TAENIA SAGINATA CYSTICERCOSIS IN CATTLE IN TANZANIA

BY

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DECLARATION.

The work presented in this thesis has been carried out by myself except where otherwise acknowledged and it has not been submitted previously for any degree.

Godfrey Elikalia Maeda

Copenhagen, May, 1993

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SUMMARY

A review on the epidemiology and diagnosis of human taeniasis and bovine cysticercosis with special reference to East Africa is given. All humans are susceptible to the adult tapeworm, *T. saginata*. Cattle, is the predominant intermediate host, young animals being more susceptible than older ones. Susceptibility of a few wild ruminants makes them potential reservoirs of infection. Characteristics of *T. saginata*, including a long life span, a high reproductive potential, spontaneous shedding of proglottids from human carriers, occult nature of the cysticerci in cattle, etc, contribute to maintenance of infections. Dispersion and survival of *T. saginata* eggs are determined by sanitation, personal hygiene, coprophagous animals and weather conditions. Prevalence rates of cysticercosis in cattle reported from various countries depend on local meat hygiene legislations, efficiency of meat inspection, and record keeping in the abattoirs.

In this thesis, factors promoting the spread of *T. saginata* infections in Tanzania were investigated, by interview information from 105 cattle owners, belonging to Masai, Arusha, Iraqw, Gogo and Rangi ethnic groups, from 52 villages in Tanzania. Taeniasis and cysticercosis were reported as common problems among members of the ethnic groups interviewed. Lack of awareness of the source of human tapeworms, scarcity of medicines against taeniasis, habits of consuming raw beef, consumption of uninspected meat, defaecation in the bush, were some of the outstanding factors elucidated. The details of this investigation are discussed and it is concluded that some of the observations need confirmation through further studies in the villages of the ethnic groups concerned. Prevalence rates of taeniasis recorded at Mbulu Hospital were 10% in 1990 and 21% in 1991.

In a separate investigation, cysticercosis was detected in 52 (10.5%) out of 496 cattle

slaughtered in municipal abattoirs of Arusha, Dodoma, Iringa, Morogoro and Mpwapwa districts in Tanzania during the period between June 1991 and November 1991. The prevalence rates in the individual abattoirs were 16.7% (Arusha), 8% (Dodoma), 9.6% (Iringa), 6.5% (Morogoro) and 7.6% (Mpwapwa). The overall annual prevalence rates of cysticercosis in the Dodoma and Iringa regions were lower than the rates officially recorded in these abattoirs. The results are discussed in relation to sources of infection, endemicity of cysticercosis, efficiency of meat inspection, and records keeping in the abattoirs in the country.

In a detailed examination, anatomical distribution of cysticerci of *T. saginata* (864) was analyzed in zebu cattle at Morogoro abattoir in Tanzania. The cysticerci were found located in the examined tissues preferentially in the following order: heart, M. triceps brachii, tongue, M. psoas and masseter muscles. The liver had relatively high numbers of cysts and is thus considered an important predilection site. Examination of the predilection sites for detecting carcasses positively infected with cysticerci of *T. saginata* revealed the following efficiency: 80% (heart), 80% (M. triceps brachii), 60% (masseter muscles), 60% (tongue) and 53% (liver). However examination of the heart, M. triceps brachii and the liver together detected all infected carcasses. Most (60%) of the infected carcasses had viable cysticerci. In conclusion, *T. saginata* taeniasis and cysticercosis are major, but underestimated problems in Tanzania. The diagnostic methods of cysticercosis in cattle and taeniasis in humans all have inherent limitations. But nevertheless, their sensitivity may be significantly be improved and the usual control may be more efficient. The various chapters of the thesis include discussions on ways to improve public control measures and educate consumers and herdsmen.

SAMMENDRAG

(Summary in Danish)

Taenia saginata cysticercose hos kvæg i Tanzania

Afhandlingen indledes med en litteraturoversigt over epidemiologi og diagnostik af human taeniiasis og bovin cysticercose med særlig omtale af forholdene i Østafrika. Alle mennesker er modtagelige for infektion med bændelormen *T. saginata*. Kvæget er den almindeligste mellemvært, og yngre dyr er mere modtagelige end ældre. Nogle få arter af vildtlevende drøvtyggere er også modtagelige, og de udgør et potentielt smittereservoir. Visse egenskaber ved *T. saginata*, f.eks. lang levetid, højt reproduktivt potentiale, spontan afgang af proglottider samt symptomløst infektionsforløb bidrager til infektionens vedligeholdelse. Spredning og overlevelse af *T. saginata* æg afhænger af sanitære forhold, personlig hygiejne, koprofage dyr og vejrforhold. Den rapporterede prævalens af cysticercose i kvæg i forskellige lande afhænger af den kødkontrolmæssige lovgivning og effektivitet.

I nærværende afhandling belystes de faktorer, som fremmer spredning af *T. saginata*, ved gennemførelse af en spørgeundersøgelse omfattende 105 kvægavlere tilhørende forskellige etniske grupper fra i alt 52 landsbyer i Tanzania (Masai, Arusha, Iraqw, Gogo og Rangi). Taeniiasis og cysticercose var almindeligt kendte problemer blandt de interviewede. Mangel på kendskab til smitteveje, mangel på medicin, indtagelse af ukontrolleret og råt kød og defækering i det fri var nogle af de mest fremtrædende faktorer. Undersøgelsens opbygning og gennemførelse diskuteres og det konkluderes, at nogle af observationerne kræver dokumentation gennem yderligere undersøgelser i landsbyer og blandt etniske grupper. Prævalensen af human taeniiasis på et hospital (Mbulu) var 10% i 1990 og 21% i 1991.

I en særskilt undersøgelse, gennemført af forfatterne, blev cysticercose påvist i 52 (10,5%) af i alt 496 kreaturer tilført slagtehuse i Arusha, Dodoma, Iringa, Morogoro og Mpwapwa i perioden juni 1991 til november 1991. Prævalensen på de enkelte slagtehuse var 16,7% (Arusha), 8% (Dodoma), 9,6% (Iringa), 6,5% (Morogoro) og 7,6%

(Mpwapwa). Den officielle gennemsnitlige årlige prævalens af cysticercose i Dodoma og Iringa regionerne var betydeligt lavere end den, som registreredes ved nærværende undersøgelse. Dette kan skyldes forhold vedrørende cysticercosens smittekilder og endemicitet samt kødkontrollens effektivitet og dataregistrering.

I en detaljeret undersøgelse bestemtes *T. saginata* tinters (864 stk.) anatomiske fordeling i zebukvæg tilført slagtehuset i Morogoro. Tinterne fandtes i følgende muskelgrupper med aftagende talmæssig forekomst: Hjertet, M. triceps brachii, tungen, M. psoas og massetergruppen. Leveren havde en relativ høj forekomst af tinter og må derfor betragtes som et vigtigt predelektionssted. Ved en omhyggelig opskæring af predelektionssteder hos inficerede dyr fandtes følgende detektionsprocent: Hjerte (80%), M. triceps brachii (80%), massetergruppen (60%), tungen (60%) og leveren (53%). Bestemmelse af tinteforekomst i både hjerte, M. triceps brachii og lever afslørede infektioner i 100% af tilfældene. Flertallet af inficerede kødkroppe havde viable tinter.

De kan konkluderes, at *T. saginata* taeniiasis og cysticercose udgør et beklageligt men stærkt undervurderet problem i Tanzania. De diagnostiske metoder til påvisning af såvel cysticercose som taeniiasis har iøjnefaldende begrænsninger. Metodernes følsomhed kan imidlertid øges betydeligt og den forebyggende kontrol gøres mere effektiv. Afhandlingens forskellige kapitler indeholder overvejelser og forslag til forbedring af offentlige kontrolforanstaltninger og til oplysning af forbrugere og kvægavlere.

CHAPTER 1

EPIDEMIOLOGY AND DIAGNOSIS OF *TAENIA SAGINATA* CYSTICERCOSIS WITH SPECIAL REFERENCE TO EAST AFRICA.

A literature Review

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ABSTRACT

The epidemiology of taeniasis and cysticercosis depends on the susceptibility of the hosts, characteristics of the etiological agents and the environmental factors. Humans of all ages and sexes act as definitive host for *T. saginata*. Cattle is the predominant intermediate host but a few wild ruminants are susceptible to *T.saginata* as well. Young cattle is more susceptible than older cattle and in general there seems to be differences in susceptibility from one individual to the other. The high longevity of the adult tapeworm in human, its high prolificity and the ability of gravid proglottids falling on their own from the carriers, contribute to maintenance of exposure to cattle over years. Dispersion and spread of *T. saginata* eggs depend on contamination of water, feeds and milk, of coprophagous animals, such as birds, insects, annelids, and of contaminated hands introduced to the mouths of young calves. The diagnosis and hence prevalence of cysticercosis in cattle is made by meat inspection which is influenced by inspection facilities, local meat inspection legislation, efficiency of keeping records in the abattoirs, etc. The sensitivity of meat inspection to several positive cases is variable and low in particular at low levels of infections. Attempts to elaborate serological diagnosis is present being made. Diagnosis of *T. saginata* infections in humans is mainly based on observations by the person himself, an interview, or on coprological and perianal cellophane papers methods. Development of immunological detection of copro-antigens could be a breakthrough in the diagnosis of taeniasis in humans. Diagnosis of cysticercosis in cattle is still difficult, clinically, parasitologically and immunologically.

1.1 INTRODUCTION

Taenia saginata, the beef tapeworm, for which cattle is the main intermediate host, has a high prevalence in East Africa (Geerts, 1992). However, cysticercosis in cattle is prevalent in many other parts of the world (Penfold *et al.* 1936). The adult tapeworm is an obligate parasite of the intestines of man and human taeniasis is particularly common in countries or localities where beef is eaten raw or partially cooked (Arambulo *et al.* 1976).

Human beings have lived with the tapeworm for centuries (Pawlowski and Schultz, 1972) probably since man started consuming raw beef. Close association between human beings and cattle increases the risk of exposure of cattle to eggs of *T. saginata*, excreted from a human carrier of the adult tapeworm, thus, allowing the parasite to perpetuate (Pawlowski, 1982). The parasites have adapted to their hosts in a way that infections neither show obvious clinical signs in live cattle (Urquhart, 1961) nor in humans, except for mild gastrointestinal disturbance or passage of proglottids. Passage of proglottids is known to cause embarrassment to some individuals (Proctor, 1972; Cheruiyot and Onyango-Abuje, 1984). Cysticercosis causes considerable economic losses to the beef industry, particularly in developing countries (Grindle, 1978; Joshua *et al.* 1988). Some of the economic losses incurred due to infections include condemnation of beef carcasses or organs, treatment and degradation of lightly infected beef in the abattoirs, loss of markets of fresh beef, costs of diagnosis and treatment of humans infected with adult tapeworm (WHO, 1979).

The parasite can be controlled by avoiding raw or inadequately cooked beef, by improved personal hygiene and general sanitation, e.g. with use of latrines and avoiding sewage or sewage sludge contamination of on pastures or water. Furthermore, an optimal meat inspection and treatment of human carriers of the tapeworm, help to break the life cycle. Vaccination against cysticercosis has been attempted (Urquhart, *et al.* 1963; Rickard and Adolph, 1976; Rickard *et al.* 1978; Babiker and Eldin, 1987), but is not feasible in practice. In conclusions, all these control measures depend on an effective veterinary public health system and an intensive education campaigns. However, eradication of the condition has been found to be difficult (Sewell, 1987; Geerts, 1992).

In this review, general epidemiological aspects of *T. saginata* cysticercosis are discussed with special reference to East-African conditions. The discussions form the background of the thesis as outlined in the final section of this chapter.

1.2. Hosts of *T. saginata*.

Man is the only known definitive host and individuals are susceptible to the tapeworm, regardless of age or sex (Pawlowski and Schultz, 1972). However, males in some areas of Africa have been found to be more frequently infected than females (Dada, 1980), probably because the males in Africa are the ones more frequently involved in slaughtering of cattle and consumption of roasted beef which may not be adequately cooked.

Cattle is the main intermediate hosts harboring the larval stage (metacestode) of *T. saginata*, known as *T. saginata* cysticercus, commonly referred to as *Cysticercus bovis*. Few other ruminants like reindeer, buffaloes, llamas, giraffes, gazelles and antelopes have been found to be infected (Hancock *et al.* 1989). The susceptibility to infection has been found to be higher in calves than in older cattle (Urquhart, 1961) possibly due to acquired immunity. In East Africa where cattle are likely to be infected while very young. Froyd (1964) found that older cattle (over 4 months of age) resisted infection. Urquhart, (1961) found that successful experimental infection to calves in East Africa was only possible up to an age of 80 days and in addition, there could be individual variation in susceptibility to infection. The oryx (*Oryx gazella beisa*) was found more susceptible than Boran cattle calves (Stevenson *et al.* 1982). Susceptibility of some of these wild ruminants to *T. saginata* pose a potential reservoir of infection to humans consuming meat from game.

Cattle experimentally vaccinated with irradited eggs of *T. saginata*, were shown to be immune to challenge infection (Urquhart *et al.* 1963). Other vaccination attempts, have utilised antigens collected after *in vitro* cultivation of larvae (Rickard *et al.* 1978) and hatched eggs of *T. saginata* (Babiker and Eldin, 1987). In practice vaccination against cysticercosis in cattle is not feasible due to weak and non permanent immunity after vaccination. Under conditions where calves are exposed to low levels of *T. saginata* infection, the immunity developed in those young cattle affect further challenge to the cattle.

1.3. Life cycle and etiological characteristics of *T. saginata*.

The adult tapeworm *T. saginata* is mainly confined to the small intestines of man, from where gravid segments of the tapeworm are released and are then discharged through the anus to fall to the ground. However, some eggs are also excreted with faeces (Pawlowski, 1982). Most infected humans harbor a single tapeworm in the intestine, although, multiple infections have been reported in highly endemic areas (Froyd, 1965; Pawlowski, 1982).

T. saginata eggs excreted from man could contaminate pastures, cattle feeds or water sources (Pawlowski and Schultz, 1972; Holt, 1985). The population of excreted eggs contain both mature and immature eggs (WHO, 1983), but only the mature eggs are likely to be infective to the intermediate host (Laws, 1978). Cattle acquire cysticercosis after ingestion of infective eggs of *T. saginata* but a few cases of prenatal infection in calves have been recorded in some highly endemic areas, in East Africa (McManus, 1960; McManus, 1963). Yet, experimental prenatal transmission was unsuccessful in cattle in East Africa (Urquhart, 1961). This transmission route may be epidemiologically important because thorough sanitation is hampered when such an alternative route exists (Pawlowski and Schultz, 1972).

Humans acquire *T. saginata* taeniasis from consumption of inadequately cooked, roasted or raw beef containing mature and viable cysticerci of *T. saginata* (McIntosh and Miller, 1960; Pawlowski and Schultz, 1972). The cysticercus of *T. saginata* becomes mature and infective in the intermediate host after the 10th to 12th week of infection (McIntosh and Miller, 1960, Urquhart *et al.* 1987).

Gravid proglottids begin to be passed from infected humans between 87-100 days post infection (Soulsby, 1982).

Occurrence of cysticercosis in cattle depends on the presence of *T. saginata* eggs in the environment where the cattle are raised, and on the physical environmental conditions which determine the survival and dispersion of the eggs (Pawlowski, 1982). Figure 1.1 shows the life cycle of *T. saginata* and environmental factors of importance for maintenance of its life cycle.

The adult tapeworm is very prolific, and one active human carrier of *T. saginata* may excrete six to nine proglottids per day, and each mature proglottid may contain up to 100,000 eggs. These large numbers of eggs from only one individual are potentially capable of infecting thousands of cattle. The life span of the adult tapeworm in the host may be several years, in some cases up to 25 years, unless effective treatment is instituted (Pawlowski and Schultz,

1972). Therefore, foci of infection to cattle are maintained in the environment over years (Pawlowski, 1982). If the carrier is excluded from cattle environment, the life cycle will meet a dead end (Schultz *et al.* 1970), unless sewage containing viable *T. saginata* eggs from other sources is allowed to contaminate the environment.

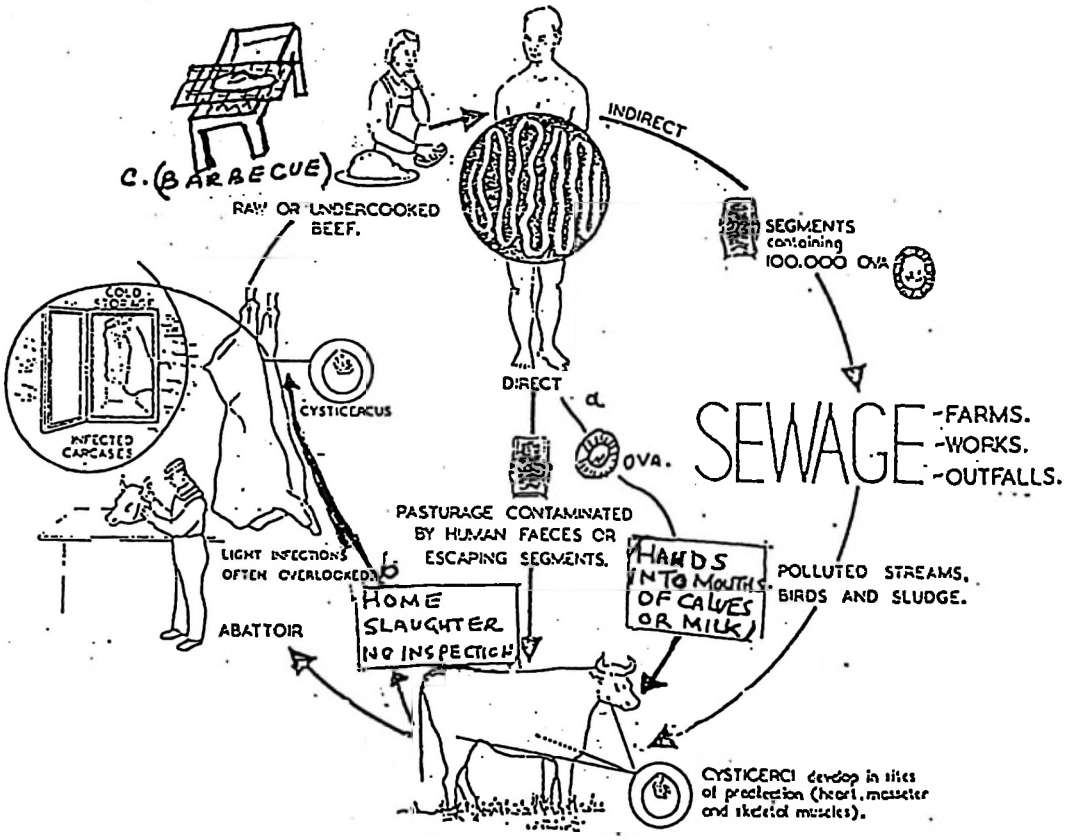

Figure 1.1 Life cycle of *T. saginata* and the factors maintaining its cycle in the enviroment. (Slight modifications (from Silverman, 1955), path: a, b, c added to the diagram, regarding Eastern Africa conditions)

1.4. Diagnosis of *T. saginata* taeniasis and cysticercosis

1.4.1 Diagnosis of taeniasis

T. saginata taeniasis in humans is generally mild, whereby infected persons may experience mild digestive disturbances or the discharge of proglottids could be the only sign observed (Pawlowski and Schultz, 1972). The infection is rarely associated with severe clinical illness (Holt, 1985). The diagnosis of human taeniasis may therefore, primarily depend on the history of persons discharging proglottids. Questioning potential carriers of *T. saginata* may not give the correct answer, due to unawareness of some infected persons (Froyd, 1965; Hall *et al.* 1981). Some may even be shy to disclose that they are infected (Proctor, 1972). Coprological examination and application of perianal adhesive cellophane tapes to detect *Taenia* eggs are reliable methods for the diagnosis of taeniasis in man (Rijptra *et al.* 1961; Chambers, 1977; Hall *et al.* 1981). However, the parasitological methods for the diagnosis of taeniasis are not 100% sensitive and it may be difficult to differentiate *T. saginata* eggs, from eggs belonging to other species of human tapeworms (Gemmell and Lawson, 1982). Detection of copro-antigens by ELISA could be a promising breakthrough in distinguishing individuals infected with *T. saginata* from those with *T. solium* (Eckert, 1989; Allan *et al.* 1990).

1.4.2 Parasitological diagnosis of *T. saginata* cysticercosis.

Diagnosis of *T. saginata* cysticercosis is difficult in the living host because of the occult nature of the infection. Diagnosis is practically made post mortem by meat inspection (Pawlowski & Schultz 1972). The parasites can be recognized in the host tissues as small translucent, colourless or pink coloured, ovoid, fluid filled bladders, measuring about 8 x 5 mm in size, each containing a single gray coloured unarmed scolex (Urquhart, 1987). These features are true only, when a cyst is fully developed and alive. Plate 1.1 shows the appearance of viable cysticerci in a bovine skeletal muscle and Plate 1.2 shows degenerated cysticerci of *T. saginata* in a bovine heart tissue.

McIntosh and Miller (1960) demonstrated that the developing cysticercus of *T. saginata* in the bovine tissue can first be grossly visible as a small gray dot measuring 3 x 2 mm in size, eleven days post infection. Sometimes the parasite may die and degenerate at this or a later stage. The infected area, may later be replaced with caseous brown coloured or calcified mass (Froyd, 1964). It is not unusual to find both degenerated, calcified and viable cysts in

the same host, infected from a single infective dose of *T. saginata* eggs (Dewhirst, *et al.* 1963).

Degeneration of the cysts in the tissues may give some differential diagnostic problems, especially if the lesions are not found in the muscles normally regarded as 'predilection sites' of *T. saginata* cysticerci in cattle (WHO, 1983). Confirmation of the lesion to be caused by of *T. saginata* cysticercus may be done by close microscopic examination or histological sectioning and staining (Geerts *et al.* 1980; WHO, 1983).

Cysticerci of tapeworms normally found in wild carnivores may occasionally be found in cattle (WHO, 1983). These cysticerci must be differentiated from those of *T. saginata* by evagination in suitable medium after which the characteristic lack of hooks in *T. saginata* cysticerci may be observed (Gathuma and Mango, 1976).

The so called 'predilection sites' include the masseter muscles, the tongue, the heart, M. triceps brachii and the diaphragm (WHO, 1983). However, the diversity of reported 'predilection sites' in the bovine has caused inconclusive agreement on a universally appropriate predilection site for all cattle (Pawlowski & Schultz, 1972). An effective diagnosis of cysticercosis will depend on the knowledge of the sites most frequently and intensively parasitized, and the number of incisions required to detect an infected carcass (Ginsberg *et al.* 1956). Heavily infected beef carcasses are easier to diagnose because the cyst will be visual on most cut surfaces of the striated muscles (Plate 1.2). However, light infections may be more difficult to diagnose due the sparse occurrence of the cysts in the tissues (Juranek *et al.* 1979; McCool, 1979; Walther and Koske, 1980). Studies on the distribution of cysts are important because they provide a better guide to formulation of more efficient meat inspection procedures (Pawlowski & Schultz, 1972). Meat inspection regulations throughout the world regarding the search for cysticerci of *T. saginata* are mostly influenced by the reported distribution and intensity of the cysts in different sites of bovine carcasses (Kyvsgaard *et al.* 1990).

The cysticerci of *T. saginata* have been found located in non-muscular tissues of the host, such as the liver, lungs, walls of the gut, fat or lymph nodes (Mitchell, 1973; Osiyemi, 1975; McCool, 1979; Nyaga and Gathuma, 1979; Kyvsgaard *et al.* 1990). Detection of *T. saginata* cysticerci in the livers alone, without finding them in other tissues of bovine, as found in zebu cattle in Africa (Ginsberg and Grieve, 1959; Mitchell, 1973; Nyaga and Gathuma, 1979) has caused suspicion of occurrence of a different strain of *T. saginata* in those areas

(Wouters *et al.* 1987).

The limitations in the diagnosis of light cysticercosis during meat inspection make freshly inspected beef potentially infective if not adequately cooked (Hird and Pullen, 1979), or treated to kill parasites.

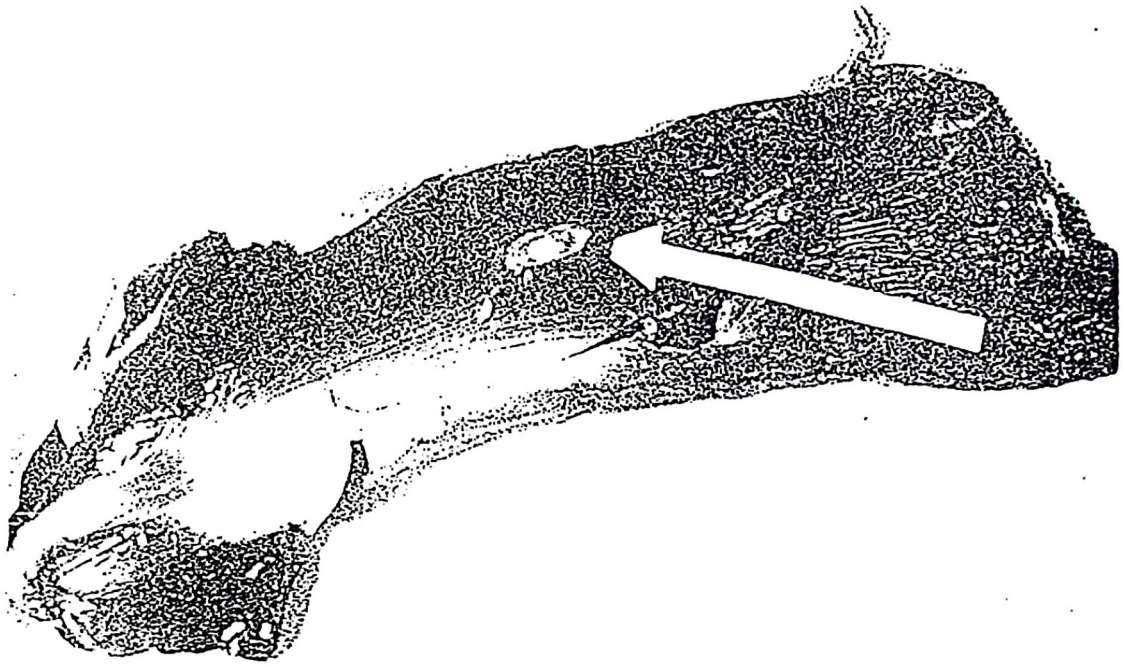

Plate 1.1. Viable cysticercus of *T. saginata* in skeletal muscle of the bovine.

Plate 1.2. Degenerated cysticercus of *T. saginata* in the bovine heart.

1.4.3 Immunodiagnosis of *T. saginata* cysticercosis.

The limitations of parasitological diagnosis of *T. saginata* cysticercosis has stimulated search for alternative, more sensitive diagnostic methods, including immunodiagostic techniques to confirm the diagnosis in the living host (WHO, 1983; Schantz, 1987). However, low antibody responses in lightly infected cattle and low sensitivity and specificity of antigens used, form limiting factors (Geerts, *et al.* 1977; WHO, 1983). Enzyme linked immunosorbent assay (ELISA) has been one of the tests considered. However, results obtained with ELISA have until now been limited to assessing herd infections rather than infection in individual animals (Harrison and Sewell, 1981; Kyvsgaard *et al.* 1991). The main reasons are low specificity caused by non specific serum factors, cross-reactivity of common antigens shared among other helminths affecting cattle (Shantz, 1987), together with difficulties related to source and preparation of the antigens used (Geerts *et al.* 1977). Crude and excretory or secretory antigens prepared from the metacestodes of *T. saginata* (Joshua *et al.* 1988), and antigens from metacestodes of related *Taenia* such as *T. crassiceps* (Harrison and Sewell, 1981) have been found to be more specific than saline extract of proglottids of *T. saginata* when applied in ELISA (Harrison and Sewell, 1981). However, these antigens were not fully reliable in the diagnosis of cysticercosis in infected herds (Harrison and Sewell, 1981). *T. hydatigena* cyst fluid has been attempted to diagnose *T. saginata* cysticercosis in live cattle but with unreliable results (Kamanga Solo *et al.* 1987; Smith *et al.* 1991).

Tracing of circulating antigens from cysticerci in live cattle has been attempted on ELISA (Harrison *et al.* 1989; Brandt *et al.* 1992), but the results were not satisfactory. Animals with dead cysticerci could not be detected as infected and cross reactions were observed with other taeniid parasites (Brandt *et al.* 1992).

From the findings above it appears that ELISA is not yet developed to reliable and practical use under field conditions to detect infected cattle, especially lightly infected cases.

1.5 Prevalence of *T. saginata* cysticercosis in cattle.

Most prevalence rates reported are mainly based on routine meat inspection records (Mitchell, 1973). However, the exact prevalence of *T. saginata* cysticercosis is difficult to ascertain in many areas, due to limited meat inspection facilities (Urquhart, 1961) and the limitations of diagnosis of *T. saginata* cysticercosis during meat inspection in all parts of the

world (Hird and Pullen, 1979). Therefore, prevalence rates of *T. saginata* cysticercosis reported until now seem underestimated for most countries (Schandevyl and Vercruysse, 1982). Furthermore, failure of meat inspection has been attributed to less thorough examination and under reporting of cases by official meat inspectors due to pressure of work and others (Onah and Chiejina, 1986). Records from export slaughter houses have been suggested to be the best indicator of the national prevalence because meat inspection standards at these abattoirs are higher than elsewhere (Grindle, 1978). Nevertheless, according to Hird and Pullen (1979) even the most efficient abattoir would discover no more than about 75% of the truly infected carcasses, due to low recovery rates of the cysts (Kyvsgaard *et al.* 1990).

Meat inspection in Tanzania is conducted according to prescribed procedures laid in the Meat Hygiene Regulations, 1962 (Tanganyika Government, 1962), applicable under the Food (Control of Quality) Act 1978 (Tanzania Government, 1978). The regulations provide special detailed instructions for searching and action to be taken, when cysticerci are detected in dressed carcasses of cattle. The inspection procedure includes general visual examination and palpation of the dressed carcass and organs, i.e. the tongue, heart, oesophagus, lungs, liver and incisions are furthermore, made to the masticatory muscles, muscles of the attachment of the tongue, the heart muscle, M. triceps brachii, the muscles of the sternal aspect of the thoracic cavity, the brisket, M. psoas, diaphragm muscle, and the rump. When more than 10 cysticerci are detected in the carcass after examining the prescribed sites, the carcass together with the viscera are condemned. However, if less than 11 cysticerci are detected of which less than six cysticerci are found in the carcass, other than in the muscles of the head, tongue, pluck, stomach and intestines, the carcass can only be saved for human consumption after treatment by freezing or boiling to kill the parasites.

Most of the Eastern Africa countries have almost similar approach, e.g. in the search for cysticerci of *T. saginata* by including M. triceps brachii in the list of predilection sites (Ginsberg *et al.* 1956), however, there are minor modifications within individual countries, such as examinations of M. gracilis (Mitchell, 1973; Pugh and Chambers, 1989), or the judgement of infected carcasses, as related to the number of cysticerci detected (WHO, 1983). According to Cheruiyot and Onyango-Abuje (1984) in Kenya and Pugh and Chambers (1989) in Zimbabwe, carcasses detected with less than 21 cysticerci may be saved for human consumption after the legally prescribed treatment to kill the parasites has been fulfilled.

Legislation in some other countries of the world where cysticercosis in cattle is not a major problem does not require incisions of M. triceps brachii. Thus, differences in the sites examined during meat inspection may influence the reported prevalence rates of cysticercosis in cattle (Pawlowski and Shultz, 1972). Beside having strict legislation regarding meat inspection, many local abattoirs, where most of the cattle are slaughtered in Africa may not keep all the necessary records needed to determine prevalence rates of cysticercosis in cattle (Cheruiyot, and Onyango-Abuje, 1984; Ogunrinade and Oyekole 1990).

Prevalence rates of *T. saginata* cysticercosis may be influenced by weather conditions, because infectivity and spread of eggs may be affected (Laws, 1978). Froyd (1965) and Cheruiyot, (1981) noted differences in prevalence rates of cysticercosis recorded in abattoirs located in geographically close areas in Kenya where ethnological factors did not influence the prevalence. At Gilgil and Naivasha (approximately 15 miles apart), prevalence rates of 10.1% and 2.1%, respectively, were recorded while at Kisii and Homabay (about 20 miles apart), prevalence of 18.8% and 4.4%, respectively, were recorded (Cheruiyot, 1981). The four areas compared were suspected to be influenced by weather, soil type or vegetation differences (Cheruiyot, 1981). Froyd (1965), (quoting R. Lewis personal communication, 1961), divided the area of the Masai District, in Kenya, extending over 15,332 square miles, according to average rainfall of 20 inches, 21-40 inches or over 40 inches. From that classification it was shown that areas of lower rainfall had lower prevalence of cysticercosis, regardless of ethnological influences.

Generally, the reported prevalence rates are based on a very small fraction of the actual cattle population in each country, and it is mainly biased to the slaughter stock including steers, bulls, and few culled females. However, the reported prevalence gives a rough estimate of the orders of magnitude of the problem in the respective areas. Some of the reported prevalence rates of *T. saginata* cysticercosis from some areas of Kenya, Tanzania, Uganda, Zimbabwe, and Botswana are given in Table 1.1. The most recent reports on the prevalence from those countries are about 4 years old, originating from Zimbabwe and Botswana. The oldest reports are from Uganda (20 years ago), from Tanzania (17 years ago) and Kenya (12 years ago). There is a need for regular monitoring and reporting of cysticercosis in the regions so that the efforts done to control the infection though meat inspection and public education can be evaluated.

Table 1.1. Prevalence rates* of *T. saginata* cysticercosis in some countries of Eastern Africa as reported by various authors from 1970-1993

Year	1970-1979		1980-1989		1990-1993	
Country:	Rate	Author(s)	Rate	Author(s)	Rate	Author(s)
Kenya	22.8%	(Gathuma and Mango, 1976)	0.74-18.8%	(Cheruiyot, 1981)	-	
Tanzania	5% 2.6-26.9%	(Nadzafov, 1975) (Petrovic, 1976)	-	-	6.5-16%	(Maeda, 1993) Unpublished
Uganda	29%	(Mitchell, 1973)	-	-	-	-
Zimbabwe	1-2%	(Chambers, 1977)	2.16%	(Pugh and Chambers, 1989)	-	-
Botswana	12-15%	(Mosienyane, 1986)	7.7%	(Grindle, 1978)	-	-

Note:
* All prevalence rates reported are from meat inspection reports.

1.5. Environmental factors associated with dispersion and survival of *T. saginata* eggs.

Epidemiological studies on cysticercosis imply some obvious logistic and technical problems (Gemmell and Lawson, 1982). Models of *Taenia spp.* affecting dog and sheep have been studied and compared to situations of *T. saginata* (Gemell and Lawson, 1982).

Certain factors have been associated with the dispersal of the *T. saginata* eggs in the environment. Water, particularly rain water may disperse *T.saginata* eggs over wide areas from a single focus during floods (Pawlowski, 1982).

Some feral birds visiting sewage works in search for food may ingest *T. saginata* eggs and later on their droppings become a potential source of infective material on pastures (Hall *et al.* 1981). Seagulls feeding on sewage plants have been found to carry *T. saginata* eggs in their guts (Silverman, 1955; Guildal, 1956). Other birds which feed on human faeces, like the village chicken in some rural areas of East Africa may perhaps be potential disseminators of *T. saginata* eggs. Similarly, coprophagous insects such as blowflies, house flies, some mosquitoes, beetles or annelids may be contaminated with *T. saginata* eggs and when ingested by birds, the eggs may be transported to pastures via their droppings (Gemmell and Lawson, 1982).

Several studies have been conducted on the survival of *T. saginata* eggs under different abiotic conditions (WHO, 1983). From these studies, it has been found that natural factors including mean rainfall, temperature, soil type, soil moisture and vegetation, may influence the life span of ova of *T. saginata* (Laws, 1968; Gemmell, 1978; Cheriuyot, 1981).

The eggs of *T. saginata* survive longer during wet seasons compared to dry seasons (Pawlowski, 1982, WHO, 1983), and they hardly survive for more than 3 weeks in dry hot weather (Froyd, 1965). This implies that wet weather allows a longer period for viable *T. saginata* eggs to be picked by susceptible hosts as compared with dry condition. That could

explain some observations on high prevalence of cysticercosis in cattle following wet seasons. However, it may not be excluded that long drought spells may cause increased prevalence because cattle are forced to graze into areas which they normally avoid when pastures are plentiful, i.e. smaller permanent water resources which could be highly contaminated with *T. saginata* eggs from congregation of persons coming to fetch water from that source.

Viability of *T. saginata* eggs is important wherever sewage sludge is used in agriculture. Studies conducted on the effect of anaerobic digestion, using viable eggs of *T. taeniaeformis* as a model for *T. saginata* eggs, confirmed possibilities of inactivation of *Taenia* eggs in sewage sludge under anaerobic digestion at 35°C for at least 5 days (Olsen and Nansen, 1990). However, field trials with the respective hosts would be necessary to confirm the applications of *T. taeniaformis* as an indicator of *T. saginata* survival (Olsen and Nansen, 1990). Practical use of the land where sewage sludge has been applied will depend on requirements stipulated in current legislation regarding agricultural use of sewage sludge (e.g. Ilsøe *et al.* 1990a)

Major risk factors that are known to influence transmission of *T. saginata* eggs and prevalence of cysticercosis in cattle have been studied in many parts of the world. Human slurry, sewage sludge or its effluent on pastures or in drinking water have been found to contribute significantly to occurrence of cysticercosis in cattle (McPherson, *et al.*, 1978; Pawlowski, 1982, Collier and Reilly, 1984; Nansen and Henriksen, 1986). Other studies have revealed that both light and massive *T. saginata* cysticercosis are mainly associated with presence of human carriers of *T. saginata* in the environments, where cattle are raised, and feeds or water sources are directly contaminated with human faecal material (Froyd, 1965, McAnich, 1974, Slonka *et al.* 1975; Fertig and Dorn, 1985). Contamination of animal liquid manure with human sewage when contractors uses the same vehicle for both purposes

has led to outbreak of cysticercosis in cattle grazing pastures fertilized with liquid manure. (Ilsøe *et al.* 1990b). Grazing or harvesting of fresh grass from recreation areas where no toilet facilities are available, or watering the animals in rivers or streams where sewage effluent is discharged have been found to pose a high risk for transmission of cysticercosis to cattle (Pawlowski, 1982 ;Ilsøe *et al.* 1990b; Kyvsgaard *et al.* 1991).

In East Africa sewage sludge is not very important for the spread of *T. saginata* cysticercosis, since sewage plants are mainly located close to major towns (Froyd, 1965). Furthermore, it is not a common practice to use sewage sludge or effluent to fertilize pastures in East Africa.

1.6. Epidemiological patterns of *T. saginata* infections.

The epidemiology of cysticercosis is so much related to taeniasis that the two conditions are epidemiologically inseparable.

Depending on the frequency and level of number of cases within the populations, recorded in a given time, the epidemiological patterns of *T. saginata* infections in both human and bovine populations may be characterized as 1) the endemic pastoral type, 2) the endemic urbanized type, or 3) the epizootic feedlot type (Pawlowski, 1982; WHO, 1983).

The epizootic type is characterized by massive outbreaks of cysticercosis in cattle herds, in areas where cysticercosis in cattle is almost non-existing, or the prevalence rates are very low. Such outbreaks are also referred to as "cysticercosis storms." (Ilsøe *et al.* 1990b). "Cysticercosis storms" have been recorded in the industrialized countries of Europe, North America, Australia and NewZealand, where the major causes have been application of sewage sludge or effluent on pasture (Urquhart, 1987). Infected workers in feedlot farms have also been associated with outbreaks of cysticercosis (Slonka *et al.* 1975; Fertig and

Dorn, 1985).

According to Pawlowski (1982), the urbanized type is characterized by consistent low levels of taeniasis in the human population and moderate cysticercosis in the cattle population while the pastoral type is characterized by high prevalence of taeniasis in the human population and high prevalence of cysticercosis in the cattle populations.

1.7. Factors associated with high prevalence in East Africa.

The epidemiological patterns of *T. saginata* infections in East Africa, where the prevalence of *T. saginata* cysticercosis and human taeniasis have been shown to be very high in certain areas (Ginsberg *et al.* 1956; Urquhart, 1961; Froyd, 1965; Mitchell, 1973), could be categorized as the pastoral type in the rural cattle raising areas and the urbanized types in the towns or suburbs.

High prevalence of 22.8% *T. saginata* cysticercosis recorded in Kenya abattoirs between (1961-1971) and previous reports on occurrence of cysticerci with hooked scolices in cattle led Gathuma and Mango, (1976) to suspect wild carnivores as contributor to the high levels of bovine cysticercosis in Kenya. During subsequent surveys conducted in Kenya, Gathuma and Mango (1976), examined 3584 cysts from 524 bovine carcasses originating from areas close to game reserves, but none of 2968 normal cysticerci examined had hooked scolices, the rest of cysts being degenerated. From that survey Gathuma and Mango (1976) concluded that wild carnivores did not appear to play a significant role in the epidemiology of cysticercosis.

Previously, Froyd, (1965) had conducted a survey in Kenya to investigate the major risk factors associated with increased prevalence of cysticercosis. He compared prevalence rates of cysticercosis in a total of 42873 slaughtered cattle with incidence of taeniasis among

members of 20 ethnic groups from 18 districts from which cattle originated. Besides he observed the sanitary conditions and eating habits of the ethnic groups and found that the ethnological groups who had the habit of eating raw or inadequately roasted beef, had more carriers of *T. saginata*, and in turn their cattle had more cases of cysticercosis. Also members of some ethnic groups avoided using toilets and defaecated in the bush, while others regarded their tapeworms as a sign of virility (Froyd, 1965). From another survey Froyd (1965) examined 127,631 cattle from 797 farms with different management systems and found that bucket fed calves had significantly higher prevalence of cysticercosis than ranch calves. The major reason suggested for this observation was contaminated hands of attendants on cattle farms, who contributed to postnatal infection of bucket fed calves. It is noteworthy that *Taenia* ova were seen in almost 50% of 96100 faecal samples examined in 54 Kenyan hospital laboratories from 1958 to 1973 (Hall *et al.* 1981).

In Zimbabwe, (by then Rhodesia), Chambers (1977) observed that there was a relationship between the prevalence of *T. saginata* cysticercosis and the concentration of mining activity in the provinces of that country. He noted that there was reluctance by some mining labourers to use toilet facilities, and they instead resorted to defaecation in the bush. In another survey conducted in the Midlands province of Zimbabwe, having a prevalence of over 6% cysticercosis in cattle, Chambers (1977) observed that only 50% of 20 randomly selected farms interviewed provided their labourers with meat from inspected sources. The labourers were not examined for taeniasis, but there was a high chance that some were infected with *T. saginata*, because it was found that 0.83% of randomly selected stool samples were positive for *Taenia* ova.

In Botswana, Mosienyane (1986) observed that meat was often eaten uninspected in the rural areas, which was likely to contribute to increased taeniasis and *T. saginata* cysticercosis,

because the prevalence of cysticercosis recorded by then was 12%-15%. The habit of eating uninspected beef is very common among pastoralists in Africa. Besides, uninspected meat is consumed in rural areas of Africa during special festivals, weddings or other celebrations. Furthermore, the limited protein food caused by the poor economy of the people sometimes even force people to eat condemned meat (Cheruiyot and Onyango-Abuje, 1984). The meat hygiene legislation which require boiling or freezing of lightly infected carcasses (with less than 11 cysts in e.g. Meat Hygiene Regulations, 1962 (Tanganyika Government, 1962), or less than 21 cyst in Kenya (Cheruiyot and Onyango-Abuje, 1984), do not exclude in practice that meat from lightly infected carcass becomes a source of infection to man. According to the Tanzanian meat hygiene regulations such carcasses have to be frozen at -10°C for 14 days, or boiled at a temperature of 82°C until all the meat is uniformly grey in colour. However, in many slaughter slabs in rural areas of East Africa there are no refrigeration facilities, and fire wood for boiling the meat may be scarce. Besides, most meat traders are aware that boiled meat at their butcher shops does not sell as fast as fresh meat. In conclusion, the prescribed boiling or refrigeration of such meat does not always take place and infected beef is presumably quite often passed on to the consumer illegally (Cheruiyot and Onyango-Abuje, 1984).

As mentioned previously the high prevalence of cysticercosis recorded during the drought seasons (Mosienyane, 1986) has been associated with close contact between cattle and humans sharing the same water sources (Froyd, 1965; Mosenyane, 1986). During drought periods cattle may be forced to drink water contaminated with human washings in few permanent small ponds, and grazing areas contaminated with human faeces are likely to contain *T. saginata* eggs.

The general practice of communal extensive grazing of cattle in East Africa has drawbacks

because one active herdsman carrier of *T. saginata* may cause widespread contamination of pastures, thus imposing high infection pressure on larger number of cattle (Chambers, 1977). The exact source of *T. saginata* cysticercosis in cattle reared under pastoral systems of husbandry or zero grazed from open fields could be extremely difficult to trace. Indiscriminate defaecation without burying faeces, reported to be common among herdsmen in East Africa (Hall *et al.* 1981), may undoubtedly contribute to the high prevalence of *T. saginata* cysticercosis.

1.9. SCOPE OF THE PRESENT STUDY

Factors known to influence the occurrence of *T. saginata* cysticercosis have been reviewed and it has been found that very limited work related to the epidemiology of *T. saginata* taeniasis and cysticercosis has been conducted in Tanzania. In this background an investigation, including interviewing cattle owners in some villages of Tanzania, was designed to determine the extent of the problem and some of the risk factors associated with occurrence of *T. saginata* taeniasis and cysticercosis. The detailed report on this study is presented in Chapter 2.

Data on the prevalence of cysticercosis in cattle in Tanzanian abattoirs very often do not relate to the origin of the cattle examined at slaughter. Besides, reports from previous authors in some countries of Africa (Cheruiyot, 1981; Onah and Cheijina, 1986) pointed to an underestimation of official prevalence rates of cysticercosis in their countries, an issue not yet investigated in Tanzania. Based on these unknown issues in Tanzania, prevalence rates were investigated in some municipal abattoirs in Tanzania and the results were compared with official records. The report on that study is presented in Chapter 3.

Studies on the distribution of cysticerci of *T. saginata* in bovine tissues have been

recommended by Pawlowski and Schultz (1972) for each country or region to enable formulation of efficient meat inspection regulations. However, data on the distribution of cysticerci in individual organs in cattle in Tanzania is lacking. Thus, in the present study, the distribution, and viability of *T. saginata* cysticerci in slaughter cattle in Tanzania were investigated and the efficacy of the sites for detecting infected carcasses during meat inspection was evaluated. The report on this study is presented in Chapter 4.

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CHAPTER 2

PRELIMINARY SURVEY ON FACTORS PROMOTING THE SPREAD OF *TAENIA SAGINATA* TAENIASIS AND CYSTICERCOSIS IN TANZANIA

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Abstract

Investigation by questionnaire on factors promoting the spread of *T. saginata* taeniasis and cysticercosis in 52 villages, occupying 6 districts of Tanzania, involved 105 cattle owners including mainly Masai, Arusha, Iraqw, Gogo and Rangi ethnic groups. Human taeniasis and cysticercosis in cattle were reported as common by recognized problems among members of the ethnic groups interviewed. Lack of awareness of the source of human tapeworms, difficulty of acquiring medicines against taeniasis, habits of consuming raw beef, indiscriminate consumption of uninspected beef, defaecation in the bush due to lack of latrines were some of the outstanding factors elucidated. Discussions on the variations in the responses on each factor from members of each ethnic groups led to the conclusion that confirmation of details needed closer studies in the villages of the respective ethnic groups. Records from Mbulu District Hospital showed that the prevalence rate of taeniasis was 10% in 1990 and 21% in 1991. Based on the factors elucidated, it was concluded that human taeniasis and cysticercosis are major problems in the areas where cattle are raised in Tanzania. It shall be strongly recommended to educate families, herdsmen and others on sources of human taeniasis and effective treatment against taeniasis should be provided.Not least should farmers be encouraged to adopt better management systems of their cattle.

2.1. INTRODUCTION.

Taenia saginata taeniasis and cysticercosis in cattle coexist in areas of the world where beef is consumed (Arambulo *et al.* 1976). The prevalence rates of the two conditions are known to be very high in areas where human and cattle populations are in close association (Mitchell, 1973; Pawlowski, 1982). General lack of sanitation, and inadequate cattle management systems are known to influence the occurrence of *T. saginata* cysticercosis (Froyd, 1965). Watering cattle from dirty surface water likely to be contaminated with *T. saginata* eggs, lack of latrines and defaecation in the bush are important factors (Froyd, 1965; Pawlowski, 1982). Others include consumption of meat that is not inspected and the habit of consuming inadequately cooked beef (Froyd, 1965; Chambers, 1977; Pawlowski, 1982; Mosienyane, 1986). The problem may be aggravated if effective treatment against human taeniasis is lacking and there is repeated infection due to lack of knowledge about potential sources of infection. Unless there is proof of existence of such problems in the human population, corrective measures can not be initiated.

The diagnosis of human taeniasis may be made from the history obtained from carriers having discharged proglottids (Hall *et al.* 1981; Holt, 1985). Interviews have been used for the purpose of detecting cases of human taeniasis when outbreaks of cysticercosis have occurred on cattle farms (Slonka *et al.* 1975; Ilsøe *et al.* 1990). The interview method is the easiest mean of assessing the human taeniasis situation in a population (Hall *et al.* 1981), however, some interviewed carriers may not be aware that they are infected (Froyd, 1965; Hall *et al.* 1981) or they may be shy to disclose that they are infected (Proctor, 1972). In Tanzania, numerous cases of taeniasis are diagnosed in hospitals or dispensaries, however, literature on its true prevalence in the country is limited. Sturrock (1966) reported a prevalence of 2.6% *Taenia* ova, in an investigation of human helminths at Hombolo,

Dodoma in Tanzania and Benett *et al.* (1970) found *Taenia spp.* rarely, in an investigation of helminths and protozoa parasites of the Hadza tribe in Northern Tanzania. However, parasitological methods for diagnosing human taeniasis are known to have some limitations (Rijpstra, 1961, Geerts, 1992).

Based on the knowledge of traditional herbal medicines used against taeniasis, it can be inferred that taeniasis traditionally has been recognized as a health problem among people in Tanzania. Patients diagnosed with taeniasis in the hospitals are effectively treated or medicines are prescribed to be purchased from pharmaceutical shops, however, the impact of treatments instituted against human taeniasis is not known, and *T. saginata* cysticercosis continues to be a most common feature in the abattoirs in Tanzania.

Cysticercosis in cattle is mainly diagnosed at postmortem examination (Hird and Pullen, 1979). Knowledge of the characteristics of the readily seen cysticerci of *T. saginata* in the bovine tissues, enables a visually sound person to suspect an abnormality in a parasitized meat directly, on sight, however, light infection with the cysticerci is difficult to diagnose (Geerts *et al.* 1977).

T. saginata cysticercosis is endemic in Tanzania (Petrovic, 1976). Petrovic (1976) reported prevalences of cysticercosis of 2.6% to 26.9% among 163,546 cattle from different parts of Tanzania, destined for slaughter at Tanganyika Packers abattoir in Dar-es Salaam, Tanzania. The factors promoting the spread of *T. saginata* taeniasis and cysticercosis in Tanzania have not been described, but surveys on the knowledge of human taeniasis and cysticercosis in cattle among the human population may provide important information required for practical control measures of taeniasis or cysticercosis (WHO, 1983). This paper reports on a study conducted in villages of Tanzania to determine the factors promoting the spread of human taeniasis and cysticercosis in cattle in the villages.

2.20. MATERIALS AND METHODS.

2.21. Questionnaire design.

A questionnaire was designed in English language (Appendix 1) and later translated into Kiswahili, the national language of Tanzania, so that it could be easily read and understood by Livestock Field Assistants (LFA) serving in the villages in Tanzania. Consideration was taken in designing the questions, knowing that some infected individuals would not disclose that they are infected with tapeworms, and none would tell that he or she defaecates in the bush. The questionnaire was designed with 36 questions which were placed into five major groups (A-E) (Appendix 1).

Group A (questions 1-3), concerned information about the location or geographical area where the interview was conducted.

Group B (questions 4-8), concerned information about personal particulars of the person interviewed. The most important question in that section was no. 8 concerning tribe or ethnic group. Questions about personal particulars of the cattle owners, particularly the ethnic group, were important because human taeniasis has been associated with habits of particular ethnic groups, such as consumption of raw or inadequately cooked beef, or avoiding the use of latrines (Froyd, 1965). The other questions, 4-7, were important if future contacts with the individual cattle owner would be desirable.

Group C (questions 9-19), concerned information about the type of cattle management and production systems, such as numbers of cattle owned, where and how the animals were grazed or watered, if communal grazing was practiced, or migrations took place during drought seasons and who grazed the animals. Communal, open field grazing or pastoralism are known factors which expose cattle to possible contaminated pastures when carriers of human taeniasis are present (Belino, 1975; Chambers, 1977). Unprotected surface water

could be polluted by various sorts of environmental contaminants including human faeces. Inquiry about employment of labourers taking care of the animals were included because it has been documented that employed workers on cattle farms have been the source of cysticercosis storms (Slonka *et al.* 1975; Fertig and Dorn, 1985). However, under pastoral system of husbandry labour force has apparently not been reported to be associated with bovine cysticercosis, partly because pastoralism is practiced mainly by individual cattle owners together with members of their families.

Group D (questions 20-24), required information if there were any protective measures taken against human taeniasis. Thus, questions were asked whether meat inspection was conducted in the village (presence of a butcher shop in the village or if animals slaughtered in the homes were ever inspected by a meat inspector). The purpose was to establish if meat acquired in the village was subjected to official inspection. A question on how beef was consumed was included in order to disclose possible risk of ingestion of viable cysticerci of *T. saginata* from raw or inadequately cooked beef among those interviewed.

Group E (questions 25-36), concerned information on human taeniasis and any efforts taken to control it. Awareness and experiences, if any, with tapeworms in the village or among the herdsmen, who in most cases would be members of the family and whether the affected persons sought treatment against the tapeworm infections in a hospital or used local herbal medicines. The first question (25) in this group was set in an indirect way of assessing taeniasis in the family of the cattle owner, because the cattle owner might know more about his or her family than knowing the situation of the whole village. The other questions aimed at disclosing which persons were most affected, and which were carriers of human taeniasis contaminating the cattle environment in the villages. Questions on medical treatment and the names of possible herbal medicines were asked to establish how cases of taeniasis were

managed among the persons in the villages. The question (31) requiring name of the hospital where the patient was treated aimed at confirming if the response given in question 30 was correct. Furthermore information on the taeniasis situation could be sought from the reported hospitals or dispensaries handling such cases. Finally questions about presence or absence of latrines in the village, and if the latrines were ever used were included to provide information on the risks of contamination of the cattle environment through defaecation in the bush, as the use of latrines is known to control *T. saginata* cysticercosis (WHO, 1983). The use of latrines serve to control other diseases, like cholera. In the rural areas of Tanzania there have been campaigns to construct and use latrines due to outbreaks of cholera in the previous years. The most important question (34) was whether the latrines were ever used in the village (indirectly implying 'in the family').

The districts were selected on convenience basis as long as cattle owners were present.

Before the questionnaires were distributed, the District Livestock Development Officers (DLDO)s in charge of the selected districts were contacted so that assistance from the LFA serving in the villages could be assured. The LFA were requested to interview some cattle owners in the villages where they served using the questionnaire. The villages and cattle owners interviewed were selected by the LFA themselves in the respective districts. Each questionnaire had a code number for the region, the district and a serial number for specific identification purposes. Each questionnaire form was meant for one cattle owner only. The completed questionnaires from the villages were returned to the author via the DLDO of the district where the villages were investigated.

Two hundred and ten questionnaires were dispatched to six districts, in three regions of Tanzania between July 1991 and September 1991, as shown in Table 2.1.

The data obtained from the questionnaires were compiled and stratified based on the major

ethnic groups interviewed in each district. The main reason for using the major ethnic groups instead of individuals was to find if there was any association between factors borne to those ethnic groups and the taeniasis or cysticercosis situations. It has been found that taeniasis which is very much related to cysticercosis in cattle, was associated with certain habits of some ethnic groups (Froyd, 1965).

2.22. Hospital records on taeniasis.

A visit was made to Mbulu District Hospital, Arusha Region to get a preliminary picture of the human taeniasis situation in the district. Laboratory records on numbers of stool specimens submitted for the year 1990 and (Jan.-Aug. 1991) were examined for those recorded as positive for *Taenia* ova. The percentage of positive samples per year was used as a rough estimate of the prevalence of taeniasis in the district.

2.3. RESULTS.

From the 210 questionnaires sent to six districts of three regions of Tanzania, only half of the of them were returned, representing 105 cattle owners interviewed in 52 villages (Table 2.1). The major ethnic groups interviewed were Masais (31%), Arushas (19%), Iraqws (11%), Gogos (15%), and Rangis (7%). The remaining, 17% belonged to other ethnic groups including Sandawis, Gagurus, Pares, Hehes, Somalis, Arabs, Ziguas and Mwasis. Appendix 2 shows a sketch map of Tanzania indicating the areas where the major ethnic groups were located in the three regions of Tanzania, where the survey was conducted.

Factors associated with human taeniasis and cysticercosis in cattle among the ethnic groups.

Table 2.2 shows the numbers and proportions of each major ethnic group reporting the presence of factors known to be associated with human taeniasis or cysticercosis, i.e. obvious cysticercosis cases in their cattle herds, taeniasis problem among members of village or family (cattle herders), consumption of beef from cattle infected with cysticerci of *T. saginata*, consumption of raw beef, lack of using latrines and difficulty of acquiring medicines against human taeniasis. Cysticercosis in cattle herds was reported by 75% of the Iraqws, 63% of the Gogos, 16% of the Masais, 14% of the Rangis and 10% of the Arushas Human taeniasis in the village (including cattle herders in the family) was reported by 92% of the Iraqws, 78% of the Masais, 50% of the Arushas, 38% of the Gogos, and 14% of the Rangis. Four out of 16 Gogos, five out of 12 Iraqws and four out of 20 Arushas did not discard meat found to be infected with cysticerci, and some members of Iraqw tribe consumed raw beef, however, none of the Masais or Rangis consumed meat infected with cysticerci. All ethnic groups interviewed consumed beef after cooking or roasting.

The 11 cattle owners who reported that cattle herders in the family had been infected with the tapeworm, claimed that those affected had been treated in hospital or used herbal medicines and had recovered. The types of herbal medicines used against human taeniasis among the ethnic groups are given in Table 2.4. The majority (69%) of all members of major ethnic groups interviewed reported that medicines against taeniasis was not easy to get (Table 2.2).

The Masais had the highest proportion (56%) of homes without latrines followed by 40% of the Arushas, 16% Iraqws, 6% Gogos whereas all Rangis' homes had latrines (Table 2.2). Nevertheless, one of the Iraqws and one of the Gogos who reported to have latrines in their homes reported that not all members of the household used the latrines.

Awareness and occurrence of taeniasis and cysticercosis in the villages.

Responses on the awareness of the source of human tapeworms varied among the persons interviewed. Seven percent responded that the tapeworm was acquired from milk, 9% thought tapeworms were from meat, while the rest responded that tapeworms were from, vegetables, dirty fruits, water, dirt "food ?", magic or did not know. Notably 91% of those interviewed did not know the source of the tapeworms.

Table 2.3 shows that all villages surveyed in Mbulu and Ngorongoro, 50% in Arumeru, 46% in Mpwapwa, 11% in Kondoa and 10% in Morogoro Rural had experienced some cases of taeniasis. Only 25% of the villages had butcher shops. The proportion of villages with butcher shops ranged from none in Arumeru to 55% in Mpwapwa district. However, 95% of the individuals interviewed in all the villages reported that their home-slaughtered animals were inspected by a meat inspector. Availability of butcher shops, suggested that meat consumed in those villages was inspected.

Records from Mbulu District Hospital, showed that 42 out of 409 (10%) stool specimens examined in 1990 and 55 out of 262 (21%) of stool specimens examined in 1991 were positive for *Taenia* ova.

Cattle management systems

The average number of cattle kept by each cattle owner varied between the different ethnic groups and were 122 for Masais (range 3-495); 48 for Gogos (range 9-150); 42 for Iraqws (range 0-107); 28 for Arushas (range 2-200); 26 for Rangis (range 12-57). There was no obvious association between average herd size and number of cattle owners reporting of taeniasis or cysticercosis in any of the ethnic groups.

About 97% of the interviewed cattle owners watered their animals in unprotected surface water sources. Among them, 25% watered their cattle in rivers, 11% in dams, 3% in wells. The rest watered their cattle wherever water was available, including furrows, ponds, rivers or dams.

All cattle owners interviewed grazed their cattle on communal pastures. Most of the cattle owners (86%) utilized members of the same family to take care of their cattle, the rest, 14% employed herdsmen from outside the family to graze the animals. Among the ethnic groups 94% of the Masais, 45% of the Arushas, 8% of the Iraqws, and none of the Rangis migrated from their homes during drought seasons. However there was no obvious association between the cattle management systems among the ethnic groups and reports of taeniasis or cysticercosis.

2.4 DISCUSSION.

The Questionnaire response rate of 50% was lower than expected. This may be due to a lack of incentive to the LFA who performed the extra duty on voluntary basis, or some individuals approached to be interviewed being uncooperative to answer questions related to human taeniasis or cysticercosis. However, the questionnaires returned may represent the actual situation in a number of the villages in the six districts surveyed. Some of the responses from the ethnic groups need further confirmation by staying in the village with members of the ethnic groups to asses the actual situation, particularly concerning the diagnosis of taeniasis and cysticercosis, handling of beef prior to consumption, and the use of latrines. This is important because some responses from the cattle owners were suspicious; for example, many cattle owners (95%) of those interviewed admitted that they invited meat inspectors to their homes whenever they slaughtered animals, something which is not very common among pastoralists or nomads in Africa.

The major ethnic group interviewed were Masais, who were found in three regions of Tanzania (Arusha and Morogoro and Dodoma). The Masais had the largest numbers of cattle with average of 122 cattle per owner. However, there was no obvious association between herd size and reports of either taeniasis or cysticercosis in the present survey.

In the present study, cysticercosis in cattle slaughtered at the homes of the cattle owners was reported by 75% of the Iraqws, 63% of the Gogos, 16% of the Masais, 14% of the Rangis and 10% of the Arushas (Table 2.2). Occurrence of cysticercosis in cattle is well known to be a result of ingestion of infective eggs of *T. saginata*, from human carriers of the tapeworm. Defaecation in the bush increases the risk of infected carriers of the tapeworm contaminating the environment with the tapeworm eggs. The use of latrine is one of the methods commonly advocated for controlling *T. saginata* cysticercosis (WHO, 1983). There

was evidence from some members of two ethnic groups, (Iraqws and Gogos) that some had latrines but only few members in the house holds used the latrines (Table 2.2). Besides, 56% of Masais had no latrines in their homes, compared to lower proportions, among other ethnic groups (Table 2.2). Only 16% of the Masais interviewed reported occurrence of cysticercosis in cattle slaughtered at their homes. High proportions for members of ethnic groups without latrines and those who reported occurrence cysticercosis in cattle at their homes could not be correlated, probably due to lack of knowledge of cysticercosis, misdiagnosis of cysticercosis in cattle or reports of having latrines and use of latrines may be exaggerated by members of ethnic groups interviewed. Therefore on site studies at the village and family level are needed to establish the actual diagnosis of cysticercosis and use of latrines for each ethnic group.

The nomadic or pastoral system of animal husbandry among the ethnic groups was very common among members of the Masais, where 94% of them reported to migrated during drought periods of the year. The nomadic system of the Masais could explain the observed high proportion (56%) of their homes with no latrines (Table 2.2). However, herdsmen among most of the cattle owners interviewed reported to spend hours (average of 8 hour) every day grazing cattle, long distances (between 1/2-14 Km) away from their homes, where no toilets facilities are available. Sometimes they are forced to use the bush. Besides, infected carriers of tapeworm could drop a tapeworm segment full of *T. saginata* eggs on the pastures (Pawlowski, 1982). Cattle grazing on communal fields are at risk of ingesting *T. saginata* eggs from infected persons who defaecate indiscriminately, or drop segments of *T. saginata* on pastures (Hall, *et al.* 1981). Communal grazing was practiced by nearly all persons interviewed, therefore it could contribute to occurrence of cysticercosis among the cattle in Tanzania.

The present study indicated that most of the cattle were watered from surface water sources. However, it was not possible to associate a particular water source to occurrence of cysticercosis in cattle, because there was no possibility of confirming the occurrence of cysticercosis in individual cattle or drinking from a particular water source by the questionnaire method. However, infected persons, either members of the family or employed workers, in the cattle environment could contribute to infection of cattle with cysticercosis (Froyd, 1965; Pawlowski, 1982). There was no evidence in the present study that employed labour specifically contributed to occurrence of cysticercosis in the cattle belonging to any members of the ethnic groups interviewed. Therefore, it can be concluded that the reported occurrence of cysticercosis in cattle is caused by lack of using latrines by members of the family of the ethnic groups interviewed, particularly those infected with the tapeworm.

Taeniasis in the family was featured in at least one member of each of the major ethnic groups interviewed (Table 2.2). All those interviewed, reported to consume meat after cooking or roasting. However, it was not possible to establish how effective roasting or the cooking was done on the beef consumed among the ethnic groups. It has been found that survival and transmission of cysticerci of *T. saginata* in meat depend on the time and size of meat portions prepared (Nadzafov *et al.* 1992). In the present study investigation was not done on the sizes or time taken to cook or roast the meat consumed by the ethnic groups interviewed. In a previous survey of taeniasis and cysticercosis in Kenya, Froyd (1965) found that the habit of roasting meat in big chunks over open fire, coincided with a high prevalence of taeniasis among members of the same tribe. It is not easy for those interviewed to know whether the meat placed near the fire was completely cooked. The inner portions of the meat chunks, if they contain viable cysticerci of *T. saginata* may not be adequately cooked, thus posing a health hazard to those consuming the meat.

Among the ethnic groups who admitted to consume raw meat or beef containing cysticerci a high proportion of the cattle owners reported knowledge of cases of human taeniasis or cysticercosis in their own cattle herds. Some Iraqws, consumed both raw and cysticerci infected beef, and the same ethnic group had the highest proportion of cattle owners reporting knowledge of cases of human taeniasis (92%) and cysticercosis in their cattle herds (75%) (Table 2.2). That observation may reflect an association of consumption of raw meat or beef containing cysticerci and occurrence of human taeniasis.

A previous survey in Kenya, Froyd (1965) noted that 28% of the Masais at Narok, were infected with taeniasis. Taeniasis as a family problem was reported by 78% of the Masais in this study. Had parasitological diagnosis of taeniasis been included in the present study, it would not have been surprising to find high prevalence of taeniasis among ethnic groups. According to Froyd (1965), the Masais of Kenya commonly consumed raw and inadequately roasted beef. However, from the present study no Masai admitted to consume raw beef. Under reporting of consumption of raw beef may explain the high occurrence of taeniasis, despite of lack of consumption of raw meat. More studies are needed to establish the circumstances of transmission of taeniasis from meat dishes among the ethnic groups in Tanzania.

Most cattle owners were aware of tapeworms because they knew that local herbs were used as medicines against tapeworms. However, more than 90% of those interviewed did no know where the tapeworms originated from. That was an important factor because it can be very difficult to control the tapeworm infections if the affected persons did not know where and how they acquire the tapeworm. Out of the interviewed members of the major ethnic groups 69% reported that, medicines against taeniasis were not easily available (Table 2.2). That observation was in agreement with the report obtained from Medical officer at Mbulu District

Hospital, that medicine against human taeniasis was scarce in that hospital when this author visited the hospital.

Seventy five percent of the villages did not have butcher shops (Table 2.3), however, 95% those interviewed reported that animals slaughtered at their homes were inspected by an official meat inspector. That high proportion (95%) may be exaggerated because the majority of pastoralist in Tanzania rarely call a meat inspector when they slaughter at their homes. No doubt this figure could have been influenced by the LFA who interviewed the cattle owners, because most persons in Tanzania have been warned against consumption of meat that is not inspected by a meat inspector. Meat inspection alone can not be relied on to prevent taeniasis (Ginsberg *et al.* 1956). However, the risk of ingesting beef infected with *T. saginata* cysts is greater in non inspected than inspected beef (Mosienyane, 1986).

Records obtained from Mbulu District Hospital showed that in 1990 the prevalence was 10.3% and in 1991 the prevalence was 21.0%. However in the Mbulu District Hospital laboratory there was no differentiation between *Taenia* ova from *T. saginata* and those from *T. solium*. The two tapeworms are known to exist in Mbulu district from records on cysticercosis in pigs originating from Mbulu. Regarding management of taeniasis in Mbulu hospital, the Medical Officer for that hospital, indicated that drugs against taeniasis were scarce in the hospital during the authors' visit (August, 1991). Lack of appropriate drugs against taeniasis in the rural hospitals could certainly cause increases in numbers of carriers of taeniasis. If all the cases discovered were effectively treated there would be a chance of reduction of environmental contamination with *Taenia* ova, thus reducing number of cases of bovine cysticercosis. From this study it can be concluded that taeniasis and cysticercosis are common problems in rural areas where cattle are raised in Tanzania. This is due to lack of knowledge among the ethnic groups and lack of methods and medicines to control the

tapeworms in humans and in cattle.

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Table 2.1. Questionnaires distributed and those returned, together with major ethnic groups interviewed for each region, district and number of villages covered in Tanzania

Region	District	Total Q*. distributed	Total Q*. returned	No. of Villages covered	Major Ethnic groups-proportion of all interviewed in district
	Mpwapwa	30	22	11	Gogos - 16/22
Dodoma	Kondoa	30	10	9	Rangis - 7/10
	Arumeru	30	16	6	Arushas - 16/16
Arusha	Mbulu	30	12	10	Iraqws - 12/12
	Ngorongoro	40	12	6	Masais - 7/12
Morogoro	Morogoro Rural	50	33	10	Masais - 24/33
Total	6 districts	210	105	52	5 Ethnic groups

Q*. = Questionnaire

Table 2.2. Occurrence of human taeniasis and bovine cysticercosis and factors associated with the conditions as reported by members of five tribes interviewed in six districts of Tanzania.

		FACTOR →	Cysticercosis as reported seen in cattle at home (%)	Taeniasis reported by cattle owner (%)	Consumption of beef with cysticerci	Consumption of raw beef	Without latrine at home (%)	Not easy to get medicine for taeniasis (%)
Tribe ↓	**District**	Number interviewed						
Masais	Morogoro	24)	5 (16)	25 (78)	0	0	18 (56)	13(59)#
	Ngorogoro	7 } 32						
	Kondoa	1)						
Iraqws	Mbulu	11)	9 (75)	11 (92)	5	1	2 (17)*	8(67)
		} 12						
	Ngorongoro	1)						
Rangis	Kondoa	7	1 (14)	1 (14)	0	0	0 (0)	7(100)
Arushas	Arumeru	16)	2 (10)	10 (50)	3	0	8 (40)	16 (80)
		} 20						
	Ngorongoro	4)						
Gogos	Mpwapwa	16	10 (63)	6 (38)	4	0	1 (6)¤	16 (100)
Total	-	87	27 (31)	59 (68)	13	1	29 (33)	60 (69)

¤ 1/16 of all Gogos interviewed claimed that "not all use latrines").

* (1/12 of Iraqws interviewed claimed that "not all use latrines")

10/32 of the Masais did not respond on the questions of availability of medicines against taeniasis.

Table 2.3. Villages reported to have had experienced taeniasis and those with butcher shops available in some districts of Tanzania.

District	Number of villages surveyed	Villages experienced taeniasis (%)	butcher shop available (%)
Mpwapwa	11	5 (45)	6 (55)
Kondoa	9	1 (11)	1 (11)
Mbulu	10	10 (100)	3 (30)
Arumeru	6	3 (50)	0 (0)
Ngorongoro	12	12 (100)	1 (5)
Morogoro Rural	10	1 (10)	2 (20)
Total in 6 Districts	52	32 (62)	13 (25)

Table 2.4: The medicinal herbs used against human taeniasis among the major ethnic groups in some districts of Tanzania.

Ethnic group	district	Proportion of major ethnic group interviewed (%)	Name* of herbal medicines used against taeniasis in among the ethnic groups
Gogos	Mpwapwa	73	"Mbakwe"
Rangis	Kondoa	70	"Mbakwe"
Arushas	Arumeru	100	"Lodwa"
Iraqws	Mbulu	100	"Qwaway"
Masais	Ngorongoro	58	"Lodwa", "Muktani
Masais	Morogoro Rural	73	"Lodwa", "Muktani"

Name* = The names presented for the medicines are given the way they are commonly referred to in the respective areas.

APPENDIX 1

QUESTIONNAIRE NO.....

SOKOINE UNIVERSITY OF AGRICULTURE
FACULTY OF VETERINARY MEDICINE
DEPARTMENT OF VETERINARY MEDICINE AND PUBLIC HEALTH

QUESTIONNAIRE FOR THE RESEARCH ON EPIDEMIOLOGY AND DIAGNOSIS OF *TAENIA SAGINATA* CYSTICERCOSIS (BOVINE CYSTICERCOSIS)

0. DATE..... NAME OF INTERVIEWER:
.....

A. GEOGRAPHICAL AREA: RESPONSE(S)
1. REGION.....
2. DISTRICT.....
3. NAME OF THE PLACE OF INTERVIEW .....
(VILLAGE/CATTLE MARKET)

B.PERSONAL PARTICULARS OF CATTLE OWNER:
4. NAME OF CATTLE OWNER:.....
5. HIS/HER ADDRESS.....
6. WHERE WAS HE/SHE BORN.....
7. HIS/HER AGE.....
8. NAME HIS TRIBE/ETHNIC GROUP.....

C. LIVESTOCK PRODUCTION / MANAGEMENT:
9. NUMBER OF CATTLE IN HIS/HER HERD.....
10. HOW FAR DO THE CATTLE GRAZE FROM OWNER'S HOUSE ?.....
11. DO THE ANIMALS MIGRATE FOR PASTURE ? .....(YES OR NO) .....
12. WHEN DO THE ANIMALS MIGRATE DURING THE YEAR ? .....

13. DO THE CATTLE GRAZE COMMUNAL, i.e. WITH CATTLE FROM OTHER HERDS ? ....(YES OR NO).....

14. WHERE DO THE ANIMALS WATER ? a) RIVER.....
OR b) DAM .....
c) FURROW .....
d) TROUGH .....
e) OTHERS .... (state other means of providing water)
.....
15. HOW MANY HERDERS TAKE THE ANIMALS FOR GRAZING ? ....(ONE).....
OR...(MORE THAN ONE).....
16. ARE THE HERDERS CHILDREN OR ADULTS ? (state whether children or adults)

.....

QUESTIONNAIRE CONT. NO.
RESPONSE(S)

17. ARE THE CATTLE HERDERS BELONGING TO THE FAMILY OR EMPLOYED
state FAMILY..... OR EMPLOYEE.....

18. IF THE HERDERS ARE EMPLOYED, WHERE DO THEY COME FROM ? .....
19. HOW MANY CATTLE ARE SOLD FROM YOUR HERD PER YEAR ? .....

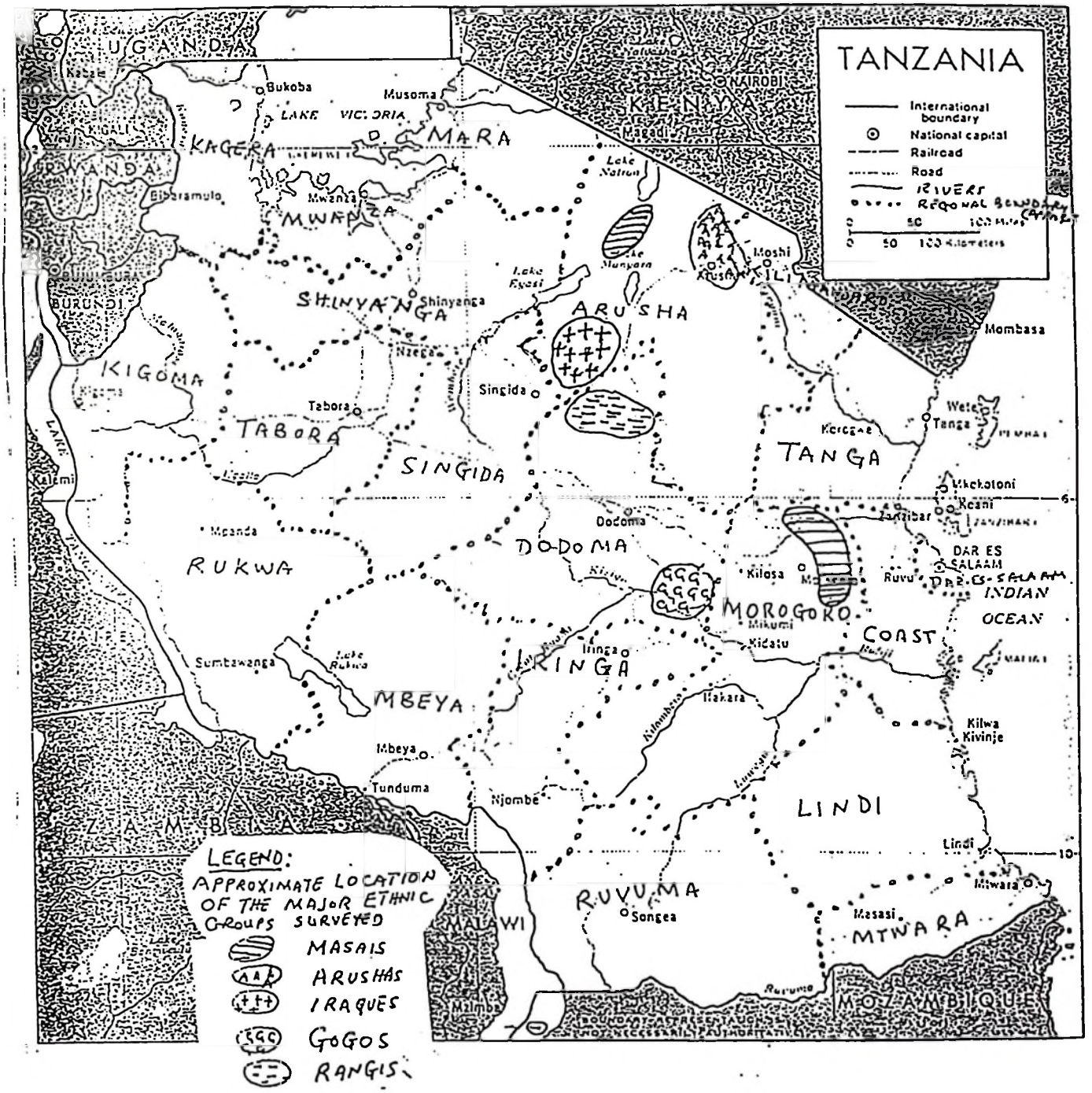
D. PROTECTION FROM TAENIASIS:
20. IS THERE A BUTCHER SHOP IN YOUR VILLAGE ? .....(YES OR NO).....
21. ARE ANIMALS SLAUGHTERED AT YOUR HOME INSPECTED BY A MEAT INSPECTOR?.....(YES OR NO).....
22. HAS THERE BEEN ANY SLAUGHTERED CATTLE WHOSE MEAT WAS FOUND TO HAVE *CYSTICERCUS BOVIS*, CYSTS ? .....(YES OR NO) .....
23. IF CYSTS ARE DETECTED IS THE MEAT CONSUMED OR NOT CONSUMED ? state consume..... or not.....
24 HOW IS MEAT CONSUMED IN YOUR FAMILY ? a) AFTER COOKING .....
b) AFTER ROASTING .....
c) RAW .....
(May tick the alternative(s))

E. HUMAN TAENIASIS SITUATION, AND ITS CONTROL IN THE VILLAGE
25. DO PEOPLE COMPLAIN OF TAENIASIS IN YOUR VILLAGE ? ...(YES OR NO)...
26. WHO ARE THE PERSONS MOSTLY AFFECTED ? a) MEN .....
OR b) WOMEN .....
OR c) CHILDREN .....

27. AMONG YOUR CATTLE HERDERS, IS THERE ANY OF THEM WHO HAS SUFFERED FROM TAENIASIS ? .....(YES OR NO).....
28. IF ANSWER TO Q.27 IS YES; WHEN ? The answer is either a) Recently ..... or b) over a year ago.....
29. WAS THE AFFECTED PERSON TREATED ? (YES OR NO).....
30. HOW WAS THE AFFECTED PERSON TREATED ? Answer IN A HOSPITAL ..... OR LOCAL MEDICINE.....
31. IF IT WAS IN A HOSPITAL, NAME THE HOSPITAL .....
32. IF MEDICINE USED WAS LOCAL GIVE THE NAME OF THE MEDICINE .....
33 IS THERE A LATRINE IN YOUR HOME? ...(YES OR NO) .....
34. DO PEOPLE USE LATRINE IN THE VILLAGE ? ....(YES OR NO) .....
35. IF SOME ONE BECOME INFECTED WITH A TAPEWORM WHERE DO PEOPLE THINK HE/SHE GOT IT FROM ? .....
36. ARE THE MEDICINES FOR TREATING HUMAN TAPEWORMS EASY TO GET? Answer is a) easy ... or b) difficult .....

NOTE: AFTER FILLING THIS QUESTIONNAIRE, IT HAS TO BE RETURNED TO ..THE HEAD, DEPARTMENT OF VETERINARY MEDICINE & PUBLIC HEALTH, P.O BOX 3021, MOROGORO.

APPENDIX 2



Sketch Map of Tanzania, showing regions and approximate location where the major ethnic groups were found during the survey. (Source main map: Kurian, 1979) Regional boundaries, and legend for the ethnic groups added by author).

CHAPTER 3

PREVALENCE OF *TAENIA SAGINATA* CYSTICERCOSIS IN CATTLE SLAUGHTERED IN SOME ABATTOIRS IN TANZANIA.

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Abstract

Cysticercosis was detected in 52 (10.5%) out of 496 cattle slaughtered at the municipal abattoirs of Arusha, Dodoma, Iringa, Morogoro and Mpwapwa district in Tanzania during the period June 1991 to November 1991. The prevalence rates in the individual abattoirs were 16.7% (Arusha), 9.6% (Iringa), 8% (Dodoma), 7.6% (Mpwapwa) and 6.5% (Morogoro), the average prevalence being 10.2%. In contrast, the Official annual prevalence of cysticercosis from 1986 to 1991 for the Dodoma and Iringa regions were 1.37% and 0.84% respectively. The results are discussed on the background of endemicity of *T. saginata* cysticercosis in the country, efficiency of meat inspection, records keeping in the abattoirs and sources of infection with cysticercosis. It is recommended to intensify health education to the public on methods of controlling human taeniasis and cysticercosis, provision of necessary facilities for meat inspection and to have separate recorders of meat inspection findings, during inspection procedures and hold regular seminars related to meat inspection in the abattoirs.

1.0. INTRODUCTION

Taenia saginata cysticercosis is one of the most important zoonotic parasitics of cattle. Its manifestation is not very spectacular, but causes considerable economic losses to the beef industry (Urquhart, 1961; Pawlowski and Schultz, 1972, Grindle, 1978). This infection is worldwide in distribution however, its prevalence seems higher in Africa and Asia than in other parts of the world (Urquhart, 1961; Froyd, 1965; Pawlowski and Schultz, 1972; Arambulo *et al.* 1976; Pawlowski, 1982). Actually, according to Mitchell (1973), Africa is considered to be the most parasitized area.

Prevalence rates of *T. saginata* cysticercosis are mainly based on routine meat inspection records (Pawlowski and Schultz, 1972; Mitchell, 1973; Urquhart *et al.* 1987). However, it has been found that routine meat inspection is generally not sufficiently reliable for the diagnosis of cysticercosis due to low recovery rates, (Kyvsgaard *et al.* 1990) and irregular distribution of the cysticerci in the bovine tissues (Dewhirst *et al.* 1967; Juranek *et al.* 1976; McCool,1979; Walther and Koske, 1980; Kyvsgaard *et al.* 1990)

It has been known for many years that *T. saginata* cysticercosis is endemic in Tanzania. Urquhart (1961) quoting the (Report of Veterinary Services, 1958, Tanzania) reported prevalence of cysticercosis in Tanzania (by then Tanganyika) to be approximately 50%. Nadzafov (1975) reported a prevalence rate of 5% at the main abattoir in Dar-Es-Salaam in Tanzania. Furthermore, Petrovic (1976) reported a prevalence rate of cysticercosis at Tanganyika Packers abattoir in Dar-Es-Salaam to vary from 2.6% to 26.9% with an average of 7.28%, out of a total number of 163,546 cattle consigned from different parts of the country. It should be emphasized that data on prevalence rates at Tanzanian abattoirs very often do not relate to the area of origin of the cattle examined at slaughter.

This paper reports on a survey conducted in municipal abattoirs of some regions of Tanzania

where beef cattle is raised , it was the aim to elucidate the prevalence of *T. saginata* cysticercosis in slaughter cattle from Arusha, Dodoma, Iringa, Morogoro, and Mpwapwa The data obtained were compared prevalence rates from already existing official meat inspection records from the Dodoma and Iringa regions.

2.0. MATERIALS AND METHODS

2.1. Abattoirs.

Visits were made to municipal abattoirs in Arusha* Dodoma, Iringa, Morogoro and Mpwapwa districts during the period between June 1991 to November 1991. Before a visit was made to the abattoirs, applications were made to the Regional Livestock Development Officer(s) (RLDO) in the respective regions, and to the meat inspector in charge of each abattoir. Each abattoir was visited for some consecutive days at the time of slaughter and the total number of cattle slaughtered and inspected, together with total cases of *T. saginata* cysticercosis detected on that day were recorded.

The cattle slaughtered in the abattoirs were brought in by individual butchers who had purchased them from nearby cattle markets. The cattle markets were supplied with animals from farmers in the surrounding villages in the regions. The main breed of cattle slaughtered in these abattoirs was Zebu.

Arusha abattoir was privately owned and was equipped with modern slaughter facilities. It slaughtered on average 35 head of cattle per day. Five visits were made to the abattoir.

Dodoma abattoir slaughtered on average 70 heads of cattle per day. The system of slaughter in that abattoir involved owners of the cattle restraining the animals in the slaughter hall, and bleeding and dressing was done on the floor, at the same place. The premise at Dodoma abattoir was very congested with persons and meat. Three meat inspectors were involved in that hall, and immediately after a carcass had been inspected the owner took away the passed carcass for retail sale. It was impossible to confirm results from the furthest inspectors while concentrating with one of the other inspectors. Therefore, carcasses inspected by one

*** Privately owned abattoir, with name; Sakina Happy sausages Company.**

inspector only, were taken as a sample for Dodoma abattoir during the two days visits at that abattoir.

Iringa abattoir slaughtered on average 28 cattle per day. Seven visits were made to that abattoir and each time the carcasses of all slaughtered cattle were taken as a sample for the abattoir.

Morogoro abattoir slaughtered on average 35 cattle per day. Five visits were made to this abattoir and all the carcasses were taken as a sample for the abattoir.

Mpwapwa district abattoir, in the Dodoma region slaughtered on the average 10 cattle daily, Slaughtering was done while it was already bright in the morning and the inspections were easily followed after dressing the carcasses. Therefore, all animals slaughtered at Mpwapwa abattoir during the five visits were taken as a sample for that abattoir.

It was not possible, at any of the abattoirs to trace the individual herd of origin for each cattle because the animals had no recognizable herd codes.

2.3. Meat inspection procedure

Meat inspection in the abattoirs was conducted by government employed trained meat inspectors who were supposed to follow the Tanzania Meat Hygiene Regulations, 1962 (Tanganyika Government, 1962). The regulations prescribe the inspection to include general visual examination of the dressed carcass and organs, palpation of special organs like the tongue, oesophagus, heart, spleen, lungs, and liver. However the regulations provide special requirements for detection of cysticerci of *T. saginata*, whereby incisions are made through the outer and inner masticatory muscles, the tongue, the heart, M. triceps brachii in both arms, diaphragm pillars, the rump, brisket, fillet and the chuck on both sides of the carcass.

During the meat inspection procedure, the author was standing nearby the meat inspector to

ensure any detected case of *T. saginata* cysticercosis to be recorded.

2.4. Data handling

Data from previous meat inspection records, including total number of cattle slaughtered and total number of cases with cysticercosis recorded for each of the years 1986 to 1991 was obtained for Dodoma and Iringa regions of Tanzania. Data from the other regions included the survey were not available.

Calculation of prevalence rates of *T. saginata* cysticercosis was based on total number of cases of cysticercosis over the total number of slaughtered cattle in individual abattoirs or regions. Regional comparisons of the prevalence rates were done for Dodoma and Iringa regions where a municipal abattoir was included in the survey.

3.0 RESULTS

A total of 52 (10.5%) out of 496 cattle were detected to be infected with cysticerci during slaughter in five abattoirs in four regions of Tanzania. The prevalence rates of *T. saginata* cysticercosis in the individual abattoirs are given in Table 3.1. The prevalence rates in the abattoirs visited ranged from 6.5% (Morogoro) to 16.7% (Arusha), while the prevalence rate for all the cattle examined was 10.5%. Thus, the prevalence rate recorded in Arusha was strikingly higher than that recorded in the other abattoirs surveyed. Official records of annual slaughter, cases of cysticercosis, and trends of prevalence of cysticercosis in Dodoma and Iringa regions from 1986 to 1991 are shown in Table 3.2. On the average the Dodoma region registered higher prevalence (1.37%), than Iringa region (0.84%).

From the table it appears that there were 856 cases of cysticercosis out of 101000 slaughtered cattle in Iringa region, while there were 1893 cases of cysticercosis out of 137195 slaughtered cattle in Dodoma region. The annual prevalence rates of cysticercosis for Iringa ranged from 0.54% to 1.16% while prevalence rates in Dodoma region ranged from 0.51% to 2.29% From the trends of prevalence rates in the two regions (Table 3.2), it shows that the highest prevalence was recorded in Iringa in 1990/91, while the highest in Dodoma was in 1988/89. The lowest prevalence in Iringa was recorded in 1988/89, while the lowest in Dodoma region was recorded in 1989/90.

Table 3.3 shows the mean annual prevalence rates of cysticercosis in Dodoma and Iringa regions compared with prevalence rates recorded in the respective municipal abattoirs during this survey. Annually, Dodoma municipal abattoir slaughtered on the average 93% of all recorded slaughter cattle in the whole region while the same figures for Iringa municipal abattoir averaged 50.6%.

The overall annual prevalence rates of *T. saginata* cysticercosis in the two regions were

strikingly lower than the rates of the present study recorded in their respective abattoirs (Table 3.3).

Table 3.1 Prevalence rates of *Taenia saginata* cysticercosis in individual abattoir in respective regions of Tanzania.

Region	Abattoir	Number of visits	Total number of cattle slaughtered	Total number of cases with *T. saginata* cysticercosis	Prevalence of *T. saginata* cysticercosis (%)
Arusha	Arusha	5	138	23	16.7
Dodoma	Dodoma	2	37	3	8.1
	Mpwapwa	5	52	4	7.7
Iringa	Iringa	7	146	14	9.6
Morogoro	Morogoro	5	123	8	6.5
Total cattle	-	-	496	52	10.5

Table 3.2 Annual prevalence rates of *T. saginata* cysticercosis in Dodoma and Iringa regions of Tanzania from 1986 to 1991. (Source: Annual reports RLDO*s Dodoma and Iringa regions of Tanzania).

Region	Iringa			Dodoma		
Year	Total number of cattle slaughtered	Cases of *T. saginata* cysticercosis	Prevalence of *T. saginata* cysticercosis (%)	Total number of cattle slaughtered	Cases of *T. saginata* cysticercosis	Prevalence of *T. saginata* cysticercosis (%)
1986 (Jan.-Dec.)	23227	219	0.94	30430	388	1.28
1987/88 (Jul.-June).	20777	192	0.92	33160	556	1.68
1988/89 (Jul.-June)	18829	101	0.54	29556	677	2.29
1989/90 (Jul.-June)	19059	122	0.64	24135	124	0.51
1990/91 (Jul.-June)	19108	222	1.16	19914	148	0.74
Total cattle	101000	856	0.84	137195	1893	1.37

RLDO* = Regional Livestock Development Officer

Table 3.3. Prevalence of cysticercosis and percentage annual kill at municipal abattoirs relative to average annual kill for Dodoma and Iringa regions of Tanzania

Region	Percentage of abattoir kill, relative to regional slaughtering	Annual prevalence rate (RLDO-figures) (%)	Prevalence rate at municipal abattoirs (this investigation) (%)
Iringa	50.6	0.84	9.6
Dodoma	93.0	1.37	8.1

4.0. DISCUSSION.

The results of the present survey and the available official records of *T. saginata* cysticercosis in Dodoma and Iringa regions of Tanzania, confirm that this infection is endemic in Tanzania. The present study at local abattoirs recorded prevalence rates ranging from 6.7% to 16.7% which roughly corresponds to the figures given by Petrovic (1976) but which were significantly lower than the figures of Urquhart, (1961).

The prevalence rates recorded in the individual abattoirs (Table 3.1), differed from one abattoir to another. Such differences have been reported by other authors in other parts of Africa (Belino, 1975; Cheruiyot, 1981). As mentioned, Arusha municipal abattoir recorded the highest prevalence of *T. saginata* cysticercosis (16.7%) as compared with results recorded from the other abattoirs which could be a reflection of the taeniasis status in the human population in that region. The majority of natives who keep cattle in the Arusha region are Masais and Arushas, who keep large herds of cattle and who have the habit of eating rare beef as part of their culture.

Data collected in Kenya by Froyd (1965), highlighted some of the reasons related to the high prevalence rates of cysticercosis and taeniasis in the rural areas of Africa. The reasons which were given for the high incidence of taeniasis among the Masais of Kenya could hold true also for the Masais of Tanzania, because their culture and customs are largely the same until now. However more information is required on the epidemiology of *T. saginata* taeniasis among the cattle herders and other people in Tanzania.

Comparison of the official prevalence rates of bovine cysticercosis for Dodoma and Iringa regions with the prevalence rates from the present survey in the respective municipal abattoirs (Table 3.3), show that the official prevalence rates were significantly lower than those rates obtained from the survey. Lower official prevalence rates of cysticercosis as

compared to survey records have been observed in some other countries in Africa (Belino, 1975; Cheruiyot, 1981; Onah and Chiejina, 1986). The survey data used for comparison in this report was limited in time and size, but the figures undoubtedly reflect an overall much higher prevalent rate than that listed in the official records. The figures of the official records from Dodoma and Iringa regions could indicate an underestimation of the prevalence due to some factors related to meat inspection procedures, or to facilities for conducting the inspection and recording the findings, as it has been noted in a Nigerian abattoir (Ogunrinade and Oyekole, 1990).

In most local abattoirs in Tanzania cattle are slaughtered early in the morning and the meat inspectors conduct the inspection in a hurry without recording the findings immediately. Practically the same inspector has to carry the inspection knife, a pen and a notebook and he is supposed to record the meat inspection findings while proceeding with meat inspection. Furthermore, the owners of the cattle are eagerly waiting to go and sell the passed meat. Due to pressure of work, there is a tendency that they record the meat inspection findings at the end of the overall inspection, when the owners have carried the passed meat away, for retail sale in their butcher shops in the towns.

An investigation which was conducted to evaluate the efficiency of meat inspection procedure for cysticercosis in a Nigerian abattoir has clearly pointed to some of the problems related to meat inspection and record keeping (Ogurinade and Oyekole, 1990). The authors compared prevalence rate of cysticercosis recorded in that abattoir with proportion of cases of cysticercosis observed in tongues, examined at three retail markets supplied with meat from the same abattoir. They found 27 (7.5%) out of 358 tongues positive for cysticercosis, and no positive case of cysticercosis recorded out of 1221 cattle slaughtered in that abattoir during the survey. A similar survey was conducted in a Belgium abattoir. In that

investigation, (Geerts *et al.* 1980) examined 100 hearts which were already passed as fit for human consumption from the abattoir and found 25% positive for cysticerci of *T. saginata.* The findings of Geerts *et al.* (1980) and Ogurinade and Oyekole (1990) clearly illustrate an underestimation of official reported prevalence rates in the abattoirs. This could be caused by inefficiency of meat inspection or lack of recording or both. From the observed operations in the local abattoirs in Tanzania it was easy for some lightly infected carcasses to escape the inspectors eyes, However, further studies may be needed to establish the extent of such possible escape in the abattoirs in Tanzania. To obtain more realistic data on the prevalence of cysticercosis it will be necessary to conduct meat inspection more efficiently and keep proper records of the meat inspection findings. It is recommended to provide adequate and necessary facilities for meat inspection, together with regular seminars to the meat inspectors, and to the recorders of meat inspection findings. This may improve meat inspection efficiency and record keeping in the local abattoirs in Tanzania.

The rather high prevalence rates of *T. saginata* cysticercosis recorded in the abattoirs should be taken seriously since they suggest presence of taeniasis in the human population where the cattle are raised. The Ministry responsible for health services should consider establishment of a Veterinary Public Health liaison office on matters related to zoonoses including bovine cysticercosis and human taeniasis.

When *T. saginata* cysticercosis is detected in abattoirs in the industrialized countries, where the prevalence rate of *T. saginata* cysticercosis is generally low, infected attendants of the cattle, sewage sludge or effluent contaminated feed or water are some of the incriminated factors (Fewster, 1967; Slonka *et al.*, 1975; Fertig and Dorn, 1985; Ilsøe *et al.* 1990). It may be easier to determine the major source of infection epidemiologically when there is a possibility of tracing back the infected animal from the abattoir to the herd of origin (Ilsøe

et al. 1990). On the other hand, considering animal production systems in the tropics, where pastoralism and nomadism are common practices, it may be extremely difficult to rule out the infection sources. Most beef cattle produced in Tanzania are raised on extensive pastoral systems where communal grazing is common practice. It is possible for one herdsman carrier of the tapeworm, to infect several cattle from several farms or villages as long as communal grazing exists.

The prevalence rates of *T. saginata* cysticercosis in cattle has been suspected to be associated with tapeworms of wild carnivores in some parts of Africa (Sachs and Sachs, 1968), due to presence of these animals in the environment where cattle is grazed. However, Gathuma and Mango (1976) in a large survey, found no evidence that wild carnivores harboured tapeworms that could give rise to the typical cysticercosis in cattle.

Kenya and Tanzania are neighboring countries, with almost similar types of wild carnivores and cattle production systems. It could therefore be unlikely for wild carnivores to have any significant role in the epidemiology of *T. saginata* cysticercosis in Tanzania.

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CHAPTER 4

DISTRIBUTION OF *TAENIA SAGINATA* CYSTS IN NATURALLY INFECTED CATTLE IN MOROGORO TANZANIA

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ABSTRACT

A total number of 864 cysticerci of *Taenia saginata* were recovered by slicing half carcasses of 15 naturally infected Zebu cattle from Morogoro abattoir, Tanzania, with a range of four to 180 cysts in individual carcasses. The cysticerci were found located in the examined tissues preferentially in the following order: heart, M. triceps brachii, tongue, M. psoas, and masseter muscles. The liver had relatively high numbers of cysts and thus considered an important predilection site. Examination of the predilection sites for detection of carcasses positively infected with cysticerci of *T. saginata* revealed the following efficacies: 80% (heart), 80% (M. triceps brachii), 60% (masseter muscles), 60% (tongue) and 53% liver. However, examination of the heart, M. triceps brachii and liver together detected all infected carcasses. It is recommended that the heart, M. triceps brachii, masseter muscles, the tongue and liver should be adopted as meat inspection sites to search cysticerci of *T. saginata* in Tanzania. As a precaution, consumers should be educated to cook beef adequately, since at least (60%) of infected carcasses at the abattoir had viable cysticerci.

4.1 INTRODUCTION

Diagnosis of cysticercosis in cattle is made by post mortem examination for the cysticerci of *T. saginata* in the host tissues (Pawlowski & Schultz, 1972). The cysticerci are most often located in the striated muscular tissues (Juranek *et al.* 1979), although, they have also been found in non muscular tissues, such as the liver, lungs, spleen, lymph nodes, fascia and adipose tissues in cattle (Osiyemi, 1976; McCool, 1979; Nyaga & Gathuma, 1979; Kyvsgaard *et al.* 1990). The tissues or sites most densely and frequently parasitized by *T. saginata* in cattle have been categorized as "predilection sites" (Ginsberg *et al.* 1956; Kyvsgaard *et al.* 1990) and these include muscles of the heart, masseter muscles, the tongue, the diaphragm and Musculus triceps brachii, which are commonly examined during routine meat inspection, to search for the cysticerci of *T. saginata* (WHO, 1983). The cystic stage of *T. saginata (Cysticercus bovis)* in cattle is found in most parts of the world (Penfold *et al.* 1936), however, it is extensively observed in Africa (Urquhart, 1987; Pugh and Chambers, 1989; Geerts, 1992).

Meat inspection procedures for detection of *T. saginata* cysticerci vary in different parts of the world, depending on reported distribution studies in those countries or regions (Pawlowski and Schultz, 1972). A previous report on the distribution of cysticerci of *T. saginata* in slaughter cattle in Tanzania indicated that the heart is the site more frequently parasitized, compared to the other examined sites (Petrovic, 1976). However, a detailed account of the number of cysticerci in individual organs or muscle groups in the carcasses were not presented. These details are important in order to determine which of the predilection sites should be examined at the post mortem inspection in a specific geographical region (Pawlowski and Schultz, 1972).

This paper therefore, reports on a study conducted on naturally infected Zebu cattle carcasses

at Morogoro abattoir in Tanzania. The aim was to determine the predilection sites, reliability of the predilection sites in detecting infected cattle carcasses during meat inspection and viability of the cysticerci, which determine the potential health hazards of passed carcasses.

4.2 MATERIALS AND METHODS.

4.2.1 Source of *T. saginata* infected materials

Fifteen half bovine carcasses, which at meat inspection were observed to harbour cysticerci of *T. saginata*, together with the corresponding hearts, heads, tongues and livers were acquired from Morogoro municipal abattoir in Tanzania. The meat inspectors at the abattoir were requested to detain any carcass found to be infected with a cysticercus of *T. saginata*, so that the required samples could be purchased from the owners. The first carcass detected on each of the visits made to the abattoir was taken as a sample. Most cattle slaughtered in that abattoir originated from nearby cattle markets in Morogoro region. The breed and sex of each individual animal detected to be infected with *T. saginata* cysts were recorded at the abattoir.

4.2.2 Slicing of tissues from carcasses and examination of cysts.

In a dissection laboratory, the muscle groups excised from the bones of each half carcass, masseter muscles and the tongues from the heads together with the hearts, and the livers were all sliced into strips not thicker than 0.5 cm. The cysticerci were counted and recorded separately for each tissue and individual carcass. Fully transparent cysts with a visible scolex were considered as viable, any other as degenerated. Confirmation of viability of cysticerci was done by placing intact enucleated cysticerci from the host capsule in 30% ox bile, diluted in normal saline and incubated at 37°C for one to two hours. Viable cysts evaginated within one to two hours of incubation and the motility of their suckers, examined under a dissection microscope was also used as a confirmatory test for viability.

The frequencies of detecting cysticerci in the sites routinely examined during meat inspection were calculated from the numbers of carcasses which were detected to have at least one

cysticerci in the particular site compared to all carcasses examined. The percentage of carcasses detected to be positive based on the results from slicing a specific groups of muscles or organ was used as an estimate for the reliability of the site in detecting cattle infected with cysticerci of *T. saginata*. Furthermore, the infected carcasses were categorized according to the viability of the detected cysticerci.

4.3 RESULTS

Twelve out of the 15 carcasses detected to be infected with *T. saginata* cysticerci were males and 3 were females. All the dissected carcasses belonged to the Zebu breed.

A total of 864 cysticerci, ranging from four to 180 and a mean ± standard deviation (s.d.) of 57.6±51.4 were detected in all the muscles and organs during the slicing of the tissues (Table 4.1). The means±s.d. of the numbers of cysticerci counted in the hearts, M. triceps brachii, tongues, masseter muscles, M. psoas, the livers, and the other muscles from fore limb hind limb as well as the trunk are also given in Table 4.1. Of the sites which are routinely examined for the presence of *T. saginata* cysticerci in Tanzania, 11.9±13.3 cysticerci were found in the hearts of the 15 examined carcasses, 5.3±7.7 in the M. triceps brachii, 2.7±2.7 in the tongues, 2.5±3.6 in the M. psoas, 1.3±1.6 in the masseter muscles, 7.4±13.1 in the livers. In the same organs or groups of muscles, 20.6% of the total number of cysticerci were found in the heart, 9.3% in the M. triceps brachii, 4.7% in the tongue, 4.4% in the M. psoas, 2.2% in the masseter muscles and 12.8% in the livers (Table 4.1). The frequency of detecting cysticerci in the predilection sites of the carcasses were as follows: Heart 12/15 (80%), M. triceps brachii 12/15 (80%), M. psoas 10/15 (66.7%), tongue 9/15 (60%), masseter muscles 9/15 (60%) and liver 8/15 (53.3%) (Table 4.1).

The liver and the heart were the only two organs where solitary cysticerci were detected among the carcasses, namely in carcass number 4 and 8 (Table 4.1). All the cysts in the heart of carcass number 8 were degenerated, while those found in that liver were alive.

The percentage of carcasses detected as positive for *T. saginata* infection by slicing and inspecting various sites in the infected carcasses alone or in combination are given in Table 4.2. When the masseter muscles and the tongue were the only sites inspected, 80% of the known infected carcasses could be detect as true positive. However, when examining the

heart in combination with the masseter muscles or the heart together with the tongue, the proportion of true positive carcasses increased to 86.7%. When examining the heart and M. triceps brachii the proportion increased to 93.3%, whereas, examination of the heart, masseter muscles, the tongue, and M. triceps brachii together, the proportion of true positive carcasses was also 93.3%. When the liver was included in this latter combination, the proportion was increased to 100%. The heart, M. triceps brachii and the liver inspected together by slicing also increased the proportion to 100%.

Forty percent of the 15 infected bovine carcasses harboured only degenerated cysticerci, whereas, 26.7% of the carcasses harboured only viable cysts and 33.3% harboured viable as well as degenerated cysticerci (Table 4.3).

Table 4.4 shows the proportions in percentage of the infected carcasses at individual site depending on the viability *T. saginata* cysticerci observed at each parasitized site in the 15 infected bovine carcasses from Morogoro abattoir. Most (92%) of the livers, (67%) of the hearts, 55.6% of the masseter muscles, 44.4% of the tongues which are categorized as offal had degenerated cysticerci only, while over 50% of the muscles in the fore and hind quarters of infected carcasses at those regions were parasitized with viable cysticerci of *T. saginata* (Table 4.4). That observation on zebu cattle infected with cysticerci of *T. saginata* make these major potential best meat sources, potentially risky to consumers of inadequately cooked beef.

4.4 DISCUSSION.

The number of *T. saginata* cysticerci detected in the half carcasses ranged from 4 to 180 cysts. The heart was infected in 80% of the examined parasitized carcasses, and 20.6% (mean$\pm$s.d.= 11.9$\pm$13.3) of the total number of cysticerci observed in the carcasses were detected in the hearts. This percentage was higher than in any of the other organs or groups of muscles routinely inspected (Table 4.1). This finding was in agreement with a previous record of Zebu cattle in Tanzania (Petrovic, 1976). The heart and the triceps muscles are routinely being examined during meat inspection. These two sites were both parasitized in 80% of the cases. When both sites were carefully dissected in the individual carcasses, the proportion of detected carcasses was raised to 93.3% (Table 4.2). In combination with the liver, the proportion rose to 100% (Table 4.2). A total of 111 (12.8%) *T. saginata* cysts were found in the livers of the 15 carcasses. This could make the liver an important site for searching cysticerci of *T. saginata* during meat inspection. If that organ was not inspected, at least one out of fifteen infected carcasses would have passed as "non infected". However, in only 8 out of 15 carcasses (53.3%) the liver was infected with *T. saginata* cysticerci. The liver was one of two organs in which *T. saginata* cysticerci were present while cysts were absent in any of the other tissues examined. Similar observations has been reported by other workers (Ginsberg and Grieve, 1959; Belino, 1975; Nyaga and Gathuma, 1979). The occurrence of *T. saginata* cysts in the livers of naturally infected cattle, has been associated to heavy infestation (Mitchell, 1973) and during experimental conditions, occurrence of *T. saginata* cysticerci in the liver has also been observed (McIntosh and Miller, 1960; Dewhirst *et al.* 1963; Kyvsgaard *et al.* 1990). However, under those conditions the livers were parasitized together with the other tissues of the host. The finding of cysts of *T. saginata* confined to the livers of naturally infected bovines made Wouters *et al.* 1987) suggest that

the detected cysticerci were larval stages of a strain of *T. saginata*. Also in a recent report by Geerts (1992) it is suggested that isolated cysts in the liver of bovines in Africa could be the larval stage a possible new species of *Taenia*, the Taiwan *Taenia* (Fan, 1988). The cysticerci of Taiwan *Taenia*, are characterized by an invaginated scolices with rudimentary hooks (Fan, 1988; Geerts, 1992). In the present study the isolated cysticerci discovered in the liver of the carcass harbouring cysts at this site only (carcass number 4) did not appear to have hooks when the scolices were examined under a stereomicroscope. However, at the time of examination it was not considered to look specifically for small rudimentary hooks. Therefore more investigations are required to determine if the Taiwan *Taenia* is present in Tanzania.

The factor or combination of factors which influence the choice of habitat of *T. saginata* cysts in the host are not known (Kearny, 1970) and the frequency of detecting cysticerci of *T. saginata* in the tissues of naturally infected cattle in the abattoirs depends on the geographical area and breeds of cattle or age (Pawlowski and Schultz, 1972). In order to give recommendations on which site are to be examined in a certain part of the world it is of major importance the predilection sites of cysticerci in cattle are determined.

The present study suggests that the predilection sites for the cysticerci of *T. saginata* in Zebu cattle slaughtered at Morogoro abattoir, Tanzania were the heart, M. triceps brachii, masseter muscles, the tongue and the liver. Therefore it is recommended that these sites should be adopted as inspection sites during meat inspection in Tanzania.

Considering the limitation of routine meat inspection, the detection rate of carcasses infected with cysticerci of *T. saginata* are generally low (Dewhirst *et al.* 1967; Rickard and Adolph, 1977; Walther and Koske, 1980; Kyvsgaard *et al.* 1990). Thus, carcasses detected with a single cyst by slicing at an inspection site may not necessarily be detected during routine

meat inspection. Walther and Koske (1980) determined an efficacy of 27-77.9% in detecting cattle carcasses infected with *T. saginata* cysts during meat inspection, depending on the extent of infection, with an overall efficacy of 38.3%. This value represented a ratio of all carcasses detected at meat inspection to all detected after slicing whole carcasses and corresponding organs. The efficacy of the sites adopted for detection of cysticerci of *T. saginata* determines the proportions of carcasses that are detected during meat inspection. All 15 infected carcasses from Morogoro abattoir used in the present study were detected only after adoption of multiple site inspection (Table 4.2). If the overall efficacy of 38.3% determined in the study by Walther and Koske (1980) is adapted in the present study the efficacies obtained using the individual inspection sites can be converted into efficacies expected to be observed at the abattoir. Thus, the maximum proportion of 80% obtained by examining the heart or M. triceps brachii (Table 4.2) corresponds to an efficacy of only 30.6%. Similarly, the proportion of 93.3% (Table 4.2) would be equivalent to a efficacy of 35.7%. From these findings the efficacies of individual predilection sites in Zebu cattle from Morogoro abattoir is estimated to range from 20.4-30.6%. However, when adopting a multiple sites inspection the efficacy increased to 38.3% With lightly infected carcasses i.e. those carcasses habouring between 1-10 cysts detected in the predilection sites, the efficacy of routine meat inspection has been determined to be 27% (Walther and Koske, 1980). The detection rates for the lightly to moderately infected carcasses (11- 20 cysts at the predilection sites) ranged from 27 to 42.9% (Walther and Koske, 1980), provided the there are adequate meat inspection facilities including experienced meat inspectors. Furthermore, considering the facilities and practices in some local abattoirs in Tanzania where individual slaughter men are dressing their own cattle carcasses in the slaughter hall, directly on the floor in the early morning hours, and considering that the necessary light for both dressing

and inspection of the dressed carcasses is inadequate, and that the dressed and quartered carcasses are piled in hanging hooks before the meat inspectors start the inspection in a hurry, the maximum efficacies determined by Walther and Koske (1980) may not be attained. However, provision of overhead dressing facilities and adequate lighting, reducing congestion in the abattoir, and availability of meat inspection supervisors, would definitely improve detection rates of cysticerci in the infected slaughter cattle at the abattoir.

The majority of cattle included in the present study were males (80%). No difference in number of *T. saginata* cysticerci, between males and female Zebu cattle was observed in the present study. However, further studies using larger study material will be needed to confirm this observation in cattle naturally infected with this parasite.

In the present study, 60% of the infected carcasses harboured viable cysticerci of *T. saginata*. Since the figure was drawn from a fraction of those carcasses likely to be infected at the abattoir (Walther and Koske, 1980), viable cysts in meat constitute a health hazard (McCool, 1976). Thus, beef consumers should be educated to cook beef adequately, as a precaution against undetected carcasses which may harbour viable cysticerci of *T. saginata.*

Overall 73.3% of the infected carcasses had degenerated cysts (Table 4.3). Numerous degenerated or calcified cysts in the flesh of carcasses render the meat unwholesome, for aesthetic reasons, due to the appearance of the affected meat or the gritty sound which may be detected during consumption of the meat. According to Geerts *et al.* (1980) meat with only a few dead and degenerated cysts may not constitute a zoonotic risk. However, the aesthetic effects of such meat is of immediate concern to the consumers.

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Table 4.1. Distribution of cysticerci of *Taenia saginata* in half carcasses of Zebu cattle from Morogoro abattoir, Tanzania.

Site	Heart**	M. triceps brachii**	Tongue**	Masseter muscle**	M. psoas**	Liver**	Other fore limb muscles	Trunk muscles	Other hind limb muscles	Total
carcass number										
1*	1	2	0	0	2	9	1	2	7	24
2*	17	10	3	2	4	0	16	41	58	151
3*	14	2	5	1	5	4	0	9	11	51
4	0	0	0	0	0	4	0	0	0	4
5	11	3	6	3	0	0	2	14	5	44
6	6	0	0	2	0	2	0	0	0	10
7	36	30	8	6	14	0	16	30	40	180
8	21	0	0	0	0	0	0	0	0	21
9	9	4	0	1	3	12	4	6	25	64
10	8	13	5	1	1	0	7	19	19	73
11	0	3	4	0	1	0	0	4	8	20
12	6	3	2	2	1	0	0	10	11	35
13	4	3	3	0	2	17	2	6	2	39
14	45	1	5	0	0	50	2	2	3	108
15	0	6	0	1	5	13	1	6	8	40
Total	178	80	41	19	38	111	51	149	197	864
% of total	20.6	9.3	4.7	2.2	4.4	12.8	5.9	17.2	22.8	100
Frequency	12/15	12/15	9/15	9/15	10/15	8/15	9/15	12/15	12/15	
detection	80%	80%	60%	60%	66.7%	53.3%	60%	80%	80%	
Mean±s.d.	11.9±13.3	5.3±7.7	2.7±2.7	1.3±1.6	2.5±3.6	7.4±13.1	3.4±5.5	9.9±11.9	13.1±16.5	57.6±51.4

* = carcass from female cattle.

** = Sites routinely examined for the presence of *T. saginata* cysticerci in cattle in Tanzania.

Table 4.2. Proportions of cattle diagnosed as carriers of *T. saginata* cysticerci by inspection of specific sites alone or in combination.

Sites inspected in the infected carcasses	Proportions diagnosed as carriers of *T. saginata* cysticerci (%)
Liver	8/15 (53.3)
Tongue	9/15 (60.0)
Masseter	9/15 (60.0)
M. psoas	10/15 (66.7)
Heart	12/15 (80.0)
M. triceps brachii	12/15 (80.0)
Masseter and tongue	12/15 (80.0)
Heart and masseter	13/15 (86.7)
Heart and tongue	13/15 (86.7)
Heart, M. triceps brachii	14/15 (93.3)
Heart/masseter/tongue/M. triceps brachii	14/15 (93.3)
Heart/ masseter/tongue/M. triceps brachii/liver	15/15 (100)
Heart/ M. triceps brachii/liver	15/15 (100)

Table 4.3. Classification according to viability of *T. saginata* cysticerci detected in 15 bovine half carcasses of Zebu cattle from Morogoro abattoir, Tanzania.

Viability of *T. saginata* cysts in carcasses	Proportion and percentage of carcasses
All cysticerci viable	4/15 (26.7%)
Both viable and degenerated cysticerci	5/15 (33.3%)
All cysticerci degenerated	6/15 (40.0%)

Table 4.4. Proportions in percentage of parasitized carcasses depending on the viability of *T. saginata* cysticerci detected at the parasitized site among the 15 half bovine carcasses from Morogoro, Tanzania.

Site examined	Number of carcasses out of the 15 detected to be parasitized at the site	Proportion detected with only viable cysticerci at the site (%)	Proportion detected with both viable and degenerated cysticerci at the site (%)	Proportion detected with only degenerated cysticerci at the site (%)
Heart*	12	8	25	67
M. triceps brachii	12	16	33.3	41.7
Tongue*	9	33.3	22.2	44.4
Masseter muscles*	9	33.3	11.1	55.6
M. psoas	10	30	30	40
Liver*	8	8	0	92
Other fore limb muscles	9	55	22.2	22.8
Trunk muscles	12	33.3	25	41.7
Other hind limb muscles	12	50	16.6	33.4

* Parts of the carcass considered as offal