men (5/89) (Figure 6). There was no significant difference between proportion of men (68.5%) and women (56.3%) who had attained at least secondary school-level education (p >0.05).



	N/Formal	Primary	Secondary	Tertiary
Female (n=112)	8.90%	34.80%	50.90%	5.40%
Male (n=89)	5.60%	25.80%	52.80%	15.70%

Figure 6: The level of education of the respondents by gender

Key: N/Formal=No formal education

4.2.2 Characteristics of household heads

The proportion of the male headed households was higher (84.5%, n=200) than the female headed households (15.5%). The average age of the household heads was 49.8±11.9. The mean age of the male household head was 50.3± 12.0 years while that of the female household head was 47.5±11.5 years. This difference in mean age was not statistically significant (p=0.22).

The mean household size was 6.2±2.4. The average number of male and female in the household was 2.9±1.49 and 3.23 ±1.62 respectively. This difference in average number of male and female was statistically significant (p=0.03).

About 93% (n=200) of the household heads had attained at least primary education. A significantly higher proportion of women ($p<0.05$) had no formal education compared to men (Figure 7). The proportion of male household heads (70.2%) having attained secondary-level of education and above was not statistically different ($p>0.05$) from that of female household heads (54.8%).

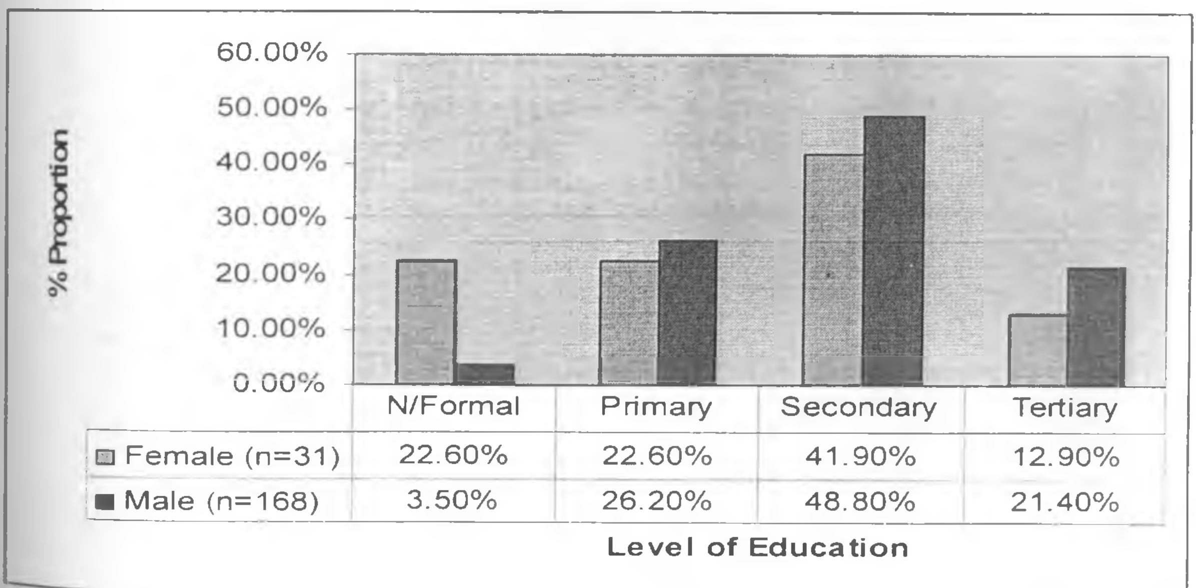
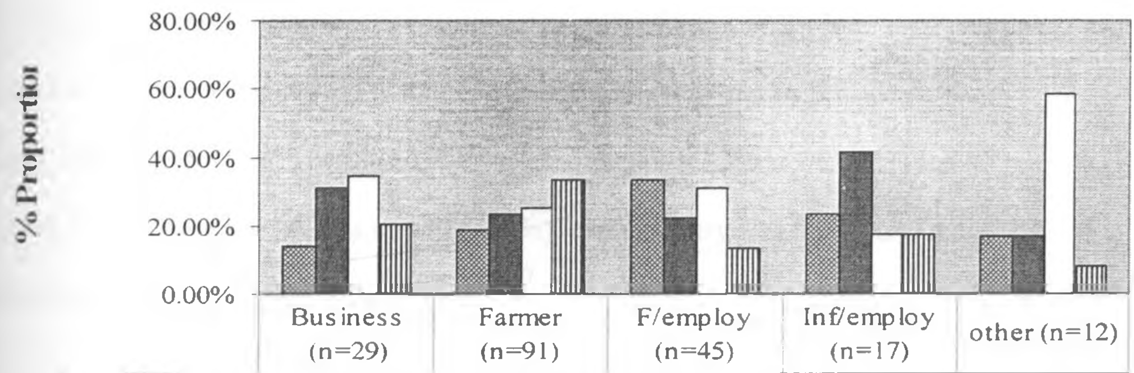


Figure 7: The level of education of the household head by gender

Key: N/Formal=No formal education

The main occupation of the household heads was farming (46.9%, n=194) followed by formal employment (23.2%). Those in business accounted for only 14.5%% of the total household heads. Others (6.2%) derived their livelihood from preaching, tenants or pension. Most of the farmers were mainly from Nakuru East (33%) and Menengai (25.3%) (Figure 8). A higher proportion of women (62.2%, n=29) was engaged in farming as compared to men (44.2%, n=165). The difference however was not statistically significant (p=0.06). Men constituted a statistically higher proportion (25.5%, p<0.05) of those formally employed while on the other hand, women in informal employment were proportionately higher (10.3%) than men (Figure 9). The difference between men and women informally employed was not statistically significant (p<0.0.5).



	Business (n=29)	Farmer (n=91)	F/employ (n=45)	Inf/employ (n=17)	other (n=12)
Kaptembwa	13.80%	18.70%	33.30%	23.50%	16.70%
Kivumbini	31.00%	23.10%	22.20%	41.20%	16.70%
Menengai	34.50%	25.30%	31.10%	17.60%	58.30%
Nakuru East	20.70%	33.00%	13.30%	17.60%	8.30%

Main Occupation Activity

Figure 8: Comparison of the main occupation among the sites

Key: F/employ=Formal employment; Inf/employ=Informal employment

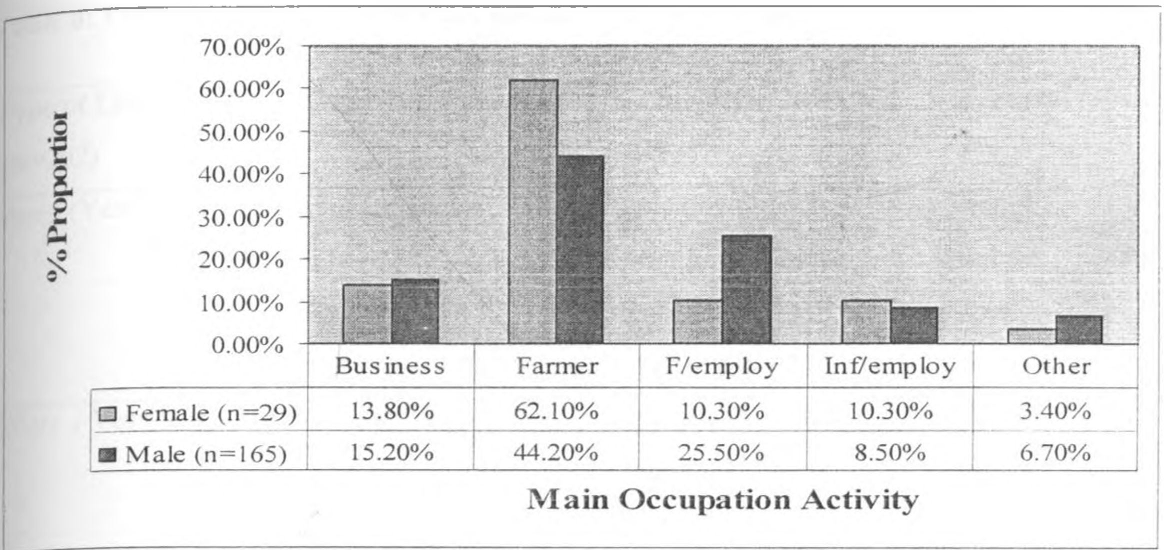


Figure 9: The main occupation of the respondents by gender

Key: F/Employ=Formal employment. Inf/Employ=Informal employment

Other types of occupation include Landlord, Pastor, and Retired

4.2.3 Livestock characteristics

Eighty four percent (84%, n=202) of the livestock farming households practiced mixed farming while the rest (16%) practiced livestock farming only. Cattle were the major livestock reared in the households sampled (83%), while poultry was the second most common kept type of livestock (Table 8).

Shoats and ducks were mostly housed at night while pigs and poultry were mostly enclosed throughout. A higher proportion of cattle were zero-grazed (49%) while about 18% were semi-zero-grazed. The rest were either complete free range or housed at night only.

Table 8: Livestock keeping by gender, site and rearing system

Type of Livestock (N=202)	% rearing by gender	% rearing by Site	% rearing system
Sheep (Yes=32.2)	Women 36.0	Kaptembwo 16.3	F/range 5.0
		Kivumbini 56.0	H/night 56.0
	Men 32.0	Menengai 30.0	S/zero 17.0
		Nakuru East 40.0	Zero 22.0
Goats (Yes=20.0)	Women 26.0	Kaptembwo 12.0	F/range 7.5
		Kivumbini 42.0	H/night 55.0
	Men 19.0	Menengai 10.0	S/zero 12.0
		Nakuru East 16.0	Zero 25.0
Cattle (Yes=83.2)	**Women 74.0**	**Kaptembwo 81.0**	**F/range 3.6**
		Kivumbini 76.0	**H/night 30.0**
	Men 85.0	**Menengai 85.0**	**S/zero 18.0**
		Nakuru East 90.0	**Zero 49.0**
Poultry (Yes=56.0)	Women 45.0	Kaptembwo 40.0	F/range 7.2
		Kivumbini 36.0	H/night 33.0
	Men 58.0	Menengai 63.0	S/zero 9.0
		Nakuru East 82.0	Zero 50.0
Ducks (Yes=8.0)	Women 9.7	Kaptembwo 7.0	F/range 5.0
		Kivumbini 14.0	H/night 56.0
	Men 7.6	Menengai 3.4	S/zero 17.0
		Nakuru East 0.8	Zero 22.0
Pigs (Yes=3.0)	Women 33.0	Kaptembwo 9.0	
		Kivumbini 0.0	S/zero 17.0
	Men 2.9	Menengai 1.7	Zero 83.0
		Nakuru East 2.0	

Key: F/range = Free range: S/zero = Semi-zero grazing; H/night = housed at night, free at daytime

Key:

Own urban or own rural implies to feed grown by the house hold either in the urban or rural area

Purchase urban or rural implies to feed purchased by the household either in the urban or rural areas.

4.2.4 Disease and non-disease risk factors associated with urban livestock farming

About 69.3% (n=202) of those asked to rank the non-disease health risks knew that animals could be of health risk to man. Among the non-disease health risks, odour was ranked overall highest followed by injuries, pollution and disease vectors. Thirty one percent (n=202) of those responding to the ranking were not aware that animals could be of any health risk to man. Majority of these (56.5%, n=62) were women.

Women ranked presence of vectors, odour and allergies highest (Table 10). Pollution and noise were considered more important by men. Injuries were thought to be equally important by both sexes. Other risks (Table 10) considered important by women, but less so by men, were poisoning from acaricides and flu.

Table 10: Gender ranking: non-disease risks associated with urban livestock keeping

Risk	Count of Men	Count of Women	Total Count	Proportion (%) of men and women	Rank
Odor	29	41	70	26.4	1
Injuries	33	33	66	24.9	2
Pollution	28	27	55	20.8	3
Breeding vectors	12	18	30	11.3	4
Noise	10	5	15	5.7	6
Allergies	5	6	11	4.2	7
Others[1]	7	11	18	6.8	5
Total	129	147	265[2]	100.00	

[1] include poisoning from acaricides sprays and flu to children

[2] Total responses

Respondents were asked to prioritize disease risks associated with urban livestock keeping. The diseases given the first priority by 81% (n=202) of the households were as listed in Table 11. Brucellosis was ranked highest by most respondents (46.6%) while anthrax was ranked second (24%). Other disease risks were ranked 4th and 5th respectively. There was no significant difference across gender in ranking of the diseases except for anthrax where a significant proportion of men ($p=0.008$) scored anthrax higher than women (Table 12). About 7% of the respondents could not associate any disease with livestock keeping.

Table 11: First category ranking of diseases

Disease Risk (1st priority)	Count of Men	Proportion (%) of men	Count of Women	Proportion (%) of women	Total Count	Proportion (%) of men and women	Rank
Brucellosis	31	43.1	45	49.5	76	46.6	1
Anthrax	16	22.2	8	8.8	24	14.7	2
Others[1]	8	11.1	22	24.2	30	18.4	3
Intestinal worms	8	11.1	6	6.6	14	8.6	4
Don't know	7	9.7	5	5.5	12	7.4	
Tuberculosis	2	2.8	5	5.5	7	4.3	5
Total	**72**	**100.0**	**91**	**100.0**	**163**	**100.00**	

[1] included cystcercosis, rabies and salmonellosis.

Table 12: Comparison of diseases ranked first by gender

Disease	1st order	Men (%)	Women (%)	Chi-Sq.	p-value
Brucellosis	Yes	43.1	49.5	1.8	0.77
	No	47.9	50.5		
Anthrax	Yes	22.2	8.8	6.9	0.008
	No	77.8	91.2		
Intestinal worms	Yes	11.1	6.6	1.3	0.26
	No	88.9	93.4		
Tuberculosis	Yes	2.8	5.5	0.9	0.3
	No	97.2	94.5		

About 40% (n=202) of the respondents listed the health risks shown in Table 13 as second priority diseases. Brucellosis scored overall highest (33.8%) followed by anthrax (18.8%) and tuberculosis (16.3%). Women scored these diseases higher (51.9%. 60%, 53.8% respectively) than men while intestinal worms were considered equally less important by both sexes. Other disease risks (Table 13) were ranked 4th and 5th.

Table 13: Second category ranking of diseases

Disease Risk	Count Men	Proportion (%) of men	Count female	Proportion (%) of women	Total Count	Proportion (%) of men and women	Rank
Brucellosis	13	35.1	14	32.6	27	33.75	1
Anthrax	6	16.2	9	20.9	15	18.75	2
Others[1]	7	18.9	4	9.3	11	13.75	4
Intestinal worms	2	5.4	2	4.7	4	5.00	6
Tuberculosis	6	16.2	7	16.3	13	16.25	3
Others[2]	3	8.1	7	16.3	10	12.5	5
Total	**37**	**100.0**	**43**	**100.0**	**80**	**100.0**	

[1] included allergy, pneumonia, poisoning from acaricides,

[2] Included aflatoxin poisoning and rabies.

4.2.4.1 Precautions against diseases risks

Precautions taken against the diseases were as summarized in Table 14. There were no significant differences between female and male responses in the precautionary measures they would take against the risks, except for anthrax where a significant proportion of men ($p=0.0006$) mentioned meat inspection as a preventive measure against anthrax while a significant proportion of women ($p<0.0001$) listed boiling of milk as a necessary precaution against intestinal problems.

Table 14: **Mitigation strategies against some of the disease risks**

Disease	Precaution(s)	Proportion (%) Male	Proportion (%) Female	Overall proportion (%)	Chi Sq.	p. value
Brucellosis (males = 26) (females=46)	Boil milk	80.8	87.0	82.7	1.4	0.23
	Others (use of artificial insemination, examination & treatment of sick animals, cleaning udder.)	15.4	8.7	13.11	0.9	0.34
	None	3.8	4.3	4.2	0.0	0.85
Anthrax (males = 19) (females=8)	Meat inspection	73.7	50.0	63.0	11.9	0.0006
	Others (culling, cook meat well)	26.3	50.0	37.0		
Intestinal problems (males = 9) (females=7)	Boil milk	22.2	57.7	37.5	26.3	<0.0001
	Cook meat well	44.4	42.9	43.75	0.00	0.83
	Deworming	33.3	0.00	18.75		

4.2.5 Use of milk by households

The respondents were asked how the households used milk from their animals. They varied in response giving more than one use. These included consumption of plain raw/boiled milk, making tea and preparation of traditional fermented milk. On the first option of how they used milk, the respondents gave the following responses (Table15). Making tea was the first priority for most respondents (97.2%, n=179) while the remaining 1.1% drank it plain, and of these two did not boil.

Table 15: First responses on use of milk

Milk Use		Count of female (n=98)	Count of male (n=81)	Total (n=179)	Proportion (%) of male and female
Drink Plain	Drink Raw (unboiled)	-	2	2	1.12
	Boil before drinking	2	1	3	1.68
Make tea		96	78	174	97.21

On the second option of milk use, 90.8% (n=141) respondents drank it plain (boiled) while 9.2% made traditional fermented milk. Ninety nine percent (n=81) of those responding to the third option made traditional fermented milk with the remaining (1.2%) drinking it plain. Out of the total respondents who made traditional fermented milk, 44.1% (n=93) used unboiled milk. There was a gender difference in those who boiled milk before use with the proportion of women being significantly higher ($p=0.01$, $\chi2=6.2$, 1 degree of freedom) than men (Table 16).

Table 16: Making of traditionally fermented milk by gender

Boil	Men Count	Women Count	Total	Chi-Sq	p-value
Yes	22	30	52	6.2	0.01
No	22	19	41		
total	44	49	93		

4.2.6 Knowledge, Attitude and Practices

4.2.6.1 Aflatoxin poisoning

Of the two hundred and one respondents who responded to whether they had heard of aflatoxins in people, only 5.9% (n=201) had not heard. Of those who had heard, 58% knew how human get intoxicated with aflatoxins and the proportion of men (0.659) was significantly higher ($p<0.05$) than women (0.523). Ninety nine percent (115/116) of those who knew how human got poisoned stated that it was through consumption of poorly/incompletely dried grains. Only 17.6% (n=188) of the respondents knew that animals could pass aflatoxins to man.

Twenty three percent (n=156) of those who responded to the question on the precautions to be taken against aflatoxin poisoning mentioned proper drying and storage of cereals as preventive measure against aflatoxin poisoning. Sixty nine percent (n=156) either did not know of any preventive measure or did not take any.

On assessment of the mode of feed storage (concentrate), a higher proportion of the respondents (48.1%, n=131) stored their animal feed in the main house. Only 31.3% (n=131) had a storage facility of some kind while the rest did not store any feed. Of the 89 households which had animal feed, 7.9% were observed store it under humid conditions.

About 17.5% of 200 respondents compounded their own feed and the difference in the proportion of men and women who did so was not significant ($p>0.05$). The commonly used ingredients included concentrate/dairy meal (60%, n=35), mineral salts (54.2%), maize germ (37.1%), chicken waste (31.4%) and pymac (31.4%). Others included molasses, damaged maize grains, rice germ, wheat bran, cotton seed cake, sunflower, limestone, fish and bone meal.

4.2.6.2 Bovine tuberculosis

Thirty four percent (n=194) knew that cattle could be infected with tuberculosis. The difference in knowledge across gender however, was not significant ($p>0.05$).
On mode of transmission of the infection from cattle to humans, the responses were as shown in Table 17. About 66.7% of the respondents listed meat and milk, especially raw milk, from infected animals as the main modes of disease transmission while 12.8% implicated air as a means of transmission. Twelve percent did not know how the disease is passed on from animals to humans. Other modes of transmission listed included contact with manure or infected animals and animal secretions.

Table 17: Modes of bovine tuberculosis transmission

Transmission	Number of households	Proportion (%)
Raw milk from infected cow	32	41.03
Milk/meat from infected cow	11	14.10
Air transmission	10	12.80
Meat from infected animal	9	11.54
Others[1]	7	8.99
Don't know	9	11.54
Total	**78**	**100.00**

[1] Contact with dung and manure, close contact with cattle or grass with infectious organisms

About 2.6% (n=194) of the respondents had had at least a family member suffer from tuberculosis and the symptoms observed included chest pains, coughing, general body weakness, labored breathing and loss of appetite. A significantly higher proportion of female respondents (p<0.01) did not know of any TB symptoms in human as compared to men (Table18)

Table 18: Symptoms that respondents could associate with human tuberculosis

Symptoms	Men count	% proportion	Women count	% proportion	Total Count	Overall proportion	p-value
Chest pains	2	20.0	0	0.00	2	8.7	0.11
Coughing	2	20.0	1	7.7	3	13.0	0.40
General body weakness	1	10.0	1	7.7	2	8.7	0.70
Difficult breathing	2	20.0	2	15.4	4	17.4	0.77
Loss of appetite	0	0.00	1	7.7	1	4.3	0.30
Don't know	0	0.00	7	53.8	7	30.4	0.0001
Others[1]	3	30.0	1	7.7	4	17.4	0.17
Total	10	100.0	13	100.0	23[2]	100.0	

[1] Fever, weight loss and headache

[2] Total responses

The mitigation strategies used by farmers against bovine tuberculosis included boiling of milk, meat inspection and proper cooking of meat among others. The difference across gender in precautions taken was not significant (p>0.05) (Table 19). Majority of the responses given were that the respondents took no or did not know of any precautionary measure against BTB (Table 19).

Table 19: Evaluation of suggested precautions by the respondents against tuberculosis.

Precautions	Men count	% proportion	Women count	% proportion	Total Count	% of total	p-value
Boil milk	19	26.8	20	21.7	39	24.0	0.46
Meat inspection	2	2.8	2	2.2	4	2.5	0.80
Cook meat well	3	4.2	3	3.3	6	3.7	0.75
None	24	33.8	24	26.1	48	29.4	0.29
Don't Know	17	23.9	34	37.0	51	31.3	0.068
Others[1]	6	8.5	9	9.8	15	9.2	0.77
Total	71	100.0	92	100.0	163[2]	100.0	

[1] Use of protective gear, culling of cattle infected with mycobacteria, avoiding consumption of products from infected cattle, and maintaining a distance between the main house and the cow shed.

[2] Total responses

4.3 TESTS RESULTS

4.3.1 Bovine tuberculosis

The households were the sampling units and the oldest animal in that household was tested for BTB in each of the 97 households sampled. Of the 97 animals tested. 17 reacted positive to the bovine tuberculin test giving an individual cattle apparent prevalence of 17.5%. About 69% (n=97) of the households tested answered to the question whether they boiled milk before use and 3/35 of those who did not had animals reacting to the tuberculin test while out of those who boiled (32), only one animal reacted positive to the test. There was no association between BTB status and the households that did not boil milk (p=0.67:1 degree of freedom).

There was no association between the rearing system and BTB status (p=0.5, $\chi 2$= 1.3 and 2 degree of freedom). Majority of cattle that reacted to the tuberculin test (47.1%, n=17) were zero- grazed while 41.2% and 11.8% were kept under free range and semi-zero grazing rearing systems respectively.

4.3.2 Aflatoxin M1

Out of the 117 milk samples tested, six (6) were positive for AFM1 residues giving an apparent prevalence of 5.1%. Out of the 35 households that compounded their own feed, only one household had its milk testing positive for AFM1, the other AFM1 positive samples were from the households using commercial feed.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Benefits associated with urban farming

Urban farming has been viewed by majority of researchers as a coping strategy to the constrained household budget resulting from high rate of unemployment which in turn is accelerated by the increasing urban population and deteriorating economic performance in developing countries (Mireri *et al.*, 2006). Livestock are mainly reared for sale as reported in studies done in Kampala (Nelly *et al.*, 2002) and Nairobi (Musiimenta, 2002; Lee-Smith *et al.*, 1987).

In Nakuru, farmers engage in livestock farming mainly for income generation and creation of employment opportunities. Kang'ethe and others (2005) reported income generation and contribution to household nutrition as the main benefits farmers in Dagoretti could associate with urban dairy keeping. These results are similar to those from case studies done in Cairo and Addis Ababa where farmers are reported to generate over 60% of their household income through livestock farming (Mougeot, 2000). In Kumasi, farmers are reported to generate twice as much farmers from the rural areas (Danso *et al.*, 2002).

The difference in mean score for these benefits however, was not statistically different between Nakuru female and male farmers (Table 6). While men attributed direct generation of income to livestock keeping, probably from the sale of animals and/or animal products as the most important, women argued that creation of job opportunities would indirectly contribute to the household revenue and thus scored it highest. This could be due to the fact that more men than women tend to get formal employment while majority of women are either informally employed or unemployed. Musiimenta 2002 in study in Kampala attributed these to lack of competitive qualifications, skills and information. This propels women to seek for alternative productive activities to engage in with an aim of improving their livelihood.

Provision of food/improved nutrition was ranked third by men and women while other benefits included provision financial security and generation of manure. The difference in the mean score for these benefits was not statistically significant across gender. Other than sale of animals, animal products such as eggs, milk and meat are also consumed at the household level thus improving household's diet and relieving cash that could otherwise be used to purchase food. In Dagoretti division (Nairobi) farmers have been reported to consume up to 25% of the milk produced, thus relieving over 650 USD daily (Kang'ethe *et al.*, 2005). Cooperative farmers in Addis Ababa consume some of their produce saving up to 10-20% of their income that would otherwise be spent on food (Tinker, 1994).

The farmers regarded livestock as a form of financial asset providing ready money in case of financial emergencies. These findings conform with those in the Mazingira report where, in addition to provision of animal products, stock maintenance and reproduction, livestock were also seen as a form of investment in the six Kenyan towns surveyed (Lee-Smith and Memon, 1994). Many households in Hubli-Dhaward, India are reported to keep a buffalo as a form of saving while in Accra small livestock are kept as asset in cases of emergency (Nugent, 1999 quoted by Kang'ethe *et al.*, 2005).

Generation of manure, which scored the least amongst the five most common benefits, was used in organic farming to improve soil fertility and hence, increase crop production. Elsewhere, farmers in Kisumu were reported to benefit from manure generated from livestock, which was either used on farms or sold (Zarina, 2006). Kang'ethe and others (2005) reported that farmers in Dagoretti attributed 80% of their crop yield to manure application.

Other benefits the study group associated with urban livestock keeping included supplementation of family's cash earnings thereby achieving other objectives such as providing funds for children's education. Overall, this helps alleviate poverty and improves the farmers' living standards. Finally, uplifted social status and dignity attributed to ownership of property was also regarded as important by the farmers.

5.2 Knowledge, attitude and practices on potential health risks

The potential public health hazards ranged from poor hygiene/pollution caused by poor sanitation, presence of flies and noise to zoonotic diseases arising from close contact with and/or consumption of animal products from infected animals. As deduced from the FGD and the household survey, farmers had limited knowledge on diseases risks associated with livestock keeping. During the FGD, the participants mentioned only brucellosis and rabies as the possible zoonoses. From the household survey, only 46.6% (n=163) gave brucellosis the first priority as a health risk of importance, 14.7% anthrax, 8.6% intestinal worms and 4.3% tuberculosis among other mentioned diseases. About 7% could not associate any disease with urban livestock keeping and thus would be at great danger of exposure to diseases of public health importance. Although there was no significant difference between men and women who had attained at least secondary education, a statistically higher proportion of women ($p<0.05$) had no formal education. With the latter constituting the highest proportion of the participants in the FGD and household survey, this could explain the findings of poor knowledge on health risks in the FGD. The non-disease risks considered important in urban livestock farming include odor, injuries, flies and noise in that order. Odor and injuries were more important to men as compared to flies and noise, which were scored higher by women. In addition to these, respondents in the household survey considered allergies, breeding of disease vectors and pollution as important.

Little has been documented regarding the health risks associated with livestock keeping in the urban areas and the farmers' perceptions on the same; however, possible public health hazards associated with the practice have been one of the main reasons why local authorities do not condone urban livestock keeping. Brucellosis, bovine tuberculosis, anthrax, non-typhoidal salmonellosis, and the emerging E. *coli* O157:H7 are some of the zoonotic diseases considered important in the developing countries (Muchaal, 2000). Zarina (2006), reported that cattle carcass condemnation due to hydatidosis and cysticercosis in the slums of Nairobi averaged 1700 and 260cases, respectively per year between 2000 and 2003. Also reported in the study was poor animal husbandry practices and limited knowledge on zoonotic diseases. In Dagoretti division of Nairobi, Kang'ethe and co-workers (2005) reported the presence of several disease risks associated with urban livestock farming and these included brucellosis, bovine tuberculosis, E. *coli* O157:H7 and cryptosporidiosis. He also reported scanty knowledge by both farming and non-farming households on the hazards investigated

5.2.1 Bovine tuberculosis

Bovine tuberculosis remains one of the devastating diseases of cattle in developing countries with implications to both the economy of farming communities and public health especially in societies where animals and human interact closely. Bovine TB in Kenya has not been officially reported however, the high prevalence of the disease in the neighboring countries (personal communication) coupled with the uncontrolled and/or illegal movement of wildlife and livestock by pastoralists within the country and across national borders in search of pastures, market or following cattle rustlings, increases the risk of transboundary infection. In this study, individual animal apparent prevalence of 17.5% was obtained. This apparent prevalence appears to be higher than what was found from a similar study done in Dagoretti division, Nairobi (10.3%) (Kang'ethe *et al.*, 2005). The high number of reactors found in this study could possibly be attributed to sensitization by *M. tuberculosis* in the human population and thus increased number of false positives.

The prevalence of BTB is said to be low when it is 5 percent or less and at this juncture the test and slaughter method may be considered as an economical option for control (Bonsu *et al.*, 2000). In this study, the prevalence can be said to be high although the observed prevalence is consistent with findings from studies done in Africa. In Ethiopia, BTB has been known to be endemic (Teklu *et al.*, 2004) and individual animal prevalence of 46.8% (Ameni *et al* 2003a), 7.6% (Ameni et al., 2003b) and 1.6 %(Laval and Ameni, 2004) using the tuberculin tests and 4.5% (Teklu *et al.*, 2004) in abattoir meat inspection have been reported. While the high prevalence has been attributed to lack of BTB control measures in the country, the low prevalence reported by Laval and Ameni (2004) has been attributed to the high resistance of the zebu cattle and the traditional farming system practiced by farmers from Boji district of Ethiopia. Bovine TB has been reported to be prevalent in all geographical zones of Tanzania and the prevalence rates ranges between 0.2-13 percent (Jiwa *et al.*, 1997; Kazwala *et al.*, 2001; Shirima *et al.*, 2003). In studies carried out in Uganda, Malawi, Democratic Republic of Congo, Niger and Cameroon, the observed cattle prevalence using either abattoir meat inspection or the tuberculin tests varied from 0.2 to 10.6% (Faye *et al.*, 2005). Eritrea and Ghana have reported prevalence of 14.5% and 13.8% respectively (Omer *et al.*, 2001; Bonsu *et al.*, 2000). An exceptionally high prevalence (50%) was found in some parts of Ghana and this was attributed to the low and relatively wetland, a risk factor for bovine infection (Bonsu *et al.*, 2000).

The implementation of the test and slaughter control measure would not be considered at this point as the BTB status in this country needs to be verified through proper surveillance and use of more specific and confirmatory techniques such culture and isolation of *M.bovis.*

Although there was no association between the rearing system and BTB status ($p=0.5$, $\chi2=1.3$ and 2 degree of freedom), majority of the animals (47.1%, n=17) that reacted to the tuberculin test were kept under zero-grazing type of management. This finding was imperative as such type of rearing system would promote transmission of the infectious agent due to close contact. The rest, 41.2% and 11.8%, were kept under free range and semi-zero grazing rearing systems respectively. Movement of livestock and probable interaction with wildlife from the nearby Nakuru National park could pose a risk factor to the transmission of *M. bovis.*

5.2.1.1 Human risk factors for bovine tuberculosis

Farmers had poor knowledge on health risks associated with urban livestock keeping. None of the participants during the FGD had heard of BTB or knew the cause, the risk factors, how the disease is transmitted or mitigated against. About 33.5% of the respondents in the household survey were aware that cattle could suffer from TB and 67% could associate raw or inadequately cooked or boiled milk and meat with BTB. This proportion correlates with 39% and 74% of the respondents in Dagoretti who knew that BTB exists and can infect human respectively (Kang'ethe *et al.*, 2005). The difference in farmers' knowledge between the two towns and across gender however was not significant. These findings further correlates to those from Wuchale-Jida district of Central Ethiopia where only 38.8% knew that cattle could contract tuberculosis and only a small proportion (30.8%) recognized that BTB is zoonotic, with 20% and 18% associating it with milk and meat consumption respectively. This knowledge however, was attributed to educational background of the respondents (Ameni *et al.*, 2003b). Mfinunga and others (2003a) found that 75% of the study population in Arusha, Tanzania had limited knowledge on BTB, its transmission and prevention. The disparity between the FGD and household survey findings in Nakuru could be explained by the delay in questionnaire implementation, allowing sharing of the workshop's proceedings between those who had and those who had not attended the community workshops. Nevertheless, the limited knowledge predisposes farmers to the risk of contracting infection either through close contact and/or consumption of animal products. This is important given that slightly less than 45% of those who prepared and consumed traditional fermented milk used raw milk and about 1%, mainly men, drank plain raw milk. A significant proportion of men do not boil milk while preparing traditional fermented milk. This puts them at risk of infection since M. *bovis* have been shown to persist in fermented milk for up to 14 days (Minja *et al.*, 1998).

The main responses to the precautions taken by farmers against BTB infection were either they did not know or use any. Thirty percent of the respondents did not know of any symptoms associated with human tuberculosis and this proportion is less than the participants in 5/8 groups who were not aware of any symptoms in the FGD. Lack of knowledge on tuberculosis infection and disease symptoms may lead to delayed diagnosis and treatment of the disease which may eventually end up in prolonged infectious period hence resulting to increased cases of tuberculosis in the community (Mfinanga *et al.*, 2003a).

M. *bovis* is an occupational hazard to agricultural workers who are exposed through handling of infected animals (Ameni *et al.*, 2003b). Livestock-related activities may predispose the individuals to infection through aerosols or contact with excretions such as urine and feces (Mfinanga *et al.*, 2003b). From this study the household members and the hired male worker were at risk of contracting *M. bovis* as a result of close contact with the animals while undertaking the routine animal husbandry practices such as feeding, watering and treating the animals as well as cleaning the sheds. This is important because almost 50% of the cattle rearing households did so in zero-grazing units.

Although men in the FGD considered themselves to be more involved in tending to the animals than women, results from the household survey showed that a higher proportion of women were more involved in farming than men. This results are consistent with findings from elsewhere, Kenya (Lee-Smith and Memon, 1994; Kang'ethe *et al.*, 2005), Zimbabwe (Hungwe 2006), Uganda (Musiimenta, 2002), Tanzania (Mireri.*et al.*, 2005; Sawio, 1994) and Lusaka (Sawio, 1994). Therefore, women were more exposed to the risk of infection through contact than any other member of the household. The least exposed was the female hired worker probably due to involvement with other house chores and less so in taking care of the animals.

5.2.2 Aflatoxin M1

The presence of mycotoxins in foods and feeds is potentially hazardous to the health of both humans and animals due to their various toxic effects and their thermal stability. Carcinogenic, mutagenic, and teratogenic effects of AFB1 have been reported for several animal species, including humans and for this reason this toxin has been included in category 1A of active carcinogenic compounds (IARC, 1993)

The findings in this study revealed that for every 100 milk samples tested five are likely to contain AFM1 residues, and that at least six members of these households are at a risk of AFM1 intoxication. The 5.1% prevalence was lower than the 45% obtained in Nairobi, Kenya using a similar test (Kang'the *et al.*, 2005; Anon, 2006). This difference could be attributed to the use of other grazing systems in Nakuru and the extensive use of fodder as the primary feed. Of the six households whose milk was found to have AFM1 residues, only one was reported to compound its animal feed. Dairy concentrate was the most common ingredient used to compound animal feed in 60% (21/35) of the households. This is important in ration contamination considering the findings by Kange'the and others (2005) of AFB1 traces in over 90% of animal feed sampled in Dagoretti, Kenya.

Studies done by Van der Linde *et al.*, (1964) in high and low milk-yielding cows showed that the toxin could be readily detected in the milk from all the cows 12-24 hours after the first AFB1 contaminated ration ingestion. The carry-over rates depend on milk yield and lactation period and further vary from animal to animal, day to day and from one milking to the next, however they fall within the range of 0-4% (van Egmond, 1994). In France where lactating cows were fed on contaminated rations above the European Commission standards, the total excreted AFM1 was 2.6% and 4.6%of the total ingested AFB1 using TLC and HPLC, respectively, (Fremy *et al.*, 1988). A similar study done by Battacone and co-workers (2003) on ewes in early and mid-lactation showed a linear relationship between AFB1 dose and AFM1 concentration. The carryover rate, however, was lower than that reported for dairy cattle and goats, suggesting a better ability of sheep to degrade AFB1. Battacone and others (2005), further reported that AFM1 concentration in milk products (whey and curd) were linearly related to AFM1 concentration in unprocessed milk.

None of the participants in the FGD had heard of aflatoxicosis in animals although a higher proportion (67%) had heard of the disease in human, better understood as "ugonjwa wa mahindi", a Kiswahili translation of a disease related to maize consumption. Twenty one percent of the participants could associate the condition with moldy grains. Of those interviewed in the household survey, about 94% knew of the existence of the disease in human and 58% of these could associate the intoxication with consumption of incompletely dried/moldy maize. The awareness of aflatoxin poisoning in human and the consumption of moldy grains as a risk factor, could be linked to the recent outbreaks in Eastern province of Kenya and the role of local news agencies in dissemination of information.

While none of the participants in the FGD knew how the disease could be passed on from animals to human, about 18% of the respondents in the household survey were aware that animals could pass on the toxins to human. The respondents were more knowledgeable than the FGD participants possibly due to their involvement in the training workshops and/or dissemination of the information by the FGD participants to those who had not attended. Nevertheless, the highest proportion was unaware of the possible risk of transmission from animal to human and therefore there is a great risk of intoxication.

Eight percent of the respondents were observed to store animal feed in humid conditions oblivious of the implications. This proportion of farmers had increased chances of feed invasion by mold and possible intoxication with mycotoxin, an important risk factor for human intoxication since 68% of the respondents either did not take or know of any precautionary measure against AFM1 poisoning.

CHAPTER SIX

6.1 Conclusions

Farmers in this study had little knowledge on risks associated with livestock keeping. On the investigated health risks, the respondents were slightly informed on the risks and this could be attributed to dissemination of information following the FGD. However, the highest proportion had limited knowledge, which puts the farmers at a risk of livestock farming-related health hazards.

The apparent prevalence obtained for BTB is high, indicating the need to verify the situation of the disease in Kenya. This will aid in identifying highly exposed groups and the level of exposure. This is important especially with the rising incidence of HIV/AIDS in human and the need to ascertain the significance of *M. bovis* in these cases.

The findings of AFM1 are significant in that the household members and other consumers of milk from these households are at a risk of intoxication. This is imperative since the cooking temperatures and the routine milk processing procedures cannot eliminate the toxin. This is further complicated by the fact that the aflatoxigenic fungi occur as natural contaminants of the agricultural products. This therefore, calls for the need and the urgency to monitor the levels of the contaminants in the raw/finished animal feed products.

6.2 Recommendations

- Generally, the study group had little knowledge of the disease risks associated with livestock farming. Therefore, there is need to educate the farmers on health hazards related to livestock farming.

- The private sector (private practitioners, feed manufacturers and distributors e.t.c) should be encouraged to participate in dissemination of information to the farmers, promoting both the animal health and animal husbandry practices.

- The high BTB apparent prevalence obtained in this study area is an indicator of the need to revise the standing official report on BTB in this country through thorough investigations. This will initiate control and preventive measures against the disease if need be.

- A study should be designed to investigate the contribution of M.*bovis* in tuberculosis cases in Kenya through isolation and identification of the causative agent.

- Stringent measures should be put in place to regulate cross boundary animal movement in attempt to reduce possible cross border infections.

- Extensive surveillance of animal feed, from the source of the raw materials to the finished products in the distribution chain, to promote quality animal feed.

- Multidisciplinary collaboration in research and epidemiological investigations of aflatoxin poisoning outbreaks in the country.

6.3 Limitations of the study

- Although 160 cattle and milk samples from the cattle farming household had been targeted for the tuberculin test and aflatoxin test respectively, only 97 cattle were subjected to the tuberculin test and 116 milk samples were tested for aflatoxin. This was as a result of:
    a) Withdrawal of households from the study due to sale or death of the animal(s) during the study period.
    b) Lack of co-operation by the farmers
    c) In addition to the above shortcomings, fewer milk samples were collected because the cow(s) in some households was/were either dry or heifer(s) at the time of study.
- The denominator in the household survey responses was not consistent due to unresponsiveness by some respondents to some questions.

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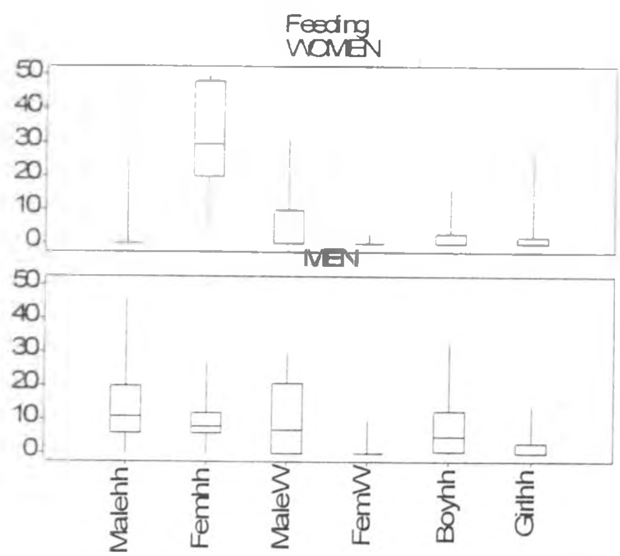
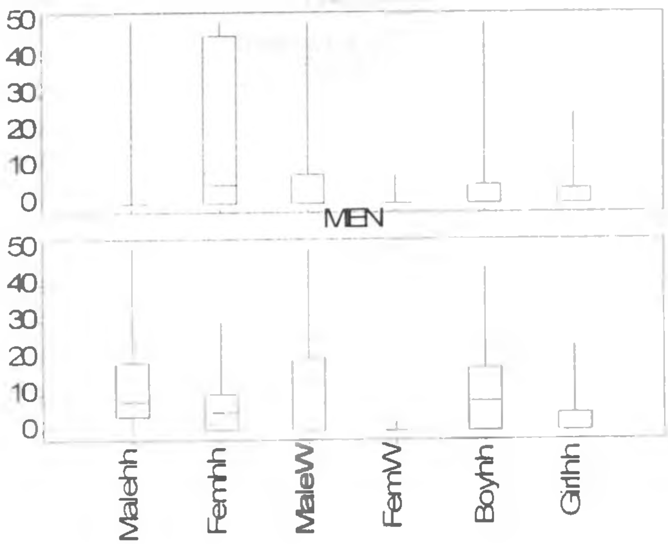
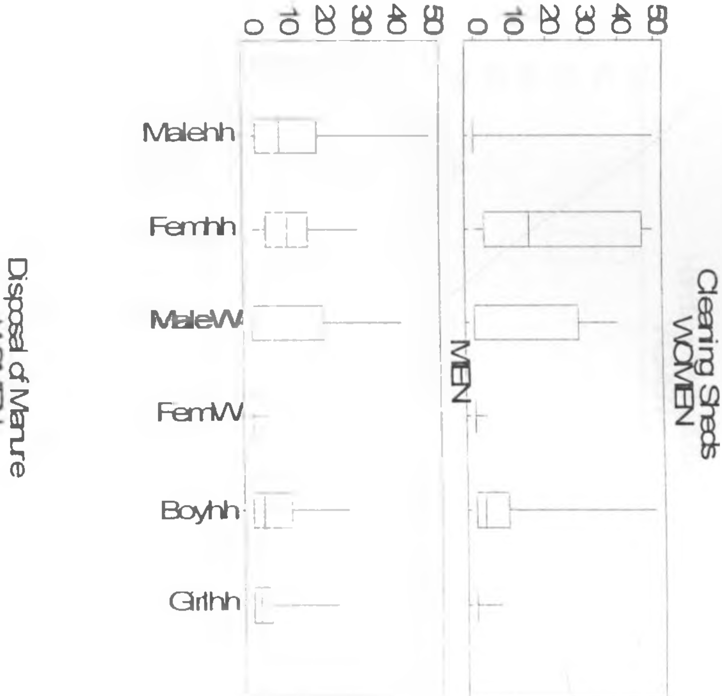
8.0 APPENDICES

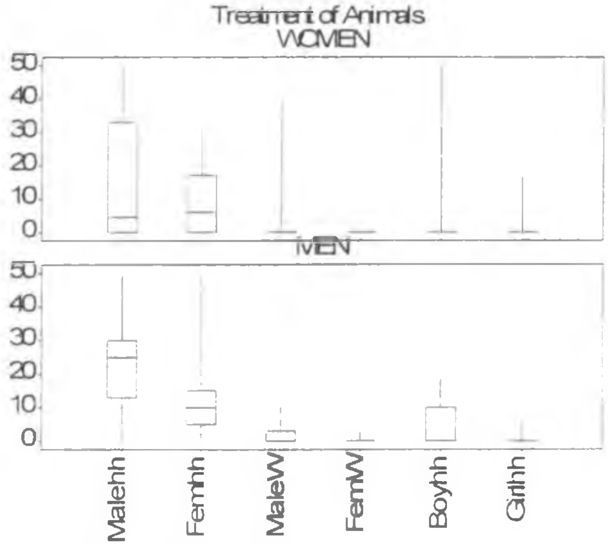
Appendix 8.1: Household Member Participatory Score in:



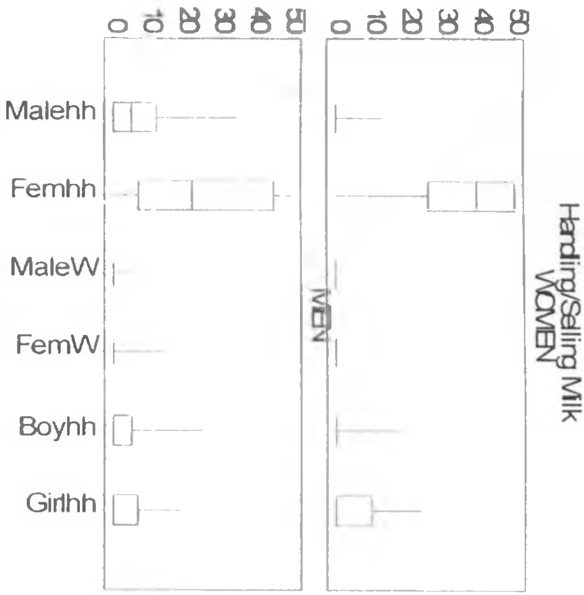


MEN
50
40
30
20
10
0
Malehh
Femhh
MaleW
FemW
Boyhh
Girlhh

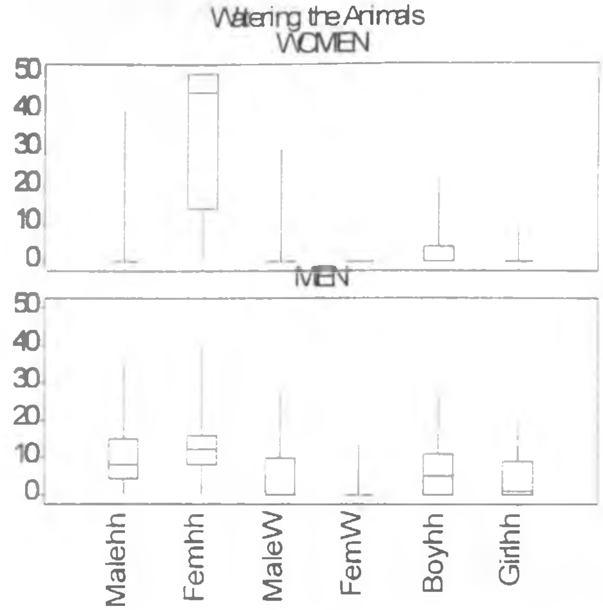

Disposal of Manure
WOMEN
MEN
Cleaning Sheds
WOMEN
Malehh
Femhh
MaleW
FemW
Boyhh
Girlhh
0
10
20
30
40
50

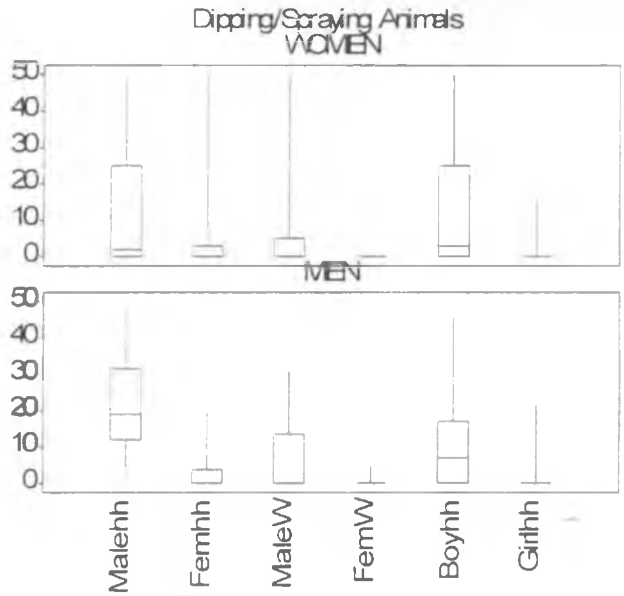


Treatment of Animals
WOMEN
MEN
0
10
20
30
40
50
Malehh
Femhh
MaleW
FemW
Boyhh
Girlhh



Handing/Selling Milk
MEN
WOMEN
Malehh
Femhh
MaleW
FemW
Boyhh
Girlhh
0
10
20
30
40
50


Watering the Animals
WOMEN
MEN
0
10
20
30
40
50
Malehh
Femhh
MaleW
FemW
Boyhh
Girlhh


Dipping/Spraying Animals
WOMEN
MEN
0
10
20
30
40
50
Malehh
Femhh
MaleW
FemW
Boyhh
Girlhh

Appendix 8.2: Focus Group Discussion Guide

(Segregated into male and female dairy farmers)

Name of moderator.................................

Venue of FGD...

Time started.............. Time ended............

No. of participants...................................

Benefits of urban dairy farming

- What benefits of urban dairy farming are you aware of?

  List down all the benefits and rank the benefits. Using the 6 highly ranked benefits, do proportion pilings show the import of each of the benefit. Use 50 pebbles. Make sure the participants understand the principle of the exercise before you start. Try and obtain from each participant the reason for the way the piling was done.

Benefit	Participants									
	1	2	3	4	5	6	7	8	9	10
Total	50	50	50	50	50	50	50	50	50	50

Health risks

Knowledge, Attitude and Perceptions

- Do you consider Livestock/dairy animals to be the source or causal to any health condition that you are aware of?

  What health risks do you think are associated with urban dairy farming? List them. Rank these and using 6 highly ranked health risk, do a proportion piling using 50 pebbles to indicate what the participants perceive to be the importance of each. Try and obtain from each participant the reason for the way the piling was done.

Disease/ Condition	Participants									
	1	2	3	4	5	6	7	8	9	10
Total	50	50	50	50	50	50	50	50	50	50

- Now we will look at some specific diseases associated with urban dairy farming

1. Tuberculosis

Knowledge

i) Have you ever heard of the disease Tuberculosis?

ii) What causes it and how is it transmitted?

iii) What are the symptoms?

iv) Do you know of some people in this community suffering from coughing blood?

v) Have you ever heard of some people in the community being treated for tuberculosis?

Attitude and perceptions

i) Do you consider yourself to be at risk of acquiring the disease?

ii) If yes, what do you think are the risk factors?

iii) If no, why don't you consider yourself to be at risk?

iv) How can the disease be prevented?

2. Aflatoxin intoxication

Knowledge

i) Have you ever heard of this food intoxication?

ii) Do you know how it is caused?

iii) Do you know how animals come to pass it to man?

iv) What are the symptoms?

v) Have you heard of people who have suffered this intoxication?

Attitude and perceptions

i). Do you consider yourself/family at risk of this intoxication?

i) If Yes, what do you consider as the risk factors?

iii) If No, why don't you consider yourself/family to be at risk?

iv). How do you think the condition can be prevented?

Practices

- What specific practices can lead to one being exposed to the health risks?
- Probe on the following practices and who does them

Practices	Male hh	Female hh	Male workers	Female workers	Boys hh	Girls hh
milking						
feeding						
cleaning sheds						
disposing of manure						
selling/handling milk						
give the treatment						
watering the cows						
dipping the cows/pest control						

- Probe on whether the following are done

Milking

i. How they use the milk - whether it is boiled, drank raw, used to make tea or used to make fermented milk

Appendix 8.3: The Survey Instrument for the Interaction between Crop Livestock Systems in Nakuru

1. IDENTIFICATION.

1.1Enumerator's name____

1.2 Estate______________Household Number_____________________

1.3 Respondent's name____

1.4 Sex of the respondent___________1=male, 0=female Age________________

1.5 Relation to household head____________________________________

1.6 Education level of respondent _________________________________

1.7 Type of farming. Livestock only --------------Crop and Livestock----------

1.8 Date_______________Start time________End time______________

2. 0 HOUSEHOLD CHARACTERISTICS

2.1. Name of household head_________________________1=male, 0=female

2.2. Sex of the Household head___________1=male, 0=female

2.3 Age of household head (yrs)________________

2.4. Education status of household head (years)...

0) No formal education 1) Primary 2) Secondary 3) Completed secondary 4) College 5) University.

2.5. Main occupation of the household head______________________________

(1) Farmer (2) Casual worker (3) teacher (4) mechanic (5) accountant (6) engineer (7) other (specify) --

2.6. Number of household members...

SECTION 1 (A-I)

APPLICABLE TO LIVESTOCK AND MIXED FARMERS ONLY

A. Livestock Production (Use codes below where necessary)

A1. Livestock types, rearing system (TABLE 1)

Livestock type	Rearing system

Livestock type: [1=Sheep, 2=goat, 3=cattle, 4=pigs, 5=chicken, 6=ducks, 7=rabbits, 8= other (specify),

Type of floor Rearing system: 1=zero grazing, 2=semi-zero grazed, 3=housed at night-free ranged day time 3=complete free range, 4= other (specify),

B. Livestock Feed Types and Sources in 2004 (TABLE 3)

Type of Livestock	Type of Fodder (F)/ Organic waste (OW)/ Concentrate (C)	Own sources						Purchased					
		URBAN (U)	Amt sourced per week (Kgs)	Who sources? MA MY FA FY MC, FC	RURAL (R)	Amt sourced per week (Kgs)	Who sources? MA MY FA FY MC, FC	URBAN (U)	Amt sourced per week (kgs)	Who source? MA MY FA FY MC, FC	RURAL (R)	Amt sourced per week (Kgs)	Who source? MA, MY, FA, FY, MC, FC

H. Livestock risk assessment

H1. What health risks apart from diseases can you associate with livestock keeping?

.... **(Rank in order of importance)**

1=Allergy, 2=Pollution from manure disposal, 3=Odour, 4= Noise, 5=Breeding flies, 6=injuries, 7= don't know, 8=other (specify)...

H2. What diseases/conditions can one get from keeping livestock or consuming their products?

.... **(Rank in order of priority)**

1=Anthrax, 2=rabies, 3=Brucellosis, 4=Tuberculosis, 5=Aflatoxins, 6=Rift valley fever, 7=Leptospirosis, 8=Cysticercosis/Teaniasis, 9=Salmonellosis, 10=other (specify)

H3. Do you take any precautions to safeguard infection against any of the disease (s) mentioned above?

Diseases from Keeping Livestock and Precautions Taken (TABLE 8)

Disease	Precaution (s)

H4. How do you use the milk from your cows?..

[1=use in making tea, 2=drink it raw, 3=boil it before drinking, 4=make traditional 'lala']

H5. If you make fermented traditional milk, do you boil the milk before?........................

[1=yes, 0=No]

H6. Have you ever heard of a disease called aflatoxin poisoning?....................................

1=Yes, 0=No

H7. Do you know whether animals can pass on the poisoning to humans?.........................

1=Yes, 0=No

H8. Do you know how humans get poisoned from aflatoxins?.......................................

Specify?...

H9. What precautions do you take to protect yourself from being poisoned by aflatoxins? (**In order of priority**)

i)..

ii)...

H10.Do you compound your own feeds?..

[1=yes, 0=No]

H11. If yes, what ingredients do you use?..

i)...

ii)..

H12. Where do you store your feeds? (Observe and record whether dry or humid place)...

H.13 Do you know whether cattle can be infected with tuberculosis?.............................

0=No, 1=Yes, 2=Do not know]

H14. Can human get tuberculosis from cattle?...

[0=No, 1=Yes, 2=Do not know]

H15. How can this transmission occur?..

i)..

ii)..

H16. Has any member of your family been diagnosed with TB in the last one year/..............

[0=No, 1=Yes]

H17. What precautions would you take to protect your family from being infected with TB from cattle? **(List in order of importance)**

i)..

ii)..