AN INVESTIGATION OF PREVALENCE AND RISK FACTORS OF PORCINE CYSTICERCOSIS AND HUMAN TAENIOSIS IN TESO DISTRICT, KENYA

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Veterinary Epidemiology and Economics

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DECLARATION

This thesis is my original work and has not been presented for the award of a degree in any other university

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This thesis has been submitted for examination with our approval as the supervisors

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DEDICATION

To my loving parents,

Mr & Mrs Aliphonce Mutua Muindi

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ABSTRACT

Cysticercosis due to *Taenia solium* is a disease of both public health and economic importance, which has been reported in developing countries of Africa, Asia and America. Infection in humans and pigs is a disease of the poor, mostly affecting the rural small-scale farmers. In this study, the prevalence of porcine cysticercosis and the potential risk factors of infection among the free-range pigs in Teso District were assessed. Information on *T. solium* infection in humans in the district was obtained from hospital records. A cross-sectional study was conducted in which a sample of small-scale pig keepers was randomly selected and pigs examined for the presence of *T. solium* larval cysts using the lingual palpation method. A total of 505 pigs from 316 survey households were examined for the larval cysts. Information on potential risk factors for porcine cysticercosis was obtained by means of standardized questionnaires administered via personal interviews.

Out of the cross-sectional sample of 316 households, a case-control sample of 31 case and 93 control-households was selected. A case household was defined as one with atleast one pig testing positive for the *T. solium* larval cysts and a control household as one where no pig tested positive for the cysts. The household prevalence of porcine cysticercosis was estimated at 9.8 % with a 95 % confidence interval (CI) of 6.5 – 13.1 %. The total number of pigs testing positive was 33, converting to a pig prevalence of 6.5 %, and a 95 % CI of 2 % – 10.7 %.

Out of the 124 survey households, 11 % did not keep any other type of livestock except pigs. Thirty–eight percent of the farmers kept only one pig and 12 % had more than five pigs. Pigs in Teso District were kept as a source of income (98 %) and for home consumption (2 %). Major

sources of pigs included purchases from within the district (94 %) and purchases from Uganda (6 %).

Two methods of raising pigs were identified, namely, free-ranging and total confinement. Most (95 %) of the pig farmers allowed their pigs to roam freely in the villages and 71 % of these practiced a mixture of free-range and tethering. A total of six (5 %) households reportedly confined their pigs, either by tethering (67 %) or by housing (33 %).

Pork was consumed in 110 (89 %) of the surveyed households. The meat was sourced from local butcheries (85 %) and home-slaughtering (15 %). Fifty-six percent of study households practicing home-slaughter had their meat inspected at "home". This "inspection" was done by household friends (56 %), the owners themselves (11 %) and government meat inspectors (33 %). The most commonly (94 %) practiced method of pork preparation before eating was frying.

Epilepsy was identified as a common disease in the villages, 56 % of the respondents reported presence of epileptics in their villages while 19 % had observed epileptics in their families. The taeniosis / cysticercosis complex was poorly understood by both the public and even the medical personnel in the district.

Most of the potential risk factors considered in the study were equally distributed in both case and control households. The only variable which was significantly more in the case households (42 %) than in the control households (19 %) was absence of latrines ($p< 0.05$; OR=3.2). The prevalence of tapeworm infections in humans in the District was 0.18 %. Other intestinal infections reported in humans were: hookworm (17.5 %); *Entamoeba histolytica* (10.1 %); *Giardia lamblia* (2.4 %); *Ascaris lumbricoides* (2.5 %); *Strongyloides stercolaris* (2.7 %) and *Schistosoma mansoni* (0.18 %).

It was concluded that porcine cysticercosis is prevalent in the locally-raised pigs of Teso District. This strongly suggests presence of human *T. solium* carriers who, due to non-use of toilet facilities, contaminate the environment with *T. solium* eggs infective to both humans and pigs, and thus maintaining the life cycle of the parasite. Appropriate and sustainable control strategies based on the scientific data collected should be devised in collaboration with the affected local populations to effectively address this emerging problem. Education of the public should be an integral component of any envisaged control programme of the taeniosis / cysticercosis complex in the district.

CHAPTER ONE

1.0 INTRODUCTION

Human infection with the tapeworm *Taenia solium* is a serious public health problem in developing countries (Craig *et al.*, 1996). Cysticercosis due to *T. solium* affects both humans and pigs. Porcine cysticercosis, i.e, the presence of the larval stage *Cysticercus cellulosae* in pigs, is a serious economic problem in pig production (Phiri *et al.*, 2002). Man is usually the definitive host of the cestode but can also act as an intermediate host with cysts developing in the central nervous system, especially the brain, leading to neurocysticercosis, a major cause of death in Latin America, Africa and Asia (Ruiz, 1997; Yasuhito *et al.*, 2000). Taeniosis, i.e, the presence of the adult tapeworm in the small intestine of man, is usually non-fatal (James, 1982; Brown, 1983).

An estimated 50 million people worldwide are infested with *T. solium* and 50,000 die of cysticercosis annually (Schantz *et al.*, 1993; Carlo *et al.*, 2003; Mafojane *et al.*, 2003). Cysticercosis in man is the most frequent parasitism of the brain, prevalent in the developing countries where sanitary conditions are substandard. *Taenia solium* infection is considered to be the main cause of epilepsy due to the resulting neurocysticercosis and a major cause of death in the world (Lightowlers, 2003).

Humans acquire the adult tapeworm by consuming undercooked infected meat with cysticerci, and within 3-4 months, may contaminate pig's feed with eggs produced by the gravid proglottids. Pigs can also pick the infection directly from faeces of infected carriers. After ingestion by the pigs, the infective eggs hatch in the intestines, followed by migration of the larvae and subsequent development of cysticerci in body tissues, including the brain and the muscles (Bernadette *et al.*, 2003).

Due to the lack of well-organized meat inspection activities and illegal slaughtering in developing countries, infected pig carcasses may be passed on to the market where the meat is sold at lower prices (Phiri *et al.*, 2003). This leads to a loss of government revenue and farmers are at risk of acquiring epilepsy due to neurocysticercosis due to the pathology induced by the parasite (Flisser, 1985). The average cost for hospitalization of a patient can be estimated, but this has been found to be hard for many of the African countries where patients are rarely hospitalized (Roberts *et al.*, 1994).

Taenia solium taeniosis and cysticercosis complex in man is associated with poor sanitation, poor methods of pig husbandry and poor meat inspection (Pedro and Boris, 1987; Phiri *et al.*, 2002). The disease is widely prevalent in human and swine hosts in many developing countries of Latin America, Africa and Asia (Sarti *et al.*, 1992; Gonzalez *et al.*, 2003). *Taenia solium* cysticercosis has been reported as a serious economic and public health problem in most of the countries of America and other regions where ecological and social conditions permit its spread (Schenone *et al.*, 1982). Globally, neurocysticercosis is considered to be the most common parasitic disease of the nervous system and a major cause of epilepsy in the developing world (Diop *et al.*, 2003).

Recent epidemiological data show that neurocysticercosis is an emerging disease in developed countries such as the USA where several cases have been reported (Flisser *et al.*, 2003).

Epidemiological studies conducted in Mexico estimated porcine cysticercosis, human taeniosis and human cysticercosis prevalences to be 35 %, 2.4 %, and 12 %, respectively (Flisser *et al.*, 2003). Taeniosis / cysticercosis has been eradicated in most of the European countries but there are risks of re-introduction due to the increased number of immigrants from endemic areas (Ito *et al.*, 2003).

Cysticercosis due to *T. solium* has been reported in West African countries including Benin, Burkina Faso, Ghana, Nigeria, Cote d'Ivoire, Senegal and Togo (Zoli *et al.*, 2003). A porcine cysticercosis prevalence of 20.5 % has been reported in Nigeria (Onah and Chiejina, 1995). Both porcine and human cysticercosis are hyperendemic in Rwanda, Burundi, Zaire and Cameroon. Prevalence in humans in Rwanda is reported to be higher than that reported in endemic regions in Latin America (Garcia *et al.*, 2003; Zoli *et al.*, 2003). The infection rates in humans in most of the West African countries are poorly documented although neurocysticercosis has been shown to be one of the major causes of epilepsy in Cameroon (Zoli *et al.*, 2003).

According to Tsang and Wilson (1995), *T. solium* cysticercosis is under-recognized in many developing countries of Africa. An international workshop on taeniosis / cysticercosis held in South Africa in 1997 provided the first indication of an emerging problem of the disease in East and South Africa (Ruiz, 1997). Another international action planning workshop convened in Arusha, Tanzania in 2002, with special focus on East and Central Africa, recognized *T. solium* cysticercosis as an emerging zoonosis that needed special attention. This led to the development of a regional action plan to combat the disease. Among the recommendations of the Arusha meeting was the development of rapid epidemiological assessment tools for identifying suspected endemic areas and the collection of surveillance data (Boa *et al.*, 2003).

Cases of human and porcine cysticercosis have been reported in the Eastern and Southern African countries. This poses a great public health problem in the region (Mafojane *et al.*, 2003). Boa *et al.* (1995) reported a porcine cysticercosis prevalence of 17.4 % in Mbulu District of Tanzania, while Phiri *et al.* (2003) reported several cases of porcine cysticercosis in Uganda. In Zambia, 20.6 % of pigs slaughtered in one of the slaughter slabs in the country had cysticercosis, while in South Africa, 28-50 % of human epileptics were positive for cysticercosis (Phiri *et al.*, 2003; Mafojane *et al.*, 2003). Results from some endemic areas of Africa Mozambique and South Africa, have indicated a strong relationship between cysticercosis and epilepsy (Newell *et al.*, 1997; Phiri *et al.*, 2003). Porcine cysticercosis seroprevalence has been shown to be strongly correlated with human taeniosis prevalence, which is reportedly rare in Muslim countries, where pork is not eaten (Garcia *et al.*, 2003; Zoli *et al.*, 2003).

In Kenya, very little epidemiological work has been done to characterize and describe the disease in pigs although cases of cysticercosis in pigs have been reported in pigs originating from districts bordering Tanzania. A report submitted to the Director of Veterinary Services (Kenya) in 2002, showed little data on the occurrence of the disease in Kenya, both in humans and pigs (Otwelo, 2002). Several cases of porcine cysticercosis were detected in a major abattoir in Nairobi; but the pigs had reportedly been imported from the Republic of Tanzania (Otwelo, 2002; Anon, 2003). Githigia *et al.* (2002) reported prevalences of 14 % for porcine cysticercosis in free-range pigs in Busia District and 10 % in South Nyanza. Out of the three cases reported in 2002 by Farmers Choice, one was from Teso District (Otwelo, 2002; Anon, 2003). Two cases of human neurocysticercosis have been reported in Kenya (Mafojane *et al.*, 2003).

Smallholder pig keeping is popular in western Kenya where pigs are kept under the extensive, free-range production system. The law requires that pigs be confined and infected carcasses condemned (GOK, 1966; GOK, 1972; GOK, 1977). Illegal home-slaughter of pigs with no inspection has been reported in some parts of Busia District and Nyanza (Githigia *et al.*, 2002).

1.1 Objectives

The status of porcine cysticercosis in Kenya is not well known despite reports of infected carcasses in some parts of the country. The present study was therefore undertaken to address the following specific objectives:

1. To estimate the prevalence of porcine cysticercosis and obtain baseline data on human taeniosis in Teso District, Kenya;

2. To determine the potential risk factors of porcine cysticercosis in Teso District, Kenya.

The findings of this study are intended to provide baseline information on the status of cysticercosis in pigs in the region. The small-scale pig farmer, government, non-governmental organizations and all those who could be involved in policy making, are considered as the immediate beneficiaries of results from this study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Epidemiology of *Taenia solium* taeniosis and cysticercosis

2.1.1 Aetiology

Cysticercosis of pigs is caused by the presence and development of the cysticercal larva (*Cysticercus cellulosae*) of *T. solium* in the striated muscles of pigs. The cysticerci are whitish vesicles measuring 8-10 mm with invaginated scoleces appearing as white spots with double rows of hooks similar to those of the adult worms (Pedro and Boris, 1987). *Taenia solium* belongs to the phylum Cestoda, Class Eucestoda, Order Taeniida and the genus *Taenia* (Reinecke, 1983). Members of the class Eucestoda are the true tapeworms. They have an armed rostellum with four suckers. Cestodes of veterinary importance have an elongate, flat, tape-like body and vary from less than a millimeter to several metres in length. The body is divided into three parts: Scolex (head) is globular in shape and has organs of adhesion consisting of four suckers and may have a rostellum, with one or more rows of hooks; the neck lies behind the scolex and this is where new segments are formed; the strobila (body) is composed of a variable number of proglottids, the small newly formed ones are located near the scolex (Reinecke, 1983). *Taenia solium* is a two-host zoonotic cestode. The adult stage is up to 10 metres in length, and lives in the small intestine of humans.

The gravid proglottid at the terminal end of the worm contains infective eggs that are infective to both pigs and humans leading to development of the larval stage. The natural intermediate host is the pig; no other final intermediate host of *T. solium* has been reported in nature (Garcia *et al.*, 2002). Humans become infected with the cysts by accidental ingestion of *T. solium* infective eggs through the fecal-oral contamination. Species of *Taenia* for which adult tapeworms occur in domestic animals and man, the definitive hosts, larval stages, intermediate hosts and locations of the larval stage are shown in Table 2.1.

Table 2.1: Definitive and intermediate hosts of *Taenia* (Urquhart *et al.*, 1988)

Adult tapeworm		**Larval stage**		
Tapeworm	**host (definitive)**	**Larva**	**host (intermediate)**	**site**
Taenia saginata	Man	*Cysticercus bovis*	Cattle	Muscle
Taenia solium	Man	*Cysticercus cellulosae*	Pig, Man	Muscle, CNS, l
Taenia multiceps	Dog	*Coenurus cerebralis*	Sheep, Cattle	Nervous s
Taenia hydatigena	Dog	*Cysticercus tennuicolis*	Sheep, Cattle, Pigs	Peritoneu
Taenia ovis	Dog	*Cysticercus ovis*	Sheep	Muscle
Taenia pisiformis	Dog	*Cysticercus pissiformis*	Rabbit	Peritoneur
Taenia serialis	Dog	*Coenurus serialis*	Rabbit	Connective
Taenia taeniaformis	Cat	*Cysticercus fusciolaris*	Mouse	Liver
Taenia krabbei	Dog	*Cysticercus terandi*	Reindeer	Muscle

2.1.2 Life cycle of *Taenia solium*

Taenia solium has a two-host life cycle which includes the pig as the normal intermediate host harbouring the cysticerci and human as the definitive host harbouring the adult form of the tapeworm (Nash and Neva, 1984; Pedro and Boris, 1987; Figure 2.1). The human host ingests infected (measly) pork containing viable cysticerci. The scolex of the metacestode then evaginates in the gut and attaches to the intestinal mucosa. The tapeworm matures over a period of 2-3 months to achieve a length of up to 10 metres. Gravid segments may contain 50-60 000 eggs which are passively released in small groups in faeces, two or three times a week (James, 1982; Pal *et al.*, 2000). The cestode sheds gravid segments, which either degenerate in the digestive tract or are expelled with the faeces. The adult worm resides in the small intestines of man and can persist there for up to 25 years (Brown, 1983). Self contamination by man from an adult infection or internal autoinfection from reverse peristalsis has been reported, resulting in development of the larval stage of *T. solium* in humans (Breaver *et al.*, 1984; Pal *et al.*, 2000). Development of cysticerci in the brain or the spinal cord of humans leads to neurocysticercosis, which is a major cause of acquired epilepsy in the developing world (Mafojane *et al.*, 2003).

Pigs are infected when they ingest eggs shed in the faeces of human tapeworm carriers, especially in environments which favour the life cycle including absence of latrines, pork consumption and free roaming pigs. Once the eggs are ingested, oncospheres hatch in the intestines, invade the intestinal wall, and migrate via blood stream to the striated muscles as well as the brain, liver, and other tissues, where they develop into cysticerci. Oncospheres have been reported to use their hooks and enzymes in the gastrointestinal system to perforate the intestinal mucosa and enter the pig's circulation. The cysts form in the muscles within 3-6 months where they remain infective for one year, their growth continues until they become the next developmental stage of the parasite (FAO, 2003). The distribution and the density of *T. solium* cysts in pig muscles differ from organ to organ. Boa *et al.* (2002) observed that most cysts were concentrated in the psoas, heart and diaphragm muscles. The cycle is completed when man eats the infected pork that is not properly cooked. Dogs have also been shown to act as intermediate hosts for *T. solium* cysticercosis in Indonesia (Ito *et al.*, 2002).

Different genotypes of *T. solium* have been identified, namely, the African and American / Asian types. The two have been shown to affect the symptomatology, diagnosis and control of *T. solium*. Cellular events during the process of parasitic infection are sequential. Four including four histopathological stages have been identified including viable cyst, colloidal cyst, nodular / granular cyst and calcified cysts (Garcia and Del Brutto, 2003; Ito *et al.*, 2003). All pigs can carry *T. solium* cysticerci but other substitute hosts such as small ruminants and dogs have been documented. Dogs that ingest human faeces and become infected with the eggs of *T. solium* sometimes show signs of cerebral cysticercosis, which may be confused with those of rabies (Pedro and Boris, 1987).

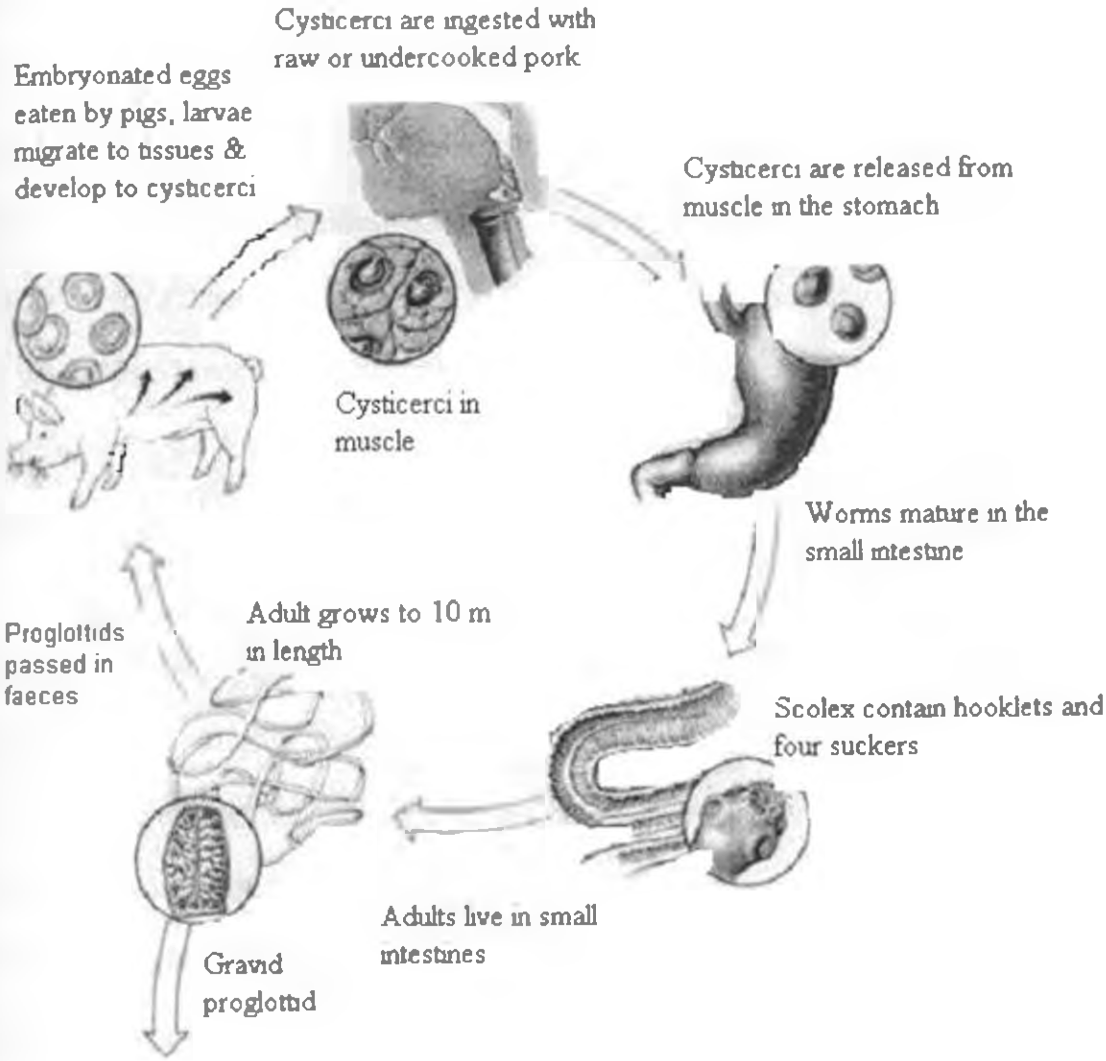

Figure 2.1: Life cycle of *T. solium* (Ukoli, 1984; modified)

2.1.3 Distribution of pigs

Pig population in the world is reported to have more than doubled in the last 30 years. The world pig population is estimated to be 917 million, of which 552 million are found in Asia, 72 million in North America, 194 million in Europe, 81 million in Southern and Central America and 18 million in Africa. Monogastrics reportedly contribute 63 % of the meat consumed globally, while about 44 % of the world's meat protein consumption is derived from pork and pork products (Faustin and Kyvsgaard, 2003).

Pig production is reportedly rare in the predominant Muslim countries of Bangladesh and Pakistan, and the Muslim communities of Malaysia and Indonesia (Perry *et al.*, 2002). There has been a significant increase in pig production in the eastern and southern Africa region during the past decade, especially in the rural, resource poor small-holder communities. The lack of grazing land for ruminants and the recognition by the farmers of the quicker returns on their investment, have contributed to an increased interest in raising pigs (Phiri *et al.*, 2003; Zoli *et al.*, 2003). South Africa has the largest number of pigs in the southern African region while Uganda has the highest number and the fastest growing population of pigs in Eastern Africa, as quoted by Phiri *et al.* (2003) and Willingham and Schantz. (2004) in recent reviews.

The growth in human population and pressures on arable farming has led to an increase in the pig population in Kenya (Appendix 8.1). Farmers Choice Ltd is the main outlet market for pigs in the country, reportedly taking 80 % of the pigs. Other small outlets for pigs include, Gourmet Bacon, Nairobi Airport Services (NAS), Cheffs` Choice and the Kenya Cold Storage

(MOA, 2000). There was a general decline in pig population in 1998 and 1999. During this period, Farmers Choice Ltd had established its own pig farms and this reportedly discouraged many pig farmers. The market, however, started to pick up in 2000 after the company lost most of its pigs due to an outbreak of African Swine Fever (MOA, 2000). This led to drastic changes in the market. It is estimated that a total of 1,426,816 pigs were slaughtered in Kenya between 1991 and 2000, converting to estimated revenue of Ksh 8, 833.4 million (CBS, 2002). Table 2.2 shows the number of pigs, cattle and small ruminants slaughtered in Kenya in the years 1997 to 2001. An increasing number of pigs were slaughtered between 1997 and 2001.

Table 2.2: A comparison of slaughter figures for pigs, cattle and the small ruminants in Kenya, 1997 – 2001 (Central Bureau of Statistics, 2002)

Year	Number of pigs slaughtered	Number of cattle slaughtered	Number of sheep and goat slaughtered
1997	88,000	1,320,000	1,603,000
1998	153,000	1,800,000	3,983,000
1999	158,000	2,536,000	4,355,000
2000	189,000	2,870,000	4,572,000
2001	214,000	1,952,000	4,671,000
Total	**802,000**	**10,478,000**	**19,184,000**

2.1.4 Occurrence of *T. solium* taeniosis / cysticercosis

Infestation with *T. solium* and its larvae is prevalent in human and pig hosts in many developing countries of Latin America, Africa and Asia (Sarti *et al.*, 1992; Allan *et al.*, 2003). Cases of human neurocysticercosis have been reported in non-endemic areas of Latin America indicating patterns of immigration from highly endemic countries (James, 2000). Cysticercosis has been shown to affect an estimated 50 million people globally, causing approximately 50,000 deaths each year (Carlo *et al.*, 2003; FAO, 2003). Many patients are diagnosed with neurocysticercosis each year in developed countries including the USA (White, 1997). Cases of neurocysticercosis have been reported in Asian countries including China, Indonesia, India, Nepal and Korea (Rajshekhar *et al.*, 2003).

Taenia solium cysticercosis in both humans and pigs is under-recognized in many developing countries of Africa especially those of central and western parts and very little epidemiological data are available (Tsang and Wilson, 1995). The infection reportedly occurs over most of the African continent with the exception of the strictly Muslim areas of North and sub-saharan areas. Both human and pig infections have been reported in South Africa, Zimbabwe, Gambia, Guinea, Togo, Rwanda, Burundi, Malawi, Swaziland, Madagascar and Zaire (Zoli *et al.*, 2003). In Tanzania, cases of porcine cysticercosis were first reported in Mbulu District by Boa *et al.* (1995) where the prevalence was estimated at 17.4 %. Ngowi *et al.* (2002) estimated the prevalence in individual villages of the district and reported prevalences ranging from 3.2- 46.7 %. In Uganda, 9.4 % of the pigs surveyed were found positive for cysticercosis with most cases coming from the rural areas (Kisakye and Masaba, 2002), quoted by Phiri *et al.* (2003).

Most pigs in Kenya are raised under the intensive system with the extensive management system being predominant in some parts of western Kenya where pigs are kept under the free-range system. Surprisingly, this free-range production system is slowly emerging in certain urban centres in the country. The ban by the Kenyan government of the free-range pig-keeping in the early 1960s reportedly led to decline in the prevalence of porcine cysticercosis (Githigia *et al.*, 2001). The problem may still exist in certain rural areas where pigs are kept under free-range system with poor sanitation. Githigia *et al.* (2002) reported a prevalence of 10 - 14 % in a study conducted in Busia and Nyanza districts. Several cases of porcine cysticercosis were detected in Kenya in the early 1960s (Table 2.3). Since 1998, a total of 39 pig carcasses were reportedly condemned at a major pig abattoir in the country during routine meat inspection as follows: 1988 (20); 1992 (2); 1994 (7); 1997 (2); 1998 (4); 2002 (3); 2003 (1) (Otwelo, 2002; Anon, 2003).

Table 2.3: Cases of porcine cysticercosis reported at Uplands Bacon Factory, Kenya, in the years 1960 - 1969 (Otwelo, 2002)

Year	Number of pigs Slaughtered	Number positive for *C. cellulosae*
1960	55399	5
1961	55957	5
1962	-	1
1963	45339	1
1969	-	6
Total	-	**18**

2.1.5 Risk factors of *T. solium* taeniosis / cysticercosis

In some societies, massive infestation with cysticercosis may be caused by the use of proglottids in treatment of various maladies. In South Africa, an interesting and potentially life-threatening scenario of cysticercosis infections is from concoctions prepared by traditional healers to which tapeworm segments are added. This has led to massive infestation with cysticercosis (Joubert and Evans, 1997). A study carried out in Zambia revealed that poor pig husbandry practices, absence of meat inspection poor knowledge of the disease, and poor sanitation in the surveyed villages increased the risk of human cysticercosis (Phiri *et al.*, 2002).

According to Schantz *et al.* (1994), cysticercosis in pigs and humans is as a result of exposure to various environmental factors and of the inability of the immune system to recognize the parasite as foreign during the initial stages of infection. A general lack of hygiene especially in rural areas where pigs have easy access to human faeces is an important factor that helps to perpetuate the life cycle of the parasite (Sarti and Rajshekhar, 2003). The risk factors for human taeniosis include; consumption of raw or undercooked meat containing viable cysticerci; travelling to endemic areas; hosting of visitors from endemic areas; and low standards of hygiene (Gutierrez, 1990; Schantz *et al.*, 1992; FAO, 2003; Sarti and Rajshekhar, 2003). Fruits and vegetables eaten unpeeled or undercooked as well as flies are considered important vectors in the transmission of *Taenia* eggs but this has not been documented for *T. solium* (Flisser *et al.*, 2003). Dogs have been shown to harbour cysticerci and in countries where dog meat is eaten as in Indonesia, taeniosis in man is possible (Flisser *et al.*, 2003). Castration and pregnancy has been shown to significantly increase prevalences of cysticercosis in rural pigs, indicating an important role played by sex hormones in susceptibility of pigs to *T. solium* infections (Morales *et al.*, 2002).

The risk factors for swine cysticercosis include: the application of human slurry over pasture or direct environmental access by free ranging pigs; the presence of tapeworm carriers on the farm; feeding of household garbage; and absence or non-use of toilets or latrines (Sarti *et al.*, 1992; Garcia *et al.*, 2003; Ngowi *et al.*, 2004). The risk factors for neurocysticercosis are poor hygiene and direct infection (Flisser *et al.*, 2003).

2.1.6 Clinical signs of human taeniosis / cysticercosis and porcine cysticercosis

Taenia solium causes two different diseases. When the adult cestode infects the human intestine, taeniosis develops. This is generally asymptomatic with the host becoming a continuous source of *Taenia* eggs expelled in faeces each day (Brown, 1983; Julio *et al.*, 2004). However, gastrointestinal discomfort including diarrhoea, flatulence and abdominal pains (hunger pains) are sometimes observed. According to Nash and Neva (1984) and Garcia *et al.* (2002), clinical signs of cysticercosis in man depend on several factors including location, growth, size and number of cysts, viability of the lesions, stage of cyst degeneration and presence of calcifications and type and degree of the host response. Individuals with neurocysticercosis may be asymptomatic although a variety of neurological signs including seizures due to cysts in the brain have been documented (White, 1997; Garcia *et al.*, 2000). The initial manifestations of neurocysticercosis include signs and symptoms including the increase of intracranial pressure, neurological deficit and deterioration of mental functions, headache and general malaise (Lotz *et al.*, 1988).

In humans, harmful cysticercosis may be acquired through consumption of contaminated food and water, self contamination from an adult infection, or internal autoinfection from reverse peristalsis carrying eggs (Beaver *et al.*, 1984). Symptoms include nausea, vomiting, headache, ataxia, confusion, vision changes, subcutaneous nodules and focal neurological complaints (Mafojane *et al.*, 2003; Zoli *et al.*, 2003). Patients with cysts in the basal cisterns can present with meningeal signs, hydrocephalus, vasculitis, and stroke (Pal *et al.*, 2000).

Porcine cysticercosis produces generally no clinical signs (Gonzalez *et al.*, 2003). At the time of infection, pigs may have slight diarrhoea due to the irritation of the intestinal mucosa by the migrating embryos. The establishment of the cysticerci may result in myositis, with locomotor disorders that may lead to progressive emaciation due to difficulty in taking and assimilating food. Encephalitic signs do occur if the cysticerci migrate to the brain producing encephalitic signs similar to those of coenurosis of sheep. Abnormal skin sensitivity may also be observed on the snout. Severe infection of the myocardium may lead to sudden death from heart failure (Urquhart *et al.*, 1988).

2.2 Diagnosis of *T. solium* taeniosis / cysticercosis

2.2.1 Pigs

Palpation of the tongue for *C. cellulosae* cysts in live pigs has been used (Phiri *et al.*, 2002; Githigia *et a.*, 2002; Ngowi *et al.*, 2004). However, this method is not very sensitive. The sensitivity of the tongue examination has been reported to be low and not appropriate for light infections (Garcia *et al.*, 2002; FAO, 2003; Phiri *et al.*, 2003). Postmortem meat inspection is more sensitive and specific and involves both palpation and incision of various parts of the carcass including the tongue for the presence of the cysts. Pig traders in Tanzania are sensitized on porcine cysticercosis and usually do the tongue test by themselves. This has been shown to reduce the number of infected pork in the market (Ngowi *et al.*, 2004). In an abattoir survey conducted by Phiri *et al.* (2002), the sensitivity of tongue palpation relative to the visual inspection of the carcass was shown to be 43 %. However, a higher sensitivity of up to 70 % has been reported (Gonzales *et al.*, 1990). In light infections, both the specificity and sensitivity of lingual palpation have been shown to be low (Sciutto *et al.*, 1998; Garcia *et al.*, 2003). Hirofoni *et al.* (1988) reported absence of cysticerci in tongue of infected pigs, an indication that the method is not sensitive.

The cysts seen during postmortem meat inspection need to be differentiated from those of sarcosporidiosis, which are smaller. Pork products are examined for the presence of cysts with scolex hooks. This involves artificial digestion with pepsin hydrochloride for 24 hours at 37^0C. The liquid is then decanted after centrifugation and the residue examined for the presence of hooks by microscopy.

Before the introduction of modern neuroimaging diagnostic techniques, knowledge of the natural history of human disease was limited and largely based on cases diagnosed either by the presence of subcutaneous nodules, by plain X-rays showing calcifications in the brain or soft tissues, by surgery of cases with intracranial hypertension, or from necropsy data (Garcia *et al.*, 2002). The Computerized Axial Tomography scan has been used to study cerebral cysticercosis at necropsy in pigs (Gonzalez *et al.*, 1987).

Antibody detection methods including enzyme linked immunosorbent assay (ELISA), complement fixation test and immunoblot have also been used (Dorny *et al.*, 2003; Garcia *et al.*, 2003). Antigen ELISA has been shown to be more specific and sensitive (Phiri *et al.*, 2002) but does not allow for the differentiation of metacestodes of *T. solium* and *T. hydatigena* (Dorny *et al.*, 2003). Dorny *et al.* (2004) used Bayesian analysis framework to estimate the real prevalence of porcine cysticercosis, a method that combines prior opinions with experimental data.

2.2.2 Humans

The direct recognition of proglottids in human faeces is the best option for identification of *Taenia* infections but it may be hard to differentiate eggs of *T. saginata* and *T. solium* which are similar morphologically (James, 1982). Obtaining gravid proglottids in saline for Indian ink injection or proglottids in formalin for sectioning and staining with Hematoxylin and Eosin has been shown to be useful in differentiating the two *Taenia* species (Mayta *et al.*, 2000). Recovery of tapeworm scolex lacking hooklets is usually indicative of *T. saginata* while armed scolex belongs to *T. solium* (Garcia *et al.*, 2003). Differentiation of the two human *Taenia* species can also be based on the number of uterine branches present in well-preserved gravid proglottids; *T. solium* has 10 or fewer uterine branches while *T. saginata* has 12 or more branches (Mayta *et al.*, 2000). Obtaining well-preserved and intact gravid proglottids or the scolex after treatment of the patient is often difficult due to the partial destruction of gravid proglottids and only immature proglottids may be recovered in stool samples.

The intermittent nature of egg excretion by humans has been shown to underestimate the prevalence, and therefore the examination of at least two samples obtained in two to three intervals has been recommended (Hall *et al.*, 1981; FAO, 2003). Coproantigen test, although specific for both *T. solium* and *T. saginata*, may be used to detect the parasite specific antigens in the host faeces (Allan *et al.*, 1990; Allan *et al.*, 2003). A highly sensitive species–specific DNA probe has been developed in order to improve on the existing methods for the diagnosis of taeniosis (Harrison *et al.*, 1990; Chapman *et al.*, 1995).

Antibody detection methods including complement fixation test, radioimmunoassay, ELISA, latex agglutination and immunoblot techniques, have all been used in the detection of human taeniosis (Tsang *et al.*, 1989; Chapman *et al.*, 1995; Garcia *et al.*, 2002). However, nearly 50 % of the patients with cysticerci have little or no circulating antibodies to *C. cellulosae* (Flisser *et al.*, 1980). Wilkins *et al.* (1999) demonstrated the use of Enzyme Immuno Transfer Blot (EITB), and reported a specificity of 100 %. An antigen detection ELISA revealed the presence of active cysticercosis in 0.4 – 3 % of the people examined in three rural communities in a seroepidemiological study conducted in Cameroon by Nguekam *et al.* (2003). A sensitivity of 94.4 % and specificity of 100 % was reported in the same study for the antigen detection ELISA test. According to Hiroshi *et al.* (2004), application of multeplex PCR is useful not only for surveillance of taeniasis / cysticercosis control, but also for the molecular epidemiological survey of both *T. solium* and *T. saginata*.

Other methods for the diagnosis of neurocysticercosis include Computerized Axial Tomography (CAT scan) of the brain (Lotz *et al.*, 1988; Pal *et al.*, 2000) and the Magnetic

Resonance Imaging (MRI), in which pathological changes are seen on radiological examination (Garcia and Del brutto, 2003)| Brain MRI has been shown to be superior in showing intraventricular or subarachnoid cysts, and for showing inflammation around a cyst, whereas Computerized Axial Tomography (CAT) scan is better for showing the calcification of inactive lesions (Pal *et al.*, 2000). Ocular cysticercosis can be detected by opthalmonic examination, subcutaneous cysticercosis by surgical removal and microscopic assessment. Imaging and presence of calcified cysts has been used for the diagnosis of muscular cysticercosis. Cysticercosis in other organs can only be detected as incidental findings. Effective diagnosis for neurocysticercosis should be based on clinical signs, imaging, immunological studies and the epidemiological history (FAO, 2003).

Important differential diagnoses for neurocysticercosis include brain abscesses, coccidioidomycosis, encephalitis, endophthalmitis, epidural haematoma, migraine, meningitis, neoplasms, status epilepticus, toxoplasmosis and tuberculosis (Lotz *et al.*, 1988; Pal *et al.*, 2000).

2.3 Treatment of *T. solium* taeniosis / cysticercosis

2.3.1 Human

There are safe and efficient cestocidal products against the tapeworm and the cysticerci (Schantz *et al.*, 1993). Treatment of neurocysticercosis is controversial; sudden destruction of the parasite may trigger an inflammatory reaction which may precipitate seizures and transient neurologic effect. However, the transient seizures can be managed by anticonvulsive therapy and host immune reaction may remove the parasite (Julio, 2004).

Antihelmintics including praziquantel and albendazole have been used for the treatment of taeniosis but can also act against the cystic larva (Garcia *et al.*, 2002; Julio, 2004). Taeniosis can be treated with 10 mg / kg bodyweight praziquantel or with niclosamide (Flisser *et al.*, 2003). Both albendazole and praziquantel have been shown to be effective for therapy of parenchymal brain cysticercosis, although albendazole is better and more effective in the penetration of the brain tissue (Sotello *et al.*, 1988; Nash, 2003; Julio, 2004). Praziquantel is given as a one day therapy using 75 mg / kg body weight per day every two hours for three doses (Corona *et al.*, 1996) while albendazole is given at 15 mg / kg body weight per day with a maximum of 400mg / twice a day for 7- 30 days (Nash, 2003). Corticosteroids, anticonvulsants, surgical therapy and general supportive therapy have all been used in the treatment of neurocysticercosis.

A panel of experts on taeniasis / cysticercosis met and discussed on the following four general recommendations on treatment and management of neurocysticercosis: Individualizing therapeutic decisions (including uses of antiparasitic drugs), based on the number, location, and viability of the parasites within the nervous system; active management of the growing cysticerci, either with antiparasitic drugs or surgical excision; prioritization of the management of intracranial hypertension secondary to neurocysticercosis before considering other forms of therapy; and management of seizures as done for secondary seizures. According to this team, treatment regimes should be undertaken only if proven to be of any clinical benefit (Garcia *et al.*, 2002; Nash, 2003).

An estimated 80 – 90 % of patients with epilepsy in developing countries do not receive adequate medical care. This increases the treatment gap for epilepsy in developing world (Pal *et al.*, 2000). Seventy- five percent of people with epilepsy in Africa have no access to health-care provisions and are not appropriately treated. This could be attributed to the poor infrastructure, insufficient availability of drugs and scarcity of trained medical personnel. There is about one neurologist for about 1- 4 million people in the world (Preux *et al.*, 2000; Diop *et al.*, 2003).

Drugs for the treatment of seizures in Africa include phenobarbital, carbamazepine, phenytoin, valproate and diazepan. Newer brands such as oxcerbazepine, lamotrigine and vigabatrin have been reported but in Africa, only Morocco, Tunisia, Egypt, Zimbabwe and South Africa have them (Diop *et al.*, 2003). Garcia *et al.* (2004) reported a 46 % reduction in the number of seizures reported after treatment with albendazole and praziquantel.

2.3.2 Pigs

Antihelmintics such as dichlorvos, levamisole, mebendazole, oxfendazole and fenbendazole have all been demonstrated to be active against the major helminths in pigs (Brander *et al.*, 1991; Sarti and Rajshekhar, 2003). Oxfendazole as a single dose of 30 mg / kg body weight has been shown to be more effective than albendazole and praziquantel (Gonzalez *et al.*, 1995; Gonzalez *et al.*, 2003).

2.4 Control and prevention of *T. solium* taeniosis / cysticercosis

Taenia solium taeniosis is considered a potentially eradicable disease because of the following factors: humans are the only definite hosts hence carriers can be diagnosed and treated; pigs are the only intermediate hosts of epidemiological importance; improved sanitary infrastructure decreases transmission; diagnostic tools exist for both taeniosis and cysticercosis which are relatively specific and sensitive; effective antiparasitic drugs are available; there are no wild reservoirs for the disease; and pigs can be monitored due to the short life span of the animal (FAO, 2003; Flisser *et al.*, 2003; Sarti and Rajshekhar, 2003).

The control and prevention of taeniosis / cysticercosis consists of breaking the life cycle by treatment of humans or by destroying eggs during their passage from man to pigs. Other measures include: enforcement of proper inspection of pig carcasses in slaughterhouses; education of the public on the life cycle and control measures; proper treatment and disposal of human waste to avoid pigs ingesting eggs; total confinement of pigs (Boa *et al.*, 2001); educating the public on how to prevent contamination of food, water and environment with human faeces (Gutierrez, 1990); imposing hygienic standards such as washing hands before handling food; proper processing of infected pork; mass human chemotherapy (Gilman *et al.*, 1999); concurrent treatment of human and porcine populations or mass chemotherapy (Allan *et al.*, 1997); and use of pig vaccines (Gilman *et al.*, 1999; Lightowlers, 2003). The vaccine field trials are still going on and their use will depend on availability and cost.

The immune response of pigs infected experimentary with *T. solium* has been studied mainly for diagnostic purposes. Experimentally infected, well-nourished pigs have been shown to destroy the parasite within several months after infection (Marcia *et al.*, 1989; Tsang *et al.*, 1991; Torres *et al.*, 1992; Aluja *et al.*, 1996). *T. solium* cysticerci do possess highly antigenic molecules. It has been reported that some of the best characterized glycoproteins are important in the biology and pathogenesis of taeniosis and neurocysticercosis (Andres *et al.*, 2003).

2.5 Importance of *Taenia solium*

Although cysticercosis due to *T. solium* is a disease of both economic and public health importance, the true impact and scope of the disease has been obscured by the lack of sensitive and specific diagnostic tools necessary for collection of reliable epidemiologic data in developing countries (Tsang and Wilson, 1995). World-wide economic losses caused by food borne parasitic diseases are difficult to assess and most of the data are fragmentary (Roberts *et al.*, 1994). There has only been a few studies conducted in developing countries to assess the monetary burden of cysticercosis in pigs which would appear to be substantial (Willingham and Schantz, 2004). Infected meat is unfit for human consumption and should be condemned according to the legislative requirements of most countries. The losses incurred due to the condition may be measured in terms of losses to the individual farmer resulting from loss of or depreciation in value of infected meat and the impact this has in pig production. An infected carcass costs only one third of the price of a healthy one (Gonzalez *et al.*, 1987; Boa *et al.*, 2002; Phiri *et al.*, 2003; Zoli *et al.*, 2003).

In Mexico, the economic loss due to porcine cysticercosis is estimated to be more than half the national investment (Willingham and Schantz, 2004), while in China, discarded pork totals 0.2 billion kg in the whole country, causing a loss of one million Chinese Yuan per Year. In Burkina Faso, half of the pigs slaughtered in abattoirs are reportedly condemned due to zoonotic disease (Coulibally and Yameogo, 2000; Engels *et al.*, 2003). In countries where there is lack of well organized meat inspection, infected meat has been reported to sell at a lower price, but in places where the infected pork is considered to be tastier than the non-infected one, it is usually expensive (Zoli *et al.*, 2003). Fresh pork infected with *C. cellulosae* has been shown to go at higher prices in Mexico, but why this is so remains unclear (Beaver *et al.*, 1984). In some villages in West Cameroon, infected pork is considered to have a better flavour than healthy meat, and thus, pork harbouring cysticerci is sometimes sold at a higher price than uninfected meat (Zoli *et al.*, 2003).

Fan and Chung (1997) estimated the annual economic loss due to taeniosis in the mountainous regions of Taiwan, Cheju Island of Korea and Samosir island of Indonesia to be US$ 18 million, US$ 13 million and US$ 2.4 million respectively. The economic impact of neurocysticercosis results from costs of medical treatment, lost working hours and losses due to carcass condemnation. The minimum estimate of the cost of admission and wage losses due to neurocysticercosis in Mexico was US$ 89 million and in Brazil it was US$ 85 million, annually (Pal *et al.*, 2000).

In Africa, the loss due to human cysticercosis is hard to estimate since in most African countries, patients are not hospitalized and the clinical picture is highly variable. Losses due to human cysticercosis are related to medical care, mainly in diagnosis, hospitalization, treatment and the associated decrease in human productivity, which are hard to quantify due to the poor infrastructure and absence of diagnostic facilities (Preux *et al.*, 1996).

According to Adamoleukun *et al.* (1999), epilepsy is considered as an African affliction due to supernatural forces and effects of ancestral spirits or bad spirits. Zoli *et al.* (2003) reported that epilepsy in some communities is considered as a shameful contagious disease, and thus the epileptics are mostly ostracised. In Cameroon, only 27 % of the epileptics get married while 39 % fail to enter into any professional jobs (Preux *et al.*, 2000).

Self-trained healers use *Taenia* segments either for benevolent (in the treatment of severe intestinal tapeworm infections) or malevolent (evil purposes), e.g, women poisoning unfaithful husbands or lovers by adding contents of *T. solium* segments in beer. This practice has been reported in South Africa (Mafojane *et al.*, 2003).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 The study area

Teso District is one of the districts of Western Province of Kenya (Figure 3.1).

3.1.1 Location and size

Teso District is bordered by Bungoma District to the NorthWest, Busia District to the South, and the Republic of Uganda to the West (Figure 3.1). The District lies between latitude 0^0 29 and 0^0 32 north and longitudes 34^0 01 and 34^0 07 east and has an area of 559 km^2. It is subdivided into four administrative divisions, namely: Amagoro (91.2 km^2); Angurai (145.6 km^2); Amukura (181.8 km^2) and Chakol (139.9 km^2).

3.1.2 Climate

The annual mean maximum temperatures range between 26 ^{0}C and 30 ^{0}C while the mean minimum temperatures range between 14 ^{0}C and 22 ^{0}C. Most parts of the District receive between 1270 mm and 1790 mm mean annual rainfall although some parts have been reported to receive an evenly distributed rainfall of up to 2000 mm annually. Reports from the Ministry of Finance and Planning (2002) indicate that approximately 50 % of the annual rainfall falls in the long rain season (March to May) while 25 % falls during the short rains (August to October).

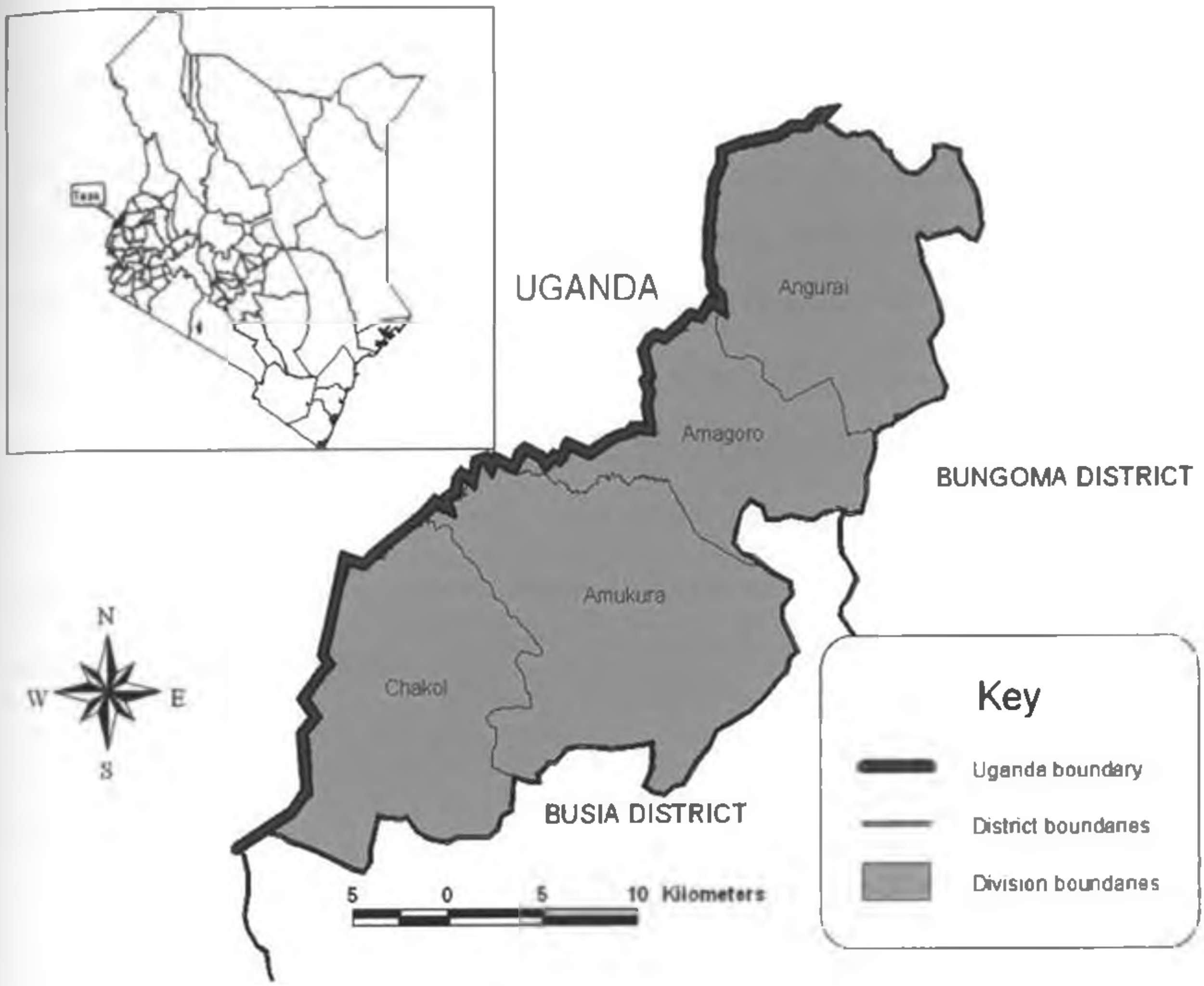

Figure 3.1: Map of Kenya showing the location of Teso District and the districts' administrative boundaries

3.1.3 Topography

Teso District rises to an altitude of 1300 metres above sea level in the south to an average of 1500 metres in the central and northern parts. Most parts of the District are suitable for both food and agricultural cash crops but some areas of Amukura Division are characterized by presence of large granite hills and tors. Absence of forests in the area has been shown to affect the overall climatic conditions of the District. There are two main rivers in the district, namely, Malaba and Malakisi originating from Mt. Elgon. Marshy swamps and numerous streams are common especially in the lowlands.

3.1.4 Human population

According to the 1999 national census, the total human population in the District was 173, 350 persons with a population density of 312 persons per Km^2. The human densities for Chakol and Amukura divisions have been projected to rise by the end of 2008. The human population in the District is evenly distributed except in Amukura Division where there are large tracks of swampy and marshy areas. Population density is highest in Chakol Division and lowest in Amukura. The standards of living are reportedly low in the region, with the largest population living under abject poverty. The characteristics of the four Divisions of Teso District are displayed in Table 3.1.

Table 3.1: Human demographic profiles of Teso District by Division according to the 1999 national census

Division	Number of males	Number of females	Total human population	Number of households	Mean number of people per household	Popula densit
Angurai	21423	23078	44501	8645	5.1	305.6
Amagoro	16751	17203	33954	7617	4.5	372.3
Amukura	23182	24884	48066	10123	4.7	264.4
Chakol	26569	28400	54969	11900	4.6	392.9
Total	**87925**	**93565**	**181490**	**38285**	**4.7**	**324.7**

3.1.5 Pig population in Teso District

The pig population in Teso District according to government annual reports of 1995 to 2000 was: 1995 (2590); 1996 (2500); 1997 (2100); 1998 (2610); 1999 (2700); and 2000 (1493). In 2002, Farming in Tsetse Infested Control Areas (FITCA) group did a livestock census in the district and reported the following numbers of pigs per division: Chakol Division (2292); Amukura Division (2094); Amagoro Division (1023) and Angurai Division (40). Pigs reared are mainly of the local breed, with the majority being kept under the free-range production system. Other livestock are also kept, including cattle (19346), sheep (8222), goats (19880), donkeys (280), rabbits (10024) and poultry (294890) (FITCA, 2002). There are eight officially recognized slaughter slabs in the District although illegal slabs have been reported. Common pig conditions encountered at slaughter in Teso District include; lungworms, hydatid cysts, pimply guts, emaciation, lung congestion, and milk spots (ML&FD, 2003).

3.2 Household survey

The study was conducted in phases between the months of September 2003 and May 2004. The first phase was a cross-sectional study that involved selection of the study households. The second phase was a case-control study in which information on the potential risk factors associated with porcine cysticercosis was obtained by means of questionnaires administered to the study households via personal interviews. In households where only children were found, a second visit was made in order to get owners` consent to examine pigs and administer the questionnaire. In addition, adult relatives of the study households were interviewed in instances where none of the household members were found.

3.2.1 Reference population

The population of interest consisted of all small-scale pig keepers in Teso District because they were the basic units of interest for the pig population study. Commercial pig farmers were excluded from the study.

3.2.2 Household sampling

Two locations in each of the four divisions of the district were randomly selected. Subsequently, a list of all small-scale pig keepers in each of the selected locations was obtained through the assistance of the local administration including village headmen, assistant chiefs and chiefs. Out of the resultant household sampling frame of 540 households, a cross-sectional sample of 316 households was randomly selected using a random number table. All pigs in the 316 households were examined for the presence of *C. cellulosae* using the lingual palpation method (Githigia *et al.*, 2002; Phiri *et al.*, 2003; Ngowi *et al.*, 2004). This procedure provided an estimation of the household prevalence of porcine cysticercosis as well as the prevalence of the disease in pigs.

3.2.3 Case control sampling

A case-control sampling strategy was conducted within the randomly selected 316 households identified in 3.2.2. This was to determine the risk factors of taeniosis / cysticercosis in the District. A case household was one that had at least one pig testing positive for *C. cellulosae* cysts using the lingual palpation method. A control household, on the other hand, was one where no pig tested positive using the same method. Most of the households had one or two pigs, in which case all the pigs were examined for the cysts.

For every case household identified, three control households were randomly selected, according to Dahoo *et al.* (2003). The randomly identified case and control households were then visited and questionnaires (Appendix 8.2) administered via personal interviews. A total of 124 households, comprising of the 31 cases and 93 controls were used for the case -control study.

The questionnaire sought information on pig husbandry practices in the study households as well as on other potential risk factors for *T. solium* taeniosis and cysticercosis. An animal health worker assisted in the administration of the questionnaire using the local Teso language but was "blinded" as to the disease status of the household, i.e, whether the household was a case or a control. This was done to avoid any potential bias.

3.2.4 The lingual palpation method

In households where the pigs were maintained purely on free-range, a pig snare was used to restrain them. With the aid of a wooden stick, the mouth was gently opened and the tongue grabbed in a piece of cloth and pulled out (Plate 3.1). It was then viewed and palpated for the presence of cysts of *C. cellulosae* on the underside. The cysts appeared as circumscribed fluid-filled lesions with a central white spot, the larval scolex.

(Arrows point to the larval cysts of *T. solium*)

Plate 3.1 Lingual palpation method of examining pigs for the larval cysts of *T. solium* (*C. cellulosae*).

3.2.5 Other data on taeniosis / cysticercosis

An introductory letter was obtained from the District Hospital as a preriquisite for the data collection. Then visits were made to at least one hospital, health centre or dispensary in each of the four Divisions of the District. An introduction on the purpose of the study was made during every visit to the health centre/ hospital. Laboratory records on the number of faecal samples submitted for gastrointestinal parasite examination and subsequent results for the last five years were reviewed (Appendix 8.4). Direct faecal examination had been used in the analysis and involved preparation of uniform wet faecal smears on glass slides, which were then covered with cover slips and subsequently examined under light microscopy. An additional questionnaire was administered to the medical personnel to supplement the secondary data from the medical records (Appendix 8.3). The questionnaire was designed to capture information on tapeworm infections in the District, epilepsy, neurocysticercosis and the general awareness of *T. solium* taeniosis among the medical personnel. The officer on duty was requested to fill the questionnaire.

3.3 Data entry and analysis

The questionnaire-derived variables were appropriately coded and entered in Ms Excel ® for descriptive statistics. Data were then exported to Genstat ® 7th edn for statistical analysis (Genstat ®, Lawes Agricultural Trust, VSN International). The household prevalence of porcine cysticercosis was computed by dividing the number of case households (numerator) by the total number of households visited (denominator). Prevalence in pigs was calculated as a proportion of the number of pigs testing positive for the cysts of *C. cellulosae* out of the total number of pigs examined (Martin *et al.*, 1987; Dahoo *et al.*, 2003). Descriptive statistics for qualitative variables were done using frequency distributions. The 95 % Confidence Intervals (C I) for both the household and the pig prevalences and their standard errors were calculated using the method in Martin *et al.* (1987).

$$95\ \%\ \text{C I for the proportion} = p \pm (SE_p * 1.96)$$

$$\text{Standard error of proportion} = \left(\frac{p(1-p)}{n}\right)^{1/2}$$

Where,

p= is the proportion of the case households and positive pigs for the household prevalence and prevalence in pigs, respectively;

n= the number of households visited and the number of pigs examined for the household prevalence and prevalence in pigs, respectively.

Associations between the potential risk factors of taeniosis/cysticercosis were assessed using the χ^2 statistic and the strengths of the associations determined using the odds ratio (OR). The proportion of the factors in the case households (F+ / D+) was compared to that in the control households (F+ / D-). For a factor to be statistically associated with the disease, the proportion of the factor in the cases must be significantly higher than that in the controls (Martin *et al.*, 1987).

Other rates computed were the estimated population attributable fraction (Estimated PAF) which is the proportion of the cysticercosis in the pig population that was due to the risk factor, and the estimated attributable fraction (Estimated AF)- the proportion of the disease in pigs in Teso District that was due to the presence of the risk factor. The rates were calculated using the method in Martin *et al.* (1987).

Estimated AF= $\frac{OR-1}{OR}$ where, OR= odds ratio.

Estimated PAF= $\frac{OR_{pop}-1}{OR_{pop}}$ where OR_{pop} =Population odds ratio.

Risk factors with p>0.05 were considered insignificant while those with p<0.05 were considered significant and were therefore included in the logistic regression (Hosmer and Lemeshow, 1989; Dahoo *et al.*, 2003).After the univariate analysis, a multiple logistic regression technique, using the step-wise procedure was used to screen variables that could determine the occurrence of porcine cysticercosis at 5 % level of significance. Risk factors with p<0.05 were considered significant and retained in the logistic regression. The goodness of fit of the logistic model was assessed by comparing model predictions with the observed probabilities and was considered fit if there were small differences between the two and not fit if this difference was large. In addition, the logistic regression analysis was also used as a method for the control of any potential confounding variables.

CHAPTER FOUR

4.0 RESULTS

4.1 Response rate

Of the 124 study households (31 cases and 93 control households) randomly selected, none of the respondents declined to participate in the study, leading to a response rate of 100 %. Most of the personal interviews involved women since most men were reportedly absent at the time this study was conducted. There was a problem of poor laboratory record keeping in the health centres visited except in Amukura Health Centre where most data were available. At Angurai Health Centre, most data were missing while in Lukolis Dispensary, laboratory facilities were newly installed and few data were thus available. However, there was a 100 % (8 / 8) response rate in the administration and answering of the questionnaires administered to the medical staff in the surveyed hospitals and health centres.

4.2 Household characteristics

The mean size of land in the District was 3.3 acres per household although there were variations by the Divisions: Chakol (5.02 acres); Angurai (2.15 acres); Amukura (3.79 acres); and Amagoro (2.3 acres). Of the 31 case households, 12 (39 %) owned less than two acres, 11 (35 %) owned between 2-5 acres and 8 (26 %) owned more than five acres of land. The land sizes of 90 control households were known, out of which 33 (37 %) owned less than two acres, 39 (43 %) had between 2-5 acres, and 18 (20 %) owned more than five acres. A small proportion (7 %; 40 / 592) of the household members in the survey households had secondary education while 60 % (355 / 592) were pursuing primary education. Of the 166 members from the 31 case households, 40 (24 %) had pre-primary school education, 100 (60 %) had primary education, and 26 (16 %) had secondary education. A total of 157 (37 %) household members from control households had pre-primary education, 255 (60 %) had primary education, and 14 (3 %) had attained secondary education.

4.2.1 Livestock kept

Of the 124 study households sampled, 14 (11 %) did not keep any other type of livestock except pigs. A high proportion (38 %; 47 / 124) of the pig farmers in the surveyed households kept only one pig and 12 % (15 / 124) had more than five pigs. The numbers of pigs expressed as a proportion of total number of livestock kept by the case and control households were 29 % (105 / 360) and 30 % (229 / 756), respectively. The types and numbers of livestock kept by both the case and control households are shown in Table 4.1.

Table 4.1: Species and numbers of livestock kept by case and control households in Teso District, 2003-2004

Livestock species	Case household	Control households	Total
Pigs	105	229	334
Sheep	45	57	102
Goat	74	222	296
Cattle	136	248	384
Total	**360**	**756**	**1116**

The keeping of female pigs was common with 53 % (66 / 124) of the households keeping exclusively females and only 14 % (17 / 124) kept exclusively male pigs. Female pigs were reportedly used for breeding purposes and the males for fattening and subsequent sale.

4.2.2 Household hygiene

Of the 124 survey households, only 6 % (8 / 124) had secure fences. Secure fencing was absent in 87 % (27 / 31) and in 96 % (89 / 93) of the case and control households respectively, respectively. Ninety-seven percent (120 / 124) of the total households visited were in rural areas, far from market centres and towns, 97 % (30 / 31) were cases and 97 % (90 / 93) were controls. The vast majority (76 %; 94 / 124) of the households had latrines. Latrines were absent in 42 % (13 / 31) and 18 % (17 / 93) of the case and control households, respectively. The proportions of households without latrines by divisions were: Chakol (47 %; 14 / 30); Amukura (30 %; 9 / 30); Amagoro (23.3 %; 7 / 30); and Angurai (0 %; 0 / 4). A small proportion (7 %; 9 / 124) of the study households did not have compounds surrounding their homesteads, of which 13 % (4 / 31) were cases and 5 % (5 / 93) were controls.

Home garbage disposal was either in the shamba (71 %) or in garbage pits (29 %). Thirty two-percent (10 / 31) of the case households and 28 % (26 / 93) of the control households had garbage pits. All the home garbage pits were shallow and not fenced-off, and thus, pigs could easily access the garbage. A high proportion (73 %; 22 / 30) of the study households without latrines did not have home garbage pits.

4.2.3 Sources of pork and its preparation before eating

A high proportion (89 %; 110 / 124) of the surveyed households had members who ate pork. Pork was eaten almost equally in the control households (87 %; 81 / 93) and in the case households (94 %; 29 / 31). Methods of preparing pork meat before consumption included frying (94 %; 103 / 110), boiling followed by frying (4 %; 4 / 110) and frying followed by roasting (2 %; 3 / 110). Frying of pork before consumption was almost practiced equally by the control (82 %; 76 / 93) and the case (87 %; 27 / 31) households. Pork meat was sourced from local butcheries (85 %; 94 / 110) and home-slaughtering (15 %; 16 / 110). A high proportion (81 %; 13 / 16) of households who sourced pork from home slaughters reportedly got some also from the local butcheries. Forty-four percent (7 / 16) of the home slaughters were not inspected. Of the nine (9) 'home inspected' pigs, 56 % (5 / 9) was reportedly "inspected" by household friends, 11 % (1 / 9) by the owners themselves, and 33 % (3 / 9) by government meat inspectors. It is worth noting that neither the household owners nor their friends had any formal training on meat inspection. All the 16 households reportedly doing home slaughter of pigs consumed pork meat.

4.2.4 Public awareness of porcine cysticercosis and human taeniosis

A high proportion (97 %; 120 / 124) of the 124 surveyed households reportedly knew of tapeworm infestations in humans with 19 % (23 / 120) of those households reportedly having human tapeworm carriers. Epilepsy was identified as a common disease in the villages; 56 % (70 / 124) of the interviewed respondents reported presence of epileptics in their villages, and

19 % (24 / 124) had observed epileptics in their families. Presence of epileptics in families was reported in 10 % (3 / 31) of the case households and in 22 % (20 / 93) of the control households. Out of the 23 households reportedly with tapeworm carriers, 13 % (3 / 23) had an epileptic patient compared to 20 % (19 / 97) of epileptic cases from tapeworm- free families. There was no association ($p>0.05$) between presence of epileptics in the households and porcine cysticercosis.

Forty–seven percent (56 / 120) of the respondents did not know the sources of taeniosis in man. Very few respondents (17 %; 20 / 120) knew that tapeworm infestation in humans is through consumption of inadequately cooked meat. Many had wild guesses, e.g; consumption of dirty foods (10 %; 12 / 120), and consumption of raw cassava (27 %; 33 / 120). Twenty–six percent (8 / 31) of the case households and 14 % (12 / 89) of the control households identified inadequately cooked meat as the source of tapeworms in man.

Sixty-six percent (82 / 124) of the study households had heard of cysticercosis in pigs, of which 68 % (21 / 31) and 66 % (61 / 93) were case and control households, respectively. Most of the respondents (66 %; 79 / 120) who reportedly knew of the taeniosis in humans also knew of the disease in pigs. The major sources of tapeworm infections in pigs mentioned included: Consumption of feeds contaminated with human faeces (5 %; 4 / 82); consumption of dirty feeds (13 %; 11 / 82); and consumption of raw feeds (13 %; 11 / 82). The vast majority (68 %; 56 / 82) of those who were aware of the problem of taeniosis / cysticercosis in pigs had no idea as to where pigs got the infection from. Of those who mentioned consumption of feeds contaminated with human faeces as a possible source of infection in pigs, 5 % (1 / 21) were from case households and a similar proportion (5 %; 3 / 61) was from control households.

Of the 120 respondents who knew about taeniosis in humans, 17 % (20 / 120) could not report any sign associated with taeniosis in man. Of these, 13 % (12 / 89) were from controls and 29 % (9 / 31) were from case households. The clinical signs and symptoms reportedly associated with tapeworm infestations in man, singly or in combination included: presence of worms in the faeces (34 / 120); stomach upsets (14 / 120); weight loss (8 / 120); and skin changes (20 / 120).

In cases of worm infestations, households reportedly sought medical assistance from three sources, namely, clinicians (53 %; 64 / 120), chemists (16 %; 19 / 120), and traditional herbs, called *ekadakada* (18 %; 21 / 120). The remaining 13 % (15 / 120) were not clear on where they sought medical assistance, one of which (7 %, 1 / 15) surprisingly sought no medical attention. Out of the 23 households with history of tapeworm carriers, 61 % (14 / 23) sought assistance from clinicians compared to 51 % (50 / 97) from households without history tapeworm carriers. The majority (78 %; 50 / 64) of the households who sought medical assistance from clinicians did not report tapeworm carriers.

4.3 Awareness of taeniosis, epilepsy and neurocysticercosis by medical personnel

Most of the medical personnel interviewed (62 %; 5 / 8) reported epilepsy as a rare disease in the District. Furthermore, they observed that epileptics in the villages were mostly young people. They gave common causes of epilepsy including hereditary (38 %; 3 / 8), brain trauma (38 %; 3 / 8), and celebral malaria (12 %; 1 / 8). Only one (12 %; 1 / 8) respondent reported neurocysticercosis as a possible cause of epilepsy in the district. Fifty percent (4 / 8) of the medical staff interviewed had not heard of neurocysticercosis in humans, many of whom (75 %; 3 / 4) were community nurses. Seventy – five percent (75 %; 3 / 4) of those who had heard of neurocysticercosis were either medical doctors or clinicians. When the respondents were asked to name the possible causes of neurocysticercosis in man, 38 % (3 / 8) identified presence of cysts in the brain as a possible cause. Only 33 % (1 / 3) could link the occurrence of neurocysticercosis to human taeniosis but could not indicate the specific *Taenia spp* responsible. In 88 % of the health facilities visited, faecal samples were reportedly requested for general examination of ova and cysts of gastrointestinal parasites.

4.4 Pig management practices

4.4.1 Pig diseases

Pig diseases were reported by 94 % (116 / 124) of the respondents as the major health problems affecting small – scale pig keeping in the study area. Common diseases affecting pigs were identified, including: malnutrition (15 %; 17 / 116); helminthosis (8 %; 9 / 116); and ectoparasites, mainly ticks and mange infestations (27 %; 32 / 116). Most (50 %; 58 / 116) of the respondents identified combination of malnutrition, helminthosis and ectoparasites, as common pig-keeping problems in the District. The farmers interviewed, most of whom were women, had reportedly no idea about cysticercosis in pigs.

4.4.2 Pig husbandry practices

Two reasons for keeping pigs in the District were identified, namely, as a source of income (98 %) and for home consumption (2 %). Main sources of pigs in the district were purchases (98 %; 122 / 124) and gifts from friends (2 %; 2 / 124). Pigs were purchased mainly from within the District (94 %; 117 / 124) and some from Uganda (6 %; 7 / 124). One out of the 31 (3 %) case households had bought pigs from Uganda compared to 6 % (6 / 93) from control households. All the seven pigs purchased from Uganda were owned by study households in the border locations of Teso District.

Two methods of raising pigs were identified, namely, free-ranging and total confinement. A total of only six households (5 %) confined their pigs, mainly by tethering (67 %; 4 / 6) and housing (33 %; 2 / 6), as shown in Plates 4.1 and 4.2. Six-percent (2 / 31) and 4 % (4 / 93) of the case and control households respectively, confined their pigs. One of the two households who housed pigs was a case household. The pig houses were temporary structures, constructed using locally available materials and all lacked concrete floors.

A high proportion of pig farmers (95 %; 118 / 124) allowed their pigs to roam freely in the villages, and 71 % (84 / 118) of these reportedly combined tethering and free-range methods.

Pigs were tethered mostly during the raining seasons to prevent them from destroying crops in shambas. Free-ranging of pigs was practiced almost equally in the case (94 %; 29 / 31) and control (95 %; 89 / 93) households. Pigs allowed to scavenge (Plate 4.3) were identified as major causes of neighbourhood conflicts in the region. Pig farmers interviewed attributed free-ranging to the scarcity of pig feeds in the study area. The free-range pig rearing method was reported to be very economical since pigs could easily scavenge for feeds with little or no cost.

Farmers were asked to rank the sources of their pig feeds in order of importance. A high proportion (52 %; 64 / 124) reportedly fed their pigs on household leftovers, scavenging and locally available foods. It is worthy noting that only one farmer (0.8 %) out of the 124 interviewed bought commercial feeds for his pigs.

Plate 4.1: A tethered pig in Amukura division of Teso District, Kenya, 2004.

Plate 4.2: A pig house constructed using locally available materials in Teso District, Kenya, 2004.

4.3: Free-range pigs scavenging in a rural village of Teso District, Western Kenya.

4.5 Prevalence of porcine cysticercosis

There were 505 pigs in the cross-sectional sample of the 316 survey households. The distribution of the survey households, numbers of pigs examined, and the numbers of pigs testing positive for cysticercosis are displayed in Table 4.2. A high proportion (91 %; 30 / 33) of the positive pigs had only one cyst detected on lingual palpation. One of the positive (3 %; 1 / 33) pigs had a cyst located on the gum area of the lower jaw.

The household prevalence of porcine cysticercosis was estimated at 9.8 % (31 / 316) with a 95 % confidence interval of 6.5 % - 13.1 %. The total number of pigs testing positive was 33, converting to a pig prevalence of 6.5 % (33 / 505), with a 95 % confidence interval of 2.0 % – 10.7 %. The household prevalences per Division were: Chakol Division (9.3 %); Amukura Division (9.8 %); Amagoro Division (12 %); and Angurai Division (0 %).

Table 4.2: Household characteristics of surveyed pig population in various Divisions of Teso District, 2003-2004.

Division	No. of households	Number of pigs examined	No. of case households	Number of pigs positive for cysts per division
Chakol	129	217	12	13
Amukura	112	180	11	12
Amagoro	63	91	8	8
Angurai	12	17	0	0
Total	**316**	**505**	**31**	**33**

4.6 Risk factors of porcine cysticercosis

4.6.1 Simple associations of risk factors

The potential risk factors which were assessed for statistical associations with porcine cysticercosis are shown in Table 4.3. Six of the seven factors were equally distributed in both case and control households. The only variable which was significantly higher in the case households (42 %; 13 / 31) than in the control households (18 %; 17 / 93) was the absence of latrines ($p< 0.05$; OR=3.2)- an indication that households without latrines were approximately 3 times more likely to have porcine cysticercosis relative to households with latrines.

The estimated attributable fraction (AF) was 69 % indicating that 69 % of porcine cysticercosis in households without latrines in Teso District was due to the absence of latrines. The estimated population attributable fraction (PAF) was 27 % indicating that 27 %, of porcine cysticercosis in the pig population of Teso District was due to the absence of latrines.

Table 4.3: A comparison of case and control households by potential risk factors in Teso District

Variable	Levels	Proportion (%) Cases	Controls	Odds ratio (OR)	P
National Border (Kenya – Uganda)	Near Far	42 58	45 55	0.9	0.75
Garbage Disposal	Garden Garbage pit	68 32	72 28	0.8	0.648
Fence	Absent/ partial Secure	87 13	96 14	0.97	0.091
Source of pigs	Uganda Within Teso district	3 97	6 94	0.48	0.5
Latrine	Absent Present	42 58	18 82	3.2	*0.008
Pig Housing	Unrestricted Restricted (tethering & housing)	94 6	96 4	0.65	0.62
Taeniosis in the family	Present Absent	10 90	22 78	0.40	0.119

* Shows significant difference at 5 % level of significance

4.6.2 Risk factors after adjusting for potential confounders

Variables in the logistic model ($p < 0.15$) included: type of fence, absence of latrine, presence of tapeworm carriers in the family and division. The dependent variable was the status of porcine cysticercosis (present / absent) in the household.

Absence or presence of latrine was the only significant variable that explained the occurrence of cysticercosis in pigs ($p<0.05$). According to the model, the absence of a household latrine increased the risk of acquiring cysticercosis in pigs- households without latrines were approximately three times more likely to have cysticercotic pigs compared to those with latrines (Odds ratio =3.05). It is worth noting that the adjusted odds ratio of 3.05 obtained in the logistic regression was almost equal to the crude Odds ratio of 3.2 obtained in the simple analysis. This was an indication that the association of porcine cysticercosis with absence of latrines was not confounded by the considered factors.

The probability of positive status in the logistic regression, if latrine was present [P (status=1) / latrine =1)] was 0.20, while the probability of a positive status in absence of latrine [P (status=1/ latrine=0)] was 0.43. This compares favourably to the observed probabilities of 0.42 (13 / 31) and 0.18 (17 / 93) for positive status in the absence and presence of latrines, respectively. The expected number of cases in households without and with latrines was 12.3 and 17.8 respectively, similar to the observed values of 13 and 18 in absence and presence of latrines. Thus, the model was considered to have a good fit.

4.7 Previous data on human taeniosis and other human intestinal infestations

The health facilities surveyed for the estimation of the prevalences of various gastrointestinal infestations of humans were: Kocholya District Hospital in Amagoro Division; the Alupe Sub-District Hospital in Chakol Division; Lukolis Dispensary and Amukura Health Centre both in Amukura Division; and Moding Health Centre in Angurai Division. The total number of faecal samples submitted from 1999 to 2003 was 6131, of which 0.18 % (11 / 6131) tested positive for *Taenia*. Most of the positive samples (82 %; 9 / 11) were reported in Amukura Health Centre, and 18 % (2 / 11) in Alupe sub- District Hospital. None of the samples from other health centre facilities had *Taenia* infestation. The least number (0.8 %; 49 / 6131) of faecal samples was reported in Moding Health Centre in Angurai Division, where most of the laboratory data were not available.

There was an upward trend in the prevalence of human tapeworm infestation since 2001. Five out of the 11 (46 %; 5 / 11) cases of taeniosis were reported in 2003 (Table 4.4). A total of 2258 samples tested positive for various gastrointestinal infestations in the District between 1999-2003. Hookworms were the most (18 %; 1078 / 6131) frequently diagnosed infestation during the period.

Direct microscopic examination of faecal samples was the most commonly used method for the diagnosis of common intestinal helminths. This was reportedly due to lack of reagents required for concentrating the faecal samples and thus improve the sensitivity of faecal testing.

Table 4.4: Prevalence of gastrointestinal parasite infections in Teso District, 1999-2003

Year	No. of samples	Hookworm	Tapeworm	*Entamoeba. histolytica*	*Giardia lamblia*	*Ascaris lubricoides*	*Strongylodes stercolaris*	*Trichuris trichuri*	*Trichomonas hominis*	*Schistosoma mansoni*
1999	405	34	0	44	0	1	2	0	0	0
2000	1105	202	0	143	24	14	52	3	1	2
2001	2019	491	3	142	30	52	36	14	5	6
2002	767	89	3	116	29	46	22	0	0	0
2003	1835	262	5	176	65	44	56	2	39	3
Total	**6131**	**1078**	**11**	**621**	**148**	**157**	**168**	**19**	**45**	**11**
Proportion (%) positive		**17.5**	**0.18**	**10.1**	**2.4**	**2.75**	**2.7**	**0.3**	**0.7**	**0.18**

CHAPTER FIVE

5.0 DISCUSSION

Animal diseases continue to constrain livestock productivity, agricultural development and human well- being in many regions of the developing world (Perry *et al.*, 2003). According to Roberts *et al.* (1994), food borne diseases are problems of greater magnitude both in terms of the extent of human illness and economic costs due to medical expenses and lost wages. The emergence of *T. solium* cysticercosis and taeniosis has been identified as one of the major constraint to profitable pig production in the developing world. It is a serious public health risk in Latin America, Asia and Africa (Mafojane *et al.*, 2003; Zoli *et al.*, 2003).

There exists very little baseline data on the occurrence of porcine cysticercois in Kenya (Otwelo, 2002). Several cases of cysticercosis have been reported in a major pig abattoir in the country, during routine meat inspection. One of the three cases of porcine cysticercosis reported in 2002 was from Teso District (Otwelo, 2002; Anon, 2003). This study serves to confirm presence of porcine cysticercosis in the study area, a surprising finding given that previous slaughter slab records in the District did not indicate any cases of the disease.

In this study, helminthosis, ectoparasitism and malnutrition were identified as common problems affecting small-scale pig farming in Teso District. Wabacha *et al.* (2004) observed that 91.9 % of small-holder pig herds in Kikuyu Division of Central Province harboured gastrointestinal worms. Gastrointestinal helminthosis is associated with decreased growth rate, reduced feed conversion efficiency and losses due to condemnation of livers and intestines at meat inspection (Corwin *et al.*, 1997). Data obtained from the Ministry of Agriculture identified feeding and access to markets as the major constraints affecting pig keeping in Kenya (MOA, 2000) but porcine cysticercosis was not a common problem in small-scale pig farming. Cysticercosis in pigs is symptomless (Urquhart *et al.*, 1988) and unless pigs are slaughtered and infection detected by meat inspectors, farmers cannot diagnose porcine cysticercosis. Pig traders in Tanzania usually employ lingual examination of pigs to detect and subsequently reject infected pigs. This reduces possible losses that could arise due to carcass condemnation at post-mortem meat inspection (Ngowi *et al.*, 2004). Studies in South America have shown that pig farmers able to diagnose cysticercosis using the lingual examination method, have declined to take infected pigs for slaughter for fear of confiscation (Gonzales *et al.*, 1990). Rodriquez-Hildago *et al.* (2003) conducted a study in Sierra of Northern Ecuador and observed that pigs with palpable cysticerci were rarely presented for slaughter in official slaughterhouses unless a financial compensation was put on condemned carcasses.

Trypanosomosis is a common problem in Western Kenya, affecting mostly cattle. The popularity of small – scale pig keeping in the study area could partly be attributed to this since farmers reported that cattle were mostly affected and losses incurred were more than for the pigs. Pig production in Kenya has grown in the recent past, mainly due to human population growth and the pressure on arable land (MOA, 2000). Small-scale pig farmers in Teso District rely on pig farming as a source of income, an indication that pig farming contributes a lot to the livelihood of the local people. Although no data on the profitability of small-scale pig farming was available in Kenya, previous reports have shown that pigs provide quicker and higher returns to pig farmers and their production is therefore more economical compared to other types of livestock (Faustin and Kyvsgaard, 2003). The increase in the number of local butcheries in most urban centres has encouraged local consumption of pork (MOA, 2000). Phiri *et al.* (2003) reported a significant increase in pig production in Eastern and Southern Africa during the past decade, especially in the rural, resource-poor, smallholder communities. According to Boa *et al.* (2004), pork is the sole source of protein for local communities in the Republic of Tanzania, with over 90 % of the population in Mgeta Division consuming approximately 5.25 kgs of pork each month.

Results of this study indicated that cysticercosis due to *T. solium* is prevalent in the locally raised pigs of Teso District. The prevalence of porcine cysticercosis (6.5 %) obtained in this study falls within the estimated range of 5 - 30 % reported in most of the endemic areas (Craig *et al.*, 1996). In addition, the prevalence compares with that of 5.5 % obtained in a similar study conducted in Nigeria by Onah and Chiejina (1995). In the Republic of Uganda, a prevalence of 44 % was reported in some parts of Moyo District while in the neighbouring Republic of Tanzania, a prevalence of up to 17 % has been reported in Mbulu District using the lingual palpation method (Boa *et al.*, 1995; Phiri *et al.*, 2003; Ngowi *et al.*, 2004). Based on post-mortem results, Zoli *et al.* (2003) reported prevalences of 26 % and 12 % for Chad and Ghana, respectively. In a recent study conducted in Busia and South Nyanza Districts, a prevalence of porcine cysticercosis of between 10 % and 14 % was reported (Githigia *et al.*, 2002), a prevalence similar to the one obtained in the present study.

The lingual palpation method was used to examine pigs for the presence of *C. cellulosae* cysts on the underside of the tongue. Most of the previous prevalence studies on porcine cysticercosis, in developing countries, were based on this method (Boa *et al.*, 2002; Githigia *et* *al.*, 2002; Phiri *et al.*, 2002; Ngowi *et al.*, 2004). The method requires technical expertise (Sciutto *et al.*, 1998), is of low sensitivity and is only capable of detecting *C. cellulosae* cysts in heavily infected pigs (Phiri *et al.*, 2002; Garcia *et al.*, 2003). Gonzalez *et al.* (1990) reported a sensitivity of 70 % and a specificity of 100 % for the lingual palpation in a study conducted in Peru. In an abattoir survey conducted in Zambia, the relative sensitivity of tongue palpation, compared to the visual inspection of the carcass, was only 43 % (Phiri *et al.*, 2002). Although the value of lingual palpation in community- based studies is questionable, the method is reportedly inexpensive and has been advocated for rapid assessment of the disease (Ngowi *et al.*, 2004).

Although most of the pigs were sourced from within the district, it was observed that few farmers purchased pigs from Uganda. This could be a possible entry point for infected pigs in to Kenya given that prevalence of porcine cysticercosis is reported to be high in Uganda (Kisakye & Masaba, 2002), and there exists possible illegal livestock movement across the Kenya-Uganda border. According to Putu *et al.* (1999), transport of pigs infected with *T. solium* larval cysts from Bali in Indonesia to Irian Yaya (Indonesia) caused an epidemic of porcine cysticercosis, which was previously non–endemic for the disease. Movement of *T. solium* tapeworm carriers or infected pigs has led to the spread of the disease from endemic to non-endemic areas leading to periodic localised outbreaks of the disease (Subahar *et al.*, 2001). It is possible then the cases of porcine cysticercosis observed in Teso District may have come from the Republic of Uganda. Several cases of porcine cysticercosis were detected in a major abattoir in Nairobi in 1988 but the pigs had reportedly been imported from the Republic of Tanzania (Otwelo, 2002; Anon, 2003).

Chakol Division had the highest number of case households in the District. This could be partly attributed to the popularity of small-scale pig keeping in the Division (FITCA, 2002). Failure to detect cases of porcine cysticercosis in Angurai Division could be attributed to the limited number of small- scale pig farmers in the Division resulting from a recent outbreak of pig diseases, especially African Swine Fever, which killed most pigs and thus made farmers reluctant to restock (MOA, 2000; MOA personell, Personal communication).

An estimate of the prevalence of porcine cysticercosis based on serological tests was not done in this study. Previous studies have shown that prevalences obtained in seroepidemiological surveys are usually higher than those obtained from the lingual palpation method (Zoli *et al.*, 2003). According to Ito *et al.* (1999), the establishment of reliable serological methods in pigs is important for the surveillance, control and prevention of taeniosis / cysticercosis in humans as well as in pigs to prevent economic loss. Dorney *et al.* (2004), observed that the performance of Ag ELISA was significantly higher than that of other tests with estimated sensitivity of 86.7 % and specificity of 94.7 %. Prevalences of over 50 % were reported in an epidemiological study conducted in Peru using ELISA and western blot methods (Flisser *et al.*, 2003). Pouedet *et al.* (2002) reported a prevalence of 6.1 % using the lingual palpation method and a relatively higher prevalence of 21.8 % using the Ag ELISA method. A seroprevalence of up to 37 % was obtained in an epidemiological study done in Bolivian Chaco (Bolivia) (Carrique-Mas *et al.*, 2001). The prevalence of porcine cysticercosis obtained in this study is likely an underestimate of the true prevalence and therefore further studies involving the use of more sensitive and specific diagnostic tools need to be conducted. This was not possible due to the limitation of resources, most important being the Ag ELISA kit that needed to be imported.

Infection of pigs with *C. cellulosae* has been shown to be strongly correlated with human *T. solium* infection, with previous reports indicating higher prevalences in pigs than in humans (Garcia *et al.*, 2003). Based on data obtained from health care centres, the prevalence of human taeniosis was far much lower compared to that of porcine cysticercosis obtained using the lingual palpation method in this study. Carrique-Mas *et al* (2001) reported a seroprevalence of 22 % in humans and a high prevalence of 37 % in pigs. In a study done in Sierra of Northern Ecuador, porcine cysticercosis was detected in 9.01 % of serum samples compared to 1.55 % positive for taeniosis in humans (Rodriquez-Hildago *et al.*, 2003).

Data collected from medical records in the district for 5 years indicated an overall human taeniosis prevalence of 0.18 %, which falls within the estimated limit of less than 1 % reported for *T. solium* endemic areas (Craig *et al.*, 1996), and compares with that of 0.1 % obtained in Cameroon as quoted by Phiri *et al.*, 2002. Allan *et al.* (1996) reported higher prevalences of up to 2.7 % in a rural Guatemalan community. Of 3109 stool samples examined microscopically in Cameroon, only four *Taenia* species were found, of which 3 (0.1 %) were identified as *T. solium* (Zoli *et al.*, 2003). The diagnostic ability and capability of the health facilities visited in this study were not adequate and thus, taeniosis diagnostic levels may have been grossly underestimated in Teso District.

Previous studies have utilized coproantigen testing to estimate the prevalences of human taeniosis, an antigen detection method that is genus-specific and is reportedly more sensitive (Allan *et al.*, 2003). The coproantigen test has been shown to be better in determining the prevalence of tapeworm infestations in man (Flisser *et al.*, 2003; Allan *et al.*, 2003). In Mexico, prevalence of taeniosis, using coproantigen test, ranged from 0.8 - 2 %, higher than that obtained in this study. Epidemiological studies carried out using coproantigen test in some parts of Peru revealed a taeniosis prevalence of up to 3 % (Flisser *et al.*, 2003), while in Bali, Indonesia, a taeniosis prevalence of 0.72 % was reported and 0.24 % for *T. solium* (Putu *et al.*, 1999). Allan *et al.* (1996) further reported a prevalence of 2.7 %, with 98 % of the worms being *T. solium*, in a Guatemalan community. Records of intestinal taeniosis from faecal surveys in KwaZulu–Natal, South Africa, revealed prevalences of between 1 to 16 % (Mafojane *et al.*, 2003). Taeniosis prevalence obtained in this study was mostly an underestimate since direct microscopy was used in the analysis of faecal samples, a method that is less sensitive compared to coproantigen testing (Allan *et al.*, 2003).

Although the historical data showed that faecal samples were analysed using the direct microscopy method, it is worth noting that most of *Taenia* eggs are passed after praziquantel treatment (Garcia *et al.*, 2003). Stool examination method has been shown to be reliable in the diagnosis of taeniosis and can be achieved by simply asking people if they have released tapeworm segments (Sarti *et al.*, 1992; Garcia *et al.*, 1995; Sarti *et al.*, 1997). This has been shown to facilitate in the identification and subsequent treatment of tapeworm carriers. The method has, however, been shown to be less sensitive for the detection of *Taenia* eggs (Rajshekhar *et al.*, 2003). Hall *et al.* (1981) reported that stool examination method underestimated the true prevalence and could not be relied on to differentiate *T. solium* and *T. saginata*. Garcia *et al.* (2003) reported that the method underestimated the true prevalence and therefore served as a poor monitoring tool for control purposes.

It was striking to note that most of the tapeworm infestations in humans were reported in one health centre in the district. The laboratory technicians in this particular health centre were possibly keener in the analysis of the laboratory samples compared to those in the other health facilities in the district. However, misdiagnosis of tapeworm infestations in the district cannot be ruled out. This was not done due to the limitation of diagnostic facilities in the district. Further studies are therefore needed on the improved diagnosis of tapeworm infestations.
One of the positive faecal samples in one of the hospitals was a mature tapeworm proglottid. It has been reported that proglottids of *T. saginata* are more motile and are likely to be expelled compared to those of *T. solium.* A coprological study conducted by Rodriquez-Hildago *et al.* (2003) in Northern Ecuador, revealed a taeniosis prevalence of 1.55 % in which 21 specimens were identified as *T. saginata* and eight as *T. solium.* Although historical data obtained in this study showed that taeniosis due to *T. solium* and *T. saginata* is prevalent in the study community, species-specific identification of human tapeworm infestation would be important for public health purposes. Indeed Mayta *et al.* (2000) demonstrated that the prompt identification of *T. solium* carriers prevented further human cysticercosis infections.

In this study, hookworm infections ranked high in the District. A similar trend of the gastrointestinal infections was reported in Vietnam where the prevalences were as follows; hookworms (52 %), *A. lumbricoides* (45 %), *T. trichiura* (50 %), *Taenia* species (0.1 %), and

Giardia species (3 %) (Verle *et al.*, 2003). In a study conducted in Indonesia, by Putu *et al.* (1999), *T. trichura* infections ranked high (34.7%), followed by *A. lumbricoides* (30.6 %) and hookworm infestation (8.43 %). Results of the present study show that other gastrointestinal parasites also constitute a major problem in the study are, in addition to the taeniasis due to *T. solium* and *T. saginata*.

Female pigs comprised the majority of pigs kept by the study households. It was evident that male pigs were easily taken for sales at times of financial need leaving females for breeding purposes. Piglets were reportedly sold early, a few weeks after birth. Cysticercosis affects all age groups of pigs with older pigs being more resistant to the infection. According to de Aluja (1998), piglets can pick the infection at the age of 2- 4 weeks with most of the metacestodes localising in the liver.

Absence of latrines was statistically associated with porcine cysticercosis. The odds ratio of 3.05 obtained in the logistic regression was similar to the crude odds ratio of 3.2 obtained in the simple analysis. This was an indication that the association of cysticercosis and absence of latrines was not confounded by the considered factors. It has been observed that for the life cycle of *T. solium* to be complete, pigs must gain access to human faeces (Sarti *et al.*, 1992; Sarti *et al.*, 2003). Presence of *Taenia* eggs in the environment has been identified as the most important risk factor for *T. solium* taeniosis / cysticercosis (Sarti *et al.*, 1992; Flisser *et al.*, 2003; Sarti *et al.*, 2003). Even if other factors favour the occurrence of cysticercosis, appropriate disposal of human waste is enough to reduce the prevalence of the disease. Stopping dispersal of *T. solium* eggs breaks the life cycle of the parasite, an aspect that can be utilized in the control and eradication strategy for the disease. Widdowson *et al.* (2000)

observed that presence versus absence of a toilet, crowded households and both corralling and letting pigs loose versus tying them up were the most important risk factors for seropositivity in pigs, thus the pig management practices observed in Teso District could favour the occurance and spread of *T. solium* taeniosis / cysticercosis.

Where latrines are lacking, household members are likely to defaecate in near-by bushes. Respondents in some households lacking latrines indicated that they used their neighbour's latrines, a practice that was limited to the day and not possible for children. Garcia *et al.* (2003) described pigs as coprophagic, constantly roaming and thus increasing their likelihood of eating *T. solium* infested faeces. Sarti *et al.* (1992) observed that access of pigs to human faeces, presence of an outdoor latrine and the indiscriminate disposal of human faeces around the pig owner's households, were important risk factors for porcine cysticercosis. Ngowi *et al.* (2004) conducted a study in Tanzania and reported a higher prevalence of porcine cysticercosis in households not using latrines than in those that had latrines. Access of pigs to human faeces was statistically associated with porcine cysticercosis (Sarti *et al.*, 1992). Diaz *et al.* (1992) reported a higher prevalence of cysticercosis in pigs in households that had latrines than in those that did not have. According to Phiri *et al.* (2002), poor sanitation is a major cause of the increased prevalence of cysticercosis in pigs. The absence of latrines reported in this study coupled with the poor methods of keeping pigs could lead to increasing prevalences of porcine cyaticercosis observed in the study area.

In those studies where no association was found between absence of latrines and porcine cysticercosis, it is probable that the sample sizes were small and thus the studies lacked power to detect those differences. There were other potential risk factors that could be associated with the cysticercosis / taeniosis complex since latrine use only contributed to smaller proportion (27 %) of the disease in the population. Thus 73 % of cysticercosis in the pig population was due to other risk factors. It was rather surprising that most of the other factors considered in this study were not statistically associated with porcine cysticercosis. In a study conducted by Phiri *et al.* (2002), statistical analysis failed to show any associations between cysticercosis in pigs and various other epidemiological risk factors. Hosmer and Lemeshow (1989) observed that modeling based on statistical criteria and not on the relative biological importance of the variables may leave out important variables in a study.

This study showed that home slaughter of pigs was common. The law (Kenya Meat Control Act, Cap 356, 1977) requires pigs to be slaughtered in licensed slaughterhouses. The home slaughter of pigs coupled with the irregular meat inspection practices observed in this study was an indication that infected pigs could be slaughtered and subsequently passed for human consumption. Carrique-Mas *et al.* (2001) identified inability to recognize infected pork as a significant risk factor for *T. solium* taeniosis in a rural population of Bolivia Chaco (Indonesia), while Schantz *et al.* (1993) observed that strict meat inspection procedures could eradicate *T. solium* zoonosis. Ngowi *et al.* (2004) reported that absence of proper slaughtering facilities in many areas of the Republic of Tanzania interfered with food safety.

Pork meat is very popular in Teso District, with most of it being prepared by frying. It is unlikely that this method cooks pork well; pork cooks on the surface and may give one a wrong impression of "cooked pork". The popularity of pork meat in the study area, the observed method of cooking pork, and the home slaughter of pigs are important risk factors that should be considered in the epidemiology of *T. solium* taeniosis / cysticercosis complex.

A high proportion of the pig farmers allowed their pigs to roam freely. It is illegal in Kenya to keep pigs under the free-range system (GOK, 1966; 1972). It was interesting to note that the small- scale pig farmers were aware of these laws that forbid free-ranging of pigs, yet they were reluctant to confine their pigs. The reasons for this were not clear but could perhaps be attributed to the governments` reluctance to enforce its regulations on pig keeping and low costs of pig rearing. Failure by the local community to understand the economic and public health implications of the disease was also a likely contributory factor. A survey carried out by Farming in Tsetse Infested Control Areas (FITCA, 2002) in Western Kenya showed that 94 % of the households did not house their pigs.

It was observed that one of two farmers who totally confined pigs, was a case household. It was obvious that the farmers never confined their pigs always, and in addition the temporary houses were not pig-proof. According to Garcia *et al.* (2003) pigs constantly roam around sampling *T. solium* contaminated environments and thus making them highly exposed. Furthermore, Rodriquez-Canul *et al.* (1999) reported that pigs allowed to roam throughout the community were far more likely to have cysticercosis. Those who preferred tethering method allowed pigs to scavenge early in the mornings and late in the evenings. They only tethered them during the day to avoid damaging field crops, especially cassava, and the resultant neighbourhood conflict and not because of the public health risks. Gonzalez *et al.* (2003)

observed that health risks of getting and transmitting cysticercosis is not always viewed as an immediate real risk in most villages.

Only a small proportion of respondents knew the mode of transmission for *T. solium*, in both humans and pigs, while a half of the medical staff interviewed had not heard of neurocysticercosis. Boa *et al.* (2001) reported a similar situation in Tanzania. They interviewed local farmers in Chunya District and found out that 94 % of the respondents were ignorant of the mode of transmission of *T. solium* / cysticercosis. Phiri *et al.* (2002) observed that general lack of knowledge of the *T. solium* cysticercosis / taeniosis complex among the medical and veterinary doctors, health care workers, agricultural extension workers, policy makers and the general public, could favour transmission of taeniosis.

Many of the respondents did not report about epileptics in their families but reported epileptic cases in their neighbourhoods. This appeared to be an indication of the social stigma associated with epilepsy as reported in many other parts of world. Mafojane *et al.* (2003) reported that 58.2 % of respondents interviewed in Tanzania knew of someone with epilepsy in their community and 35 % knew of somebody with taeniosis. According to Diop *et al.* (2003), cysticercosis is the most frequent parasitosis of the human brain. It has been reported that 69 – 96 % of symptomatic neurocysticercosis cases have one or more seizures and some will go on to develop epilepsy (Carabin *et* al., unpublished data). Epilepsy is a syndrome with considerable social, psychological, economical and physical impact in a community. It is considered as an African affliction associated with supernatural forces and effects of ancestral spirits or bad spirits (Adamoleukun *et al.*, 1999). Twelve percent of the epileptic patients seen in Harare, Zimbabwe, were found to be positive for *T. solium* on serological testing (Mason *et al.*, 1992) and the prevalence was higher in men (18 %) than in women (7 %). Although no tests were carried out in this study to find out the proportions of the epileptic cases attributable to *T. solium / C. cellulosae* infection, the high percentage (56 %) of epileptic cases found in Teso gave a strong indication of a significant contribution by *T. solium / C. cellulosae*.

In a study conducted in South Africa, the high prevalence of human cysticercosis was related to the common practice of rearing pigs on free-range basis, with a prevalence of 10 - 20 % being reported in the rural communities where most of the patients are blacks (Mafojane *et al.*, 2003). Fourteen out of 80 (17.8 %) people Elisa tested in Tete Province of Mozambique were reportedly positive for cysticercosis (Mafojane *et al.*, 2003). Cruz *et al.* (1999) observed that *T. solium* neurocysticercosis is a significant cause of epilepsy at the community level in the Andean villages of Ecuador. The presence of tapeworm carriers in the family has been reported as the main risk factor for acquiring human neurocysticercosis and porcine cysticercosis (Flisser *et al.*, 2003; Gonzalez *et al.*, 2003). There is a need to strengthen local communitys' capacity to deal with issues relating to epilepsy on a sustainable basis. Epilepsy affects medical as well as the social and economic wellbeing of patients in the community (KAWE, 2002).

Most (55 %; 68 / 124) of the small- scale pig farmers interviewed in this study were women. They were conversant with management of the pigs and addressed key issues such as feeding, treatment of pigs as well as looking after the children. Men were reportedly responsible for the keeping of cattle. Rural women make tremedious contribution to food and agricultural production. Studies in Pakistan have shown that women spend between a third to two quarters of their daily working hours in livestock-related activities (FAO, 1997; Riethmuller, 2003).

Given the public health and economic importance of *T. solium* taeniosis / cysticercosis complex, control measures need to be considered in the study area. The disease is potentially eradicable (Flisser *et al.*, 2003). Potential control measures include; surveillance of incidence and prevalence of target diseases in humans and animals, training of workers on diagnostic technology, establishment of community based support schemes for medical and animal health workers, and establishing mechanisms of collaboration between the ministries of Health and Animal resources through establishing a national committee for the control of zoonoses (Coulibally and Yameago, 2000). Collaboration between the Ministries of Health and that of Agriculture / Livestock is questionable in East and Southern African countries and this could be one of the obstacles hindering prioritization of *T. solium* taeniosis / cysticercosis complex, according to a Technical Advisory Group Meeting held in Nairobi in 2004.

Case control studies are characterized by a number of biases (Martin *et al.*, 1987). Due to the poor sensitivity and specificity of the lingual palpation method, it was not possible to ascertain whether the controls were truly disease-free and therefore, false negatives could not have been ruled out (misclassification bias). Antigen Elisa, which has been reported to have a high sensitivity and specificity (Phiri *et al.*, 2003), should ideally have been able to discriminate the cases and the controls.

In conclusion, this study revealed that taeniosis / cysticercosis complex is a major public health problem in Teso District. In addition, the problem is poorly understood by both the public and even the medical personnel. Given the unacceptably high prevalence of porcine cysticercosis in the District, there is a need for the formulation and implementation of appropriate control measures for this serious zioonosis. Educational programmes targeted at the public and the medical personnel would be an integral component of the programmes.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Within the limits of the data collected and information volunteered by the small-scale pig farmers in the study area, the following conclusions can be drawn:

1. Porcine cysticercosis is prevalent (6.5 %) in the locally raised-pigs of Teso District, strongly suggesting presence of human *T. solium* carriers who, due to non-use of toilet facilities, contaminate the environment with *T. solium* eggs infective to both humans and pigs and thus maintaining the life cycle of the parasite.

2. Taeniosis is a common (0.18 %) and poorly understood problem in Teso District. This high prevalence could be associated with the relatively high cases of epilepsy reported by the human population of Teso District.

3. There are many epileptic cases in Teso District, an indication that *T. solium* cysticercosis / neurocysticercosis is a possible differential diagnoses.

4. Pigs play an important role in the livelihood of small-scale farmers in Teso District, Western Kenya.

5. The prevailing conditions of pig management, namely, free-ranging and tethering in the fields favour the occurrence and spread of the parasite.

6. Most of the small-scale pig farmers are not aware of the potential risk factors of porcine cysticercosis, an important aspect in the epidemiology and control of the disease. This necessitates the training of the farmers and pork consumers on the control and management of *T. solium* taeniosis and cysticercosis.

7. Home slaughter of pigs, coupled with irregular meat inspection, is common in the study area.

8. Pigs are not kept in pig-proof houses as required by the law. Free ranging and tethering are the most common methods of raising pigs in the District, and thus pig farmers in Teso District are practicing an illegal method of pig keeping according to the Animal diseases Act (Cap 364) and the Pig Industry Act (Cap 361).

6.2 General recommendations

1. Appropriate and sustainable control strategies based on scientific evidence collected should be devised in collaboration with the local populations to effectively address this serious zoonotic problem. The fact that cysticercosis cases were reported in the locally raised pigs indicates that the disease is endemic and that there are human *T. solium* carriers in the population. Public education should be an integral component of the control programmes.

2. There is a need for more detailed epidemiological studies to confirm the findings of this study and provide further evidence on the true prevalence of the disease. These should include community-based studies involving more sensitive and specific serological testing and postmortem examination of the locally raised pigs, coproantigen testing and purgation for human taeniosis surveys as well as surveys for epilepsy and its aetiology including human cysticercosis.

3. Since the laws of Kenya clearly state that the outdoor method of pig keeping is illegal, these laws should be enforced.

4. Since small-scale pig farming appears to be very popular in the country, more work needs to be done to investigate the economic worth of the practice; previous reports show that the traditional method of keeping pigs is less profitable (Faustin & Kyvsgaard, 2003).

5. There is a need to be able to differentiate between *T. solium* and *T. saginata* infestations in human beings since the historical data indicated that taeniosis was common in the district. More sensitive and specific methods including molecular approaches, e.g; restriction fragment length polymorphism (RELP), single-strand conformation polymorphism and polymerase chain reaction (PCR) and purges for the recovery of the worms and subsequent species differentiation using either the scolex differences or uterine branching, need to be used, to differentiate the two owing to their different clinical manifestation.

6. Public health education to the population and in particular setting up of latrines for appropriate human waste disposal should be instituted and encouraged in order to cut off transmission cycle of the parasite.

7. Increase awareness of the disease problem and its seriousness to the health providers.

CHAPTER SEVEN

7.0 LIST OF REFERENCES

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CHAPTER EIGHT

8.0 APPENDICES

Appendix 8.1

Pig population in Kenya by province 1986 – 2000 (MOA, 2000)

Province	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Nyanza	2420	2920	3733	1600	6174	8481	8444	10500	23078	10800	11300	14460	19756	17242	17173
Riftvalley	8500	9890	18640	4867	1094	24894	24860	37020	17150	33460	47845	60540	63420	42690	43881
Central	42070	45400	40394	50232	55747	50962	113655	92740	24524'	117990	113140	117120	107355	95670	142666
Eastern	3240	6230	2497	3021	6870	14534	6780	8510	18410	21430	34200	40910	41500	42475	36001
Western	8090	13760	12612	1689	15630	15901	16370	14680	21880	32461	28800	31090	32006	45540	40943
Coast	8500	7200	1834	61	2461	2565	2730	2830	4600	2730	3168	1552	1942	2219	1886
Nairobi	5500	6540	16484	1282	26849	29677	34245	29580	49410	39600	40000	41500	38000	47942	35534
	78320	**91940**	**96194**	**62752**	**114829**	**147014**	**207084**	**195860**	**369745**	**258471**	**278453**	**307172**	**303978**	**293778**	**318084**

Appendix 8.2

A survey of porcine cysticercosis in Teso District, Kenya.

Interviewer: ______________________________

Survey (house number) ____________________Date_______________________

Division___________________________________Sub location ___________________

Address (family name) ______________________Interviewer____________________

1. For the following, circle the appropriate answer:

<u>Locality</u>: Town Village Rural area

<u>House type</u>: House only House and compound Farm

<u>Fences:</u> No fence Partial fence Secure fence 6

2. For the following, answer in the space provided:

Pre school children________________

Primary School age________________

Secondary School age________________

Adults__________________.

3. What is the size of your homestead__________ (acres)

4. What is the main method of garbage disposal (choose one) ✓ 0

Municipal council pick up

Taken.to a public dump

Home garbage pit

Other (specify)

5. Does the household have a latrine____ (Yes / No)

6. Give the current number of pigs in the household by age and sex class:

	Male	Female
Breeders		
Piglets		
Fatteners		

7. If your household does not have a pig, is there a reason______ (Yes/ No)

8. If yes, please explain______________________________________

9. Other animals owned by the householder

Cattle: ____ Poultry (specify):_____ Sheep: ____

Goats: ____ Donkeys: _____ others (specify):____

10. Livestock Housing (Choose the main housing type):

	Zero grazing	Restricted grazing	Free ranging
Cattle:	__________	______________	_______
Sheep:	____________	__________	_______
Pigs:	_____________	______________	______
Other (specify):	____________	____________	_____

11. Do you ever purchase replacement pigs? _____________ (Yes/No)

12. If yes, from where?

Purchase from within the neighbourhood.

Purchase from outside the neighbourhood

Given as a gift from neighbour.

Given as a gift from outside the neighbourhood.

Any other (specify) _______________.

13. Reasons for keeping pigs:

Home consumption

Commercial

Security (as a bank)

Other (specify)____________.

14. Rank in order of importance the sources of your pig's feeds:

(1=Most important; 2, 3, 4=less important; 0= not a source)

Household leftovers or waste

Neighbours leftovers

Scavenges widely

Other (specify____________

15. Health problems of pigs:

Cysticercosis

Malnutrition

Helminthosis

Others (please specify)________________

16. Do members of your household eat pork? _________(Yes / No)

17. If yes, in what form?

Boiled

Fried

Roasted

Other (specify) _____________

18. Source of pork:

Home slaughter

Butchery

Other (specify)

19. If the pigs are slaughtered at home, is the meat inspected? _______ (Yes/ No)

20. If inspected, by who?

Government meat inspector.

Owner inspects.

Friend inspects.

Other (specify)____________

21. Do you know of tapeworm infestation in humans? ________________ (Yes/ No) (5)

22. Has any household member had tapeworm infestation in the last one year? _________ (Yes/ No)

23. How does one acquire tapeworm infestation?

Eating raw or inadequately cooked pork.

Eating raw or inadequately cooked beef.

Other (specify)__________________________

24. How can you tell when a person has tapeworm infestation?

Stomach upsets

Worms in the feces

Weight loss

Other (specify) ____________________

25. Who would you consult if you had worms?

Public health worker

Medical doctor

Other (specify) ____________________

26. Has any household member had epilepsy? ____________ (Yes/ No)

27. If yes, when____________________________________ (Year)

Appendix 8.3

A survey of taeniosis, epilepsy and neurocysticercosis in Teso District

Name of respondent: ______________ Date: ___________

Designation: (Doctor, Clinical officer) ______________

Name of Hospital / Clinic ___________________

1. Which type of parasites do you request for when you send faecal samples to the laboratory for examination? ____________________________________

2. Is tapeworm infection common in this area?__________________________

3. How do you make diagnosis for tapeworm infection?

a) Clinical history

b) Clinical presentation

c) Faecal examination

d) Any other

4. Is epilepsy common in this area? Yes / No_________

5. What is the most likely cause?

a) Brain trauma

b) Neurocysticercosis

c) Hereditary

d) Any other

6. Which age is mostly affected?

a) Adult (>18 years)

b) Young

c) Both adults & young

7. Have you heard of neurocysticercosis in man? Yes / No _________

8. If yes, is it common in the District? Yes/ No____________

9. What is the most likely cause of neurocysticercosis?

a) Brain trauma

b) Cysts in brain

c) Idiopathic (unknown reasons)

Appendix 8.4

Monthly faecal examination results from 1999- 2003

1999

Parasite	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct.	Nov.	Dec.	T[illegible]
Hook worms	-	-	3	3	2	1	5	7	3	2	8	0	[illegible]
Tape worms	-	-	0	0	0	0	0	0	0	0	10	0	[illegible]
E/ histolytica	-	-	2	1	0	0	0	2	11	10	0	8	[illegible]
Giardia	-	-	0	0	0	0	0	0	0	0	0	0	[illegible]
A/lubricoides	-	-	0	0	0	0	0	1	0	0	0	0	[illegible]
S/stercolaris	-	-	0	0	1	0	0	1	0	0	0	0	[illegible]
Trichuris	-	-	0	0	0	0	0	0	0	0	0	0	[illegible]
T/ hominis	-	-	0	0	0	0	0	0	0	0	0	0	[illegible]
T/mansoni	-	-	0	0	0	0	0	0	0	0		0	[illegible]
Total	-	-	5	4	3	1	5	11	14	12	18	8	[illegible]

2000

Parasite	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct.	Nov.	Dec.	Tota
Hook worms	0	28	26	42	16	23	22	29	9	6	0	1	202
Tape worms		0	0	0	0	0	0	0	0	0	0	0	0
E/ histolytica	2	9	26	32	16	32	12	14	0	8	2	0	153
Giardia	0	0	1	1	5	6	2	5	1	1	0	0	24
A/lubricoides	0	4	2	0	2	4	0	2	0	0	0	0	14
S/stercolaris	0	15	19	5	0	3	7	1	2	0	0	0	52
Trichuris	0	0	2	0	0	0	0	1	0	0	0	0	3
T/ hominis	0	0	0	0	1	0	0	0	0	0	0	0	1
T/ mansoni	0	1	0	1	0	0	0	0	0	0	0	0	2
	2	57	76	81	40	68	43	52	12	15	2	1	451

2001

Parasite	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct.	Nov.	Dec.	Total
Hook worms	31	24	34	26	45	46	46	62	46	44	47	40	491
Tape worms	0	2	0	0	0	0	0	0	0	0	0	0	2
E/ histolytica	14	18	5	8	12	17	13	11	12	14	10	8	98
Giardia	1	1	3	3	3	6	0	2	2	4	2	3	30
A/lubricoides	3	8	2	7	5	2	3	6	3	6	1	6	52
S/stercolaris	2	2	2	1	5	3	4	4	0	5	5	3	36
Trichuris	0	1	0	0	2	4	0	1	3	0	1	2	14
T/ hominis	1	0	1	0	0	0	1	0	0	0	2	0	5
T/mansoni	1	0	0	1	0	1	0	0	0	0	1	2	6
Total	54	56	47	46	72	79	67	86	66	73	69	64	734

2002

Parasite	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct.	Nov.	Dec.	T
Hook worms	40	23	34	16	25	41	39	44	32	20	20	20	8
Tape worms	0	1	0	0	1	0	0	0	0	0	0	1	3
E. histolytica	6	6	0	11	10	20	23	6	13	7	8	6	1
Giardia	0	0	1	1	2	10	8	2	3	2	0	0	2
A .lubricoides	1	2	5	6	6	10	10	0	5	1	0	0	4
S. stercolaris	0	2	1	0	0	4	3	3	1	2	3	3	2
Trichuris	0	0	0	0	0	0	0	0	0	0	0	0	0
T. hominis	0	0	0	0	0	0	0	0	0	0	0	0	0
S. mansoni	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	47	34	41	34	44	85	83	55	54	32	31	30	3

2003

Parasite	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct.	Nov.	Dec.
Hook worms	17	22	21	26	10	16	30	38	33	12	11	26
Tape worms	1	1	0	0	1	0	0	1	0	1	0	0
E/ histolytica	4	10	11	7	16	14	18	22	28	15	11	20
Giardia	5	10	9	4	4	5	4	4	11	7	0	2
A/lubricoides	6	2	3	1	8	2	9	0	1	5	4	3
S/stercolaris	4	4	4	8	6	2	6	8	4	3	2	5
Trichuris	0	1	0	0	0	0	0	0	0	0	0	0
T/ hominis	2	5	3	1	5	3	3	2	3	7	4	1
T/ mansoni	1	0	0	0	0	0	0	1	1	0	0	0
Un/ Ova	1	0		0	4	3	0	0	0	0	0	0
Total	41	54	51	47	53	45	70	76	81	50	32	57