



EPIDEMIOLOGY OF *TAENIA SAGINATA* TAENIOSIS AND CYSTICERCOSIS IN  
THREE SELECTED AGRO-CLIMATIC ZONES IN CENTRAL ETHIOPIA

by

Alice Tembo

December, 2001

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A thesis submitted in partial fulfilment for the degree of Master of Science in Tropical  
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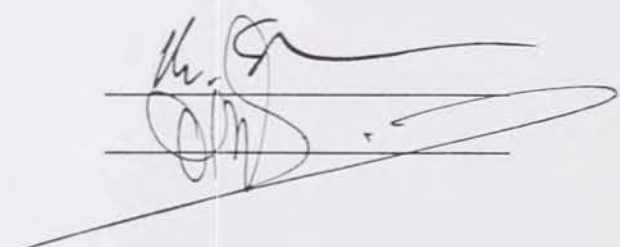


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## DEDICATION

This work is dedicated to my beloved mama, nieces and nephews for their never failing love and encouragement.

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## LIST OF ABBREVIATIONS

Adigrat	Addis Phamaceuticals
asl	above sea level
CI	Binomial exact confidence interval
ELISA	Enzyme linked-immunosorbent assay
EPHARM	Ethiopian Pharmaceuticals
FAO	Food and Agriculture Organisation
FVM	Faculty of Veterinary Medicine
ILCA	International Livestock Center for Africa
MAB	Monoclonal antibodies
MA	Ministry of Agriculture
ng	Not given
OIE	Office International des Epizooties
OR	Odds ratio
Prof	Professional category
Rbc	Raw beef consumption
WHO	World Health Organisation

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## ABSTRACT

This study was conducted in three agro-climatic zones in central Ethiopia, namely Akaki (highland), Debre Zeit (mid-altitude), and Nazareth (lowland) with the overall objective of providing baseline data on the epidemiological situation of *Taenia. saginata* cysticercosis and taeniosis. The study comprised an abattoir survey (retrospective data analysis and active data collection) at the Addis Ababa slaughterhouse, a household heads questionnaire survey and an inventory of pharmaceutical plants (Adigrat and EPHARM) and pharmaceutical shops (pharmacies, drug stores and rural drug vendor shops) in all the study areas.

Analysis of a 7-year period (1994 – 2000) meat inspection records, from the Addis Ababa Abattoir showed that 794, 091 carcasses were inspected and of these, 887 (0.11%) were found with *Cysticercus. bovis*. 25 (2.82%) of these measly carcasses were condemned due to generalized cysticercosis. Active abattoir data collection took place in March/April and May/June (2001), and a total of 2,250 randomly selected adult bovine carcasses were examined. 70 (3.11%) were found positive for cysticercosis due to *C. bovis*. Analysis of the active data revealed that there was no significant difference ( $\chi^2 = 0.12$ ,  $df = 1$ ,  $P = 0.73$ ; OR = 1.42 (0.24 – 10.46) in the infection proportion between male and female cattle. Similarly, the two study periods (phase 1 and 2) indicated no significant differences ( $\chi^2 = 0.58$ ,  $df = 1$ ,  $P = 0.47$ ; OR = 1.19 (0.74 – 1.92). Up to 6 cysts were found in 66 of the infected carcasses while 4 carcasses harboured 15 and more beef measles. Apart from the classical predilection sites in striated and cardiac muscles, *C. bovis* were also found in livers and gluteal muscles. The vitality test of all isolated bladderworms showed that 68.5% were viable. The shoulder and heart muscles had the highest numbers of viable 113 (94.95%) and dead 59 (73.75%) cysts.

The questionnaire survey strongly showed that *T. saginata* taeniosis is a widespread problem among respondents and households in all the three study areas in central Ethiopia. 346 (89.41%) of the respondents and 365 (94.32%) of the households had contracted taeniosis due to *T. saginata*, at least once in their lifetime.

Six potential risk factors of taeniosis namely, sex, age group, religion, educational level, professional category and status of raw beef consumption were considered. Univariate analysis showed that significant differences exist between sex (male and female,  $\chi^2=16.85$ ,  $df = 1$ ,  $P = 0.000$ ; OR = 3.95 (2 – 7.8)), professional category (low and high risk groups,  $\chi^2 = 23.15$ ,  $df = 1$ ,  $P = 0.000$ ; OR = 4.81 (2.44 – 9.46)) and status of raw beef consumption (beefeaters and non-beefeaters,  $\chi^2 = 241.09$ ,  $df = 1$ ,  $P = 0.000$ ; OR = 201.48 (68.50 – 591.60)). In addition, multivariate analysis (logistic regression) showed that sex and status of raw beef consumption are the most important taeniosis risk factors in central Ethiopia. A model was developed for the logit probability of taeniosis (backward fitting of the model). Conversion of the model coefficients into odds ratios revealed that non-consumption of raw beef and being of the female gender were associated with odds of 0.19 and 0.004 fold odds of taeniosis compared to being in the raw beef eating and male gender category, respectively. The questionnaire survey also revealed that lack of sanitary facilities especially in the rural sites, perpetuate *T. saginata* infection cycle thereby increasing infection levels in the bovine hosts. It can therefore be stated that the Ethiopian habit of eating raw and semi-raw beef dishes and indiscriminate defecation are very important risk factors for *T. saginata* infections in the three study areas in central Ethiopia. Inventory of pharmaceutical plants and shops further showed that *T. saginata* is a problem in the the study areas. This was indicated by the annual estimates of narrow and broad-spectrum taenicial drugs in the studied areas. Analysis of data showed that the respective adult doses of narrow and broad-spectrum taenicial drugs consumed per year were 61,556 in Akaki, 90,688 in Debre Zeit and 209,411 in Nazareth. Niclosamide was the most popular of the used drugs. The annual *T. saginata* treatment cost in the three study areas was estimated to be 1,471,821 Eth. birr.

The study unequivocally proved the high public health importance, economic significance and impact of *T. saginata* taeniosis in central Ethiopia hence, it should be accorded the serious attention it deserves by the various stakeholders in order to ensure the well being of the Ethiopian consumers and a viable beef industry. Policy decisions targeted at institutionalisation of vigorous meat inspection procedures, prohibition of backyard slaughter, educating the public on various aspects of *T. saginata* infections and further research work are strongly encouraged.

**Keywords:** *Cysticercus bovis*, *Taenia saginata*, central Ethiopia, risk factors, public health importance, economic significance.

## 1.0 INTRODUCTION

Ethiopia lies in the Horn of Africa, between 3½° and 18° N latitude and 33° and 48° E longitude. Eritrea bounds the country in the northeast, Djibouti in the east, Somalia in the southeast, Kenya in the southwest and Sudan in the west and northwest. The area of Ethiopia is 1,128,176 km<sup>2</sup>. The estimated human population in 2000 was 63,000,000 (Debre Zeit Municipality, 2000).

The economy of the country heavily depends on earnings from the agricultural sector. Traditional agriculture, including the raising of livestock (cattle, sheep, goats, horses, donkeys, mules, camels and chickens) is the most characteristic form of Ethiopian economic activity (Microsoft Encarta, 1994). The country has the highest livestock population in Africa with an estimated number of 30 million cattle (13% of the African cattle population), 22 million sheep, 17 million goats, 8.6 million equines (horses, donkeys and mules), 1.03 million camels and 55 million poultry of which 99% are local and 1% exotic (FAO, 1998). Cattle constitute about 24% of the livestock population and are managed by small holder farmers under extensive low input traditional systems (ILCA, 1993).

*T. saginata* taeniosis is so common in Ethiopia that infected individuals often do not even consult physicians but treat themselves (Mamo, 1988). The long-standing tradition of eating raw beef is an established phenomenon among Ethiopian nationals. The finding of a crawling proglottid on oneself is considered taboo and associated with a great deal of shame such that the administration of taenicidal herbal drugs to brides and expectant mothers is an important aspect of pre-nuptial and pre-childbirth rite.

The recurrent necessity of removing the worm from the body has brought forth the use of a large variety of taenicial herbs in different parts of the country (Desta, 1995). Rollo (1970) reported that the infection is a widespread problem where over 80% of the adult population has to take taenicial medication every three months. Therefore, bovine cysticercosis should be invariably widespread as man plays an active role in the dissemination of *T. saginata* eggs.

Despite the fact that a large proportion of the Ethiopian population frequently take taenicial drugs, no systematic scientific study has so far been undertaken to evaluate the importance and epidemiology of *T. saginata* infections in the country. Few isolated studies of specific sectors of the population (for example students and prisoners), conducted by Ethiopian medical practitioners, revealed infection percentages of human taeniosis and few studies on either bovine cysticercosis or taeniosis can be cited. This could be attributed to the fact that *T. saginata* taeniosis and cysticercosis are not notifiable diseases. Hence, this study was conducted to provide baseline data on the epidemiological status of taeniosis and cysticercosis in the three selected agro-climatic zones in central Ethiopia. It is anticipated that the outcome of the present study will serve, as a benchmark for further investigations on *T. saginata* infections in the country.

### Specific objectives

1. To establish the proportion of bovine cysticercosis cases detected at the Addis Ababa Abattoir.
2. To establish the relative frequency of *T. saginata* taeniosis cases and impact of the disease in the three selected agro-climatic zones in central Ethiopia.
3. To assess the potential risk factors associated with *T. saginata* infections.

## 2.0 LITERATURE REVIEW

### 2.1 Taxonomic classification

*T. saginata*, the unarmed beef tapeworm of man and its metacestode, *C. bovis* belong to the Class Cestoda of the Order Cyclophyllidea, Family Taeniidae and Genus *Taenia* (Despommier and Karapelou, 1987; Smyth, 1994; Urquhart *et al.*, 1996).

### 2.2 Morphology

#### 2.2.1 The adult parasite

The adult *T. saginata* measures 4 to 8 m (rarely up to 15m) (Soulsby, 1982) or 5 to 15 m in length (Urquhart *et al.*, 1996) and reside in the human small intestines where it attaches by its scolex and may survive many years. The adult is ribbon-shaped, flattened, multisegmented and hermaphroditic flatworm consisting of scolex (head), neck and strobila (Berkow, 1987; Urquhart *et al.*, 1996) (Figure 1).

The scolex measuring 1 to 2 mm in diameter has 4 strong hemispherical suckers, no rostellum and hooks and is attached to the intestinal mucosa usually in the proximal jejunum.

The neck is a short unsegmented germinal structure immediately behind the scolex, which continually produces proglottids (strobilization continues to take place unless the scolex is detached from the site of attachment by an efficient anticestode).

The strobila is a chain of segments made up of sexually immature, mature and gravid segments in linear sequence. Each segment is called a proglottid. Strobilization occurs at the distal part of the neck.

An adult *T. saginata* tapeworm has 1000 to 2000 proglottids, each of which is hermaphroditic with one set of reproductive organs and genital pores which open on the lateral margin(s) of the segment. Both self and cross fertilization between and among proglottids is possible. The gravid proglottids which are 20 to 30 mm long and 5 to 7 mm wide and filled with eggs (80 000 to 100 000) detach from the strobila singly and leave the host via the anus. This implies that coproscopic examination has a limited value in the diagnosis of taeniosis due to *T. saginata* infection.

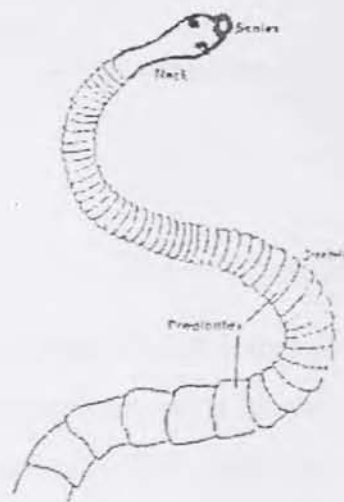


Figure 1: *T. saginata* structure of scolex and neck (after Urquhart, 1996).

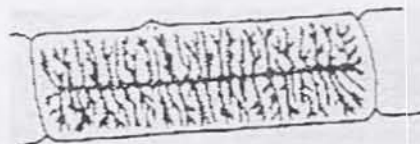


Figure 2: *T. saginata* gravid proglottid (after Smyth, 1994).

### 2.2.2 The egg

*T. saginata* eggs consist of the hexacanth (6-hooked) embryo (oncosphere), a thick dark radially striated "shell" the embryophore and a true shell. The eggs are dark brown to yellow in color, oval in shape measuring 39 - 41µm in diameter and 46 to 50 µm in length and (Soulsby, 1982; Uquhart *et al.*, 1996).



Figure 3: Typical *Taeniid* egg structure (after Uquhart *et al.*, 1996).

### 2.2.3 The larval form

The larval stages, or metacestodes also referred to as "beef measles", are found in all striated muscles of the intermediate hosts (Dunn, 1978). *C. bovis* are small (pea-sized), oval shaped, semitranslucent cysts filled with fluid containing an invaginated scolex of the tapeworm showing a dense white area measuring about 10 mm in diameter and 6 mm in length. When incised the cysts show a single scolex of a future tapeworm.

## 2.3 Life cycle

The life cycle of *T. saginata* is indirect where the definitive host is man and intermediate host cattle. Man is infected by the ingestion of raw or undercooked measly beef. In man, the cysticerci evaginate and the scolex attaches to the mucosa in the proximal jejunum and begins the process of strobilization.

The strobila may extend to the terminal ileum. Very rarely, proglottids have been found in the gall bladder, appendix, and nasopharynx (Pawlowski and Schultz, 1972). Gravid proglottids leave the host spontaneously and are shed in human feces or crawl out of the anus and may be found on bedding or cloth. Man passes out gravid proglottids about 100 days (prepatent period) after infection (CTA, 1981; Soulsby, 1982). Disintegration of the proglottids and release of eggs takes place outside the host and may remain viable several weeks or months in sewage, rivers and on pasture. Normally a single *T. saginata* tapeworm parasites man. However, an infected individual may harbor as much as 10 to 20 adult *T. saginata* worms each releasing 20 to 30 gravid segments per day (Dunn, 1978). Podyapolskaya and Kapustin (1958) reported that multiple infections occur in highly endemic areas and that about 150 tapeworms have been recorded in one person.

Cattle are infected by ingestion of embryonated eggs on pasture or feedlots, via workers defecating in hayfields. The hexacanth embryos then penetrate the intestinal mucosa, are disseminated throughout the body via blood, and develop in skeletal and cardiac muscles, viscera and organs. Heart and masseter appear to have highest density. It has been stated in the past that muscles of predilection are masseter, heart, diaphragm and tongue, but usually cysticerci are spread throughout the musculature (Soulsby, 1982). Cysticerci develop and become infective in 10 to 12 weeks (Dunn, 1978; Soulsby, 1982; Urquhart *et al.*, 1996).

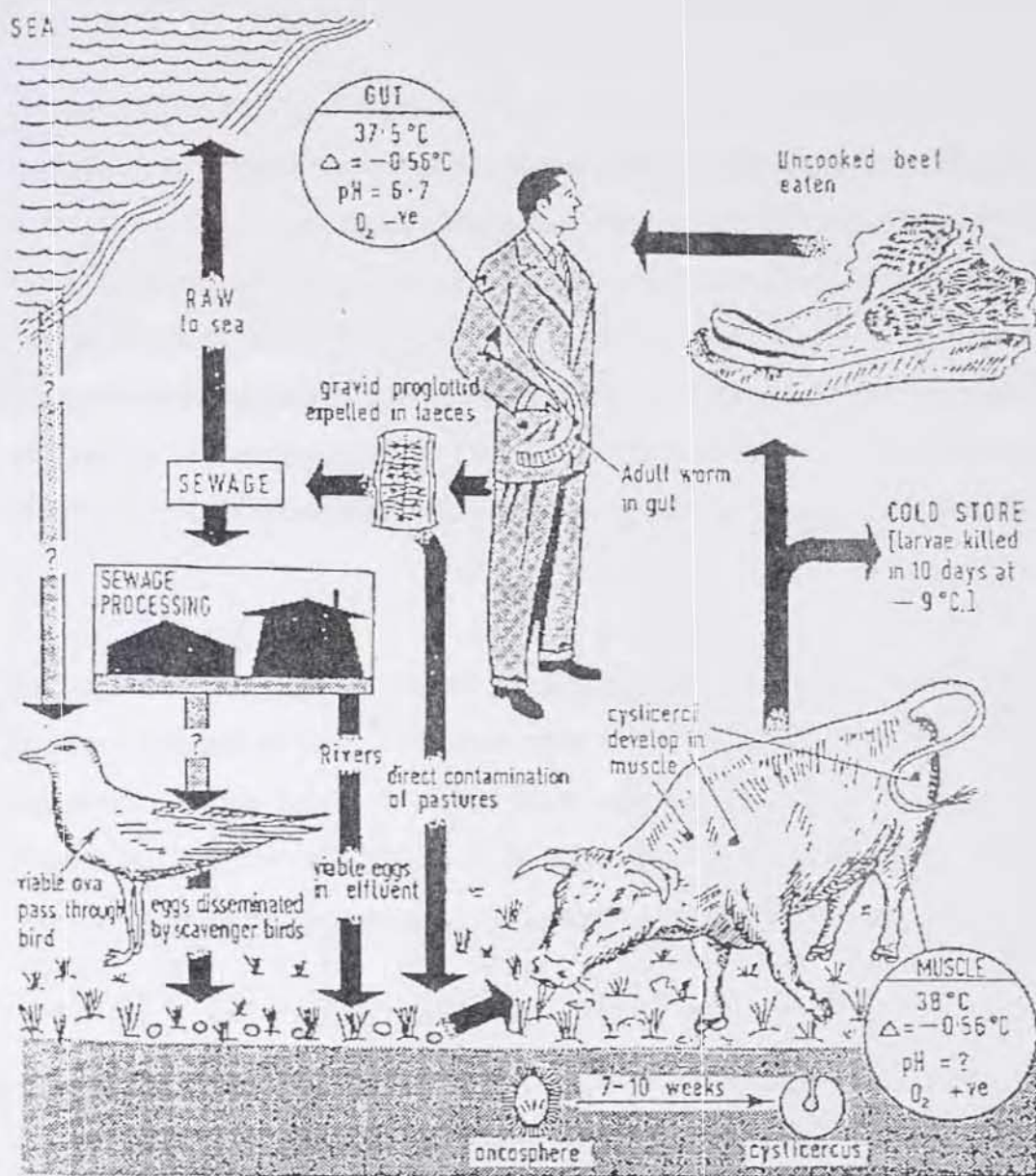


Figure 4: Life cycle of *T. saginata* (after Smyth, 1994)

## 2.4 Epidemiology

### 2.4.1 Host range

Humans are the only final hosts of *T. saginata*. Man can not spread taeniosis to their own species. It is generally accepted that man is not a host for the larval stage. However, a few cases of *T. saginata* metacestodes have been reported in man (in various sites and in association with presence of *T. saginata* in the small intestines). Fontan (1919) reported a case in which cysticerci were found in a mammary gland. Nino (1950) and Rivas (1937) reported cysticerci in lymph nodes. Pawlowski and Schultz (1972) reported several cases of cysticerci accompanying intestinal *T. saginata* infection. Unfortunately, the reports lack sufficient documentation. Needless to say, the phenomenon is extremely rare.

The preferred intermediate hosts of *T. saginata* are cattle (CTA, 1981). However, in the northern districts of Russia reindeer were found to be infection sources for man. In reindeer cysts are localized in the brain and not in skeletal muscles (Dunn, 1978). Parasitism is sometimes observed in other ruminants (sheep, goats, some antelopes, gazelles, buffalo and dromedaries) but cysticerci development is unlikely (CTA, 1981).

### 2.4.2 Mode of infection

Human food habits and mode of life are responsible for the spread of *T. saginata* infections.

Man's cultural customs and traditions of consuming raw or inadequately cooked beef dishes like: shishkebab and tikka in India (Anataraman, 1974), beef tartar shashlik in the

former USSR (Abdullaev, 1968), kourt, tirie kitfo, melasna sember and lebleb kitfo in Ethiopia, containing viable bladder worms perpetuate human infection.

Indiscriminate defecation by man has contributed greatly to the dissemination of bovine cysticercosis. Cattle are infected by ingestion of pasture and water contaminated with eggs of *T. saginata*. Calves may be infected prenatally although this may not be a common route of infection (McManus, 1960). Dispersion of *T. saginata* eggs in the environment where cattle graze has been related to several incidents such as:

1. Infected persons of the farmer family, farm personnel or other people defecating in the environment of cattle (McAninch, 1974; Holt, 1985).
2. Use of immigrant labor from countries with high prevalence of infection in feedlots (Pawlowski and Schultz, 1972).
3. Use of sewage sludge as fertilizer for pasture (Macpherson *et al.*, 1978; Haugaard, 1984; Holt, 1985, Nansen and Henriksen, 1986).
4. Irrigation of pasture with sewage effluent (Jepsen and Roth, 1950; Arundel and Adolph, 1980; Wilkens, 1981).
5. Scavenger birds like sea gulls feeding on sludge at sewage farms which may ingest eggs that pass through the birds gut unhatched and may be distributed over wide areas of grazing land (Silverman and Griffiths, 1955).

#### 2.4.3 Host related factors

All age groups of cattle are susceptible to infection. Young animals are however more susceptible than older ones, which tend to be more resistant to infection (Dunn, 1978; CTA, 1981; Okolo, 1986). In heavily endemic areas it is likely that calves encounter infection in the first few days of life (Urquhart, 1961) after which they become progressively more resistant. In Kenya it was recorded that infection can only be rarely established in animals older than 4 months of age (Froyd, 1964 a). Both sexes are affected. Reports indicate more males being affected than females. Pugh and Chambers (1989) reported a higher incidence rate of *C. bovis* in males (bulls and oxen) than females (cows).

Different breeds of cattle probably show different levels of susceptibility to infection due to the differences in genetic composition and immunological status. However, Darwin *et al.* (1994) observed that sex and breed of cattle are not significant risk factors of bovine cysticercosis.

#### 2.4.4 Agent related factors

##### 2.4.4.1 Tenacity of eggs

*T. saginata* eggs are very resistant to extremes of temperature and humidity within the environment and can survive many months. Low to moderate temperatures and high humidity are considered to favor long-term survival of Taeniid eggs (WHO, 1983). Climatic conditions are very important since eggs are very resistant under wet conditions and can survive for several months, but are rapidly destroyed by desiccation during the dry season (CTA, 1981).

Suvorov (1965) reported that under laboratory conditions, the viability of isolated *T. saginata* eggs is much higher than inside proglottids. Egg longevity was seen to vary with

temperature at which the eggs were exposed: 27 to 29 days at 19°C, 2 to 3 days at 37°C and 62 to 64 days at -4°C. The shorter survival of oncospheres inside proglottids was attributed to putrefaction processes. Under laboratory conditions, Penfold et al. (1937) demonstrated that a small proportion of a batch of *T. saginata* eggs stored in saline at 2 – 5 °C maintained infectivity for 95 days.

Froyd (1962) demonstrated that *T. saginata* eggs may remain viable in liquid manure for 71 days, 33 days in water, 5 months on grass and that under optimum conditions of temperature and humidity for a year. In Denmark, Jepsen and Roth (1952) showed that eggs of *T. saginata* remained infective after 159 days at outdoor exposure in a situation where feces containing tapeworm segments were deposited on grass in winter (February). However, the maximum duration of survival of eggs was not demonstrated.

It is significant to note that *T. saginata* eggs have been shown to survive almost all stages of sewage treatments (Table 1).

Table 1: Tenacity of *T. saginata* eggs in sewage and sludge (after Bürger 1984).

Medium	Conditions	Survival (days)	Infectivity remaining
Sewage	laboratory, 18°C	16	yes
Sewage	exp. plant, trickling filter	42	no
Sewage	septic tank	40	not tested
Sewage	plant, raw waste water	yes	yes
Sludge	lab, anaerobic digestion, 25 – 29 °C	200	not tested
Sludge	lab, anaerobic digestion, 35°C	<5	no
Sludge	plant, anaerobic digestion, 26 – 28°C	56	not tested
Sludge	plant, anaerobic digestion, cold	38	not tested
Sludge	exp. plant, activated sludge	42	not tested
Effluent	plant, activated sludge	yes	yes
Effluent	plant, trickling filter + lagoon	no?	no?
Effluent	plant, lagoons	no	no

#### 2.4.4.2 Survival of *C. bovis*

The cysticercus can survive for several years in the animal. Cysticerci degenerate 4 to 6 months after infection and by 9 months a large number are dead. Penfold (1937) demonstrated that in heavy artificial infections, almost all cysticerci are dead 9 months after infection. However, the longevity of the cysticerci is dependent on the degree of infection (Soulsby, 1965). The earlier in life the infection occurs, the longer the survival of the cysts. It has been shown that when calves are infected during the first three weeks of life, viable cysts are present for up to 2½ years.

Dead cysticerci may be fibrosed or associated with caseous or yellow-green puslike matter or calcified (Froyd, 1964 b).

#### 2.4.5 Environmental factors

Evans and Pratt (1978) reported that bovine cysticercosis was one of the diseases that showed strongest seasonal variability with carcass condemnations occurring most frequently in the second half of the year. The risk of cattle coming into contact with *T. saginata* eggs is much higher when cattle are at pasture (spring and summer months).

Management of the animals in their natural environment predisposes them to infection. Communally grazed cattle have a higher risk of picking up *T. saginata* eggs since they are frequently in contact with human feces compared with commercial herds.

### 2.5 Prevalence of *T. saginata*

#### 2.5.1 Worldwide

*T. saginata* is globally distributed (Soulsby, 1965; Hammerberg *et al.*, 1978; Anonymous, 1979) and affects both developing and developed countries. Taeniosis prevalence could be classified into three groups (Pawlowski and Schultz, 1972; Acha and Szyfres, 1987):

1. highly endemic with taeniosis prevalence exceeding 10%.
2. moderate infection rates.
3. Low infection rates less than 0.1%.

The highly endemic areas include Central and East African countries (Ethiopia, Kenya, Zaire). Endemic areas occur in the Caucasian and south-central Asian republics of the former USSR and in the Mediterranean region (Syria, Lebanon and Yugoslavia).

In some parts of Serbia and Montenegro, up to 65% of children have been reported to harbor *T. saginata* (Petrovic *et al.*, 1982).

Moderate prevalence is found in southeast Asia (Thailand, India, Vietnam, and the Philippines), Japan as well as in countries of western Europe and South America while Canada, United States, Australia and some countries of the western pacific have low prevalence.

Urquhart *et al.* (1996) reported that two quite distinct epidemiological patterns are found in developing and developed countries. In developing countries, cattle are reared on an extensive scale, human sanitation is of comparatively lower standards and the inhabitants traditionally eat raw or inadequately cooked meat. The prevalence of taeniosis is well over 20% in certain areas of these regions. Based on routine carcass inspection, the infection rate of bovine cysticercosis is often around 30 to 60% although the real prevalence is considerably higher.

*T. saginata* infections are also common in developed countries where standards of sanitation are high and meat is carefully inspected and generally thoroughly cooked. Prevalence in these parts of the world is less than 1%. Occasionally, however, cysticercosis "storms" have been reported on particular farms. The cause of the "storms" has been attributed to use of human sewage on pasture.

### 2.5.2 Africa

The highest prevalence of *T. saginata* infections occurs in Africa where cattle, rather than pigs are commonly grazed (Soulsby, 1965; Anonymous, 1979). Bovine cysticercosis has been reported in several African countries. According to the FAO/WHO/OIE Animal Health Yearbook (1995) report, *T. saginata* cysticercosis is enzootic in Botswana, Burkina Faso, Eritrea, Mozambique, Namibia and Uganda. It is reported to occur sporadically in Cote d'Ivoire, Egypt, Kenya, Malawi, Morocco, Swaziland, Tunisia and Zimbabwe. The disease exists but its distribution and occurrence is unknown in the following countries: Angola, Ethiopia, Guinea, South Africa, Sudan, Tanzania and Togo. Bovine cysticercosis is suspected to occur in Zambia but has not been confirmed. In total, bovine cysticercosis is reported in 25 countries through the region (Figure 5). In some regions, the prevalence of bovine cysticercosis is over 80% while the general prevalence is about 10% (Dunn, 1978). Giesecke (1997) reported that prevalence of *C. bovis* ranges from 1.0% to 40% in slaughtered cattle in Kenya, Uganda, Sudan, Tanzania, Nigeria, Botswana, Zimbabwe and South Africa. Few prevalence studies have been conducted in Africa (Table 2).

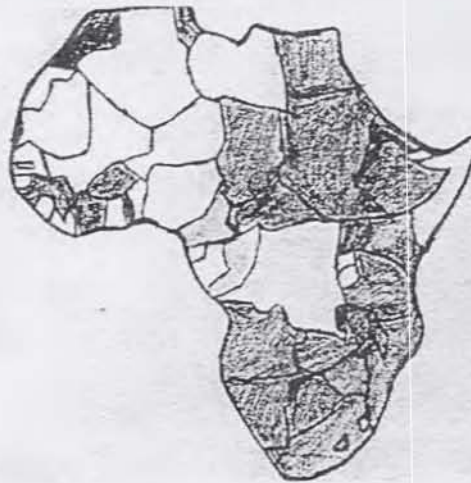


Figure.5: Distribution of *T. saginata* taeniosis/cysticercosis (after FAO/WHO/OIE Animal Health Yearbook, 1995).

### 2.5.3. East Africa

East African countries show the highest endemicity of *T. saginata* infections. This could be attributed to the close contact between the pastoralists and their cattle as well as their traditions and customs of eating raw or inadequately cooked meat. For instance, Froyd (1965) reported that 53% of cattle owned by Masai tribes' men had cysticercosis and the prevalence of taeniosis among the adult was 28%. The Masai eat meat roasted in large pieces over an open fire; keep cattle near their huts during the day and sleep close to their stock at night. Contamination of the manyatas (homestead enclosures) with *T. saginata* eggs is heavy. Kenya has very high prevalence in both humans and cattle. Other countries with high *T. saginata* infections are Ethiopia, Sudan, Tanzania and Uganda (Table 2).

### 2.5.4 Ethiopia

Few prevalence studies on taeniosis have been done in Ethiopia. However, surveys of intestinal parasites in different parts of the country have revealed *T. saginata* infection rates ranging from 0.5% among pre-school children in Addis Ababa (Taticheff *et al.*, 1981) to 16% among primary school students (Wang, 1965). Lemma *et al.* (1968) reported infection rates of 11.8% and 5.9% among Gondar and Bahir Dar prisoners respectively and 4.2 and 7.4% among Addis Ababa and Debre Zeit school children. Woldemicheal *et al.* (1990) reported infection rate of 2.3% among students of Wonji-Shoa sugar estate and Wondimagegnehu *et al.* (1992) reported infection rate of 3.5% among the Melka Sedi banana plantation residents in Middle Awash Valley.

Table 2: Prevalence of taeniosis in some African countries.

Country	Cysticercosis in cattle	Taeniosis in man	Reference
Botswana		7.7%	Grindle (1978)
Cameroon		14%	Foba-Pagou et al. (1980)
Ethiopia	21% 13.8%	16% 4.4% 2.5% 3.5%	Ahmed, 1990 Getachew, 1990 Wang, 1965 Tedla (1986) Woldemicheal et al., (1990) Wondimagegnehu et al., (1992)
Kenya	5.9 20.2%	Up to 50% 2 – 63	Hall <i>et al.</i> , (1981) Cheruiyot and Onyango-Abu (1984) Mitchell (1973)
Morocco	0.27 - 1.03%	0.15 – 0.34	Pandey et al. (1985)
Nigeria	0.53%	11.5% 8.6%	Dada (1980) Dada <i>et al.</i> , (1993) Onah and Chiejina, (1995)
Zimbabwe	2.6%		Pugh & Chambers (1989)
Sudan	20.2%	10.4%	Karrar and Rahim, (19995) Mitchell (1973)

## 2.6 Economic and public health significance

The metacestodes of *T. saginata* frequently present economic problems to the beef industry and are a public health hazard (Urquhart *et al.*, 1996). Cysticercosis in domestic animals is a significant food safety problem and causes economic loss in food production. Mann (1983) estimated an annual loss of US\$ 1,800,000,000 due to bovine cysticercosis in Africa (overall infection rate 7%). The South African feedlot industry alone losses about R19, 000,000 annually due to cysticercosis (Giesecke, 1997).

In Kenya and Botswana, bovine cysticercosis annual losses amounted to US\$ 4,000,000 and US\$ 2,000 000, respectively (Grindle, 1978).

Nfi and Alongé (1987) reported carcass condemnations valued at US\$ 49,193 while parts and organs amounted to US\$ 5,622 in Cameroon. Abdussalam, (1975) estimated that bovine and porcine cysticercosis caused an annual loss of US\$ 428,000,000 in South America (overall infection rate 2.0%). Oryan *et al.* (1995) reported an approximate cysticercosis economic loss of about 100.1 million Rials during 1990 to 1993 in Iran. A cysticercosis condemnation rate of 18% was reported in Zimbabwean carcasses (Chambers, 1987). Cysticercosis and taeniosis in humans give rise to medical costs and wage losses (as well as food production losses). Roberts, (1985) estimated that an annual loss of US\$ 100,000 (US\$ 111 per patient) due to the treatment of taeniosis occurs in the USA. Fan (1997) estimated an annual taeniosis economic loss of US\$ 18,673,95 in the mountainous areas of Taiwan, US\$ 2,425,500 on Samosir Island (Indonesia) and US\$ 13,641,021 on Cheju Island of Korea. This indicates that taeniosis is not only a significant public health problem but also an important economic problem in Asia.

## 2.7 Clinical manifestation

### 2.7.1 Man

The infection is asymptomatic although abdominal pain, nausea, debility, weight loss, flatulence and diarrhea or constipation may occur. A patient may have one or several of these symptoms. A high percentage of patients experience gastric hyposecretion. Individual reactions to the infection differs and may be influenced by psychogenic factors, since patients often notice symptoms only after they see proglottids (Pawlowski, 1982).

The gravid proglottids of *T. saginata* sometimes migrate to different organs (appendix, uterus, bile ducts, nasopharyngeal pathways), causing disorders related to the site in which they settle (Acha and Szyfres, 1987). Sometimes the tapeworms may cause intestinal obstruction as was seen in one patient in Zimbabwe (Bordon, 1992).

## 2.7.2 Animals

Under natural conditions, the presence of cysticerci in the muscles of cattle are not associated with clinical signs. However, experimentally infected calves dosed with massive *T. saginata* eggs develop severe myocarditis and heart failure associated with developing cysticerci in the heart (Urquhart *et al.*, 1996).

## 2.8 Diagnosis

### 2.8.1 Man

Tentative diagnosis is made based on the symptoms of the patient. Confirmatory diagnosis is by the identification of gravid proglottids in the feces. Examination of the gravid segments also reveals Taeniid eggs. These eggs are not distinguishable by morphological features. Feces may be examined by floatation techniques; however, anal swabs should be used rather than direct examination of fecal samples. Proglottids are not eliminated on a daily basis; therefore the examination should be repeated if results are negative (Acha and Szyfres, 1987). The only parasite which has to be differentiated is *T. solium*. Proglottids of *T. solium* have less uterus branches in comparison to *T. saginata*. A "dip stick" technique based on an antigen capture ELISA, to detect coproantigens in feces has been developed for *Taenia* species in humans (Allan *et al.*, 1993).

### 2.8.2 Animals

The metacestodes are readily visible in the organs or musculature at autopsy therefore, diagnosis of bovine cysticercosis is usually done during postmortem examination in abattoirs. Individual countries have different regulations regarding the inspection of carcasses, which usually attempt to reconcile the interests of owners and those of the consumers.

The following examinations are recommended: two longitudinal incisions in the tongue; full-length section of the heart and examination of the cut surfaces; horizontal slicing of the masseter; examination of the subscapular connective tissue and muscle surfaces exposed by lifting the shoulder blade.

Considerable research has been done on the detection of serum antibodies produced by presence of cysticerci, however, lack of serological specificity has been a major constraint in the trials (CTA, 1981). Several workers (Brandt *et al.*, 1992; Hughes *et al.*, 1993; Draelants *et al.*, 1995 and Onyango - Abuje *et al.*, 1996 a) reported that a monoclonal antibody (MAb)-based ELISA for the detection of circulating excretory – secretory (ES) products in *T. saginata* cysticercosis shows promising results and may prove useful in meat inspection for the ante-mortem detection of cysticercosis.

## 2.9 Differential diagnosis

### 2.9.1 Man

Man is the final host for three *Taenia* species: *T. saginata*, *T. solium* and Asian/Taiwan *Taenia* (*T. saginata asiatica*) all of which parasitise the human intestine. Differentiation of the taenia species is important in order to relate infection to particular species and hence correctly determine the prevalence and incidence rates associated with each species. A number of characteristics are employed in the differentiation of the *Taenia* species. These include: morphological characteristics of the scolex in the adult tapeworm and cysticercus, number of the lateral branches of the uterus in the gravid proglottids, ovary and vagina; site of cysticerci development; preferred intermediate hosts and egg size (Table 3). However, some of the differentiation characteristics can not be fully relied upon, for example, eggs of *T. saginata* and *T. solium* can not easily be distinguished and the scolex of the adult tapeworms often remain in the gut (and may regenerate) or otherwise get lost (Smyth, 1994).

A much-used criterion is the number of lateral branches of the uterus in the gravid proglottids, observed by compressing a specimen between two glass slides. Uterine lateral branches number 14 – 32 in *T. saginata*, 7 – 11 in *T. solium* and 12 – 26 in Asian/Taiwan *Taenia* (*T. saginata asiatica*). Proglottids with 10 branches or fewer are considered likely to be *T. solium* and those with more than 16 branches as *T. saginata* (WHO, 1983).

Recently, more precise differentiation methods have emerged with the development of molecular biological techniques and use of DNA probes. Accurate identification is now possible (McManus, 1990; Gottstein *et al.*, 1991). Fan *et al.* (1995), demonstrated that the Asian/Taiwan *Taenia* is a subspecies of *T. saginata* (now designated *T. saginata asiatica* contrary to the review of Bowles and McManus (1994) which claimed it was a new species) using genetic methods.

#### 2.9.2 Animals

The metacestodes found in cattle should be differentiated from:

1. *Sarcocystis* species which form white, soft nodules measuring 4 to 6 mm long in the esophagus and sometimes in the heart and other muscles.
2. *Onchocerca dukei* measuring 3 to 6 mm in diameter which form intramuscular and subcutaneous nodules that are firm to touch and reveal worms surrounded by pus when sectioned (CTA, 1981).
3. *Cysticercus dromedarii* (*C. cameli*) the metacestode of *T. hyaenae* which is twice as large as *C. bovis* measuring 12 to 18 mm in length, pearly white in color and possesses a double row of hooks on the lateral invaginated scolex (CTA, 1981).

**Table 3:** Some characteristics differentiating *T. saginata*, *T. saginata asiatica* and *T. solium* (after WHO, 1983; Dunn, 1978 and Fan *et al.*, 1995).

Characteristic	<i>Taenia saginata</i>	<i>Taenia saginata asiatica</i>	<i>Taenia solium</i>
Intermediate host	cattle, reindeer	pig and wild boar* pig, calf, goat, monkey**	Pig, wild boar
Development site	muscle, viscera, brain	Mainly liver	Brain, skin muscle
Scolex:			
Suckers	4	4	4
Rostellum	absent	present	present
Hooks	absent	present	hooks
Cysticercus size	10 mm by 6 mm	1320 (450 to 3520) µm by 1237 (400 to 3219) µm	20 mm by 10 mm
Mature proglottids:			
Ovary	2 lobes	2 lobes	3 lobes
Vaginal sphincter	present	present	absent
Egg size	46 to 50 µm by 39 to 41 µm	33 (21 to 45) µm by 28 (16 to 34) µm	46 to 50 µm by 39 to 41 µm
Gravid proglottids:			
Uterine branches	23 (14 to 32)	17 (12 to 26)	8 (7 to 11)
Passing of Proglottids	spontaneously, singly	spontaneously, singly	passively in groups

\*Preferred intermediate hosts

\*\* Experimental intermediate hosts

## 2.10 Treatment

### 2.10.1 Animals

There is no licensed drug available which can destroy all cysticerci in the muscles of cattle. However, Praziquantel has been extensively tested against experimental bovine cysticercosis and shown to be effective in a single dose of 50 mg/kg body weight against 3 months but not 1 month old cysticerci (Gallie and Sewell, 1978).

### 2.10.2 Man

#### 2.10.2.1 Modern drugs

Synthetic drugs such as Praziquantel and Niclosamide are claimed to be the drugs of choice for man although they are relatively expensive. Low doses, 5 mg/kg of Praziquantel and 2000 mg (adult dosage) of Niclosamide have been shown to be effective and safe (Tesfa and Yohannes, 1990; Pawlowski, 1991).

#### 2.10.2.2 Traditional drugs

Desta, (1995) reported that a number of taenicidal herbs are used in the treatment of taeniosis in Ethiopia and observed that:

1. More than 90% of the taenicidal herbs studied are associated with a worm expulsion time of less than 24 hours (which was significant in the sense that traditionally, it is preferable to resolve taeniosis in one day)
2. Most of the herbs studied are of rather low toxicity in the amounts they are generally used in traditional therapy.

3. It is necessary to develop taenicial medications of low toxicity, high potency and short worm expulsion time.
4. Ten of the most frequently used taenicial herbs in decreasing order of preference based on the lower toxicity, higher potency and shorter worm-expulsion time are: *Embelia scrimperi*, *Cucurbita pepo*, *Thymus serrulatus*, *Hagenia abyssinica*, *Myrsine africana*, *Maesa lanceolata*, *Cynodon dactylon*, *Echinops gigantea*, *Glinus lotoides* and *Plantago lanceolata* (Table 4).

The regular intake of taenicial drugs in Ethiopia has been associated with a variety of side effects. The most popular Kosso flowers (*Hagenia abyssinica*) are responsible for hepatocarcinoma (Tsega, 1977), visual disturbance and blindness (Rokos, 1969). The flowers contain kosotoxin, which is closely related to filicic acid. *Glinus lotoides* fruits (Metterie) are known for their neurotoxicity and depressive action. Gastrointestinal ailments have also been attributed to the usage of taenicial drugs (Chernishov and Aragie, 1978).

Taenicial herbs are effective in treating taeniosis and their use should be encouraged as long as traditional herbalists come up with proper dosages to ensure that the bad side effects are overshadowed by the benefits.

Table 4: Ten taenicidal herbs used in Ethiopia arranged in decreasing order based on higher potency, lower toxicity and shorter worm-expulsion (after Desta, 1995).

Herb	Local Name
<i>Embelia schimperi</i>	Enkkokko
<i>Cucurbita pepo</i>	Dubafre
<i>Thymus serrulatus</i>	Ttossigne
<i>Hagenia abyssinica</i>	Kosso
<i>Myrsine africana</i>	Kkettchemo
<i>Maesa lanceolata</i>	Kkelewa
<i>Cynodon dactylon</i>	Serdo
<i>Echinops gigantea</i>	Dendero
<i>Glinus latiodes</i>	Metterie
<i>Plantago lanceolata</i>	Gortteb

### 2.10.3 Control

#### 2.10.3.1 Prevent infection in cattle

Treating all *Taenia* carriers either through mass campaigns or at a local level (staff of ranches, feedlots or members of a family farm) periodically with antehelminthics of choice prevents dissemination of infective *T. saginata* eggs into the environment of cattle (CTA, 1981). Vaccination with heterologous species of *Taenia* such as *T. hydatigena* has been shown to increase resistance against *T. saginata* (Wilkerhauser et al., 1971). In a field trial carried out in Australia (Rickard et al., 1982), a reduction in both the rate of infection and the level of infection (number of cysticerci) was confirmed in animals immunized with antigens of *T. hydatigena*. It was concluded that although the method significantly reduced infection rates, it might not be practical for common use unless homologous antigens of *T. saginata* are employed.

Other investigations, centered on providing passive immunity to newborns through colostrum by immunizing cows have been carried out. Antigens secreted in culture medium by activated oncospheres of *T. taeniaformis* and *T. saginata* have proved to be effective in immunizing pregnant cows by intramuscular or intramammary inoculation and for the subsequent passive transference of immunity to calves via colostrum (Soulsby and Lloyd, 1982).

Educating humans on environmental sanitation, use of latrines (in rural areas) and avoidance of using human sewage sludge as fertilizer for cattle pastures should be a continual process (Acha and Szyfres, 1987).

#### 2.10.3.2 Prevent human infection

Health education of the general public is a key factor in the prevention of taeniosis/cysticercosis. Meat inspection in abattoirs is the major way of ensuring that consumers are supplied with "measly" free beef as long as the law enforcement concerning carcasses with *C. bovis* are strictly followed. Although completely satisfactory inspection is never possible in abattoirs (Dunn, 1978), it has been shown that each additional muscle group included in the inspection, greatly increases the detection rate. In South Africa, the addition of a shoulder incision was found to increase detection rate by 47% (Heaver and Reinecke, 1963). When infection is detected in a carcass, its fate is subject to the precise regulations of the country. It has been recommended by FAO/WHO, (1983) that: less contaminated meat should be trimmed; slight or moderate infected carcasses should be thoroughly cooked (thermal death point of cysticerci is 57°C), pickled in brine or frozen. Freezing is the most elegant method used in abattoirs of international standard. In general, freezing 48 hours at a temperature of -18°C is advised. The joint FAO/WHO (1983) Committee proposed freezing for 10 days at a temperature of -10°C. The other possibility is to freeze the carcass for 54 hours at -15°C. The method is quicker and cheaper especially for carcasses less than 200 kg but less reliable (CTA, 1981).

### 3.0 MATERIALS AND METHODS

#### 3.1 Description of study area and population

##### 3.1.1 Study area

The study was conducted in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) situated in central Ethiopia. The map of the study area is shown in Appendix I.

Akaki is a small peri-urban commercial town situated on the southern outskirts of Addis Ababa at an altitude of 2000 m asl. Its average annual rainfall is above 930 mm. The temperature ranges from 6 to 22°C and soils are chiefly vertisol. The town has one *Kefitegna* and two *Kebeles* with an estimated total population of 6, 000 (Debre Zeit Municipality, 2000).

Debre Zeit is located just at the escarpment of the Great Rift Valley about 45 km southeast of Addis Ababa at an altitude of 1850 m asl. The annual average temperature, rainfall and relative humidity are in the order of 18.7°C, 866 mm and 58.9% respectively. The soils in Debre Zeit are also predominantly vertisol. The town is divided into 2 *Kefitegnas* with a total of 15 *Kebeles* and an estimated population of 95,000. The Adaa' Woreda, of which Debre Zeit is the capital, comprises 42 Peasant Associations with an estimated total population of 179,000 (Debre Zeit Municipality, 2000).

Nazareth is a relatively big commercial city found within the Great Rift Valley, located at an altitude of about 1500 m asl 100 km south of Addis Ababa. Temperatures in Nazareth range from 13.9 to 27.7°C. The town receives rainfall of about 830 mm per year.

The soils in Nazareth are nitosol. The town is administratively divided into 4 *Kefitegnas* and 20 *Kebeles* with an estimated total population of 193,600 (Debre Zeit Municipality, 2000).

The field research commenced in February 2001 and was completed in June the same year. Data were collected from the Addis Ababa Abattoir (AAA), two major pharmaceutical plants namely Adigrat (Addis Pharmaceuticals) and Ethiopian pharmaceuticals (EPHARM), Ministry of Health Drug and Control Department (MHDCD), Pharmaceutical Shops, and 387 households.

### 3.1.2 Study population

#### Retrospective abattoir survey

794,091 cattle passed through routine meat inspection procedure at the Addis Ababa Abattoir during a seven-year period (1994 – 2000). Annual cattle slaughters during this period ranged from 105,715 – 124,625.

#### Active Abattoir survey

2250 cattle presented for slaughter at the Addis Ababa Abattoir were examined for presence of *C. bovis* following customary meat inspection procedures stipulated in the Ministry of Agriculture's (MA) Meat Inspection Regulations (1972). Cattle slaughtered at the Addis Ababa Abattoir were predominantly indigenous Zebu (*Bos indicus*) and only a few (about 1%) exotic (*Bos taurus*) breeds mainly Holstein-Friesian and crosses. The study population was composed of culled older male (bulls and oxen) and a small number of old cows.

These cattle originated from diverse places in the country from as far off as Harar, Borana and Northern Shoa, to areas within a radius of 100 km from Addis Ababa which included, Debre Zeit and Nazareth feedlots as well as urban and peri-urban sites in and around Addis Ababa.

#### Questionnaire survey

387 households were randomly selected from the various *kebeles* in the study areas. Out of this 18 were in Akaki, 54 in Debre Zeit rural, 135 in Debre Zeit urban and 180 in Nazareth. Respondents of the questionnaires were the 387 household heads from the selected households.

#### Inventory of pharmaceutical plants and shops

An inventory of the two pharmaceutical plants in Ethiopia namely Addis Pharmaceuticals (Adigrat) and Ethiopian Pharmaceuticals (EPHARM) and 34 Pharmaceutical Shops which included all pharmacies, drug stores and rural drug vendor shops from the study areas (4 in Akaki, 10 in Debre Zeit and 20 in Nazareth) was conducted.

### 3.1.3 Sample size determination

#### Active abattoir survey

2250 adult bovine carcasses presented for slaughter at the Addis Ababa Abattoir were randomly selected during the active abattoir survey.

## Questionnaire survey

The questionnaire survey sample size (number of households) was determined based on the following sample size determination formula given in Noordhuizen *et al.* (1997).

$$n = [1 - (1 - P1)^{1/d}][N - (d-1)/2]$$

Where N = Human population size of each selected study site

d = Number of affected people in the population (30% of N)

n = Required sample size

P1= Probability of finding at least 1 case in the population (95%)

Based on the formula shown above, nine households were selected from each of the *kebeles* in the three study areas. This amounted to selection of 387 households. Appendix 2 shows the population sizes, number of *kebeles* and households selected for the the purpose of this survey.

### 3.2 Study design

The study design consisted of abattoir (retrospective abattoir record analysis and active abattoir work) and questionnaire surveys as well as inventory of pharmaceutical plants and shops. Appendix 3 shows the study design flow chart.

#### 3.2.1 Retrospective abattoir data

Retrospective records for a 7-year period (1994 - 2000) kept by the Addis Ababa Abattoir Meat Inspection Team were analyzed for cases of bovine cysticercosis.

Bovine carcasses which were found with at least five cysticerci were considered as cases of bovine cysticercosis by the inspection team. All cases with less than five cysts were regarded as light infestations and thus not recorded. In addition, condemnation proportions due to generalized bovine cysticercosis were determined. Bovine carcasses and offals that had generalized cysticercosis and declared unfit for human consumption were regarded as condemned *C. bovis* cases.

### 3.2.2 Active abattoir survey

The abattoir survey was conducted in two phases, each comprised routine examination of 1125 randomly selected cattle that were presented for slaughter at the Addis Ababa Abattoir. The first phase was conducted between March and April while the second phase was done between May and June. Although meat inspection procedures concerning detection of *C. bovis* are clearly laid down in the Ministry of Agriculture's (MA) Meat Inspection Regulations (1972), only the shoulder muscles were routinely examined for *C. bovis*. The tongue and masseter muscles were not examined at all. Other muscles were inspected only in few cases. Records of the slaughtered animals were kept on specially designed recording sheets (Appendix 4). Recorded information comprised date, carcass lot and number, age, sex, breed, number of cysts found in the inspection sites. Suspected "measly beef" samples were collected and transported to the Parasitology Laboratory at the Faculty of Veterinary Medicine (FVM), Debre Zeit for confirmation. There, the cysts were incubated at 37°C in 40% ox-bile solution diluted in normal saline for 1 – 2 hours. A cyst was regarded as viable if the scolex evaginated during the incubation period. *T. saginata* metacestodes were identified based on the cysticercus size and absence of hooks on the rostellum of the evaginated cyst (WHO, 1983).

### 3.2.3 Questionnaire survey

Questionnaires were administered to each of the nine randomly selected households in the various *kebeles* of the three selected areas. 387 (18, 54, 135, and 180 in Akaki, Debre Zeit rural, Debre Zeit urban and Nazareth, respectively) questionnaires were administered. Accordingly, individual interviews of household heads were conducted in order to determine the relative frequency of *T. saginata* taeniosis and identify the risk factors associated with transmission of the infection. The questionnaire comprised 53 questions. Of these, question numbers 29 and 33 were used for univariate analysis of respondents and households with history of taeniosis. These two questions were used to derive the variables respondents and households with taeniosis history which were subsequently used in the establishment of relative taeniosis cases among respondents and households. The following items were covered in the questionnaire study: the number of cattle owned, general management of cattle with particular emphasis on husbandry and feeding practices, the aim of keeping cattle, peoples status regarding consumption of raw beef, frequency and type of cattle commonly slaughtered at home, presence and usage of sanitary facilities especially toilets, knowledge of *T. saginata* life cycle progression, specific questions regarding medical history related to traditional and modern taenicidal medicines, impact of taeniosis and possible options for rational control.

### 3.2.4 Pharmaceutical inventory

An inventory of the two main pharmaceutical plants and all pharmaceutical shops in the three study areas was conducted. Total yearly taenicidal drug sales and adult doses were gathered and analyzed to estimate the impact of taeniosis.

## 3.3 Data management and analysis

Abattoir data were collected and recorded on specially designed forms and preliminary analysis was done in Microsoft Excel 97 (Microsoft Corp.).

The outcome variable for the abattoir study was cases of "beef measles" detected during routine postmortem inspection at the Addis Ababa Abattoir. Univariate screening (chi-square and odds ratio) for the risk factors study period and sex, both of which were on the categorical scale, was conducted using Stata 6.0 (StataCorp.) to determine the effect they had on detection of "beef measles". The observed values of the risk factors, study period and sex were, period one (March – May), period two (May – June), male and female carcasses, respectively.

The questionnaire and pharmaceutical inventory data were coded and analyzed in SPSS Release 10.07 (2000). The outcome variable for the questionnaire survey was history of taeniosis among respondents and households derived from question numbers 29 and 33 of the attached questionnaire. Six potential risk factors of taeniosis, all under categorical scale, were univariately analyzed for their effect on taeniosis. These were gender, age group, status of raw beef consumption, religion, educational levels and professional categories. All these risk factors had two values except educational levels, which had 5 values namely, illiterate, elementary, secondary, college and university levels. The respondents were grouped into two professional categories based on their taeniosis risks. The low risk group comprised housewives, students and the unemployed while the high-risk group consisted of farmers, retirees, professionals and non-professionals. Univariate analysis of the risk factors was conducted (chi-square and odds ratios) using Stata 6.0 (StataCorp.).

- Multivariate analysis (logistic regression) was conducted using significant univariate risk factors of taeniosis. These included sex (coded as 1 for male and 2 for female), status of raw beef consumption (coded as 1 for eating raw beef and 2 for not eating raw beef) and professional category (coded as 0 for low risk category and 1 for high-risk category). However, upon further analyses, the professional category risk was excluded from the model (backward fitting of the model). A final model was developed and included coefficients  $b_i$  where:  $i = 1$  was sex coded as 1 for male and 2 for females and  $i = 2$  was rbc coded as 1 and 2 for eating and not eating beef, respectively. The coefficients were converted to odds ratios ( $OR_i = \exp(b_i)$ ) for  $i = 1, 2$ ) by Stata 6.0 (StataCorp.).

## 4.0 RESULTS

### 4.1 Abattoir survey

#### 4.1.1 Retrospective abattoir data

During the period 1994 – 2000 (7 years), a total of 794, 091 bovine carcasses were examined and passed through routine meat inspection procedure at the Addis Ababa Abattoir. This figure corresponds to annual slaughter ranges varying from 105, 715 – 124, 625. Out of these, 887 (0.11%) carcasses had cysticerci. On average, 100 cases (0.1%) of bovine cysticercosis were recorded annually. The annual proportions of bovine cysticercosis cases during the seven-year period (1994 – 2000) ranged from 0.09 to 0.15% (Figure 6). Significant differences were observed between 1994 - 1995, 1994 - 1996 - 1994 – 2000 as indicated by the 95% exact binomial confidence intervals, which did not overlap.

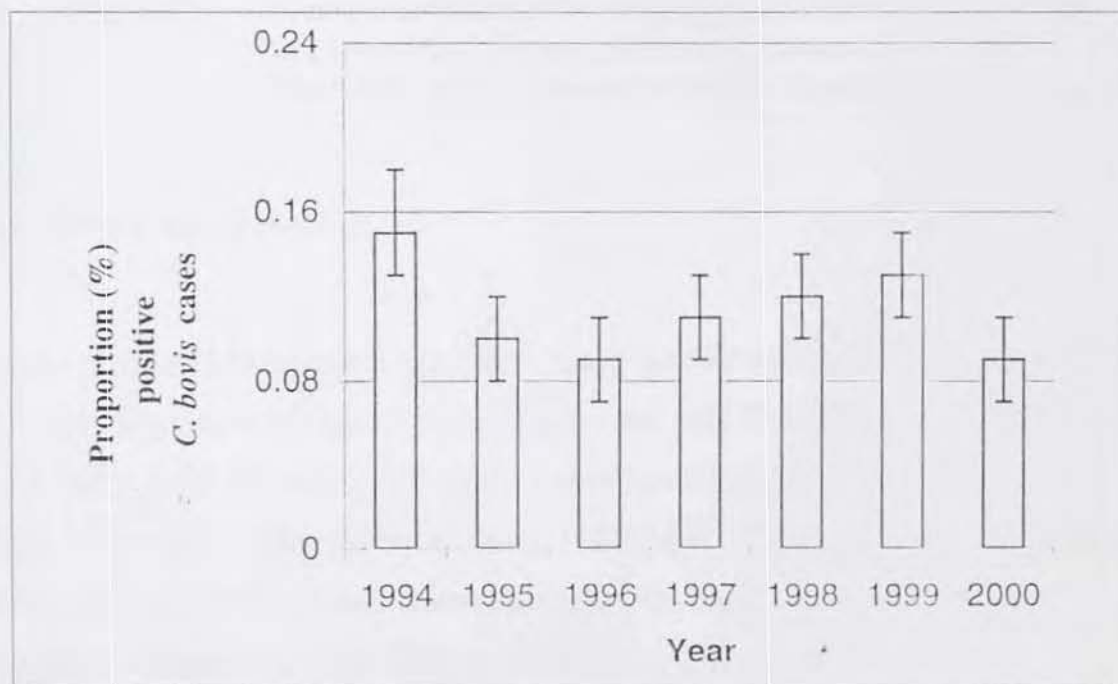


Figure 6: Annual proportions of bovine cysticercosis cases recorded at the Addis Ababa Abattoir during a 7-year period (1994 - 2000).

In addition, it was noted that 25 (2.82%) carcasses found positive were totally condemned due to generalized bovine cysticercosis during the seven-year period (1994 – 2000). This corresponds to annual condemnation proportions (95% CI) of 2.0% (0.24 - 7.04), 6.36% (2.60 - 12.67), 9.17% (4.66 - 15.81), 3.08% (0.84 - 7.69) and 1.11% (0.03 - 6.04) for the year 1995 and from 1997 – 2000, respectively (Figure 7). There were no significant differences in condemnation proportions among five years (1995 and 1997 – 2000).

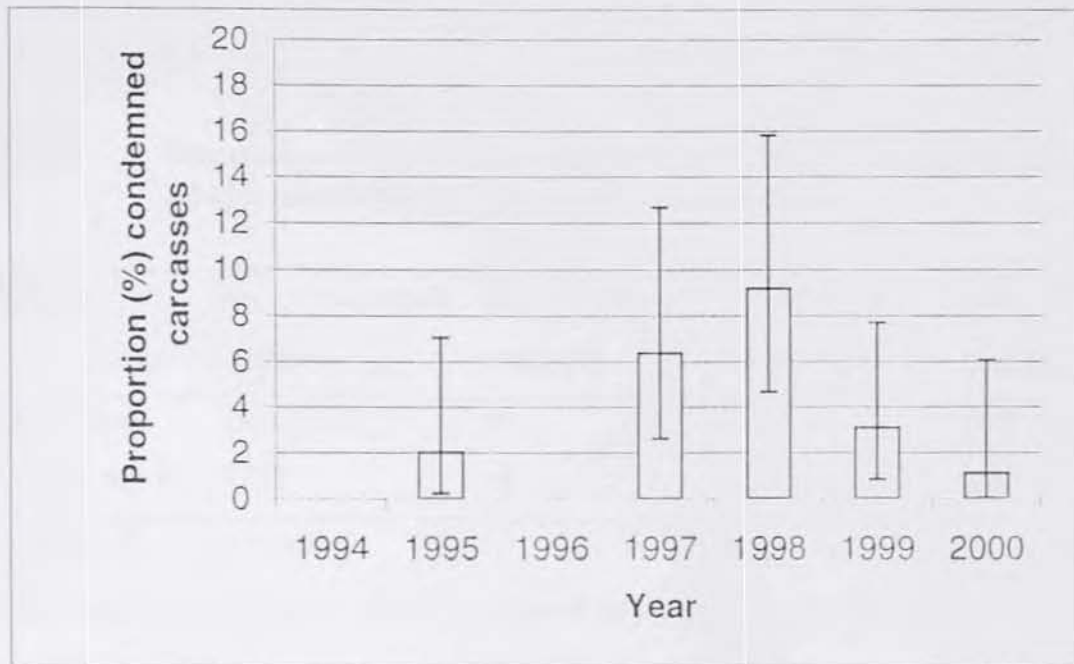


Figure 7: Annual condemnation proportions of carcasses condemned due to generalized bovine cysticercosis among infected carcasses at the Addis Ababa Abattoir during a 7-year period (1994 - 2000).

#### 4.1.2 Active abattoir survey findings

From a total of 1125 carcasses examined during the first phase (March to April), 1097 (97.5%) were older male carcasses (old oxen) and only 28 (2.5%) females (old cows). Of these, 38 (3.38%) (37 male and 1 female) were found infected with cysticerci due to *C. bovis*. In the second phase (May to June), 1125 (1108 male and 17 female) carcasses were examined. 32 (2.8%), all male carcasses were infected. The overall *C. bovis* proportion was thus computed as 3.11% (70 out of 2250 examined carcasses).

The numbers of inspected and infected carcasses recorded during the two study phases are shown in Table 5. The overlapping of the 95% exact binomial confidence interval and the 95% CI of the odds, which included one, indicate that there was no significant difference in proportions of bovine cysticercosis cases between the two phases. Similarly, there was no significant difference in proportions of bovine cysticercosis cases between male and female carcasses (95% CI for male = 0.06 – 11.77 and 95% CI for female = 2.44 – 3.94,  $\chi^2 = 0.12$ , df = 1). Correspondingly, the 95% CI of the OR for male (1.42) included one (Table 6).

**Table 5: Proportion of bovine carcasses infected with *C. bovis* at the Addis Ababa Abattoir during the study period (2001).**

Study period	No. of carcasses inspected	No. of infected carcasses	Proportion(%) positive	95% Exact Binomial Confidence Interval
May – June	1125	32	2.84	1.95 – 3.99
March – April	1125	38	3.38	2.40 – 4.61

$\chi^2 = 0.58$ , df = 1, P= 0.47

OR for study period March - April1 compared to May - June = 1.19 (0.74 – 1.92)

**Table 6: Proportion of bovine carcasses infected with *C. bovis* in male and female carcasses at the Addis Ababa Abattoir during the study period (2001).**

Sex	No. of carcasses inspected	No. of infected carcasses	Proportion(%) positive	95% Exact Binomial Confidence Interval
Female	45	1	2.22	0.06 – 11.77
Male	2205	69	3.13	2.44 – 3.94

$\chi^2 = 0.12$ , df = 1, P = 0.73

OR for male compared to females = 1.42 (0.24 – 10.46)

66 (94.29%) of the infected carcasses had 1 to 6 cysts (Figure 8). Carcasses with more than five cysts were detained for a ten-day freezing period. During the study period (both phase 1 and 2), no carcass was condemned due to generalized bovine cysticercosis.

Figure 9 shows the frequency distribution of *C. bovis* metacestodes in different predilection sites in infected carcasses examined during the study period. Accordingly, shoulder and heart muscles were found to harbor the highest numbers (113 (94.95%) and 59 (73.75%), of viable and dead cysts respectively (Table 7).

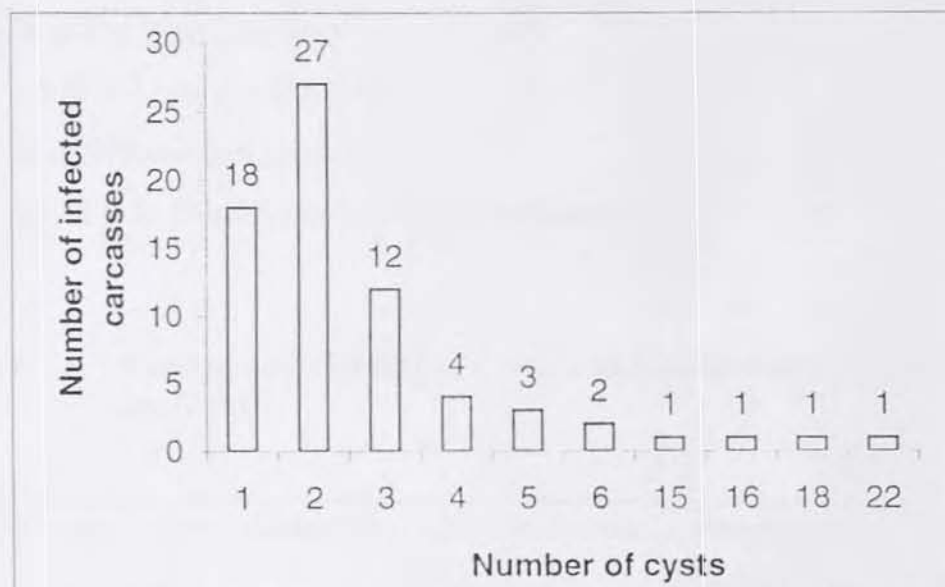


Figure 8: Number of *C. bovis* cysts per infected carcasses found in inspection sites at the Addis Ababa Abattoir during the study period (2001).



**Figure 9:** Frequency distribution of *C. bovis* metacestodes by inspection sites of the infected carcasses at the Addis Ababa Abattoir (2001).

H & Lv: Heart and liver

Lv & S: Liver and shoulder

H & S: Heart and shoulder

Gl, H & S: Gluteal muscles, heart and shoulder

**Table 7:** Number and viability of *C. bovis* in infected carcasses by predilection site (2001).

Inspection site	No. viable cysts	No. dead cysts	Proportion (%) viable cysts	Proportion (%) dead cysts
Shoulder muscles	113	6	94.95	5.04
Heart	21	59	26.25	73.75
Liver	12	5	70.59	29.41
Gluteal muscles	6	0	100.00	-
<b>Total</b>	<b>152</b>	<b>70</b>	<b>68.47</b>	<b>31.53</b>



a



b



c



d

Figure 10: Measly heart samples collected from the Addis Ababa Abattoir during active abattoir survey (a and b) and microscopic appearance of scolex of *C. bovis* showing the 4 suckers and absence of rostellum and hooks (c and d).

## 4.2 Questionnaire data

Three hundred and eighty seven questionnaires were administered to household heads to gather information on *T. saginata* infections. Only the questions from which the outcome variables taeniosis history among respondents and households respectively were derived from (question numbers 29 and 33) were used for detailed analyses. The other questions were used for cross checking of the gathered data (Appendix 5).

### 4.3.1 Household data

The survey revealed that the average household family size of the study population was 6.0 (Question 7, Appendix 5). 350 (90%) and 37 (9.56%) of the respondents were christians and moslems, respectively. Classification based on their educational levels, showed that 264 (22%) and 123 (31.78%) of the respondents were literate and illiterate, respectively. On the other hand, 331 (85.53%) of the respondents had either a toilet or latrine at home (Question 16, Appendix 5). Closer analysis of the data, however, indicated that 52 (96.29%) of the rural study population defecated in the field or backyard (Question 28, Appendix 5).

The respondents also reported that home cattle slaughter is a common practice during festive occasions (Question 18, Appendix 5). This is done at least three times a year when groups of five to eight people pool resources together and buy an animal. This practice of sharing beef among community units is locally referred to as "Kircha". Older non-productive cattle (oxen, or cows) are usually slaughtered and carcasses are rarely inspected (Questions, 19 and 20 Appendix 5).

349, (90.18%) of the respondents consumed raw (*kourt, melasna sember and tirie kitfo*) and semi-raw (*Leb-leb kitfo*) Ethiopian cuisine beef dishes (Questions 21 and 27, Appendix 5). Although 266 (68.7%) of the respondents had been advised against eating raw beef, only 46 (17.29%) permanently stopped consumption (Questions 22 and 24, Appendix 5). Out of these, 25 (54.3 %) stopped consumption of raw beef because of aesthetic reasons. Factors without apparent direct relationship of fear of contracting taeniosis such as old age, fear of HIV AIDS and lack of finances were other reasons given for the stoppage of raw or undercooked beef dishes (Question 26, Appendix 5).

346 (89.41% of the respondents contracted taeniosis, at least once in their lifetime. Most 334 (96.53%) of them diagnosed the infection by themselves based on observation of proglottids in the feces (Question 32, Appendix 5). Consequently, 142 (41.2%) taeniosis respondents took taenicidal medication at least three times every year.

The respondents reported usage of both modern drugs and traditional herbs for treatment of taeniosis (Question 34, Appendix 5). The commonly used modern taenicidal drugs were Niclosamide and Mebendazole and among the traditional herbs, *Kosso, Enkokko* and *Meterie*. In addition, *kachemo, dife-dife* (highly concentrated alcohol), *duba-fre* (pumpkinseeds) and benzene were also used.

The respondents reported that ill-health complications related to taenicidal drug usage were more frequently experienced after treatment with traditional herbs than with modern drugs (Questions 40 and 41, Appendix 5). The reported complications included diarrhea, vomiting, esophageal irritation, epigastric pain, sight problems, general malaise and unconsciousness. 193 (49.3%) claimed to have heard about death(s) related to usage of taenicidal drugs (Question 42, Appendix 5).

186 (76%) of the respondents reported that they knew the cause of taeniosis. However, they had little or no knowledge about the life cycle progression of *T. saginata* (Questions 43 – 46, Appendix 5).

#### 4.3.2 Herd structure and management

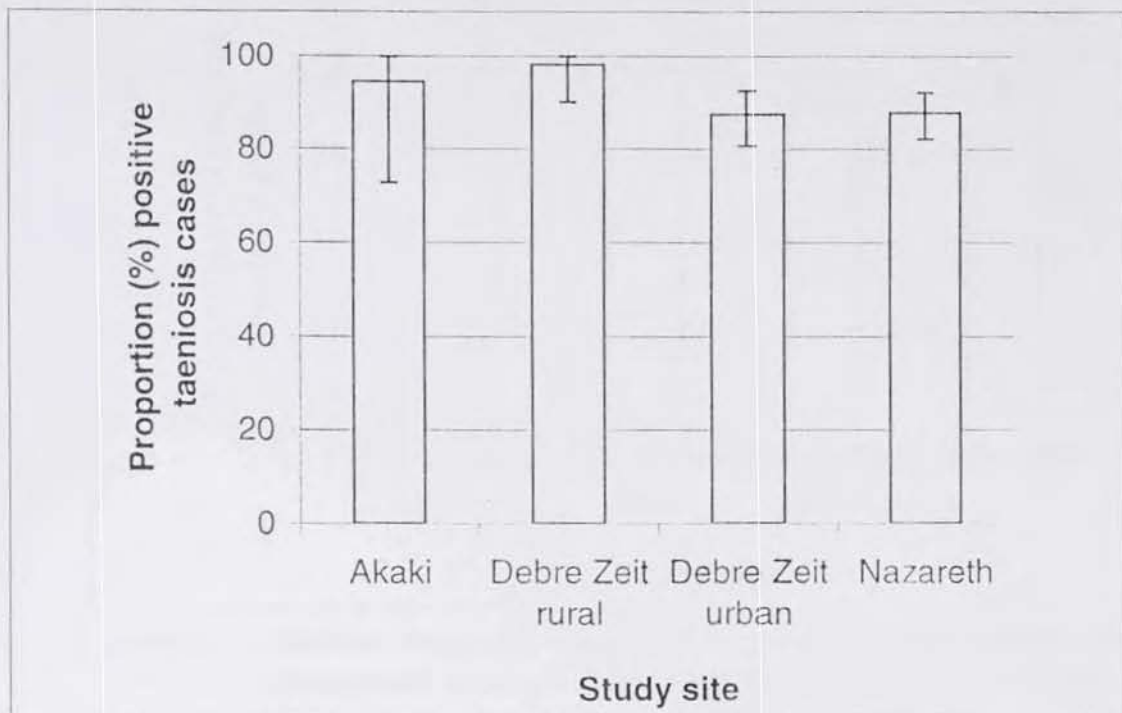
The respondents owned different types of livestock. These included cattle, sheep, goats, donkeys, horses and poultry (Question 9, Appendix 5). 153 (34.88%) of them owned cattle which were mainly kept for multipurpose uses (milk, meat, draftpower, manure, fuel, income) and were managed on communal grazing fields (Questions 10 – 12, Appendix 5). Cattle were generally grazed about 3 km from the living quarters and herded by old men and children (Questions 14 and 15, Appendix 5). There were no latrines in the cattle grazing grounds (Question 16, Appendix 5). Consequently, the herders defecated on the grazing grounds. The respondents acquired their cattle keeping knowledge and skills from their parents and through informal training (Question 13, Appendix 5).

#### 4.3.3 Taeniosis in the study areas

##### 4.3.3.1 Relative frequency of *T. saginata* taeniosis cases

###### Among household heads

Out of the 387 respondents, 346 (89.41%) had suffered from taeniosis at least once in their lifetime. Of these, 17, 53, 118 and 158 were from Akaki, Debre Zeit rural, Debre Zeit urban and Nazareth, respectively. There were no significant differences in the proportions of relative frequency cases of taeniosis among respondents from the three study areas (Figure 11).



**Figure 11:** Relative frequency cases of *T. saginata* taeniosis among household heads in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia (2001).

#### Among households

365 of the 387 households (94.32%) had experienced at least a case of taeniosis. Of these, 123 (91.11%) were in Debre Zeit urban, 170 (94.44%) in Nazareth and 18 (100%) in Akaki and 54 (100%) in Debre Zeit rural (Figure 12). Analysis of the results indicated that there were no significant differences in proportions of households with at least one taeniosis case among the study areas.

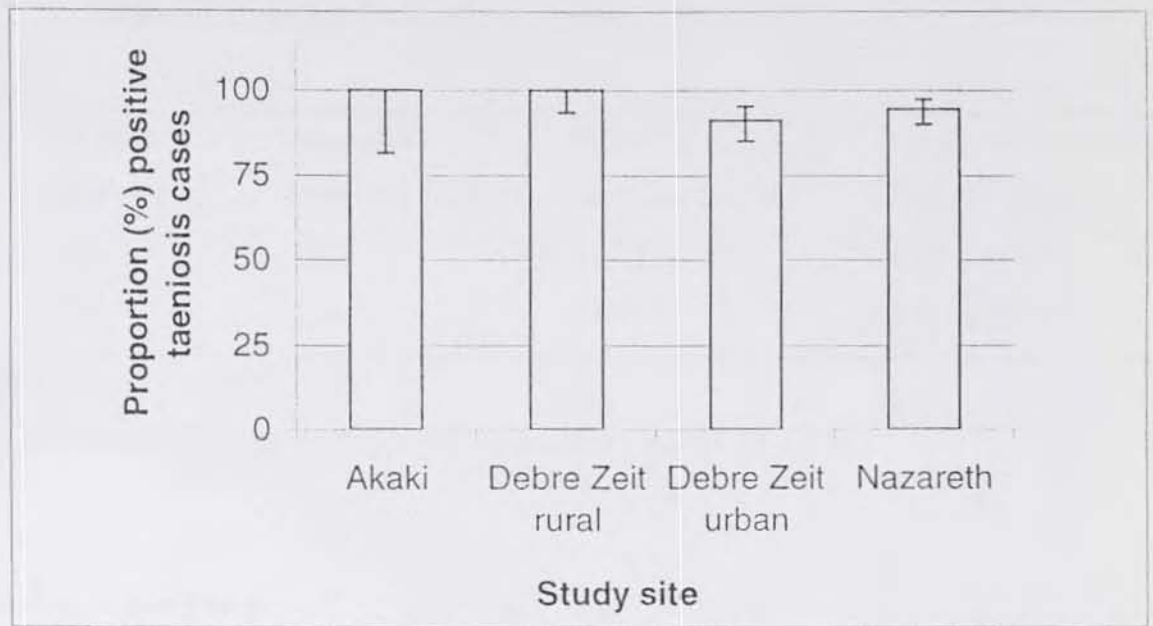


Figure 12: Relative frequency cases of *T. saginata* taeniosis among selected households in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia (2001).

#### 4.3.3.2 Effect of risk factors on taeniosis

##### Gender

The relative frequency proportions (95% CI) of taeniosis cases between male and female subjects was 94.51% (90.80 – 97.04) and 81.13% (74.16 – 87.22) respectively (Table 8), with a statistically significant difference between the two proportions ( $\chi^2 = 16.85$ ,  $df = 1$ ,  $P < 0.05$ ). Males had 3.95 fold odds of suffering from taeniosis compared to females.

**Table 8:** Relative frequency cases of *T. saginata* taeniosis among respondents in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia stratified for gender (2001).

Gender	No people interviewed	No people taeniosis positive	Proportion (%) taeniosis positive	95% Exact Binomial Confidence Interval
Female	150	122	81.33	74.16 – 87.22
Male	237	224	94.51	90.80 – 97.04

$\chi^2 = 16.85$ ,  $df = 1$ ,  $P = 0.00$

OR (95% CI) of male compared to female respondents = 3.95 (2 – 7.8)

#### Age group category

Out of 346 infected respondents, 106 (86.18%) were young (less than 30 years) and 240 (90.91%) old (above 30 years) (Table 9). There was no significant difference in proportions of relative frequency cases of taeniosis between the two age groups ( $\chi^2 = 1.98$ ,  $df = 1$ ,  $P > 0.05$ ).

**Table 9:** Relative frequency cases of *T. saginata* taeniosis among respondents in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia stratified for different age groups (2001).

Age group category	No people interviewed	No people taeniosis positive	Proportion (%) taeniosis positive	95% Exact Binomial Confidence Interval
>31 years	264	240	90.91	86.78 – 94.09
16 – 30 years	123	106	86.18	78.80 – 91.74

$\chi^2 = 1.98$ ,  $df = 1$ ,  $P = 0.16$

OR (95% CI) of 16 – 30 years compared to > 31 years age group = 0.62 (0.32 – 1.19)

## Consumption of raw beef

349 (90.18%) respondents ate raw beef. Out of these, 340 (97.42%) had at least one infection in their lifetime. 38 respondents did not eat raw beef. Of these, however, 6 (15.79%) ate undercooked beef. Table 10 shows the status and effects of raw beef consumption on taeniosis. Statistical analysis showed that there was significant difference between respondents who ate and those who did not eat raw beef ( $\chi^2 = 241.09$ ,  $df = 1$ ,  $P < 0.05$ ). Those who ate raw beef had 201.48 (68.50 – 591.60) fold odds of taeniosis compared to those who did not.

**Table 10:** Relative frequency cases of *T. saginata* taeniosis among respondents in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia stratified for status of raw beef consumption (2001).

Raw beef consumption	No people interviewed	No people taeniosis positive	Proportion (%) taeniosis positive	95% Exact Binomial Confidence Interval
Do not eat	38	6	15.79	6.23 – 31.25
Eat	349	340	97.42	95.16 – 98.81

$\chi^2 = 241.09$ ,  $df = 1$ ,  $P = 0.00$

OR (95% CI) of eating raw beef compared to non-beef eating = 201.48 (68.50 – 591.60)

## Religion

Out of 350 christian respondents, 313 (89.43%) had suffered from taeniosis. Similarly, out of 37 moslems 33 (89.19%) contracted taeniosis (Table 11). There was no significant difference in taeniosis experiences between respondents of the two religious faiths ( $\chi^2 = 0.00$ ,  $df = 1$ ,  $P > 0.05$ ).

**Table 11:** Relative frequency cases of *T. saginata* taeniosis among respondents in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia stratified for different religions (2001).

Religion	No people interviewed	No people taeniosis positive	Proportion (%) taeniosis positive	95% Exact Binomial Confidence Interval
Moslem	37	33	89.19	74.58 – 96.97
Christian	350	313	89.43	85.72 – 92.45

$\chi^2 = 0.00$ ,  $df = 1$ ,  $P = 0.96$

OR (95% CI) of Christian compared to Moslem faiths = 1.03 (0.36 – 2.98)

### Educational levels

Most of the respondents, 264 (68.22%) had formal education. The odds ratios of the four educational levels (illiterate, secondary, college and university) as compared to elementary educational level were 1.67 (0.64 – 4.36), 1.13 (0.48 – 2.65), 1.09 (0.28 – 4.11) and  $\infty$  (0.17 – ng), respectively (Table 12). There was no significant difference in proportions of relative frequency cases of taeniosis among respondents of the various educational levels ( $P$  values > 0.05).

### Occupations

Out of 261 respondents in the high-risk occupational group, 247 (94.64%) indicated having suffered from taeniosis at least once in their lifetime. The low risk group comprised 126 respondents of which 99 (78.57%) had at least one experience of taeniosis (Table 13). There was significant difference in proportions of taeniosis cases between the two occupational groups ( $\chi^2 = 23.15$ ,  $df = 1$ ,  $P < 0.05$ ). The high-risk professional group had 4.81 fold odds of taeniosis compared to the low risk group.

**Table 12:** Relative frequency cases of *T. saginata* taeniosis among respondents in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia stratified for educational levels (2001).

Educational level	No people interviewed	No people taeniosis positive	Proportion (%) taeniosis positive	95% Exact Binomial Confidence Interval
Illiterate	123	113	91.87	85.56 – 96.03
Elementary	62	54	87.10	76.15 – 94.26
Secondary	172	152	88.37	82.61 – 92.75
College	25	22	88.00	68.78 – 97.45
University	5	5	100.00	47.82 – 100.00

1. OR (95% CI) of illiterate compared to elementary = 1.67 (0.64 - 4.36)  
 $\chi^2 = 1.07$ , df = 1, P = 0.30
2. OR (95% CI) of secondary compared to elementary = 1.13 (0.48 - 2.65)  
 $\chi^2 = 0.08$ , df = 1, P = 0.79
3. OR (95% CI) of college compared to elementary = 1.09 (0.28 – 4.11)  
 $\chi^2 = 0.01$ , df = 1, P = 0.91
4. OR (95% CI) of university compared to elementary =  $\infty$  (0.17 – ng)  
 $\chi^2 = 0.73$ , df = 1, P = 0.39

**Table 13:** Relative frequency cases of *T. saginata* taeniosis among respondents of different occupations in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia (2001).

Professional category	No people interviewed	No people taeniosis positive	Proportion (%) taeniosis positive	95% Exact Binomial Confidence Interval
Low risk	126	99	78.57	70.38 – 85.38
High risk	261	247	94.64	91.16 – 97.04

$\chi^2 = 23.15$ , df = 1, P = 0.000

OR (95% CI) of the high risk group compared to low risk group 4.81 (2.44 – 9.46)

## Logistic regression

A logistic regression model was developed using a backward fitting of the model:

$$\text{Logit Pr (Taeniosis)} = b_0 + b_1\text{sex} + b_2\text{rbc} + b_3\text{prof} + \text{error}$$

Where:

- $b_0$  = intercept
- $b_1$  = coefficient of sex (coded as 1 for male and 2 for female)
- $b_2$  = coefficient of rbc (coded as 1 for eating raw beef and 2 for non-beef eating)
- $b_3$  = coefficient of prof (coded as 0 for low risk and 2 for high risk)

Logit Pr (Taeniosis) = Logit probability of taeniosis

Significant risk factors from univariate analysis were used as independent factors of the model above. The non-significant coefficients were eliminated from the model using Stata 6.0 (StataCorp.). Coefficients of the final model are shown in Table 14 a. The coefficients were converted to odds ratios by Stata (Table 14b). The odds ratios revealed that non-consumption of raw beef and sex (being female) were associated with 0.19 and 0.004 fold odds of taeniosis compared with eating raw beef and being male, respectively. The final model is shown below:

$$\text{Logit Pr (Taeniosis)} = b_0 + b_1\text{sex} + b_2\text{rbc} + \text{error}$$

Where  $b_0$  = intercept

- $b_1$  = coefficient of sex
- $b_2$  = coefficient of raw beef consumption
- rbc = raw beef consumption

Logit Pr (Taeniosis) = Logit probability of taeniosis

**Table 14a: Logistic regression results showing coefficients of the model.**

Risk factor	Coefficients	Standard Error	Z	P > Z	95% Confidence Interval
X1	-1.65	0.61	-2.72	0.006	-2.84 – (-0.46)
X2	-5.44	0.62	-8.71	0.000	-6.67 – (-4.22)
Constant	11.64	1.53	7.60	0.000	8.64 – 14.64

X1 = Sex: coded as 0 for female and 1 for male

X2 = Status of raw beef consumption: coded as 0 for not eating and 1 for eating

**Table 14b: Logistic regression showing coefficients converted to odds ratios.**

Risk factor	Odds ratio	Standard Error	Z	P > Z	95% Confidence Interval
X1	0.1919	0.1164	-2.72	0.006	0.058 – 0.629
X2	0.0043	0.0027	-8.71	0.000	0.001 – 0.015

X1 = Sex: coded as 0 for female, 1 for male

X2 = Status of raw beef consumption: coded as 0 for not eating and 1 =

$OR_i = \exp(b_i)$  where  $i = 1$  : sex (coded as 1 = male, 2 = female)

$i = 2$  : rbc (coded as 1 = eating raw beef, 2 = non-raw beef eating)

## 4.4 Inventory of pharmaceutical plants and drug shops

### 4.4.1 Findings from pharmaceutical plants

The Ministry of Health Drug and Control Department (MHDCD) regulates locally manufactured and imported taenicidal drugs in Ethiopia. EPHARM (located in Addis Ababa) and Adigrat (located in the Northern Administrative Region of Tigray) are the two major taenicidal drug manufacturing companies in the country. Taenicidal drugs manufactured by EPHARM for a five-year period (1996 to 2000) are presented in Table 15. Production of Diclorophene was banned in the year 2000 (MHDACD, 2001).

**Table 15: Taenicial drug production at the Ethiopian Pharmaceutical Company (EPHARM) for a 5-year period (1996 to 2000).**

Year	Niclosamide annual doses	Diclorophene annual doses	Total annual doses
1996	2, 548, 500	2, 225, 667	4, 774, 167
1997	4, 484, 000	538, 500	5,022, 500
1998	9, 418, 125	2, 665, 333	12, 083, 458
1999	4, 484, 000	416,833	4, 900, 833
2000	5, 033, 875	-	5, 033, 875
<b>Total</b>	<b>25, 968, 500</b>	<b>5, 846, 333</b>	<b>31, 814, 833</b>

Adigrat, a newly established pharmaceutical enterprise had produced about 45 million Niclosamide tablets (9 million adult doses) by June of 2001. Several stakeholders (private, international organizations, and government) distribute taenicial drugs to various parts of the country. However, study site-specific information regarding the quantities and worth of locally manufactured and imported taenicial drugs could not be gathered from EPHARM, Adigrat or MHDCCD.

#### 4.4.1 Findings from pharmaceutical shops

An inventory of pharmaceutical shops (pharmacies, drug stores and rural drug vendor shops) was conducted in all the three study sites. It was noted that the modern taenicial drugs sold in these shops were produced locally or imported from abroad (Cyprus, Egypt, France, Germany, India, Italy, South Africa and USA). The Red Cross Pharmacies and government owned pharmacies sold taenicial drugs cheaper than privately owned pharmaceutical enterprises.

Estimates of yearly adult taenicial drug doses and worth collected through personal interviews with the pharmacists, their assistants or shop owners revealed that a total of 361,655 adult taenicial drug doses worth 1,471,821 Eth. birr were used in the three study areas during the year 2000 (Table 16). The taenicial drug preference trend in the three study areas showed that Niclosamide and Mebendazole were the most preferred drugs (Figure 13). In Akaki, Nazareth and Debre Zeit, the annual percentages of Niclosamide usage were in the order of 54, 51 and 41%, respectively whereas for Mebendazole 24, 34 and 40% were recorded in the same areas. Praziquantel was the least used taenicial drug mainly because of its relatively high cost per unit dose. Despite having been banned from the market two years ago (MHDCD, 2000), it was observed that Diclorophene was still being sold in some pharmaceutical shops.

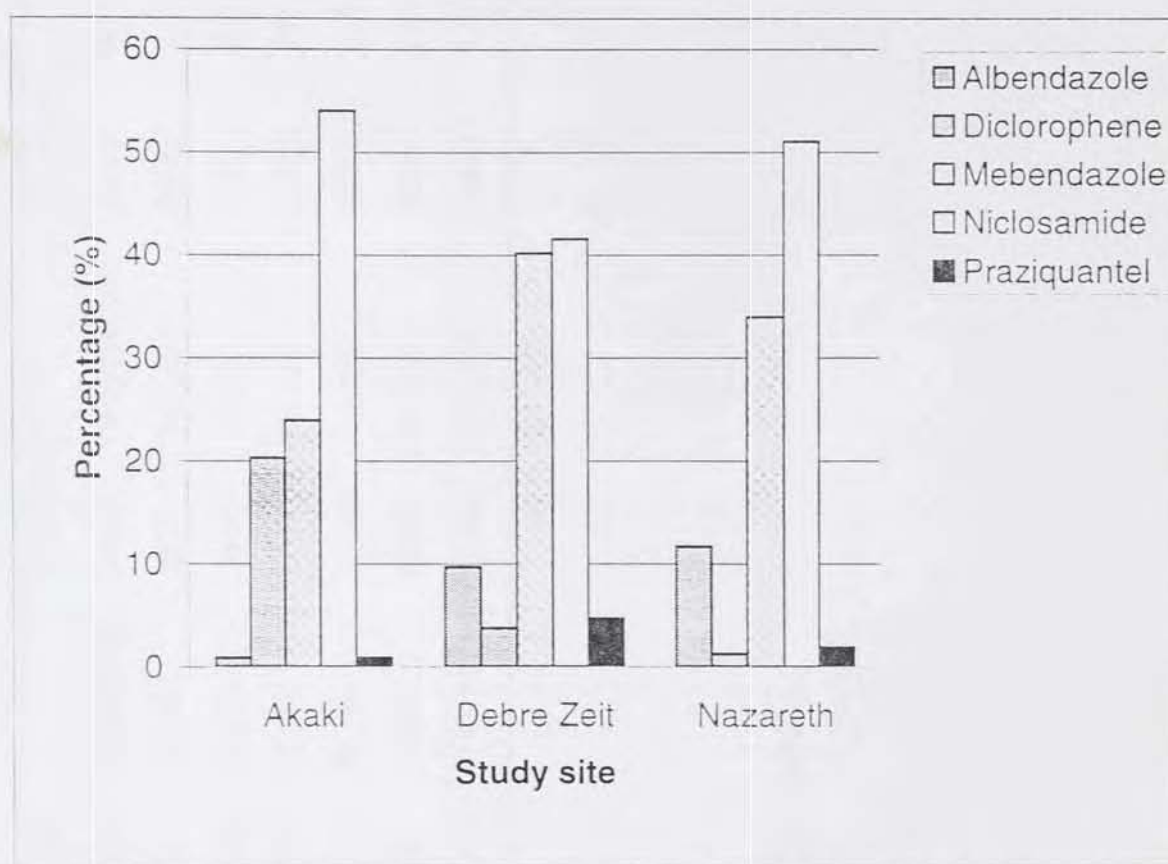


Figure 13: Taenicial drug preferences in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia (2000).

**Table 16: Inventory of annual taenicidal drug doses and their worth in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) in central Ethiopia.**

<i>Taenicidal</i>	<i>Akaki</i>		<i>Debre Zeit</i>		<i>Nazareth</i>		<i>Total</i>	
	<i>Doses</i>	<i>Worth(birr)</i>	<i>Doses</i>	<i>Worth (birr)</i>	<i>Doses</i>	<i>Worth (birr)</i>	<i>Doses</i>	<i>Worth (birr)</i>
<i>Drugs</i>								
Albendazole	553	11,446	8825	105,691	24526	486,039	33904	603,176
Diclorophene	12520	19,406	3443	5,352	2738	4,107	18701	28,865
Mebendazole	14711	54,587	36422	99,223	71187	481,992	122320	635,802
Niclosamide	33219	30,783	37720	35,466	106882	113,211	177821	179,460
Praziquantel	553	1,490	4278	9,592	4078	13,436	8909	24,518
<b>Total</b>	<b>61556</b>	<b>117,712</b>	<b>90688</b>	<b>255,324</b>	<b>209411</b>	<b>1,098,785</b>	<b>361655</b>	<b>1,471,821</b>

## 5.0 DISCUSSION

*T. saginata* cysticercosis and taeniosis are global problems that affect many countries of the world (Soulsby, 1965; Hammerberg *et al.*, 1978; Anonymous, 1979). The public health and economic significance caused by the two diseases should not be overlooked simply because they are not notifiable diseases. There are no recent reports regarding the *T. saginata* situation in Ethiopia. This study was therefore conducted to provide baseline information on the epidemiological status of taeniosis in central Ethiopia.

### 5.1 Abattoir survey

Proportions of bovine cysticercosis cases obtained from the retrospective abattoir data were too low compared to results of the active abattoir survey. This could be attributed to the fact that the abattoir slaughtered far too many animals than its capacity such that less time was spent on inspection of individual carcasses mainly due to work pressure. Furthermore, the inspection team recorded only carcasses that had at least five cysts in the inspected sites. However, the proportions of bovine cysticercosis cases determined during the active abattoir survey were still relatively low, taking into account the fact that the masseter and tongue muscles were not examined. Contrary to the routine practice at the Addis Ababa Abattoir, published literature report high cyst loads in the masseter and tongue muscles (Walker, 1972; McCool, 1979; Okolo, 1986). Inadequate lighting and working space in the abattoir may have also influenced the relatively low bovine cysticercosis cases detected during the active abattoir survey period.

Surveys which followed meticulous dissection and slicing of muscles considered as predilection sites of *C. bovis*, report high proportions of bovine cysticercosis cases (McCool, 1979). Walther and Koske (1980) also showed this. The authors inspected 79 bovine carcasses that originated from a highly endemic area. 38.3% of the carcasses were found to be infected when they employed routine meat inspection procedures. Out of these, 21.7% had cysts only in the triceps. The percentage of the infected carcasses rose to 75.9% after careful dissection and slicing. It is worthy noting that 56.7% of the carcasses did not have bladderworms at the predilection sites (masseter, heart and tongue). After artificially infecting cattle, Schröder (1993) completely sliced bovine carcasses and counted the cysts on their localization sites. Between 14 to 39% of all isolated bladderworms from the infected carcasses, were found in predilection sites. Geerts *et al.* (1980) and Van Knapen (1981) reported that detailed dissection of predilection sites revealed 5 to 50 times higher cysticercosis percentages than routine meat inspection. However, despite the high detection proportions obtained following careful dissection of carcasses, several studies for example (Onyango-Abuje *et al.*, 1996 b; Dorny *et al.*, 2000) reported that the proportions of bovine cysticercosis detected by meticulous dissection was underestimated by a factor of 3 to 10. Belino (1975) was also of the opinion that meticulous dissection did not guarantee "measly-free" carcasses. These observations may support the findings of the present study in view of the low frequency of bovine cysticercosis and relatively high taeniosis proportion in the definitive host observed in central Ethiopia.

It is worthy noting that inspection procedures for *C. bovis* could be improved by making more incisions as per standard recommendations (WHO, 1983). However, there are practical and economic constraints to be considered for example, time spent to inspect an individual carcass and the subjective nature of the procedure. Efficacy of *C. bovis* detection during routine meat inspection largely depends on the skills and motivation of the meat inspectors. Therefore, meat inspectors should establish a compromise according to stipulated legal procedures in individual countries to efficiently inspect bovine carcasses so that interests of consumers and the beef industry are well balanced.

Cysticercosis proportions obtained from retrospective abattoir data could not be stratified for age or sex as such records were not available. However, we can state that the trend could follow the same pattern as older male cattle are mostly slaughtered at the Addis Ababa Abattoir. Higher proportions of *C. bovis* cases have been reported in younger than older cattle (Gallie and Sewell, 1972; Grindle, 1978; Gracey, 1981). However, bovine carcasses examined during the active abattoir survey (2001) were predominantly from older cattle. As per the observations of Darwin *et al.* (1994), sex of cattle was found not to be associated with occurrence of cysticercosis. These authors reported that sex or type of cattle were not significant risk factors for bovine cysticercosis.

During the active abattoir work, cysts were found most frequently in the triceps and heart. The high proportion of cysts in the shoulder muscles could probably be due to the higher activity of the muscles in the African Zebu, which travel long distances in search of grass and water or are grazed on extensive rangelands. Cysts were also detected in sites other than the customary predilection sites (Walther and Koske, 1980; Maeda *et al.*, 1996) and included gluteal muscles and liver. A similar observation was reported by Yilma (1983) at Debre Zeit Abattoir and Fuad (1986) in Asmara. These cysts were confirmed to be *C. bovis* and not *C. dromedarii* or *C. taiwanii*. According to Bessonov (1988), bladderworms have been found frequently in livers of experimentally infected cattle using *T. saginata* strains that originated from Sudan and Ethiopia. The bladderworms that were localized in the liver during this present study were unarmed and had no rostellum and could be regarded as larval stages of *T. saginata* and not other sub-species or even a new species of *Taenia*.

Out of 222 sampled cysts, 152 (68%) tested viable. The shoulder muscles had more viable cysts than other inspected sites, a finding that concords with that of McCool's (1979), which revealed high proportions of viable cysts in skeletal than cardiac muscles.

Despite the limitations observed in the detection of *C. bovis* during routine meat inspection practice at the Addis Ababa Abattoir, it should be realized that the procedure is still an invaluable methodology for diagnosing bovine cysticercosis.

Serological methodologies have been used as epidemiological tools for detection of cysticercosis for example Hughes *et al.* (1993) and Onyango-Abuje *et al.* (1996 a and b) used the Ag-ELISA to detect *T. saginata* cysticercosis in Kenya and Swaziland, respectively. They reported that the test was at least three times more sensitive than meat inspection. Dorny *et al.* (2000) also reported sero-prevalence of bovine cysticercosis which was at least ten times higher than annual prevalence of cysticercosis reported by the Institute of Veterinary Inspection in Belgian cattle. Van Kerckhoven *et al.* (1998) demonstrated that use of IgG-Mab- based ELISA (sandwich ELISA) significantly improved detection of circulating antigens. Therefore, it can be assumed that if the antigen ELISA is adopted for the ante-mortem inspection of cattle, followed by careful dissection of the carcasses, there would be a great improvement in the efficacy of detecting beef measles at the Addis Ababa Abattoir and hence significantly prevent human infection. However, there are practical drawbacks such as the cost and lack of specificity that should be considered before implementing such a programme. According to Schuster (2001), an antigen detecting ELISA kit for detecting viable beef measles developed in Europe, failed to yield favorable results in South Africa due to lack of specificity (false positive reactions). A similar experience was encountered in Kenya by Wanzala *et al.* (2001). Therefore, in order to get more accurate results from sero-epidemiological investigations in Africa, further research work on development of Ag-ELISA should be done (improvement of the specificity and sensitivity of the test).

## Questionnaire survey

The results of this survey strongly suggest that taeniosis is a widespread problem in Akaki (highland), Debre Zeit (mid-altitude) and Nazareth (lowland) all of which are situated in central Ethiopia. This could probably be due to the deep cultural habit of consuming raw beef inherent among the people. Generally, it was observed that the deep inherent habit of eating raw (*kourt*, *tirie kitfo*, and *melasna sember*) or semi-raw (*leb-leb kitfo*) beef is a widespread phenomenon in central Ethiopia. Furthermore, the results revealed that there was no significant differences in taeniosis cases among the three study areas. This indicated that the disease was not associated with variations in the ecological environment prevailing in the three study areas.

The habit of backyard or field defecation by the people might have undoubtedly led to contamination of pastures where cattle grazed and consequently increased the spread of the infection in endemic areas. This habit was more evident in the rural than urban study sites. Accordingly, this could have perpetuated infection cycle, as environmental conditions in the study areas were favorable for propagation of the *T. saginata*. The lack of sanitary facilities in the study sites could suggest that a considerable degree of environmental contamination in cattle grazing areas occurs considering that one tapeworm produces 6 – 9 gravid proglottids per day each of which contains 80,000 – 100,000 eggs. Due to the high biotic potential of *T. saginata* adult tapeworm, it is possible for one infected person to contaminate cattle grazing environment with more than half a million tapeworm eggs per day (Flisser *et al.*, 1982). It has been reported from Canada that one feedlot attendant (taeniosis carrier) infected more than 500 adult cattle. Therefore, indiscriminate defecation could also be regarded as one of the vital risk factors for bovine cysticercosis.

Discussing the infection risk of cattle, we have to consider the tenacity of *Taenia* eggs. According to literature data, under conditions of low and sufficient humidity (WHO, 1983) they may stay infective up to one year. *T. saginata* eggs could have been easily propagated in the study areas during the long rainy and short rainy seasons (high-risk infection periods) when temperatures and humidity were more favorable. These periods were between June – September and February – March, respectively. However, since mainly adult cattle were slaughtered the infection proportions shown were thus accumulated. There is therefore no seasonal variation in detection of cysticercosis as shown in active abattoir investigation.

Taeniosis affected both male and females. Males had 3.95 fold odds of taeniosis compared to females. This could be attributed to the fact that males control financial matters of the household and hence have more opportunities of eating raw beef both in public places than their female counterparts who exclusively (if at all possible) eat raw beef at home. Furthermore, groups of five to eight people (men) slaughter a bovine animal, at least three times per year. This happens during special festive occasions for example Easter, New Year, Christmas, Epiphany, Meskel and weddings. Men eat raw beef together as comrades in the field immediately after the slaughter of a bovine animal. Traditionally, the women folk are not needed around the slaughter and hence do not participate in eating of the tongue which is considered as the best part to be eaten raw. It is noteworthy that these preferred parts are considered predilection sites for *C. bovis* (Walther and Koske, 1980; Maeda *et al.*, 1996). The relative economic privilege that men have over their female counterparts is a contributory factor. In line with this Gryseels and Anderson (1983), reported that groups of eight to ten farmers purchased either a culled ox or cow jointly during festive occasions. The questionnaire survey also indicated that backyard slaughter of cattle is a common practice among Ethiopians in the three study areas especially during festivals and weddings. This is in agreement with an anonymous report (1994) published in Ethiopia.

The proportions of taeniosis cases among respondents who consumed raw beef were higher than those who did not. Eating undercooked beef dishes caused taeniosis among the non-raw beefeaters. The odds of taeniosis among the raw beefeaters were 241.09 compared to those who did not. Therefore, consumption of raw and undercooked beef could be regarded as very important risk factors for taeniosis (WHO, 1983). The questionnaire survey showed significant differences in taeniosis frequency proportions between the low and high risk professional categories. Lack of monetary power to buy beef could be the major force behind the low infection levels among the low risk professional grouping.

Taeniosis cases were higher among older than younger respondents. The older the people, the greater the chance of eating raw beef and hence contracting taeniosis. Correspondingly, the frequency of eating raw or semi-raw beef is closely related to chances of getting infected with taeniosis (WHO, 1983).

The survey results revealed that religion was not a significant risk factor of taeniosis due to *T. saginata*. The deep cultural habit of eating raw beef prevailed against religious beliefs. There are no documented results about effect of religion on *T. saginata* taeniosis percentages with which to compare findings of this study. However, it is worth noting that Ethiopians do not eat pork due to religious beliefs (both christians and moslems), hence we could state that taeniosis in Ethiopia is principally due to *T. saginata*.

### **Inventory of pharmacies**

The results of the pharmaceutical inventory revealed the public health significance of taeniosis. Taeniosis was found to be a widespread problem in all the three study areas as reflected from the estimates of the taenicidal drug doses.

The respondents indicated usage of both broad and narrow spectrum taenicial drugs. Broad-spectrum taenicides included Mebendazole and Albendazole while narrow spectrum drugs comprised Niclosamide, Diclorophene and Praziquantel. Niclosamide and Mebendazole were the preferred drugs in all the study areas. It is noteworthy that despite having been banned, Diclorophene was still being used for taeniosis treatment. Literature encourage use of Niclosamide and Praziquantel which have been known to be drugs of choice and been used in prevention programs in some countries for example Czechoslovakia, the former USSR and Poland (WHO, 1983).

If the amount of sold cestodes is compared with the population in the study areas without even considering usage of herbal taenicides, we could state that at least one person on average suffers from *T. saginata* infection per year in the three study sites in central Ethiopia. Since pigs do not play a role, we could state that Ethiopian human cestodosis is due to *T. saginata*. Annual costs that resulted from taeniosis treatment were estimated at 1,471, 821.00 Eth. birr. This indicated that taeniosis diminishes household financial resources which could be easily avoided by eating well cooked beef dishes.

## 6.0 CONCLUSION

The proportion of bovine cysticercosis cases determined from retrospective abattoir records kept by the Meat Inspection Team at the Addis Ababa Abattoir were relatively lower than those determined during the study period (March – June). In light of this, it is recommended that for further abattoir works to produce results that are more accurate, meticulous dissection of carcasses should be undertaken. Meat inspection procedures at the Addis Ababa Abattoir should include examination of the tongue and masseter muscles.

The questionnaire survey indicated that taeniosis is a widespread problem in all the study areas. Screening of the potential risk factors revealed that gender and consumption of raw and undercooked beef were very important risk factors of taeniosis. Additionally, it was also revealed that indiscriminate defecation perpetuate infection of bovine hosts.

Although many people claimed to know the cause of taeniosis, very few had knowledge about the life cycle progression of *T. saginata*. Inventory of pharmaceutical shops in the study areas revealed that taeniosis is a widespread problem. Annual medical costs incurred due to taeniosis were estimated at 1,471, 821.00 Eth. birr. Based on the results of this study, the following recommendations are suggested in order to reduce the spread of *T. saginata* taeniosis and bovine cysticercosis:

- Educating the public on the life cycle progression of *T. saginata* through the media, schools and veterinary extension services.
- Educating the public about environmental hygiene through use of toilets or latrines.
- Construction of latrines especially in the rural areas.
- Prohibition of backyard and home cattle slaughters.
- Institution of a nationwide and rigorous meat inspection procedures.
- Advising the public about benefits of using highly effective drugs like Praziquantel.

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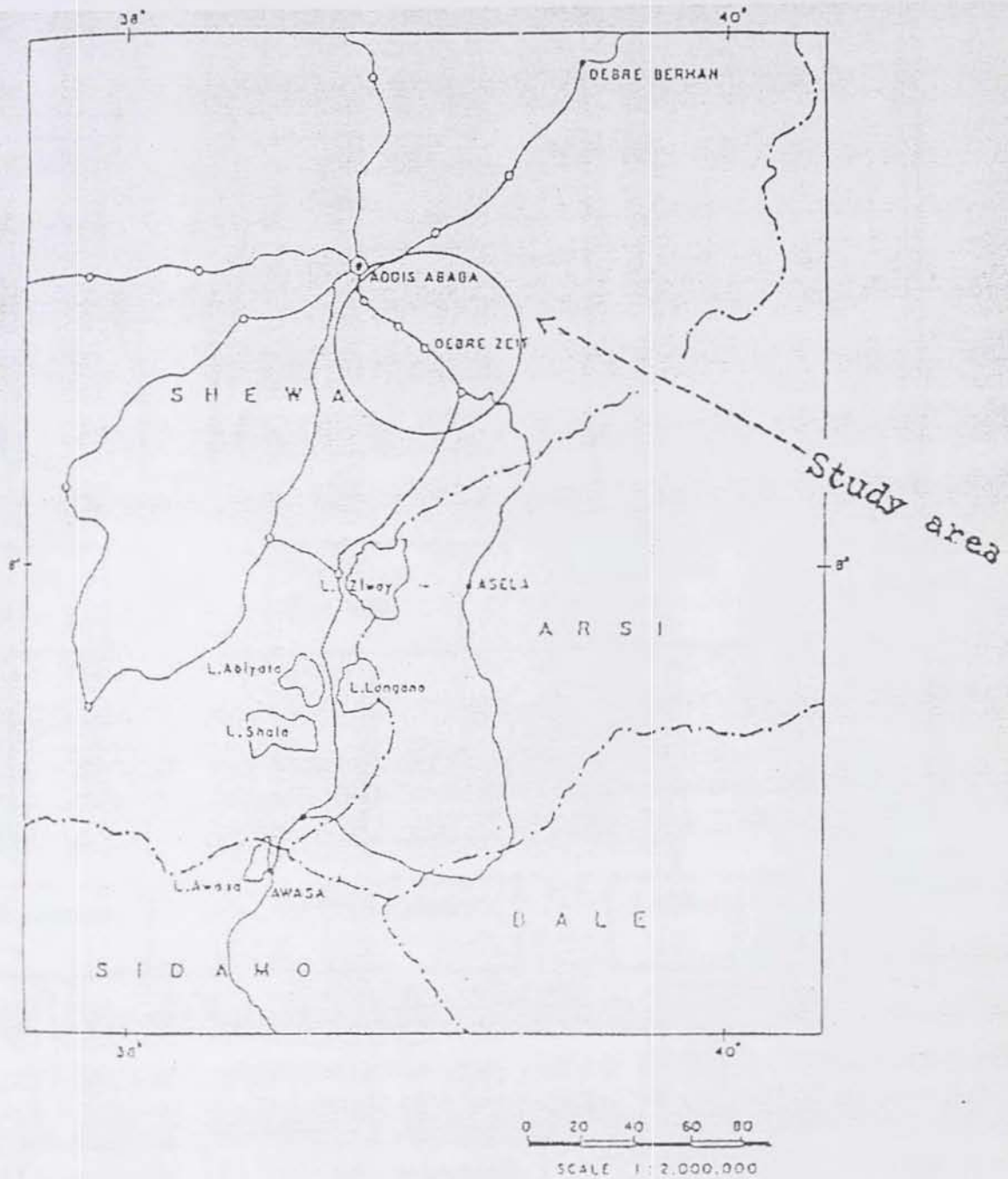
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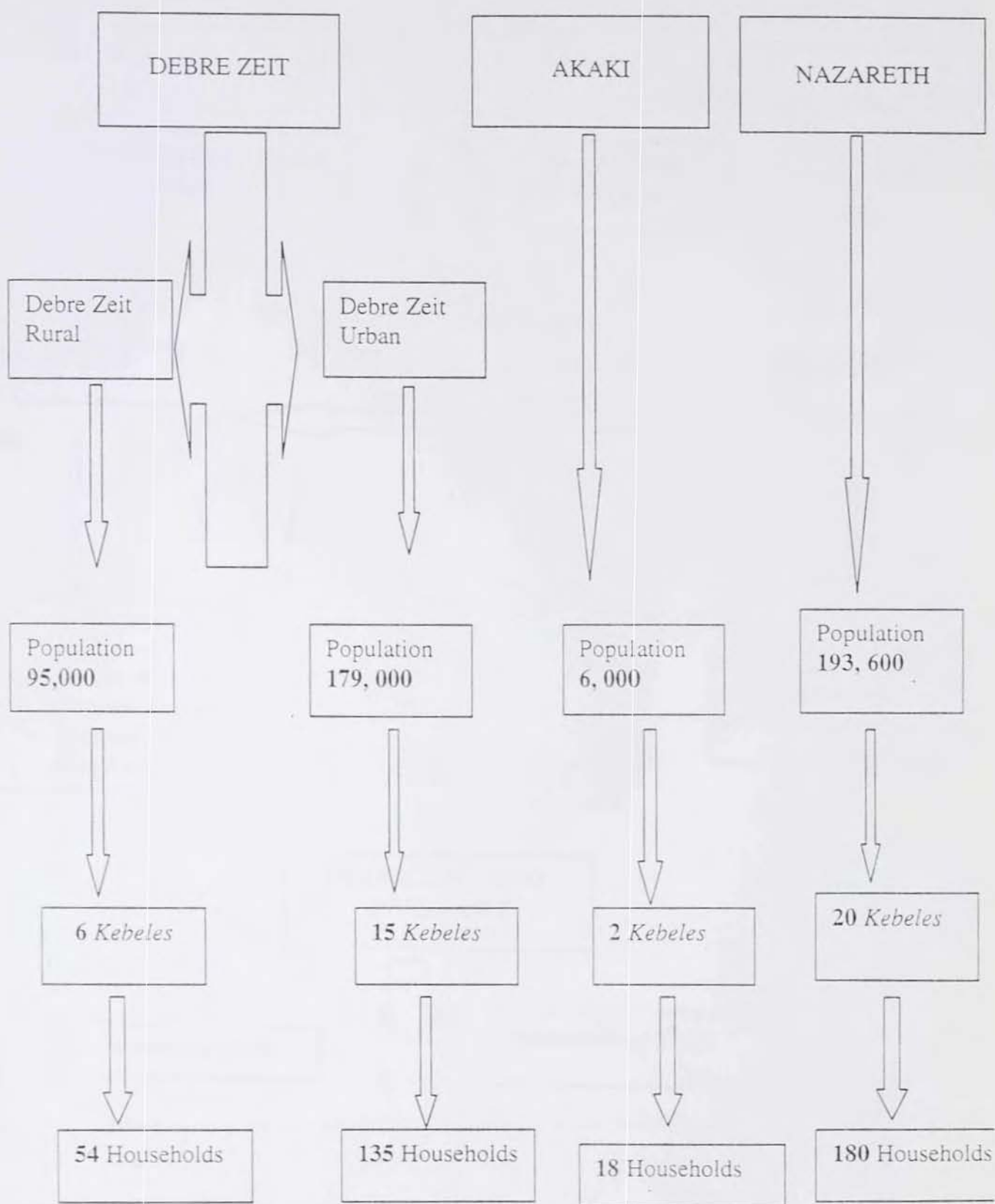
8.0 APPENDICES

Appendix 1

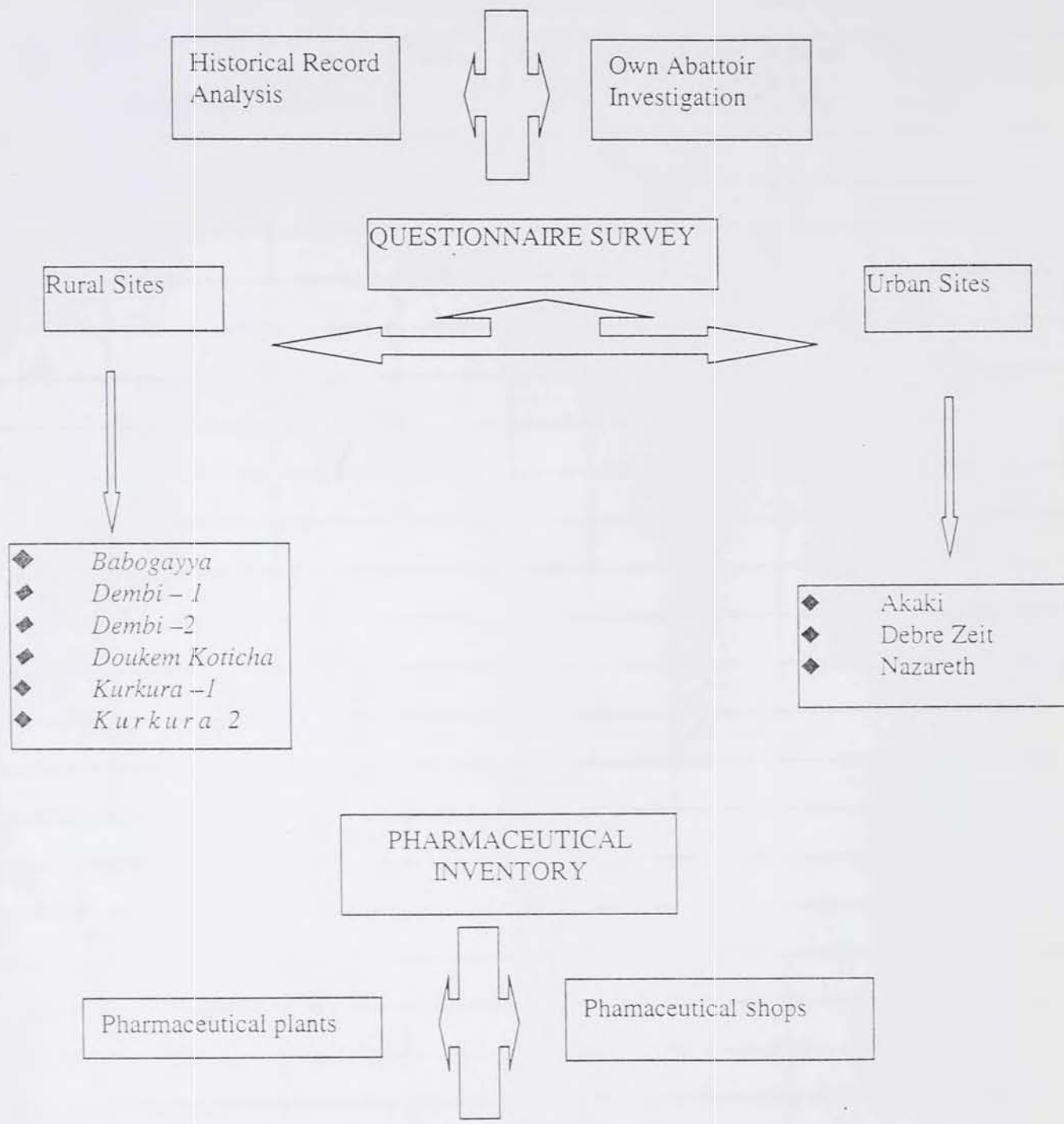


Map indicating study areas (Central Ethiopia)

Appendix 2



Flow diagram showing sampling procedure of selected households



LAYOUT OF THE STUDY DESIGN



## Appendix 5

Questionnaire: Set to determine epidemiology of *T. Saginata* taeniosis and cysticercosis.

Peasant Association \_\_\_\_\_

Date \_\_\_\_\_

Village \_\_\_\_\_

Code \_\_\_\_\_

1. Address: \_\_\_\_\_

2. In which of the following age categories do you place yourself?

0 - 15    16 - 20    26 - 30    31 - 40    above 40

3. Sex:

Female    Male

4. Religion:

Christian    Moslem

5. Occupation: \_\_\_\_\_

6. What was the last school you attended?

No formal Education

Elementary

Junior High school

College (Diploma)

University

7. Number of household members: \_\_\_\_\_

8. Do you own any livestock?

Yes    No

9. What type of livestock do you own?

Cattle    Small ruminants    Donkey    Horses    Poultry

10. Number of cattle owned and their age groups:

Age (years)	Number of animals
Young cattle	
Old cattle	

11. Reasons for keeping cattle:

- Source of food     Source of income  
 Draught power     Other (specify) \_\_\_\_\_

12. How do you manage your cattle?

- Tethered     Communally grazed     Stall-fed

13. How did you acquire the knowledge of keeping cattle?

- From parents     Informal training

14. If cattle are communally grazed, how far from the living quarters is the grazing land?

\_\_\_\_\_

15. Who herds the cattle?

- Herd boy     Old man     Children     other \_\_\_\_\_

16. Are there any latrines in the areas where cattle are grazed?

- Yes     No

17. Do you have a latrine at your homestead?

- Yes     No

18. How many times do you slaughter cattle for home consumption in a year?

\_\_\_\_\_

19. What type of animals do you normally slaughter for home consumption?

- Young animals     young and old animals  
 Old animals (cows, bulls and oxen)

20. Is meat inspection done when you slaughter cattle at home?

- Yes     No

21. Which of the following statements best fits your situation with regard to raw beef consumption?

Never tasted raw beef       used to eat but currently quitted

Stopped but restarted       Might decide to stop in future

Never dared to stop and have no intentions to do so

22. Have you ever been advised in the past 'not to eat raw beef'?

Yes       No

23. If 'Yes' to question 13 above, by whom?

Parents/Family members       School teachers       Friends

Elderly in village       through mass media

24. If 'Yes' to Question 13 above, what was your practical response?

I have accepted the advice and permanently stopped eating raw beef

I have tried to stop eating raw beef but couldn't succeed

I was not convinced and do not even attempt to stop eating raw beef

25. When did you stop eating raw beef (if applicable)?

a few months ago       a year ago       2 - 5 years ago       more than 5 years ago

26. If you stopped eating raw beef, for reasons other than advice received from other people, please indicate why?

---

27. Please rank, in order of your preference (i.e. 1 = best and 8 = least), the following foodstuffs (the same rank could be given for more than one item).

semi-roasted minced beef (*Leb-leb Kitfo*)       raw beef (*Kourt*)

properly cooked minced beef (*Yetetebese Kitfo*)       raw minced beef (*Tirie Kitfo*)

raw tongue & rumen folds (*Melasna sember*)       properly roasted beef (*Tibs*)

roasted intercostal muscle (*Yegodin Tibs*)       properly cooked beef (*Kikel*)

28. Which one of the following sewage (human manure) disposal systems do the majority of the people commonly practice?

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Sewage Disposal system	In your current habitation area	In your former habitation area (if applicable)
------------------------	---------------------------------	--

---

Use of toilets (latrines)

Disposed backyard/field

29. Have you ever suffered from taeniosis?

Yes  No

30. Have you observed any symptoms of illness whenever you get infected with tapeworms?

Yes  No

31. If 'Yes' Questions 20 above, which one(s) of the following symptoms have you noted?

diarrhea  hunger pain  constipation  epigastric pain

nausea  increased appetite  decreased appetite

weakness  headache  loss of weight

dizziness  disturbance by crawling segments

32. If 'Yes' to Question 20 above, how do you realize that you have got the infection?

33. How many people in your household have suffered from tapeworm infection(s)?
- 

34. Which one of the following taenicidal drugs (tapeworm treatments) have you used in the past to treat yourself?

A. From the modern drugs available in pharmacies

Vermox (Mebendazole)  Kosofarm (Niclosamide)

Dichlorophene  Praziquantel

Others (specify) \_\_\_\_\_

---

B. From the traditional herbs commonly used in Ethiopia

*Kosso*     *Enkoko*     *Meterie*     *Ananas Juice*

Others (specify) \_\_\_\_\_

35. How often do you take taencidal drugs (tapeworm treatments)?

---

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36. Where do you get the taenicidal drugs?

Pharmacy     Herbalist     Home preparation

37. Approximately, how many times in your lifetime have you taken these tapeworm treatment? Modern drugs: \_\_\_\_\_ Traditional herbs: \_\_\_\_\_

38. Roughly, how much does a single dose of tapeworm treatment cost you?

Modern drugs: \_\_\_\_\_ Traditional herbs: \_\_\_\_\_

39. Which drugs do you think are more effective to treat tapeworm infection(s)?

Traditional

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

40. Have you ever had ill-health complications upon taking these treatments?

	Yes			No
	Only once	Rarely	Commonly	
Modern drugs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Traditional herbs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Both	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

41. If 'yes' to question 30, could you please state the major symptoms of complication you have observed.

---

42. Have you ever heard of serious complications (death) from taking taenecidal drugs?  
 Yes       No
43. Do you know the cause of tapeworm infection(s)?  
 Yes       No
44. In your opinion, which food animal species serves as a source of human tapeworm infection?  
 cattle       sheep       goats       camel       poultry       fish
45. In the identified animal above (Question 34), which organs, or tissues or parts of the flesh do you think contain the infective form of the parasite?  
\_\_\_\_\_  
\_\_\_\_\_
46. How do animals get the cysts?  
\_\_\_\_\_  
\_\_\_\_\_
47. Do you recognize the tapeworm infective forms in meat?  
 Yes       No
48. Do you believe that butchers inform their customers on whether the meat is infected or not?  
 Yes       No
49. Do you think tapeworm infection(s) (taeniosis) can be prevented?  
 Yes       No
50. If 'yes' to question 39, how can this be achieved?  
\_\_\_\_\_

51. State your opinions as 'Yes' or 'No' to the following assertions?
- A. Backyard and home cattle slaughter tradition in Ethiopia is one of the major factors for the high prevalence of human tapeworm infection in the country.
- Yes     No
- B. Institution of a nationwide and rigorous (thorough) meat inspection procedure helps to dramatically reduce tapeworm infection prevalence in Ethiopia.
- Yes     No
- C. Prohibition of backyard and home slaughter of cattle is one of the prerequisites if a rational control of taeniosis/cysticercosis is envisaged (contemplated) in Ethiopia.
- Yes     No
- D. Do you intend to stop eating or undercooked beef just because of the tapeworm infection?
- Yes     No

52. What economic repercussions (consequences), if any are associated with taeniosis/cysticercosis?

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53. What policy decisions, if any, do you think are required for successful taeniosis/cysticercosis control in Ethiopia?

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## 9.0 CURRICULUM VITAE

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- Veterinary Surgeon, Medivet Clinic (Show grounds) Lusaka 1995 (January – May)

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Languages: English, Nyanja and Bemba

Hobbies: Charity work, gardening, craft, music, reading and cooking

2000/1  
19/15  
2/2

10.0 DECLARATION SHEET

I the undersigned, declare that the thesis is my original work and has not been presented for a degree in any University.

Name ..... ALICE TEMBO .....

Signature ..... *Alice* .....

Date of submission ..... 21/12/01 .....

This thesis has been submitted for examination with our approval as University advisors

.....

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C-1

2001/ALI/1738

AUTHOR Alice Tembo

TITLE Epidemiology of Taenia saginata  
Taeniosis & Cysticercosis in three...

DATE DUE

BORROWER'S NAME

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2001

ALI/1738

Epidemiology of taenia saginata taeniosis  
& Cysticercosis in three selected Agro-  
Climatic zones in central Ethiopia

Alice Tembo

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