PREVALENCE AND RISK FACTORS OF PORCINE CYSTICERCOSIS
ASSOCIATED WITH TRADITIONAL PIG PRODUCTION AND
MARKETING IN ANGÓNIA DISTRICT, MOZAMBIQUE

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTERS OF VETERINARY
MEDICINE OF SOKOINE UNIVERSITY OF AGRICULTURE.
MOROGORO, TANZANIA.

2008
ABSTRACT

This study was carried out to estimate the porcine cysticercosis prevalence by meat inspection, identify the risk factors of porcine cysticercosis along the pig/pork marketing channels and describe the pig productions systems. Data for prevalence were obtained using census of all pig carcasses going through the meat inspection point over a 3-months period. A ledger was used to register information regarding all cysticercosis post mortem inspection findings. The meat inspection was evaluated by total dissection of 30 inspected carcasses. Questionnaire survey was used to access the production systems, risk factors and marketing chains. Out of 205 inspected carcasses, 11 were positive for porcine cysticercosis, giving a prevalence of 5.4% (CI 3.0% to 9.3%). Evaluation of routine meat inspection by dissection of randomly purchased inspected carcasses, revealed a prevalence of 26.7% (CI 11.0% to 42.3%). Although there was good agreement between findings of meat inspection and dissection (Kappa 73.4%), the difference was attributed to laxity in adherence to inspection procedure. Predilection sites in order of magnitude for cysticerci in pigs were gluteus, Triceps brachii, psoas, masseter, diaphragm, heart, brain, and tongue muscles. Investigation of pig/pork marketing revealed short chains in which pigs/pork passes through few market participants or succession of markets before reaching the consumers. Potential risk factors for porcine cysticercosis along the chains were identified as poor pig management, complete lack of and improper pork inspection, pork consumption, and ignorance about the mode of transmission of Taenia solium/cysticercosis among the key players in the trade. Pigs were only housed when crops were in the fields; after harvest were allowed to graze freely. Animals were fed on kitchen leftovers, pasture, sweat potato leaves, and maize bran.
Meat inspection and meat dissection findings confirm that porcine cysticercosis is common in Angónia district and is potentially a serious health problem to pigs and humans.
DECLARATION

I, Cláudio Afonso Gule, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has not been submitted for a degree award in any other University.

Student signature: …………………………… Date: ………………………………..

The above declaration is confirmed by the supervisor:

Name Signature Date

Prof. Sharadhuli I. Kimera …………………………. ………………………………..
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ACKNOWLEDGEMENT

I am thankful to God for giving me a chance and enabling me to perform this work. Let his name be honoured forever. My great and sincere gratitude is accorded to my supervisors: Prof. S.I. Kimera of Department of Veterinary Medicine and Public Health at Sokoine University of Agriculture, Tanzania, Dr Sónia Santana Afonso of Veterinary Faculty at Eduardo Mondlane University, Mozambique, and Prof. Stig Milan Thamsborg of Danish Centre for Experimental Parasitology, Faculty of Life Sciences, University of Copenhagen, Denmark for their tireless effort, advice, constructive suggestions and constant encouragement during the whole period of undertaking this study. I am highly grateful to Cross-Disciplinary Risk Assessment of Cysticercosis in Eastern and Southern Africa (CESA) project founded by Danish International Development Agency (DANIDA) for wholly sponsoring my study. This great financial support is highly appreciated.

I am grateful to Prof. James Mlangwa, Dr Lee Willingham and Dr Helena Ngowi for their guidance and assistance during my studies and research work. I am also indebted to Gabinete do Plano de Zambeze (GPZ) and staff of Estação Zootécnica de Angónia, Mozambique for great cooperation and support during my data collection in the district. My colleagues at Provincial Veterinary Services, Tete, Drs Santana, João and Tesoura and Mrs Odete Coelho for encouraging me to join master program. I acknowledge with thanks the great cooperation and help received while at SUA from my fellow MVM students and friends Erik Komba, Mecku Kessey, Ernatus Mkupasi and Richard Mwakapuja.
I am extremely grateful to my friends Happiness Jackson, Serafina Vilanculos, Rehema Shoo, and Angelo Mwilawa for their encouragements, support and advice during my study. I extend my sincere gratitude to my brothers, Filimão, Aderito and Afonso Jr. as well as to my beloved sisters, Ermelinda, Isilda, Engracia, and Amarilis for their moral and material support, love, prayers, and patience while I was out of home doing my studies. Since it is not easy to thank and mention each and every one, I would like to record my sincere appreciation to all who in one or another way have assisted in the entire course of preparing this dissertation.
DEDICATION

This work is dedicated to my father, Afonso Ventura Gule, my late mother Helena Mambo and my beloved Maria Kapella for their encouragement and advice during the entire period of study. You are always being loved and valued simply for being you.
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<tr>
<td>CESA</td>
<td>Cysticercosis in Eastern and Southern Africa</td>
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<td>CI</td>
<td>Confidence Interval</td>
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<td>DANIDA</td>
<td>Danish International Development Agency</td>
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<td>ESA</td>
<td>Eastern and Southern Africa</td>
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<td>GPS</td>
<td>Geographical Position System</td>
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<td>ILRI</td>
<td>International Livestock Research Institute</td>
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<td>NCC</td>
<td>Neurocysticercosis</td>
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<td>USA</td>
<td>United States of America</td>
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<td>WHO</td>
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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Pig production has increased markedly in Eastern and Southern Africa (ESA) region during the past decade, especially those raised in rural smallholder communities (Phiri et al., 2003). The growth trend seems to continue at increasing rate attributed to several factors including, the higher consumer demand for pork in urban areas due to the ever increasing demand for animal protein and increased market value of pork.

The shortage or lack of grazing land for ruminants and the recognition by farmers of quicker and higher returns on their investment in pig industry have also contributed to increased interest in raising pigs (Phiri et al., 2003). However, the increased smallholder pig production and consumption in the ESA region is confronted with the serious problem of porcine cysticercosis (Phiri et al., 2003). Although modern management is on the increase in some countries and communities in the region, the main form of pig keeping is under extensive, free-range system where provision of traditional housing is provided. In spite of greatly increased popularity of consuming pork there is still a general lack of slaughter house facilities for pork inspection, and regulation of pork trade is poor or absent in many ESA countries.

Evidence gathered through research in recent years, indicates that porcine cysticercosis, caused by zoonotic tapeworm *Taenia solium*, is emerging as a significant problem affecting not only the wellbeing of smallholder farming
communities but also posing a serious public health risk for the population in most of developing countries (Phiri et al., 2003). The economic losses due to porcine cysticercosis in endemic areas have been estimated for some countries; in these instances the costs were found to be significant. For example, in Mexico the annual loss due to porcine cysticercosis was estimated at US$43 million (Flisser et al., 2003). However, very few figures are available for Africa. In 10 West and Central African countries the annual losses amount to US $39.2 million (Zoli et al., 2003). Ngowi et al. (2004) found that the reduction of pork value due to porcine cysticercosis in pigs raised in Mbulu District in Tanzania was 60%. The economic impact of this disease is related to smallholder farming communities failing to sell their pigs, cost due to the disease in humans and cost of the control programmes to mitigate or eradicate the disease. Condemnation of pig carcasses result in the loss of an important source of protein (Eddi et al., 2000).

1.2 Study Justification

Currently Mozambique has about 2.34 million pigs of which more than 90 % belong to so-called family sector farmers, most of whom are very poor (Penrith et al., 2007). Figures of the Mozambican Livestock Directorate show that the greatest concentration of pigs in Mozambique exists in the northern part of the country, where there is almost no commercial pig farming (Penrith et al., 2007). These pigs are important to their owners not only as a source of protein but mainly as a source of income. Worldwide, livestock have been described as an important enterprise for smallholder farmers and traders for enhancing the economic viability, supporting the livelihoods and provide insurances in time of need (ILRI, 2002). Furthermore,
livestock are a powerful means of enhancing the purchasing power of the poor through the sale of their products, income that can be used for the purchase of food, education and health care (ILRI, 2002) and paying for dowries. The rapid expansion of smallholder pig production under free range system in Mozambique has led to a significant increase in cysticercosis in pigs and humans. In addition to the importance of this relatively neglected food-borne zoonosis as a cause of morbidity and mortality in the country, it is also being recognized as a cause of loss of income for farmers due to condemnation of carcasses (Phiri et al., 2003).

One study in 11 districts of rural Tete Province in Mozambique showed that porcine cysticercosis sero-prevalence ranged from 6.5-33.3% (Afonso et al., 2001) and human cysticercosis in the same Province was 20% (Vilhena and Bouza, 1994). In addition, abattoir records indicate that porcine cysticercosis is present in all Provinces of the country (Afonso et al., 2001). However, these studies did not provide sufficient information about the factors associated with transmission of porcine cysticercosis and cannot give explanation on the prevalence of infection in live pig population.

Information about porcine cysticercosis, pig production and marketing channels in Mozambique is still scarce. There is a need therefore to understand the existing production and market setup in relation to porcine cysticercosis in order to develop appropriate strategies for pig production improvement. For this reason, the proposed study will be important in assisting the formulation of decision supporting systems for improving smallholder pig production, marketing, meat inspection and sustainable control of cysticercosis in the country, particularly in Angónia District.
1.3 Objectives

1.3.1 General objective

To determine the prevalence and risk factors of porcine cysticercosis associated with traditional pig production and marketing in Angónia District in Mozambique.

1.3.2 Specific objectives

1. To determine the prevalence of porcine cysticercosis in slaughtered pigs by meat inspection and dissection.

2. To describe the pig production systems and different channels of pig and pork marketing from production to consumers in Angónia District.

3. To determine the frequency of known cysticercosis risk factors along the pig and pork marketing channels.
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Aetiology and Morphology of T.solium

Taenia solium is a member of the family Taeniidae and genus Taenia and is commonly called the pork tapeworm because of its close relationship with pigs, although the final host is man. This is an obligate parasite with a life cycle involving two stages: The adult tapeworm, living in human small intestine, and the larvae or cysticerci, usually located in the muscles of domestic pigs, wild boar and rarely humans and dogs (Soulsby, 1982).

Porcine cysticercosis is an important parasitic infection of pigs caused by the larval stage of a zoonotic tapeworm, Taenia solium. The adult worm is flat with a tape-like shape (Fig. 1). Its strobila can measure between 2m to 4m in length with a total of 800 to 1000 proglottids (segments). The gravid proglottids contain from 30,000 to 50,000 eggs, which detach from the strobila in groups of five or six and are expelled with faeces (Pawlowski, 2002). The adult has neither coelomic cavity nor a digestive apparatus, and nutrition occurs through the tegumental surface. The excretory system is made of two channels located laterally and run (longitudinally) anteroposteriorly in the proglottids, connecting to those in the next proglottid and open to the outside in the last proglottid. The genital pores are located on the lateral edge of each proglottid at medium height. Three sections of the tapeworm can be observed: head, neck, and body or strobila. The head or scolex is globular in shape and 1 mm in diameter. It has a rostellum, with a double crown of hooks (large and small), arranged alternately. It
also has four muscular suckers that together with the hooks are used for attachment to the host’s intestinal mucosa (Soulsby, 1982). The neck is short and thin, measuring 5 to 10 mm long, and is the section with highest biosynthetic activity because the formation of the immature proglottids starts off at the neck. The body is the longest section of the parasite and is composed of hundreds of proglottids of the following kinds:

- The immature proglottids, which have a transversal diameter longer than the longitudinal one.

- The mature proglottids follow the immature ones are square in shape, 1 cm wide, 1-2 cm long, and 2-3 mm thick. The female genital apparatus can be seen with a trilobulated ovary, as well as the male genital apparatus with 375 to 575 testicular masses.

- Gravid proglottids are rectangular in shape, with a slightly predominant longitudinal diameter. Most of the male and female genitalia are atrophic, and only the uterus can be seen with tens of thousand of eggs. The uterus is branched (arboriform) with an axis alongside the proglottid, up to 12 primary branches coming out, and smaller, dendritic ramifications arising from the primary branches (Soulsby, 1982; Pawlowski, 2002).

Ova of *Taenia* species are spherical, yellowish brown and measure 26 – 34 µm in diameter (Fig. 2). The shell is thick and radially striated and contains an onchosphere with 3 pairs of hooklets (Schantz, 1996).

The larval stage of *T. solium* is commonly known as *Cysticercus cellulosae* (Soulsby, 1982). The morphology of the cysticercus is that of a vesicle, but at times, in the brain, this morphology can vary to irregular forms (racemose form) (White, 2000).
Cysticercosis is the disease caused by infection with the larval form of the intestinal tapeworm, *Taenia solium* (Nash, 2003). *Taenia solium* live in the small intestine of
man, the definitive host (Figure 3; note 6). The gravid segments (note 1) are very active and escape through the anus, releasing large numbers of eggs (note 1) in the peri-anal region or on the ground where they can survive for long periods. When ingested by pigs (note 2), the eggs hatch, each releasing an oncosphere which migrates through the intestinal wall and blood vessels to reach striated muscle within which it encysts forming cysticerci (formerly named *Cysticercus cellulosae*) (note 3). When raw or inadequately cooked pork infected with cysticerci, containing an invaginated protoscolex is eaten by man, the oncospheres excyst (note 4), settle in the small intestine and develop there into adult cestode (note 5) over the next 2 months (Pawlowski, 2002). The segments of *T. solium* are somewhat less active than those of the beef tapeworm but its eggs, if released in the upper intestine, can invade the host (auto-infection), setting up the potentially dangerous larval infection known as cysticercosis in muscle, of any other site. (Peters and Gilles, 1995).

Both humans and pigs are necessary to complete life cycle of *Taenia* (Peters and Gilles, 1995). It has been reported recently that dogs can be an important source of taeniosis in humans in areas where dog meat is consumed by human beings (Ito et al., 2002). Human being may also act as an intermediate host when one ingests the parasite eggs in contaminated food or from dirty hands (Soulsby, 1982). Eggs ingested by the intermediate hosts usually contain oncospheres. The oncospheres then hatch out in the duodenum, pass into the intestine where they penetrate the intestinal wall and are then carried by the circulation to be deposited in tissues (usually muscle). There they develop into cysticerci larvae which are white and ovoid, measuring approximately 8 x 5mm (Soulsby, 1982). The fully developed cysticercus measures up to 20 by 10 mm and is infective after about nine to ten
weeks. Pigs can harbour thousands of these cysts making the pork from these animals unsafe to eat (Phiri et al., 2003). The life cycle of *Taenia solium* is summarized in Fig. 3.

---

**Figure 3: Taenia solium life cycle**

Source: www.dpd.cdc.gov/dodx
2.3 Taxonomic Status of *T. solium*

The origin and taxonomics of tapeworms still remain a controversial issue. According to recent systematics, there are two major subclasses of tapeworms: *Cestodaria* and *Eucestoda*. *Taenia solium* belongs to the subclass, *Eucestoda*, order, *Cyclophyllidea* and family *Taeniidae* (Pawlowski, 2002). The family *Taeniidae* comprises 11 genera of small to large sized tapeworms. They have a holdfast organ—the scolex—and an elongated-segmented tape-like body. Each segment has intricately developed sexual organs but does not have an alimentary canal. The genus *Taenia* has about 20 species; important among these are *T. solium* (pork tapeworm), *T. saginata* (beef tapeworm), *T. hydatigena* (canine tapeworm) (Pawlowski, 2002).

2.4 Morphological Differences Between *T. solium* and *T. saginata*

Several morphological abnormalities of the strobila or individual proglottids of *T. saginata*, and less frequently *T. solium* adult tapeworms have been noted, often giving rise to taxonomic confusion in the past. The taxonomic revision of genus *Taenia* recognizes only two species of *Taeniidae*, namely, *T. solium* and *T. saginata* as capable of parasitizing the human intestines (Pawlowski, 2002). The so called Asia *Taenia*, first described in 1980s in Taiwan, was initially proposed to be new species but is now accepted to be a subspecies of *T. saginata*, namely *T. saginata asiatica* (Pawlowski, 2002). The differences between scolices of *T. solium* and *T. saginata* were recognized as early as the 17th century. *T. saginata* (the ‘beef’ tapeworm) does not cause human cysticercosis, while *T. solium* (the “pork tapeworm”) does (Peters and Gilles, 1995). The *T. solium* scolex is armed with small and large hooks.
alternately arranged around the rostellum, while *T. saginata* scolices are not armed with hooks (Keeseon and Han-Jong, 2001). *Taenia solium* is morphologically similar to, but smaller than, *T. saginata* with the body length ranging between 2 and 4 m. The internal structures of *T. solium* can easily be seen owing to a thin muscular layer that is rather transparent compared to that of *T. saginata*. The structure of mature proglottids is quite similar to that of *T. saginata* except the following points:

- The number of testes, 375 to 575, is far less than of *T. saginata* which has 800 to 1,200 testes, but their distribution is wider, involving the region behind the vitelline gland.
- The cirrus sac of *T. solium* is so large that it reaches the excretory canal, while that of *T. saginata* is small and doesn’t reach the secretory canal.
- The ovary in *T. solium* is divided into three lobes, while that of *T. saginata* is in two lobes.
- The vagina does not have a sphincter, while that of *T. saginata* does.
- The uterus has fewer lateral branches but more secondary and tertiary branches than that of *T. saginata*.
- Each *T. solium* proglottid has fewer eggs, about 40,000 on the average, while those of *T. saginata* have about 80,000 eggs (Soulsby, 1982; Pawlowski, 2002).

### 2.5 Economic Burden

Porcine cysticercosis rarely causes symptoms in infected animals but has an important economic impact due to production losses stemming from condemnation of infected carcasses and control measures (Pawlowski *et al.*, 2005). Only a very approximate estimation of the global burden imposed by *T. solium* have been
partially evaluated in a few studies from Latin America and even fewer studies from sub-Saharan Africa and parts of Asia (Pawlowski et al., 2005). In Mexico, for instance, the annual loss due to porcine cysticercosis was estimated at US $43 million (Flisser et al., 2003), while in China, discarded pork caused a loss of approximately US $21 million per year (Ito et al., 2002). In Africa, the annual losses due to pig cysticercosis in 10 Western and Central countries amount to about US $39.2 million (Zoli et al., 2003), whereas in Eastern Cape Province of South Africa, the losses were estimated to an average of US$ 5.0 million (Carabin et al., 2006). A study by Ngowi et al. (2004) in pigs raised in Mbulu District in Tanzania found that the reduction of pork value due to porcine cysticercosis was 60%.

2.6 *Taenia solium* Cysticercosis: An Overview of Prevalence and Distribution

Taeniasis/cysticercosis caused by *T. solium*, often referred to as the pork tapeworm, is a classical zoonosis, recognized since antiquity, which, as a result of a variety of demographical, technological and political factors, has emerged as an increasingly important disease in regions where it has long been endemic, as well as in regions into which it has been imported or introduced (Schantz, 2002). *T. solium* infection is widely endemic in rural areas of developing countries in Latin America, Asia, and Africa, where poverty conditions such as poor sanitation and intimate contact between humans and their livestock are commonplace (Murrell, 2005; Pawlowski et al., 2005). Although the life cycle cannot be maintained in regions that have adequate sanitation and good animal husbandry practices, developed countries are vulnerable, owing to immigration of people from highly endemic regions carrying infections of the adult stage. Such introduced infections account for an increased
global distribution to non-endemic areas such as the United States of America and Europe. These human carriers can contaminate the environment, leading to secondary infections (Murrell, 2005; Pawlowski et al., 2005). For example, it is estimated that the movement of people in both directions across USA-Mexico border exceeds 200 million persons per year (Flisser et al., 2004), and human cysticercosis is now emerging as a problem in USA (Schantz et al., 1998).

2.6.1 America

Published reports document the occurrence of clinical neurocysticercosis (NCC) in most of the countries of the Americas (most notably Mexico, Guatemala, El Salvador, Honduras, Colombia, Ecuador, Peru, Bolivia and Brazil). The infection was reported to be present in 18 countries of South and Central America whose combined populations represented 94% of the total population of the Latin American countries (Schantz, 2002). Studies indicate that the incidence of porcine cysticercosis is quite alarming (Flisser et al., 2004). In some regions, between 15 and 60% of the pigs kept in traditional systems have antibodies against the parasite, indicating that they have been in contact with it during their lifetime (Flisser et al., 2004).

Porcine cysticercosis is also frequently found at meat inspection in the abattoirs of Latin America but again these data are thought to be conservative indicators since ostensibly infected pigs (often identified by simple lingual palpation) are usually not taken to the slaughterhouse, but slaughtered elsewhere (clandestine marketing) (Gonzales et al., 2003). In the Republic of Peru, where infection rates in pigs vary from 14 to 25%, virtually no recognized infected pigs are processed at local slaughterhouses. In Bolivia between 1.4 and 2% of the people in rural areas have the
T. solium parasite in their intestines; and this is considered to be a serious public health problem (WHO, 2002). Of the American countries, only Canada, the United States, Argentina and Paraguay appear to be free of the transmission in the pig-human cycle. However, these latter countries are observing an increase in imported and introduced infections related to immigration and travel of persons from neighbouring countries where T. solium infection is endemic (Schantz, 2002). A retrospective analysis of hospital records (1995-2000) in Oregon in the USA revealed 89 hospitalizations due to cysticercosis, five of which occurred in people who had not travelled or lived outside the United States (Engels et al., 2003).

In California, over a 12-year period (1989-2000) a total of 124 cysticercosis deaths were identified, representing a death rate of 3.9 per million population; the large majority were foreign born, predominantly from Mexico (Dorny et al., 2003). However, nearly 14% of deaths were among people born in the United States, some of whom may have had autochthonous infections, although travel-related exposure cannot be ruled out as a source of infection. No information is available concerning the occurrence, or absence, of infection in Guyana, Suriname and French Guiana (Schantz, 2002).

### 2.6.2 Europe

Neurocysticercosis is infrequently encountered in most of Europe. However, owing to increased immigration and travel, T. solium cysticercosis is likely to be diagnosed with increasing frequency and there is evidence that in some regions in Europe T. solium infection can be acquired locally; a recent survey revealed that out of a total
of 45 cases of neurocysticercosis diagnosed between 1996 and 2000, 11 were autochthonous cases (Overbosch et al., 2002).

2.6.3 Asia

In Asia this zoonosis has been known to occur for several hundred years, but until recently, it has not received much attention; consequently, epidemiological information for the region is not extensive (Rajshekhar et al., 2003).

*T. solium* taeniasis and cysticercosis is common in the Republic of Indonesia (Simanjuntak and Widarso, 2004). Very high prevalence in the Wissel lakes area in western Irian Jaya has been associated with an "epidemic" of epilepsy and burns. The prevalence of *T. solium* infections is also high in Bali. Serosurveys in Irian Jaya using immunobLOTS revealed an 8 to 10% prevalence rate; approximately 2% of 548 examined persons had demonstrable taeniasis, half of whom were diagnosed as *T. solium*. Studies in Irian Jaya indicate that the majority of people with epilepsy harboured *T. solium* cysticercosis (Rajshekhar et al., 2003).

Cysticercosis is prevalent in nearly all of the Republic of India, particularly in the north (Rajshekhar, 2004). Significantly, neurocysticercosis accounts for 8.7 to 50% of patients with recent onset of seizures. The peculiarity of the disease in the Republic of India is the high incidence of patients with the solitary form of the disease (solitary cysticercosis granuloma). It is estimated that 60 to 70% of Indian patients with neurocysticercosis have a solitary cysticercosis granuloma. The prevalence of taeniasis is reported to be between 0.5 to 2%, although surveys in Uttar Pradesh found 38.7 percent of people in a pig rearing community had taeniasis (Rajshekhar, 2004).
T. solium infections have also been reported from the Kingdom of Thailand, the Republic of Korea and are sporadically reported in the Taiwan Province of China. A recent assessment of the cysticercosis situation in the People's Republic of China revealed that human cases of taeniasis and cysticercosis were found in 29 Provinces, municipalities and autonomous regions, with five particularly endemic zones (Chen and Zhou, 2004). The average incidence of T. solium taeniasis in the regions surveyed range from 0.05 to 15%, while the number of people with cysticercosis was estimated at 3 to 7 million. In the endemic areas, pig cysticercosis varied from 0.4 to 15%, and occasionally up to 40%.

Willingham et al. (2003) concluded that human cysticercosis is a serious health problem in Vietnam. One detailed human cysticercosis community-based study has been published, confirming the suspicion of an important focus in two rural communities (mountainous and coastal areas) (Somers et al., 2006). Reports on taeniasis show that circulating cysticercus antigens, suggesting active infection, were detected in 5.3% and 0.6% of the sampled individuals from the mountainous and coastal regions, respectively (Somers et al., 2006). Taenia copro-antigens were found in 0.3% and 1.8% of the stool samples from the mountainous and coastal communities, respectively (Somers et al., 2006). An analysis of secondary data of porcine cysticercosis in Hanoi slaughterhouses revealed that out that of 2,091,000 examined pigs 836 were infected making the overall prevalence 0.04% (Rajshekhar et al., 2003).
2.6.4 Africa

2.6.4.1 Other countries

In Africa, _T. solium_ is transmitted throughout most of the continent with the exception of the strictly muslim areas of North and sub-Saharan Africa (Schantz, 2002). Infections have been reported in several countries including Nigeria, Benin, Cameroon, South Africa, Tanzania, Kenya, Uganda, Zimbabwe, Zambia, Mozambique, Burundi, and Madagascar (Phiri _et al._, 2003). Data from West and Central Africa suggest that investigations of human cysticercosis based on the prevalence observed in the pig population often underestimate true transmission rates but that there are regions of hyperendemicity (hyperendemic prevalence indicates a constant occurrence of the disease at a high transmission level). The high prevalence of pig cysticercosis should be expected to be accompanied by obvious and frequent _T. solium_ tapeworm infections in man. A similar pattern is seen in Eastern and Southern Africa, where the prevalence in pigs is reported to range from 20 to 40 percent and human cysticercosis ranges from 10% to 41% (Mafojane _et al._, 2003).

The incidence data in humans are very limited owing to a lack of adequate surveillance, monitoring and reporting systems, although the recognition of its status as a serious and emerging threat to public health is increasing. Concern is growing in Eastern and Southern Africa that the rapid expansion of pig farming and pork consumption will exacerbate the problems with _T. solium_ cysticercosis; since 1961 the pig population in the countries of Uganda, Tanzania, Kenya, Zambia, Zimbabwe, and Mozambique has increased nearly threefold (in Uganda over six fold) (Phiri _et al._, 2003) (Figure 4).
2.6.4.2 Mozambique

In Mozambique, it is very difficult to evaluate the prevalence of porcine cysticercosis because on one hand the slaughter and meat inspection practices do not exist in many rural areas or unreliable data are reported (Phiri et al., 2003). On the other hand most of pigs raised in typical poor rural areas are slaughtered and consumed at the homestead of the pig owner and a substantial amount of pork may be sold without inspection (Phiri et al., 2003). It is important to note that cases of porcine cysticercosis detected in official abattoirs represent a significant underestimate of the true prevalence of porcine cysticercosis in endemic countries (Phiri et al., 2003).

Data for cysticercosis is rather scanty in Mozambique, however abattoir records indicates that the disease is present in all Provinces of the country (Afonso et al., 2001). A seroprevalence study in 11 districts of Tete Province showed that 15 of 387 pigs were seropositive with prevalence by district ranging between 6.5% and 33.3% using an antibody detecting ELISA (Afonso et al., 2001).
Serra (1968) reported the first post-mortem case of neurocysticercosis (NCC) in Mozambique, while the first clinical case of NCC was reported at Maputo Central Hospital in 1999 (Santos et al., 1999). In a cross-sectional sero-epidemiological study in humans conducted in Tete City, 32 out of 157 sera (20%) from presumed epileptic cases were found positive by antibody-ELISA (Vilhena and Bouza, 1994). Another study on epileptic patients conducted in northwest Tete Province found that 14 out of 80 (17.8%) were positive for cysticercosis by antibody-ELISA testing (Mafojane et al., 2003). A similar serological survey conducted at Maputo’s Central Hospital found seropositivity rate of 12.1% (59 out of 489 patients with epilepsy) (Vilhena et al., 1999).

2.7 Risk Factors for the Transmission of *Taenia solium*

The occurrence of *T. solium* is associated with certain risk factors. Some risk factors or their interactions are specific for the occurrence of porcine cysticercosis, human taeniosis or neurocysticercosis. Absence of latrine in households has been reported as risk factor for the occurrence of porcine cysticercosis (Ngowi et al., 2004). Free ranging pigs is likely to facilitate the transmission of porcine cysticercosis by access to human faeces that are randomly disposed in the environment, especially in areas where latrines are not available, are not used or are poorly constructed (Ngowi et al., 2004), use of pigs to scavenge and eat human faeces (“sanitary policeman”); deliberative use of human faeces as pig feed; connection of pig pens to human latrines (“pig sty privies”); use of sewage effluent, sludge or “night soil” to irrigate and/or fertilize pig pastures and food crops; involvement of humans carriers in pig rearing and care (Eddi et al., 2000). The prevention of free ranging and scavenging can be very effective in interrupting the transmission of *T. solium* to pigs. Among
humans, tapeworm carriers are potential sources of contagion to themselves and to those living in their close environment (Eddi et al., 2000).

2.8 Clinical Signs

Porcine cysticercosis is usually without conspicuous signs but intracranial involvement is not uncommon (Gonzalez et al., 2003). A pig with numerous cysts (over 400) in the brain from Mbulu District in Tanzania was observed to be frequently circling (Boa et al., 2002). In man the cysts lodge in the brain, muscles, subcutaneous tissue and the eye. Cysts in the brain often lead to epileptic seizures while those in the eye may lead to visual loss. Neurocysticercosis (NCC) has been shown to cause arachnoiditis, hydrocephalus, stroke, dementia and numerous other neurological problems (Del Bruto et al., 2001). In human symptoms such as abdominal pain, distension, diarrhoea and nausea have been attributed to the tapeworm infestation, but, there are no controlled studies that have demonstrated their association with human taeniosis (Schantz et al., 1998).

2.9 Diagnosis

In endemic countries porcine cysticercosis is commonly diagnosed by tongue examination, which is very specific but has low sensitivity (Gonzalez et al., 1990), resulting in a serious underestimation of the true prevalence (Phiri et al., 2006). In Peru, Gonzalez et al. (1990) studied 77 pigs from Huancayo an endemic area for cysticercosis. By using the tongue examination technique, 23.4% of the pigs were found positive, while by necropsy 31.2% were positive and 51.9% by the enzyme-linked immunoelectrotransfer blot (EITB) test. Calculated sensitivity of tongue examination, Ab-ELISA and EITB were 70%, 79.2%, and 100% respectively. While
the specificities were 100% for lingual examination, 76.2% for Ab-ELISA, and 100% for EITB. Tongue examination, although specific, is only moderately sensitive, requires highly trained person, is time-consuming and there is a risk of being bitten. However, it is relatively inexpensive and gives immediate results. The enzyme-linked immunoelectrotransfer blot, is highly specific, and is more sensitive than necropsy or tongue examination. Therefore, it is most suited for use in field surveys. Pork inspection is of limited use for epidemiological studies, because in endemic countries most pigs are killed at unofficial slabs on a pre-purchase order basis (The Cysticercosis Working Group in Peru, 1993).

Antibody detection methods have important drawbacks in clinical settings since they may indicate exposure to the infection rather than presence of viable infection and antibodies may persist long after the parasite has been eliminated (Dorny et al., 2003). Additionally, maternal antibodies transferred through colostrum may persist for most of the pig’s life and therefore limit the use of these techniques in endemic areas (Gonzalez et al., 1999). Antigen detection techniques have been developed and provide a useful tool in identifying individuals with active infections and therefore a tool for serological monitoring of anti-parasitic therapy (Dorny et al., 2003).

2.10 Control of Porcine Cysticercosis

Theoretically, considering the biology of *T. solium* transmission and reservoirs, global eradication of *T. solium* and cysticercosis is feasible (Pawlowski et al., 2005). In most industrialized countries it was eradicated following improvements in sanitation, properly maintained commercial piggeries and functional slaughterhouse control (Verastegui et al., 2003). However, in developing countries cysticercosis
remains highly endemic, with seroprevalences of up to 25% in humans and 50% in pigs in rural areas (Ngowi et al., 2004; Sikasunge et al., 2007).

Recently much progress has been made in research on treatment and prevention of porcine cysticercosis, although more operational research is still needed (Pawlowski et al., 2005). Several groups are working on the development of vaccines against porcine cysticercosis (Flisser et al., 2004), but an effective one has not yet been commercialized. Additionally, successful treatment of pigs with inexpensive, effective drugs has been achieved (Gonzalez et al., 2001). For instance, the use of oxfendazole as a single-dose has demonstrated to be an effective therapy for porcine cysticercosis by protecting treated pigs for at least three months after therapy. However, there are some minor drawbacks since some cysts may survive in the pig’s brain after treatment, and infected meat in treated pigs needs at least eight weeks for all the cysts to degenerate and up to 12 weeks to achieve a clear, acceptable appearance for human consumption (Gonzalez et al., 2001). Nevertheless, this treatment provides a new control tool in field conditions and is a potentially beneficial option to prevent this zoonosis, and reinforce control programs in *T. solium* endemic areas and to give rural farmers access to commercial markets with better prices for their animals.

In spite of this, global eradication of *T. solium* infection is still unlikely in the near future. Major obstacles to practical implementation of control measures include low levels of sanitation and health education amongst endemic populations, ineffective health services infrastructure and inadequate socioeconomic development in these areas (Engels et al., 2003; Pawlowski et al., 2005). Efforts to educate villagers at
schools, village meetings, and on an individual basis have been highly successful in terms of teaching villagers the parasite live cycle and the connection between infected pigs and themselves, or others getting cysticercosis (Gonzalez et al., 2003). Farmers should be informed of the risks associated with allowing pigs to have access to human faeces, and the use of human sewage for fertilization and/or irrigation of pasture, and they should be instructed on the benefits of providing effective toilet facilities for their own and worker's families (Kyvsgaard and Murrell, 2005). Therefore, they should be convinced of the importance of: (i) having all cases of taeniasis reported and properly treated; and (ii) using effective toilets when available or, if not available, avoiding defecation in places either directly accessible to susceptible animals or with potential for contaminating animal feeds (Kyvsgaard and Murrell, 2005). Pig owners should be informed of the life cycle and the health risks to their families and to the consumers of the meat they produce. They should also be informed of the economic implications (possible closure of their small business by the health authorities and the loss of customers). Sometimes the best way to involve these animal owners is through their children, who can be taught the life cycle of these parasites and the means to prevent infection at school (Kyvsgaard and Murrell, 2005).

2.11 Pig Production Systems in Mozambique

In Mozambique more than 90% of pigs belong to smallholder farmers, characterised by low levels of investments, productivity and limited access to veterinary and extension services (Penrith et al., 2007). There is still scarce information about pig production system in Mozambique. A study conducted in Angónia and Boane Districts by Dias (2005) indicated that in Angónia about 68% of smallholder farmers
keep their animals under free range system, 20% in total confinement, and 5% seasonal confinement, while in Boane 19% of the farmers keep their animals under free range, 72% in total confinement and 0% seasonal confinement.

In Angónia, pigs of local breed are farmed in traditional systems, spending most or all of their time at free roaming searching for their own food, with some supplementation by the owners, particularly when confinement of pigs is required to protect the crops. The smallholder farmers in Angónia feed some maize bran to the pigs, and a variety of other supplements including forage, crop gleanings, and kitchen waste (Dias, 2005). In Boane, the great majority of pigs are permanently confined, and many of the pigs are cross-bred or modern breeds. Basic feed consist of maize or wheat bran, supplemented with forage, crop gleanings, and pumpkin, and a few owners use waste products (begasse) that resulted from industrial or home processing (Dias, 2005). In Gorongosa District, central part of the country, where pig production is practiced almost totally by the small holder farmers, in many situations they don’t invest money in housing and equipment for the pigs.

The common attitudes is the use of local materials, such as vegetal materials locally available for building small and restrict cages with capacity to keep an average of not more than two or three pigs of a maximum of about 100 kg (Dias and Kamba, 2001). Usually the constructions do not have a roof, but in event of having, it is commonly made by straw. In some cases, the cages are built under trees, or under the family granary. The equipment, such as feeders, are made by local materials such as tree bark (Dias and Kamba, 2001).
Regarding the types of animals produced in Gorongosa, it is difficult to identify exactly the dominant breeds, but it seems that the majority of pigs belong to Landim group characterised by completely black skin, or black with white spots skin (Dias and Kamba, 2001). In feeding aspects, there are differences depending in each region of the district. There are regions within the district where pigs are not given any supplements to the basic feed. These animals are kept free, grazing in the fields earlier used for maize and sorghum crops. There is a period of the year in which pigs are kept permanently in cages, to avoid the invasion of cultivated fields. During this time animals are fed maize and sorghum skim and several kind of vegetable, like cocked or crude pumpkin. In Gorongosa town, the pigs are kept in permanent captivity due to the control made by the authorities and because the holder is more aware of theft (Dias and Kamba, 2001).

### 2.12 Pig Marketing Channels

Pig marketing is among the most important components especially for smallholder farmers compared to other classes of livestock. Various studies involving smallholder farmers have indicated that pigs are mainly kept for income generation through selling of pigs (Ngowi, 2005). Many countries in Southern Africa have both formal (regulated) and informal (unregulated) livestock marketing systems. Unregulated or informal marketing systems refer to systems in which government do not substantially intervene, either directly through trading or indirectly through regulation (Mbogoh, 2008) and in official or regulated marketing system, the government, has, or should be in a position to intervene (Evans, 2008).
Marketing systems vary from country to country. For instance, in Vietnam as the majority of pig farmers raise few pigs, the marketing systems assemble pigs from a large number of small-scale farms (Tung et al., 2005). Pig farmers use two marketing channels: sale to assemblers and sale to slaughterhouses, of which the former is the most common. Assemblers are individuals specialized in the collection of fattened pigs from farmers and their onward sale to larger assemblers or slaughterhouses (Tung et al., 2005). Based on output channels, pig slaughterhouses in Vietnam belong to one of three categories: slaughterhouses selling both wholesale and retail (70%), slaughterhouses selling only wholesale (24%), and slaughterhouses only selling to end consumers (6%) (Tung et al., 2005).

In Nigeria, most of the traded pigs brought to the markets are from pig farmers. At village levels, itinerant traders visit the homes of pig farmers to buy pigs in small numbers such as one or two (Ajala and Desehinwa, 2007). They are then sold at local village markets to intermediate traders who are assemblers with more funds and capacities for bulking larger numbers. These intermediate traders visit similar smaller markets, and gradually build up a herd for live sale in the urban market (Ajala and Desehinwa, 2007). Traders themselves rarely own vehicles for transportation; they use the services of other transporters. Between the farmers’ homesteads and the immediate local village market, animals are trekked.

Transportation of pigs to subsequent markets is usually by trucks of varying sizes and capacities depending on distance and number of animals involved. In some cases pigs are trekked from neighbouring villages directly to the markets. Two principal buyers in the urban market are wholesale traders who take animals to the cities and
the local butchers (retailers) who slaughter for fresh pork sales in open markets both in urban and in the neighbouring villages (Ajala and Desehinwa, 2007). In addition to these, some traders buy for resale either immediately or after some minor fattening operations. Direct purchases by some hoteliers/restaurateurs for slaughtering also occur. Some pork consumers purchase pigs cooperatively for slaughter and distribute among the group members (Ajala and Desehinwa, 2007).

A study done by Dias and Kamba (2001), in Gorongosa District, central region of Mozambique, showed that there was no market for live pigs, and local slaughter and sell of pork was very rare. Local pig producers preferred to produce the pigs for sale whether to traders, or directly to markets in Beira city. The traders also sold the pigs away from the district, preferably in Beira city, where it was possible to fetch reasonable prices (Dias and Kamba, 2001). These traders were normally resident in Gorongosa, and choose two or three days of the week to travel with the animals to Beira, taking ten to fifteen pigs each time. The traders purchased the pigs directly from the producers (Dias and Kamba, 2001).
CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Study Area

The study was carried out in Angónia District. Angónia is located in north-western Mozambique, between latitude 14° 46’S and longitude 34° 45’E, bordering Malawi to the North and East. The district is characterized by a humid climate that receives an annual rainfall ranging between 1100 and 1200 mm. The rainy season extends from about October to mid-March and the dry period extends from April to September. Relative humidity is about 70% and mean annual temperature ranges from 18° to 22°C. The total number of households in the district is 1080 and pig population is 3500 animals (Direcção Distrital de Agricultura de Angónia, 2006, census performed in 2006). The district inhabitants are mainly of Chewa ethnic group and occupy mostly highland areas and practice mixed peasantry farming.

Pigs are raised in many homes as a source of household income and animal protein. Few farmers house their pigs. Animals are housed when there are crops in the fields; and fed on cut grass, kitchen leftovers, sweet potato leaves, and maize bran. However, after harvest, very few farmers house their pigs permanently and animals are usually allowed to graze freely. Slaughtering of pigs takes place mostly at home and the meat is consumed locally or transported to markets where inspection may or may not take place. Besides pig farming, villagers raise cattle, goats, and chickens. All places in the study (markets, inspection facilities, butchery, etc.) were geocoded using a hand-held Global Positioning System (GPS) receiver.
Figure 5: Map showing the study area (Angónia District) in Tete Province, Mozambique
Figure 6: Angónia District showing pork marketing places
3.2 Study Design

3.2.1 Determination of the prevalence of porcine cysticercosis in slaughtered pigs during meat inspection

A cross-sectional study design was employed to determine the prevalence of porcine cysticercosis in slaughtered pigs during routine meat inspection. Ulôngue town, a major pig carcass inspection point was selected in the district based on a reasonable number of carcasses inspected per day (up to 5) and reliable inspection. Data was collected using census of all pig carcasses going through the meat inspection point over a 3-months period. A total of 205 carcasses were registered and inspected. A ledger was prepared and used to register information regarding to all cysticercosis post mortem inspection findings, residence of the trader, and origin of the pigs. The meat inspector of the place was trained on how to use and fill in the ledger. The routine meat inspection was evaluated by total dissection of 30 meat inspected carcasses (including heads), purchased at random in the meat inspection place. The meat dissection was performed as described by Phiri et al. (2006), with slight modifications. The muscle groups were excised from the left half carcasses together with the complete heart, tongue, and head, psoas muscles, glutæus muscles, triceps brachii muscles, diaphragm, lungs, liver, and brains. Slicing was done in such a way that all fully developed cysts could be revealed (Phiri et al., 2006). The total number of cysticerci for those muscle groups where cysts were only counted in half of the carcass was calculated by multiplying the detected unilateral number by two (Dorny et al., 2004).

In the head, two longitudinal incisions were made into the external masseter muscles and one incision into the internal masseter muscles on both sides of the lower jaw and the presence of the cysts was noted (Phiri et al., 2006). The pig head was opened
to access the brain where the presence of cysts was checked. The tongue was
detached from the head, the surface inspected and several deep longitudinal incisions
were made on the ventral surface, covering the entire length of the tongue, and
examined. After visual examination, the heart was incised into both ventricles and
septum followed by visual inspection. Several deep incisions were done through the
*triceps* muscles into the shoulder and the incised surface inspected. Both psoas
muscles were incised longitudinally and examined for the presence of cysticerci. All
the muscles and organs were sliced to visualize the cysts (i.e. each slice was about
0.5 cm thick) (Phiri *et al.*, 2006). All cysts in predilection sites were enumerated.

### 3.2.2 Production systems, marketing channels and risk factors

#### 3.2.2.1 Sampling procedures

To describe the production systems and to assess marketing channels and risk factors,
a cross-sectional study using structured questionnaires and direct observation was
carried out to collect data from all levels involved in the production and marketing
chain namely; farmers, intermediary level (i.e. retailers) and terminal level (slaughter
slabs). In this study, sampling units were farmers, retailers, and meat inspection
points (appendixes 1, 2, and 3).

**Farmers**: Simple random sampling of farmers as the sampling frame was done using
the village register of farmers. The required sample size for farmers was 126 from 9
selected villages.

**Retailers/Traders**: Pre-survey was carried out in different marketing places of the
district aimed at establishing pig/pork marketing trader population number. A total of
47 traders were found and all were included in the study. This is in accord with
Alreck and Settle (1985) who recommends that ten percent of the total population or 30 respondents is reasonable and representative sample where statistical analysis is to be done.

**Staff at meat inspection points:** All responsible staff for pork inspection in places where meat inspection was done was included in the sample.

Furthermore, qualitative methods of data collection involving participation of farmers, pig traders and other key informants were used to obtain more information about pig/pork marketing. Group discussion and key informants interviews were conducted to collect data and answer research questions. Four groups of nine farmers and two composed by ten traders each were formed and interviewed. Pig raisers and traders were grouped as different categories at the village level and interviewed separately. Each farmer group discussion included three women and six mans. Data was obtained by using designed checklists (appendix 4), which guided the discussion and the interviews. Key informants in this study included the village government leaders. The principal moderator of the discussions was the researcher, and the interviews were conducted by the researcher and with local veterinary technician.

### 3.2.2.2 Data collection

For marketing channels, collected information included the source of pigs and its final destination (final customers). For risk factors recorded data included awareness of porcine cysticercosis, destination of infected pig/pork and pork inspection.

Before data collection, the questionnaires were translated from English to Portuguese and back to English by an independent interpreter and pre-tested to check any inconsistence in the wording of items to ensure clarity and comprehensiveness.
3.3 Data Analysis

3.3.1 Determination of prevalence in slaughtered pigs by meat inspection

Collected data were entered and cleaned in Microsoft Excel, then exported to designated SPSS® and Medcalc® analytical software for analysis. Prevalence at 95% confidence interval (CI) was calculated using the formula by Friis and Sellers (1999):

$$ p = \frac{\text{Total number of disease cases}}{\text{Total number of pig carcasses inspected or dissected}} \times 100\% $$

McNemar’s exact test was employed to determine the significance difference between meat inspection and meat dissection prevalence. The 0.05 level of significance was used for the judgment. Kappa statistic test at 95% CI was performed to compare the agreement between meat dissection and meat inspection tests for detection of porcine cysticercosis. Kappa statistic is given by the formula (Woodward, 2004):

$$ K = \frac{(P_o - P_e)}{(1 - P_e)} $$

Where:

$ P_o $: Observed proportion of agreement

$ P_e $: Proportion expected by chance

3.3.2 Production systems, marketing channels and risk factors

After data entry in Excel and exporting to SPSS® software for analysis, descriptive statistic was performed to summarize the information related to each variable. The distributional proprieties were analysed by use of frequency distribution, percentages, mean, standard deviations and charts. Components of verbal discussion
held with key informants and focus group discussion were analyzed in detail with the help of content analysis method. In this way the recorded dialogue with respondents was broken down into smallest meaningful units of information or themes to ascertain values and attitudes of respondents.

3.4 Ethical Consideration

Before the research started the proposal was submitted to and approved by the ethical and scientific committee at Veterinary Faculty of Eduardo Mondlane University, Mozambique for ethical clearance.

The aim and benefits of the study were explained to the key community leaders and participants in the study area.

3.5 Limitations of the Study

The encountered problem during research was the limitation of literature on pig production systems and marketing reflecting Mozambique situation. Hence, the author used mostly general literature on pig production systems and marketing. Web based information was also sought. One of the objectives of this study attempted to understand the marketing chains of pigs/pork in Angónia, but it had some limitations in some marketing questions directed to farmers where low rate of response was verified.
CHAPTER FOUR

4.0  RESULTS

4.1  Determination of Prevalence by Meat Inspection in Angónia District

Two hundred and five pig carcasses were inspected by the meat inspector in Ulóngue meat inspection premise and registered using a ledger during three months of data collection. Out of this number, eleven were positive to porcine cysticercosis, giving a prevalence of 5.4% (CI 3.02 % to 9.34%). There was a great variation in the origin of inspected pigs. Most of them (87.8%) were bought out of the location of the meat inspection premise (Vila Ulóngue) (Appendix 5). Table 1 below shows the total number of inspected pigs and positive cases per month during the period of study. December was the month with the highest number of inspected pigs (133), followed by November (45) and lastly January (27), giving a mean of 17 inspected carcasses per week.

Table 1: Cases of porcine cysticercosis from inspection premise in Angónia District, from November 2007 and January 2008.

<table>
<thead>
<tr>
<th>Month</th>
<th>Carcasses examined</th>
<th>Positive cases</th>
<th>% Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>November</td>
<td>45</td>
<td>5</td>
<td>11.1</td>
</tr>
<tr>
<td>December</td>
<td>133</td>
<td>4</td>
<td>3.0</td>
</tr>
<tr>
<td>January</td>
<td>27</td>
<td>2</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>205</strong></td>
<td><strong>11</strong></td>
<td><strong>5.4</strong></td>
</tr>
</tbody>
</table>
4.2 Comparison of the Two Diagnostic “tests”: Meat Inspection and Detailed Meat Dissection

A total of 30 randomly purchased carcasses were inspected by the meat inspector using the normal procedure and dissected by the researcher. For the meat inspector, seven of thirty carcasses were found infected with cysticerci of *T. solium*, giving a prevalence of 23.3% (Table 2). Cysticerci were found in eight of the thirty slaughtered pigs by detailed meat dissection, giving the prevalence of 26.7%. The 95% prevalence CI for meat dissection ranged from 11% to 42.3%, and for meat inspection was 8%-38.4%. McNemar’s exact test detected no significant difference (p=1.0) between meat dissection and meat inspection prevalence. The difference was 3.3% and the 95% CI of the difference ranged from 7.7 to 8.9%. Agreement statistic test was performed to test the percent agreement of both meat inspection and meat dissection (n=30). The agreement between the two methods was 73.4% (95% CI: 44.8 - 102%) which indicates fair to good agreement.

Table 2: Measure of agreement between meat inspection and meat dissection for detection of porcine cysticercosis

<table>
<thead>
<tr>
<th>Meat Inspection</th>
<th>Meat dissection</th>
<th>Apparent prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Positive 6</td>
<td>Negative 1</td>
</tr>
<tr>
<td>Negative</td>
<td>Positive 2</td>
<td>Negative 21</td>
</tr>
<tr>
<td>Total</td>
<td>Positive 8</td>
<td>Negative 22</td>
</tr>
</tbody>
</table>

Odds ratio for meat inspection as gold standard test for cysticercosis detection method was 83.7% (95% CI 0.26 to 2.7) which indicates less likely to detect the
cysts than meat dissection. However, there was no significant differences between the odds ratios (p=0.76).

### 4.3 Distribution of Cysts of *T. solium* in Pig Carcasses

The distribution of *T. solium* cysts in the individual pig carcasses is shown in Appendix 6. Cysts were frequently localized in gluteal muscles (*M. gluteus*), triceps muscles (*M. triceps brachii*), psoas muscles (Fig. 7), heart, masseter muscle, tongue, brain (Fig 8) and diaphragm. Cysts were not found in kidneys, and lungs of all 30 carcasses dissected. The total number of cysts in carcasses was found to be ranging from 1 to 429 cysts. From the 30 carcasses purchased, three (10%) carcasses had moderate to high infestations (above 100 cysts) with 104, 119, and 429 cysts respectively, and five (16.6%) had light infestation with 8, 20, 58, 65 and 67 countered cysts. No cysts were found in twenty two (73.3%) carcasses.
Figure 7: *Taenia solium* cysts in psoas muscle (arrows heads)

Figure 8: *Taenia solium* cysts in the brain (arrows heads)
The differences in cysts number count in different organs and muscles are shown in Figure 9. Gluteus muscles showed the highest number of cysts, followed by Triceps brachii, and Psoas. The total number of cysts in these muscles was 230, 218, and 192 respectively. Gluteus muscles showed the high percentage distribution of cysts, (26.4%), followed by Triceps brachii (25.1%), psoas (22.1%), masseter (10.8%), diaphragm (6.1%), heart (4.9%), brain (3.0%), and lastly tongue (1.6%).

![Figure 9: Distribution of cysts in different muscles and organs](image)

4.4 Production Systems

4.4.1 Herd size and pig breeds

A total of 126 small holder farmers were randomly selected in the district. Of the 126 respondents, the minimum pig number per herd was 1 and the maximum was 15 animals. The mean number of animals per herd was 4.7 (standard deviation: ±3.49).
Most farmers were keeping one to two pigs (42%) whereas only 0.8% had herds of fourteen or fifteen pigs (Fig. 10). All respondents (100%) were keeping local or native pig breed, i.e. the Landim breed. From visual observation these pigs are black in colour or white with black spots, small, with a big head implanted to the body by a short neck. The snout is narrow and long, and the ears are small and upright. The body is thin, with long legs.

![Figure 10: Total number of pigs in the herd in Angónia District](image)

### 4.4.2 Housing facilities and equipment

In many situations, the farmers did not invest cash money in constructing pig pens and for buying equipment for the pigs. The common characteristic was the use of local available materials for building small pig pens. Stones, wood were commonly used to construct thatched mud pens (Fig. 11) or logs/woods enclosure (Fig. 12). In most of cases, the roofs of these pens were commonly made by straw or polythene
sheet. In places were some equipment such as feeders were found, they were also of local material, mainly dug out tree stems (Fig. 13). Some farmers used cut old tyres as feeders.

Figure 11: Pig housing for smallholder in Angónia (Thatched mud house)
4.4.3 Feeding systems

The questionnaire based survey indicated that feeding systems for pigs in Angónia mainly consisted of local forage, kitchen leftovers and other products such as cabbage, maize bran, and sweet potato leaves (Table 3). Most farmers (97.6%) fed their animals on kitchen leftover followed by other products (73%) and local pasture (68.3%). Only one farmer (0.8%) fed the pigs with commercial ration and none was using industrial by-products as feed to pigs. Out of the farmers that used other products to feed the animals, the mostly used product was maize bran (52.4%), followed by a combination of sweet potato leaves and maize bran (3.7%), and lastly cabbage (offal from production for humans) (1.8%). In all cases, the farmers were unable to describe a standard feed quantity given to the animals per day.
Table 3: Feeding systems in Angónia District

<table>
<thead>
<tr>
<th>Feed</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>86</td>
<td>68.3</td>
</tr>
<tr>
<td>Kitchen leftover</td>
<td>123</td>
<td>97.6</td>
</tr>
<tr>
<td>Commercial ration</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Other products</td>
<td>73</td>
<td>57.9</td>
</tr>
</tbody>
</table>

4.4.4 Pig management practices

As regards to pig management practices in different seasons indicated that during the crop planting season 126 (100%) of the respondents kept their animals confined. During crop growing season most of the households (99.2%) confined the pigs, while during crop harvesting and fallowing seasons only 14 (11.1%) and 11 (8.7%), respectively, confined the animals (Table 4). During these last two periods, in most farms (88.9% and 91.3% respectively) pigs were allowed to free range (Fig. 14) and consume crop residues in the fields.
Table 4: Pig management practices in Angónia District during a typical year

<table>
<thead>
<tr>
<th>Season</th>
<th>Pig management</th>
<th>N=126</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop Planting</td>
<td>In pens</td>
<td>126</td>
<td>100</td>
</tr>
<tr>
<td>(November-December)</td>
<td>Free range</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Crop growing</td>
<td>In pens</td>
<td>125</td>
<td>99.2</td>
</tr>
<tr>
<td>(December-April)</td>
<td>Free range</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Crop harvesting</td>
<td>In pens</td>
<td>14</td>
<td>11.1</td>
</tr>
<tr>
<td>(May-June)</td>
<td>Free range</td>
<td>112</td>
<td>88.9</td>
</tr>
<tr>
<td>Fallowing</td>
<td>In pens</td>
<td>11</td>
<td>8.7</td>
</tr>
<tr>
<td>(June-October)</td>
<td>Free range</td>
<td>115</td>
<td>91.3</td>
</tr>
</tbody>
</table>

Figure 14: A pig in free range in Angónia
4.5 Pig Marketing Channels in Angónia District

From the survey carried out, Angónia District pig marketing channels comprised of: (1) pig producers, (2) pig retailers (or traders) who at same time acted as butchers, (3) and lastly the consumers. No wholesaler was participating in the channels. During the survey, 173 market participants interviewed consisted of 126 farmers, and 47 traders.

In Angónia District there was no official slaughter house for pigs and there was no market where farmers or traders bring live pigs. All pig slaughter process took place at farm level. Angónia District had twelve principal places where pork was sold, out of these, 1 official butchery and 11 markets (Table 5). There were only two official places under control of the District Veterinary Services where pork inspection takes place (Vila Ulóngue and Calio). In the ten other markets pork was sold directly to the consumers without an inspection. Respondents who conducted home slaughter were 40 (31.7%) and persons who said that the pork was not inspected were 38 (30.2%).

Of the 126 farmers, only 10 (8.1%) sold live pigs directly to the traders 9 (7.1%) sold carcasses at market. Additionally to this, the consensus from farmers’s focus group discussion was that live pigs were sold in most cases directly to the traders and home slaughtering of pigs and sale of meat locally or to nearby markets was a common practice in case of urgent need of cash. Government village leaders were asked to describe the pig and pork marketing outlets. They reported that the traders were the common buyers of live animals from the smallholders in their villages.
Forty seven (100%) interviewed traders said that they were buying the pigs from pig keepers. Pigs bought from the small pig keepers by the traders were subject to pre-purchase lingual examination in order to determine the infection status of the pigs. Traders did not buy a positive animal, and if it was positive it was immediately left with the owner (farmer). Negative pigs were slaughtered locally by the traders and transported by bicycles to the main butchery in Vila Ulóngue or Calio market where the meat inspection takes place or to one of the ten other markets where the meat was sold directly to the consumers without inspection. In the two locations where the meat inspection was done, if it was found that a pig carcass was positive for cysticercosis; the entire carcass was rejected by the inspector and was not allowed to be sold within the butchery or in the market. The traders then had their own final decision about what to do with the infected pig carcasses. The out flow of estimated number of pig carcasses sold per week in different markets or butchery is shown in Table 5 below. Out of 80 total estimated carcasses in all places, 59 were not inspected and 21 were inspected. The unknown quantities were those of home slaughter which were sold directly to the consumers at village level, representing public health risk.

The markets and butchery had different days of marketing, depending on the village area (Table 5). There were differences between the places where pork was sold. A butchery had well organized structure, and the minimum requirements facilities of hygiene. In the markets, a collection of structures were made using local available materials, and pork was sold without minimal facilities of quality control. Apart from selling meat also they sold other commodities like vegetables, local brew, and clothes.
Table 5: Pork marketing places in Angónia District

<table>
<thead>
<tr>
<th>Name</th>
<th>Setting</th>
<th>Pork inspection</th>
<th>Marketing days</th>
<th>Estimated throughput – number of animals per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiridze</td>
<td>Market</td>
<td>Absent</td>
<td>Saturdays</td>
<td>4</td>
</tr>
<tr>
<td>Dambulangondo</td>
<td>Market</td>
<td>Absent</td>
<td>Wednesdays</td>
<td>3</td>
</tr>
<tr>
<td>Chipindo</td>
<td>Market</td>
<td>Absent</td>
<td>Thursdays</td>
<td>7</td>
</tr>
<tr>
<td>Nkhame</td>
<td>Market</td>
<td>Absent</td>
<td>Tuesdays</td>
<td>4</td>
</tr>
<tr>
<td>Calio</td>
<td>Market</td>
<td>Present</td>
<td>Daily</td>
<td>4</td>
</tr>
<tr>
<td>Lifidzi</td>
<td>Market</td>
<td>Absent</td>
<td>Mondays/Saturdays</td>
<td>8</td>
</tr>
<tr>
<td>Maldeia</td>
<td>Market</td>
<td>Absent</td>
<td>Tuesdays/Fridays</td>
<td>10</td>
</tr>
<tr>
<td>Chabualo</td>
<td>Market</td>
<td>Absent</td>
<td>Daily</td>
<td>6</td>
</tr>
<tr>
<td>Vila Ulóngue</td>
<td>Butchery</td>
<td>Present</td>
<td>Daily</td>
<td>17</td>
</tr>
<tr>
<td>Chindegue</td>
<td>Market</td>
<td>Absent</td>
<td>Daily</td>
<td>3</td>
</tr>
<tr>
<td>Chimualuha</td>
<td>Market</td>
<td>Absent</td>
<td>Fridays</td>
<td>3</td>
</tr>
<tr>
<td>Mulanguene</td>
<td>Market</td>
<td>Absent</td>
<td>Wednesdays/Saturdays</td>
<td>11</td>
</tr>
</tbody>
</table>
Figure 15: Diagrammatic representation of marketing channels of pigs and pork in Angónia

Key:
- Red arrow: Risk of porcine cysticercosis pig/pork marketing channels
- Green arrow: Low risk of porcine cysticercosis pig/pork marketing channels

Marketing channels participant characteristics

The participant’s characteristics are presented in Table 6. The table shows that 51 (29.4%) of the participants did not have formal education, the figures were from 28.6 per cent among the farmers and 31.9 per cent among the retailers. Formal education was possessed by 70.5 percent of the respondents with 5.8 percent, 58.4 percent and 6.4 percent of the respondents attaining adult education, primary and basic education respectively. None went beyond basic education level. Primary education level is defined as from the first up to the fifth year of schooling, and the basic from the sixth
up to the seventh year. Adult education is provided to adult people who couldn’t attend school while they were young. Among the 126 farmers, 87 (69%) were males, and 39 (31%) were females. Of the retailers, 46 (97.9%) were males, and 1 (2.1%) was a female.

Table 6: Characteristics of market participants operating the pig marketing channels in Angónia District

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Farmers (n=126)</th>
<th>Retailers (n=47)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No formal education</td>
<td>36 (28.6%)</td>
<td>15 (31.9%)</td>
</tr>
<tr>
<td>Adult education</td>
<td>0</td>
<td>10 (21.3%)</td>
</tr>
<tr>
<td>Primary education</td>
<td>79 (62.0%)</td>
<td>22 (46.9%)</td>
</tr>
<tr>
<td>Basic education</td>
<td>11 (6.35%)</td>
<td>0</td>
</tr>
<tr>
<td>Category of respondent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>87 (69%)</td>
<td>46 (97.9%)</td>
</tr>
<tr>
<td>Female</td>
<td>39 (31%)</td>
<td>1 (2.1%)</td>
</tr>
</tbody>
</table>

4.6 Risk Factors Along The Pig/Pork Marketing Channels

4.6.1 Porcine cysticercosis knowledge and attitudes

Porcine cysticercosis is known as Massesse in Chichewa language, most of the farmers, 88 (69.8%) and all traders knew this. One hundred and two (81%) farmers said that they eat pork. However, 78 (61.9%) and 44 (93.6%) of the farmers and traders, did not know how a pig becomes infected, respectively. Farmers who didn’t know what to do with an infected pig were 87 (69%), while among 47 traders, 43 (91.4%) said that infected carcasses were returned back to the farmers and get back
their money. Four (8.6%) of the traders were using the infected meat to pay their workers in the farms.

There were only two pork inspectors in the study site, one in Vila Ulóngue butchery and the other at Calio market. Both had secondary level education and were doing pork inspection in the mentioned places, although the latter was a technician for human care services.

Interviews concerning cysticercosis knowledge showed that both were aware about the disease, but only the Ulóngue butchery inspector knew how pigs got infected.

### 4.6.2 Pig management practices

Examination of known cysticercosis prevalence risk factors showed that four households (3.2%) lacked latrines and 55 respondents (43.7%) had poor pig housing structures that allowed pigs to escape. Free ranging system was practiced by 115 (91.3%) respondents during the non-cropping season.
5.0 DISCUSSION

5.1 Prevalence by Meat Inspection In Angónia District

The results from this research showed that only eleven positive carcasses for porcine cysticercosis were detected out of two hundred and five inspected and registered pig carcasses during the study period in Angónia meat inspection premise, giving a prevalence of 5.4% (CI 3.02% to 9.34%). This figure is slightly low compared to the recent study done in the same district, where the reported prevalence through tongue palpation for cysticercosis detection at household level was 7.6% (Pondja, A. personal communication, 2008). This is in contrast with what was expected and with other studies findings, where the meat inspection as a diagnostic tool is more sensitive on detection of cysticercosis than tongue examination (Phiri et al., 2006). This is probably because traders/butchers in the study area were aware of the relationship between the presence of cysts under the tongue and condemnation of the carcass during meat inspection at the butchery level; they did not purchase positive pigs detected by tongue examination at farm level, and due to this filtration of positive cases at farm level by the traders, few infected carcasses were encountered in inspection places (Ngowi, 1999).

In this study, it was found that infected pigs which were discovered through tongue examination at the household level were not transported out of their area. Thus, true picture of disease in rural community cannot be reflected by the data obtained from inspection places. Similar findings were also reported by Sarti et al. (1992) that
abattoir surveys appear to underestimate the real prevalence of the disease at farm level.

The findings from this study concur with those carried out in other countries in the southern and eastern African region (between 5.1 and 45.0%). However, the overall prevalence of 5.4% for Angónia district was lower than the findings by Sikasunge et al. (2008) from Zambia, in which the overall prevalence at farm level was found to be 23.3%. Previous studies by Afonso et al. (2001) using antibody ELISA test have shown that Angónia district is endemic for porcine cysticercosis, and 33.3% was reported as prevalence at farm level. These results were higher than what was found by this study because the serological test is more sensitive on detection of cysticercosis than meat inspection. According to Dorny et al. (2004) the sensitivity of the Ag-ELISA for the detection of porcine cysticercosis is 86.7% while that of meat inspection is 22% (Phiri et al., 2006). Meat inspection, however, remain the only method available today for protection of consumers against cysticercus infected pork. It is widely used because it is simple to perform and less time consuming requiring simple equipment, being possible to carry out even in developing countries, it is a routine in normal slaughter process of food animals.

The routine meat inspection was evaluated by total dissection of 30 randomly purchased pig carcasses that have been inspected by government meat inspector in Vila Ulóngue butchery. The sampled pigs were brought by the traders/butchers from poor farms, mainly from Angónia District. Meat dissection revealed the prevalence of 26.7%, CI 11% to 42.3%. This rate is high enough indicating transmission of the disease is occurring in significant proportions, thus making the disease being common in the district. No significant differences in the prevalence between meat
dissection and routine meat inspection (p=1.0) were found. This was subsequently confirmed by agreement statistic test, which showed good agreement between the two methods used to detect *Taenia solium* cysts.

The differences on prevalences of 5.4% and 26.7% by meat inspection for three months and meat dissection respectively could be due to the fact that the first test had big sample size (n=205) and the second one had a small sample size (n=30).

Post mortem meat inspection method is one way of breaking the transmission cycle of this parasite and has been employed for many years to check the fitness of meat for human consumption. In order to formulate appropriate guidelines for routine post mortem detection of porcine cysticercosis in Mozambique and various regions of the world, it is important to determine the predilection sites of cysticerci of *Taenia solium* in slaughtered pigs. By definition these are organs or muscle groups that harbour a high proportion of cysts, and are parasitized in the vast majority of animals examined. Examining such organs facilitates the identification of infected pig carcasses and when combined with appropriate judgement, safe and wholesome pork for human consumption can be provided.

In this study the gluteus muscle was found to be an important site for localization of cysticerci in pigs since it ranked high as a site of predilection, having the highest proportion of total cysts as well as being parasitized in almost all the positive carcasses examined. The gluteus was followed by muscles of *Triceps brachii*, psoas, masseter, diaphragm, heart, brain, and tongue. Cysts were not found in livers, and lungs. Similar findings were also reported from Zambia by Phiri *et al.* (2006) who also did not find cysts in livers and lungs.
The results from this study are in accordance with previous reports by Viljoen (1937) who found the predilection sites as fore-quarters above the elbows, psoas muscles, tongue and heart. Similar findings to this study were made by Boa et al. (2002) in Tanzania who found the masseters and triceps muscles to be predilection sites for the cysts.

Though the Mozambican Meat Inspection Regulation of 1973 includes detailed instructions concerning normal procedure on detection of porcine cysticercosis in predilection sites in Angónia these instructions were not followed in details, incisions were only done in frequent cases in gluteus and triceps muscles, and occasionally in heart, liver, and kidney. The reason for this is simply because traders/butchers did not allow the inspector to do several incisions in all the muscles/organs where the cysts are supposed to be localized claiming that doing so will destroy the meat. Meat dissection, though is time consuming it has more accuracy and sensitivity on detection of cysts because slicing of meat is done in such way cysts are easily exposed. Meat inspection can sometimes fail to detect light infections (Phiri et al., 2006). So, it is important for the local meat inspector to make more incisions in another muscles recommended by regulation.

5.2 Production Systems

Production systems findings showed that pig herd size in Angónia District was ranging from one to fifteen animals, with average herd size of five animals. This study highlighted that most of the farmers (20.6%) were keeping one to two animals, while only one (0.8%) had the largest herd of 14-15 pigs. All respondents were keeping local or native pig breed, i.e. the Landim breed. This is consistent with the
surveys of Dias and Kamba (2001) from Gorongosa District, central part of Mozambique, where the mean of herd size was reported to be 5.9 pigs and local pig breed was kept and having the same characteristics as the reported in this study. The herd size contrasts with surveys of Ocampo et al. (2005) done in Rain Forest of Colombia who reported that the pig herd was ranging from one to seventy six animals, with a mean of 13.6 pigs. Different findings were also reported in study by Wabacha et al. (2004), from Kenya who found a median of 9 (a range from 1 to 115) pigs per herd, and all farmers keeping crossbred pigs (mainly of Large White or Landrace breeds and a few of the Hampshire breed). These differences on findings could be attributed to the fact that in these places farmers kept pigs mostly for commercial pork production. In contrast Dias (2005), in a study done in Boane district, Mozambique found that many of the pigs were cross-bred or modern breeds. This could be related on fact that Boane is nearby Maputo city where most of the pork processing industries are found and therefore good meat quality is needed.

Findings from Paraíba, Brazil by Silva Filha et al. (2005) revealed that smallholder farmers did improve pig shelters. Cement and barbed wire picket were used, and roofs were constructed with mud tile. This is in contrast with the Angónia’s findings, where the common characteristic of the farmers was the use of local available materials for building the pig pens. Pig pens were commonly constructed by use of stones, wood, and straw or polythene sheet to make the roofs. These findings were similar to those from Dias and Kamba (2001), from Gorongosa District, central Mozambique where farmers do not spend monetary cash for constructing pig pens.
The district extension services in Angónia provide more sensitization and advice to crop production farmers than those in animal production. The same scenarios hold for district veterinary services, which concentrate more inputs in animal health care than animal production and this might explain the poor pig management practices observed.

On pig feeding, it is believed that the use of cabbage, sweet potato leaves, and maize bran by the pig keepers could be related to fact that Angónia is one of the major crop producer in Tete Province and therefore the diversification and use of these feed by the farmers. There is assumption that these feed supplies are seasonal and inadequate to meet pig maintenance and production feed requirements throughout the year but this cannot be substantiated. However, the availability of maize bran, the sub-product of maize grain, could probably solve the shortage of seasonal feed, but this could bring competition since is needed for human consumption and for local brew and are not readily available for feeding pigs, especially in rural areas of developing countries (Chikwanha et al., 2007). Pasture is one of pig feed alternative, but this is also related with the seasons. It is more available during the rains and scarce in dry period. Feeding pigs with kitchen leftovers was common in the district, but this probably is used without knowledge of its disadvantage. The experience of Paraiba, Brazil showed that feeding monogastric animals, especially pigs with kitchen leftover brings health problems to the animals once the farmers fed from the accumulated previous day’s kitchen remains (Silva Filha et al., 2005). The results in this study were different from Gorongosa District described by Dias and Kamba (2001) where the farmers feed their animals by use of maize, straws, pulps, sunflower and molasses. The source of energy (molasses) provided to animals in
Gorongosa District was bought from the nearby Sena sugarcane company. Different findings were also reported by Dias (2005) in Boane District, Mozambique, where pigs were fed wheat and maize bran supplemented with forage and pumpkin. A study conducted by Silva Filha et al. (2005) in Paraíba, Brazil reported similar practices with this study, where the most smallholder pig farmer preferred kitchen leftover to fed the animals.

Smallholder pig raisers in the current study had seasonal management for their animals. Most of the interviewed farmers indicated that during the crop planting and crop growing seasons they were keeping the pigs confined, while during crop harvesting and fallowing seasons only few confined the animals. It is believed that the confinement of the pigs during the planting and growing periods was done mainly to avoid crop damage and to avoid neighbours complaints. In harvesting and fallowing seasons, pigs were allowed to free range and consume crop residues in the fields. The two last seasons coincide with the dry period (May to September), and farmers do not confine their animals as it is difficult to find fresh local forages for the pigs and there is no crop in the fields. Although after harvest, maize bran is adequately available, it was infrequently used because most of it is used preparation of local brew which is also one of the sources of income to a number of households. The results from this study are consistent with the previous surveys by Dias (2005) in the same study. However, pig management practices in our study area differ from those in Boane District (Dias, 2005) where the great majority of pigs were reported to be permanently confined throughout the year. These differences are believed to be due to the fact that cropping in Boane District is done all over the year and thus allowing free range animals could result in destroyed crops and thus conflicts between the farmers. Dias and Kamba (2001) reported that in Gorongosa District
pigs were kept in permanent confinement due to the restrictions made by the district authorities as well as the threat of theft. Studies in Colombia indicate that confinement of the animals depends on herd size; and that pigs are confined when the herd size is larger than five animals (Ocampo et al., 2005).

5.3 Pig and Pork Marketing Channels In Angónica District

The marketing chains for pigs and pork in the study area were short in that pigs/pork passes through few market participants (intermediaries) or succession of markets before reaching the final consumers. The major actors in the channelling of pigs/pork in the district therefore included the pig producers (smallholder farmers), traders/butchers and lastly the consumers. No wholesaler or assembler is involved in the marketing channels. Although one of the ways of pork reaching to the final consumers was home slaughter and home or market sale (this is mostly done in case of urgent need of cash). Findings from smallholder pig farmers group discussion indicated that they preferred to sell the animals to traders/butchers. At village levels, itinerant traders (traders/butchers) visited the homes of pig farmers to buy pigs in small numbers. At this level, the animals were slaughtered and taken to the main butchery in Vila Ulóngue town or to different markets where pork was sold directly to the consumers. The main reasons adduced to that are probably due to quick and guaranteed payment for their animals, the reduction of risks associated with transportation and the reduction of costs associated with the performance of marketing functions that could well be efficiently undertaken by traders/butchers.

The itinerant traders did not own vehicles and the most common way of pig transportation was the bicycle simply because only one or two pigs were bought. Pig/pork marketing in the place was entirely in the hands of traditional middlemen (traders/butchers). Government involvement was limited to the areas of disease
surveillance where pork inspection was done and in some information gathering and provision of public market infrastructures, without direct participation or regulatory measures. A study done by Holness (1999) in Zimbabwe reported similar findings where home slaughter and sale was done by the households when there was immediate financial need.

Findings from Dias and Kamba (2001) revealed that in Gorogosa District, although there was no market for live pigs like Angónia, the marketing channels were somehow more complex, involving not only pig farmers, retailers butchers, and consumers; but as well wholesalers, markets and supermarkets. Pigs were bought from the farmers by wholesalers or retailers who would sell directly to the butchers in Beira city and there after the meat is sent to markets, supermarkets and finally consumers. Local slaughter and sale of pork in Gorongosa was rare (Dias and Kamba, 2001).

The marketing chains of pig and pork in Angónia are basically for provision of meat needs to the local consumers. There were probably some interchanges with consumers from neighbouring Malawi, through some markets located along the border. In contrary, in Nigeria (Ajala and Adesehinwa 2007), pig market movement flow through many and long channels where ownership of pigs change hands two or three times before reaching the central pig market. Moreover, the transportation between the farmers’ homesteads and the immediate local village market in Nigeria, animals are trekked and transportation of pigs to subsequent markets is usually by trucks of varying sizes and capacities depending on distance and number of animals involved.
5.4 Cysticercosis Risk Factors Along the Pig and Pork Marketing Channels

The epidemiological survey in Angónia District identified consumption of pork, free ranging of pigs (limited to certain period of the year), home slaughters, lack of pork inspection at household level, and lack of porcine cysticercosis transmission knowledge as risk factors.

The relationship between porcine cysticercosis and home-slaughter may possibly be explained by the fact that home slaughtered pigs were mostly consumed by members of households thus increase risk of human taeniosis and hence higher risk of cysticercosis among the pigs due to lack of latrine. Another possible explanation could be the tendency of smallholder farmers after suspecting that the slaughtered pigs have cysticercosis, they may give the infected meat to other people who are unaware of the disease. Pigs slaughtered at home and not officially inspected pose a serious public health risk.

Some respondents admitted to use the infected pork to pay their workers or to exchange with farm produce such as maize, beans, and rice (Gule, personal observation), contrary to assumption that infected pork has no value after being condemned and disposed at the inspection place. Previous findings by Ngowi (1999) support this observation whereby infected pigs had some value, because as they were sold at low prices. Although infected pork had some value in the district, there was no clandestine marketing of infected pigs/pork, unlike the findings from Mbulu District, Tanzania where Ngowi (1999) reported that some of the detected infected pigs were sold at lower price to butchers who normally slaughter the pigs at home.

Other different findings were those from Peruvian Sierra, endemic for porcine cysticercosis where infected pigs were sold only in the informal sector (Gonzalez et al., 1993). Porcine cysticercosis in this area was found to be so common that one out
of every five or six pigs is likely to be infected. Such pigs would normally be confiscated and destroyed if they were channelled through the formal marketing sector. Therefore, the threat of confiscation without compensation forced farmers to use the informal clandestine markets (Gonzalez et al., 1993).

To overcome the problem of clandestine marketing of pork infected with cysticerci of *T. solium* governments have to provide financial market incentives to reimburse the farmers and/or slaughterhouses for infected pigs that are taken out of circulation or made safe for consumption by processing the meat only after boiling. In most of these rural communities of the developing world pigs are not inspected due to shortage of meat inspectors, lack of transport for the meat inspectors, and lack of slaughter slabs/abattoirs (Gonzalez et al., 1990; Phiri et al., 2003). Under these situations infected pork can have a significant value to the owner and will always have a market and later find its way to the dining table (Gonzalez et al., 1993; Phiri et al., 2003).
CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Meat inspection and meat dissection findings confirm that porcine cysticercosis is common in Angónia District and is potentially a serious health problem to pigs and humans, even those not involved directly in the production process. Though the tongue palpation is done by the trader/butchers at the farm level, infected pigs reach the market. The gluteus muscle was found to be an important site for localization of cysticerci in pigs since it ranked high as a site of predilection, and a high proportion of total cysts as well as being parasitized in almost all examined carcasses. The gluteus was followed by muscles of *Triceps brachii*, the psoas, masseter and less than 16% of cysts were found in diaphragm, heart, brain, and tongue, as important sites for localization of cysticerci in pigs.

As regards to pig production systems, smallholder pig farmers in Angónia District feed their animals with kitchen leftover, maize bran, and cabbage. These animals are kept confined during the crop planting and crop growing and the pigs are free ranging during the harvesting and fallowing seasons.

The marketing channels for pigs/pork in the study area are short in that pigs pass through few intermediaries or succession of markets before reaching the final consumers. The main pig/pork channels involved are:

1. Farmer → traders/butchers → markets → consumers;
2. Farmer → traders/butchers → butchery → consumers;
3. Farmers → consumers, and
4. Farmers → markets → consumers.

Important (potential) risk factors responsible for transmission and maintenance of porcine cysticercosis in Angónia District were described as poor management (free range) of pigs, lack of pork inspection, pork consumption, and ignorance about the mode of transmission of \textit{T. solium} taeniosis/cysticercosis.

6.2 Recommendations

Efforts must be taken to provide smallholder pig farmers with extension advice and education on transmission and importance of porcine cysticercosis. Such education should be extended to traders/butchers and consumers.

The adoptions of safe animal husbandry practices are recommended. In general, these strategies are:

1. Establishment and distribution of standardized pig slaughter premises specifically in markets and township in the district is crucial;
2. Meat inspection practices at village level to prevent human infection;
3. Recruitment of pork inspectors is required in order to control \textit{T. solium} taeniosis/cysticercosis in Angónia.
4. Improved farm management to ensure that pigs are protected from ingesting feed or water contaminated with human faeces to prevent cysticercosis in animals (primarily establishment of confinement for pigs); and,
5. Health education of farmers, pig traders and consumers.
6. Improved hygiene and sanitation with proper faeces disposal.
Sensitization on good management and feeding practices should be given to the farmers through extension services or District Veterinary Services.

Further studies are needed to:

1. Assess the prevalence of porcine cysticercosis by meat inspection in all remaining markets without meat inspector and;

2. Identify tests with higher sensitivity at slaughter to complement visual examination

Call for a national strategy for control and eventual eradication of the disease in human and animals is recommended.
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APPENDICES

Appendix 1: Questionnaire for smallholder pig farmers

I. GENERAL INFORMATION

Date of interview: ___ ___/___ ___/___ ___ ___
(dd/mm/yyyy)
District: ………………………………………………………………………………
Village: …………………………………………………………………………
Household number: ……………………………………………………………
Name of interviewer: ……………………………………………………………

II. HOUSEHOLD INFORMATION

1. Name of interviewee: ……………………………………………………………

2. Age: ……………… (years)

3. Sex:
   Male ☐
   Female ☐

4. What is the highest schooling grade you have completed?
   None ☐
   Primary school ☐
   Basic school ☐
   Middle school ☐

5. What further education have you completed?
   None ☐
   College ☐
   University ☐
   Technical/vocational ☐
   Other ☐ (please specify): ………………………………………………………

6. What is your main occupation? …………………………………………………
III. INFORMATION ON DRINKING WATER AND SANITATION

7. From where do you usually get your drinking water?
   River ☐
   Well ☐
   Bore-hole ☐
   Tap ☐
   Rain catchments ☐
   Other ☐ (please specify): ………………………………………………….

8. Has your drinking water been boiled before you drink it?
   Always ☐
   Almost always ☐
   Sometimes ☐
   Rarely ☐
   Never ☐

9. Do you have a latrine at home?
   Yes ☐
   No ☐ (please skip to Q. 11)

10. How often do you use a latrine when you have to defecate?
    Always ☐
    Sometimes ☐
    Never ☐

IV. INFORMATION ON PORK CONSUMPTION

11. Do you ever eat pork?
    Yes ☐
    No ☐ (please skip to Q. 14)

12. How often do you eat pork?
    a. At least once a month ☐
    b. Less than once a month but at least once a year ☐
    c. Less than once a year ☐

13. How is the pork that you eat prepared?
    Boiled ☐
    Fried ☐
    Barbeque ☐
    Other ☐ (please specify): …………………………………………………….
V. INFORMATION ON PIG MANAGEMENT

14. Do you or anyone in your household keep pigs?
   a. Yes ☐
   b. No ☐ (please skip to Q. 27)

15. What type of pigs do you keep?
   a. Foreign ☐
   b. Native ☐
   c. Both foreign and native ☐
   d. Can not remember, do not know ☐

16. What is the aim of keeping pigs?

   Sell: ☐ Local market
   ☐ Other villages market
   ☐ Pig traders
   Home consumption ☐
   Reproduction ☐
   Other ☐ (specify) ........................................

17. Which category of pigs do you sell?
   Piglets ☐
   Growing castrated males ☐
   Growing non castrated males ☐
   Growing females ☐
   Mature males ☐
   Mature females ☐

18. Where do you keep your pigs in the different seasons? (Check where appropriate)

<table>
<thead>
<tr>
<th>Seasons</th>
<th>In pens</th>
<th>Free ranged</th>
<th>Tethering</th>
<th>Other (please specify)</th>
</tr>
</thead>
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<tr>
<td>Planting</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Growing</td>
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<td></td>
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<tr>
<td>Harvesting</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fallowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

19. The animals do escape from the pig pen?
   Yes ☐
   No ☐

20. What is the quality of your pig pen? (Help with your observation)
   Good ☐
   Reasonable ☐
   Bad ☐
   Other observations:..................................................

21. Do you or any in your household raise piglets?
   Yes ☐
No (please skip to Q. 24)

22. Are you used to buy piglets out of your farm?
   a. Yes □
   b. No □
      If yes, a) where .................................................................
   c. What is the frequency of buying .............................

23. For how long do you leave the piglets to roam freely?
   Not at all □
   Less than 1 month □
   Between 1 – 2 months
   Other (please specify) □: .................................................................

24. What do you feed your pigs?
   Pasture □
   Kitchen leftovers □
   Commercial feed □
   Industrial by products (specify) □: .................................................................
   Others (please specify) □: .................................................................

25. What is the amount of feed given per day and per animal category?
   Piglets.................................................
   Growing males .................................
   Growing females ..............................
   Mature males .................................
   Mature females .................................

26. Do you or any in your household ever slaughter any of your pigs?
   Yes □
   No □ (please skip to Q. 35)

27. How often are pigs slaughtered at your home?
   At least once a month □
   At least once a year □
   Never slaughtered □
   Can not remember, do not know □ (please skip to Q. 35)

28. Have you ever had your home slaughtered pork inspected by a meat inspector?
   Yes □
   No □ (please skip to Q. 35)

29. How often is your meat inspected by a meat inspector?
   Always □
   Almost always □
   Sometimes □
   Rarely □
   Never □
   Can not remember, do not know □
30. What is the value of a pig when it is ready to be slaughtered?
(please specify the currency used) ………………………at month/age ……

31. What is the value of a piglet aged 4 months or less?
……………… (please specify the currency used) ……………………………

32. Have you or any in your household ever owned pigs?
Yes ☐
No ☐ (please skip to Q. 35 )

33. When did you or your household member own pigs?
Yes, in the past year ☐
Yes, one (1) to five (5) years ago ☐
Yes, more than five (5) years ago ☐

34. What kind of pigs were they?
Foreign ☐
Native ☐
Both foreign and native ☐
Can not remember, do not know ☐
VI. INFORMATION ON PORCINE CYSTICERCOSIS

35. Have you ever seen or heard of white nodules (rice) in pig carcasses?
   Yes □
   No □ (please skip to Q. 39)

36. Do you know where you can find nodules on a live pig?
   I don’t know □
   It is not possible to find them on a live pig □
   Under the skin □
   Under the tongue □
   Somewhere else □ (please specify) ...........................................

37. Do you know how pigs get these nodules?
   I don’t know □
   By eating human faeces □
   By eating pig faeces □
   From another infected pig □
   Other □ (please specify) .........................................................

38. What would you do if you discovered that your pig had nodules?
   I don’t know □
   Sell the pig □
   Treat it with herbs □
   Pierce the nodules □
   Other □ (please specify) ...........................................................

39. Have you ever heard of the disease ‘porcine cysticercosis’?
   Yes □
   No □ (please skip to Q. 43)
   Can not remember, do not know (please skip to Q. 43)

40. Have you ever seen or been told that your pigs were infected with cysticercosis?
   Yes □
   No □ (please skip to Q. 43)
   Can not remember, do not know (skip to Q. 43)

41. When was the last time you became aware of cyst (cysticercosis) in your pigs?
   In the past year □
   More than one year ago □
   Can not remember, do not know (skip to Q. 43)

42. When that happened, were you able to sell your pigs?
   Yes □
   No □
   Can not remember, do not know □

THIS IS THE END OF THE INTERVIEW
THANK YOU VERY MUCH FOR YOUR COOPERATION
[Interviewer: The following 2 questions should be answered by you after direct observation of the household’s latrine]

43. OBSERVATION

A. Which type of latrine does the household have?
   Absent ☐
   Present and completely enclosed ☐
   Present and partially enclosed ☐
   Present and open (easily accessible to roaming pigs) ☐

B. Is there evidence of recent use of the latrine (by anyone)?
   Yes ☐
   No ☐
Appendix 2: Questionnaire for pig traders

A. General information
   1. Village ………………………….. GPS coordinates …………………………….
   2. Name of trader ……………………………….. sex: ☐ female, ☐ male
   3. Category of trader: ☐ retailer, ☐ whole seller, ☐ both
   4. Date of interview ……………………………………

B. Personal information
   1. What is your area of domicile? Village ………….district……………………
   2. What is your education level?
      ☐ No formal education, ☐ Adult education, ☐ primary school 1\textsuperscript{st} degree
      ☐ primary school 2\textsuperscript{nd} degree, ☐ secondary: 1\textsuperscript{st} cycle, ☐ secondary: 2\textsuperscript{nd} cycle
   3. For how long have you practiced pig business ……………………………….
   4. What is the status of your pig business? ☐ full time, ☐ part time
   5. Besides pig business, what other activities do you do to earn money for your living?
      ☐ crop farming, ☐ livestock farming, ☐ artisan, ☐ others (specify) …………

C. Sources of purchased pigs
   1. How many days per week do you trade pigs …………(days)
   2. Which areas/locations do you purchase your pigs?
      ☐ within village, ☐ Neighbors villages, ☐ Far villages in the district, ☐ other districts within the Province
   3. Who are the sources/suppliers of pigs?
      ☐ Pig keepers, ☐ Retail traders, ☐ Whole sellers, ☐ Others (specify) …………………
   4. Which types of pig purchased per month? ☐ Piglets, ☐ Castrated growers’ males, ☐ Non castrated growers’ males, ☐ Growers’ females, ☐ Mature males
   5. Indicate the number of pigs you purchase per month? ☐ 0-10, ☐ 10-50, ☐ >50
   6. Are there major seasonal variations? ☐ Yes, ☐ no; if yes; when does it peak? …………………

D. Perceptions, awareness and limitations of porcine cysticercosis in pig marketing
   1. Are you aware of porcine cysticercosis disease? ☐ Yes, ☐ No (skip to Q 13)
   2. If yes, what is local name for porcine cysticercosis? …………………………….
3. How can a pig acquire an infection?  
- by eating human faeces,  
- does not know,  
- any other explanation  

4. Who gave you the information about it?  
- Extension officer,  
- pig keepers,  
- other pig traders,  
- others (specify)  

5. How often have you encountered pig infected with cysticercosis among your purchases this year (number of case(s)) per month?  

6. Have you experienced any limitations/losses owing to cysticercosis infection in your pig business?  
- Yes,  
- No  

7. Which technique(s) do you use to identify whether the pig is infected with cysticercosis or not?  
   (a)  
   (b)  

8. Who gave you the knowledge on how to identify the cysticercosis infected pig?  
- My fellow pig traders,  
- extension officers,  
- pig keepers,  
- others (specify)  

9. How do you rate the reliability of method you’re using?  
- very reliable,  
- moderately reliable,  
- less reliable,  
- not reliable,  
- I don’t know  

10. From your experience, pigs from which locations are most often encountered with cysticercosis?  
    Name of location (a)  
    Name of location (b)  

11. Suppose you have decided to purchase the infected pig weighing 50 kg, what proportion of price do you normally pay compared to non infected pig of the same weight?  

12. What do you normally do when you find out that the pig you have already purchased is infected with cysticercosis?  
    - seek veterinary advice,  
    - use traditional medicine (mention) get rid of it,  
    - the respondent does not know,  
    - any other explanation  

13. How do you rate awareness and knowledge levels of your clients on pig infected with cyst?  
    - knowledgeable  
    - not knowledgeable  

E. Market outlets
1. To whom (customers) do you sell your pigs?
   □ Retailers, □ Butchers, □ Pig consumers

2. Which locations do you normally sell your pigs?
   □ Neighbor villages, □ Far villages in the district, □ other districts within the Province,
   □ other places outside the Province

3. What are the main constraints you face in your pig business

   ...........................................................................................................................................

   THIS IS THE END OF THE INTERVIEW
   THANK YOU VERY MUCH FOR YOUR COOPERATION

   INTERVIEWER: ..................................................................................................................
Appendix 3: Questionnaire for: slaughter slabs – meat inspectors

A. General information
1. Village (location)……………………GPS coordinates: ………………………
2. Name of inspector ……………………………….sex: ☐ female, ☑ male
3. Date of interview ………………………

B. Personal information
1. What is your education level?
   ☐ No formal education, ☑ Adult education, ☑ primary school 1st degree
   ☑ Primary school 2nd degree, ☑ secondary: 1st cycle, 6 = secondary: 2nd cycle
2. For how long have you practiced meat inspection? ………………………
3. What is the condition of your job? ☑ full time, ☐ part time

C. Pig slaughtering, inspection and perceptions on porcine cysticercosis
1. How many slaughter slabs do you have in your area? ………………………
2. On average how many pig carcasses per day do you inspect? ………………..
3. Do farmers in your area do home slaughter? ☑ yes, ☐ No
4. If yes, do they call you for pork inspection? ☑ yes, ☐ No if yes, how often?………………………
5. Are you aware on porcine cysticercosis? ☑ yes, ☐ No
6. If yes, what is the local name of infection? …………………………………………
7. Who gave you the information/knowledge about porcine cysticercosis? ☑
   Extension officer, ☑ veterinarian, ☐ others (specify) …………………………
8. Do you know how pig can get the disease?
   ☑ By eating human faeces
   ☐ Does not know
   ☐ Any other explanation: ………………………
9. Have you ever seen infected carcasses with cysticercosis? ☑ Yes, ☐ No
10. If yes, in average how many cases do you experience per day in relation to
    number examined? …
11. In which part of the carcass are you used to see the
cysts…………………………….
12. Do you sometimes characterize the infection as low or high grade? □ yes □ no; 
   if yes, how do you define .................................................................

13. Under normal situations, what is your decision if you find out that the carcass you 
   have inspected is infected with cysticercosis 
   □ remove the cyst, □ advice the consumer how to cook it, □ don’t know

THIS IS THE END OF THE INTERVIEW
THANK YOU VERY MUCH FOR YOUR COOPERATION

INTERVIEWER: ________________________________
Appendix 4: Guide for the focus group discussions during a study for marketing chains of pigs/pork in Angónia District

1. Who is responsible for pig management in your family?
2. Do you have a latrine at your home?
3. Where do you obtain water for your home consumption
4. Do you eat pork?
5. Do you know porcine cysticercosis?
6. How can a pig acquire porcine cysticercosis?
7. How could you prevent your pig from getting cysticercosis?
8. What is the aim of keeping pigs (pig keepers)?
   a. Sell: Local market
      Other villages market
      Pig traders
   b. Home consumption
   c. Reproduction
   d. Other (specify) ...........................................
9. Where do you acquire your pigs? (traders)
   a. From the pig keepers
   b. From whole sellers
   c. From my fellows traders
10. Which category of pigs do you sell (farmers)?
    a. Piglets
    b. Growing castrated males
    c. Growing non castrated males
    d. Growing females
    e. Mature males
    f. Mature females
11. Do you or any in your household ever slaughter any of your pigs?
    a. Yes
    b. No
12. How often are pigs slaughtered at your home?
    a. At least once a month
    b. At least once a year
    c. Never slaughtered
Can not remember, do not know
Appendix 5: Pig origin
<table>
<thead>
<tr>
<th>Pig Village origin</th>
<th>Remark</th>
<th>Negative</th>
<th>Positive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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