Farmers' knowledge and practices influencing *Taenia solium* infection in smallholder pigs in Mbozi and Mbeya Districts

L.K. Mwemezi[1], A.N. Ngowi[2], J.E.D. Mlangwa[2], E.M. Mkupasi[2], and M.V. Johansen[3]

[1]Tanzania Livestock Research Institute (TALIRI) - Uyole, P. O. Box 6191, Mbeya, Tanzania
[2]Department of Veterinary Medicine and Public Health, College of Veterinary Medicine and Biomedical sciences, Sokoine University of Agriculture, P. O. Box 3021, Morogoro, Tanzania
[3]Section for Parasitology and Aquatic Pathobiology, Department of Veterinary Disease Biology, Faculty of Health and Medical Sciences, University of Copenhagen, Dyrlægevej 100, DK-1870 Frederiksberg C, Denmark

E-mail: mwemezie@gmail.com

SUMMARY

Taenia solium has been reported to be endemic in the southern highlands of Tanzania. Based on Ag-ELISA, prevalence of *T. solium* cysticercosis in pigs was reported to be about 31% in 2008 and 17% in 2015 in Mbeya and Mbozi districts of Mbeya and Songwe regions, respectively. This study aimed to estimate the current status the disease in pigs and understand farmers' knowledge and practices influencing disease occurrence and transmission. *T. solium* cysticercosis in pigs was determined by tissue slicing while a questionnaire survey assessed farmers' knowledge and practices. A total of 890 households were surveyed and 282 pigs examined. Only 18.5% of respondents knew *T. solium* taeniosis in humans, 32% of whom did not know how the infection is acquired. Also, 61.2% of respondents who had seen cysts in meat were not aware that consumption of the meat could cause cysticercosis. More than 90% of latrines were not enclosed and 45% of them were accessible by pigs. Twenty seven pigs (9.7%) had *T. solium* cysts, four of them had non-viable cysts (three with both viable and non-viable cysts and one with non-viable cysts only). About a half (51.9%) of the pigs had light infection burden (0-100 cysts), 14.8% had moderate infection (101-1000 cysts) and 33.3% had heavy burden (>1000 cysts). The study revealed low levels of farmers' knowledge and risk practices which may contribute to perpetuation of the disease. Improvement in the local knowledge of the disease epidemiology is suggested for inclusions in future control programs.

Keywords: Knowledge, practices, *Taenia solium*, smallholder, pigs

INTRODUCTION

The pig tapeworm *Taenia solium* is a zoonotic cestode which is transmitted between pigs and humans. Pigs are natural intermediate hosts harboring the larval stages of the parasite (cysticercosis) while humans are definitive hosts harboring the adult tapeworms (taeniosis). Humans may develop cysticercosis following accidental ingestion of *Taenia* eggs, with encystment of the brain(neurocysticercosis-NCC), being the fatal form of the disease (Sciutto et al., 2000). Transmission is perpetuated when pigs have access to human faeces (directly or through contaminated feed/water), and humans have access to cyst infected pork. This happens in poor communities where personal hygiene and sanitation are poor, pigs are left to roam and meat inspection is inadequate or missing.

In Tanzania, the disease was first reported in 1985 in the northern eastern highlands of the country (Boa et al., 1995; Nsengwa and Mbise, 1995). More recently, in humans, based on serology, prevalence of taeniosis and cysticercosis of up to 5.2% and 16%, respectively, have been reported (Mwanjali *et al.,* 2013). In pigs, prevalence of up to 17.4% and 32% based on lingual palpation and serology, respectively, have been reported (Komba *et al.,* 2013; Ngowi *et al.,* 2004).

by dipping (vs running water) (Ertel *et al.,* 2015; Mwanjali *et al.,* 2013). For porcine cysticercosis (PC), risk factors have been reported to be free ranging of pigs, poor or lack of use of latrines, feeding pigs with potato peels and providing them with water from ponds & rivers (Kavishe *et al.,* 2017; Shonyela *et al.,* 2017; Braae *et al.,* 2015; Komba *et al.,* 2013 and Ngowi *et al.,* 2004).

T. solium taeniosis/cysticercosis is responsible for considerable economic and public health problems (Praet *et al.*, 2009; Trevisan *et al.,* 2016; Zoli *et al.,* 2003). On a global scale, the disease tops the list of foodborne parasitoses and was identified as a leading cause of deaths from food-borne diseases (WHO, 2016; WHO and FAO, 2014). In SSA, it is estimated that between 1.9 and 6.2 million people suffer from NCC (Winkler, 2012) and about 30% of epileptic cases in *T. solium* endemic areas are associated with NCC (Ndimubanzi et al., 2010). In Tanzania, Trevisan *et al.* (2016) determined that in 2012 the number of Disability adjusted Life Years (DALYs) per thousand person-years for NCC-associated epilepsy was 0.7 (95% UI, 0.2–1.6). In the same year it was ascertained that around 5 million USD (95% UI, 797,535–16,933,477) were spent due to NCC-associated epilepsy and about 3 million USD (95% UI, 1,095, 960–5,366,038) were potentially lost due to PC (Trevisan *et al.,* 2016).

Of recent, the disease has been given an increased attention. For example, in 2010 the World Health Organization (WHO) included *T. solium* infection in a list of neglected tropical diseases (WHO, 2010) and later adopted a resolution during a World Health Assembly in 2013, aimed at eliminating the disease (WHO, 2013).In Tanzania, taeniosis/cysticercosis was added in the list of the country's health research priorities from 2015 to 2020 (Anonymous 2016).

In humans, risk factors have been identified to be poor or lack of knowledge on the disease, age, sex, unsafe water sources and hand washing

This study aimed atestimating the current status of the disease in pigs in the rural areas of Mbeya and Songwe regions. Further, the study sought to gain an insight into the pig farmers' knowledge and practices which may influence its occurrence and transmission in the area.

MATERIALS AND METHODS

Description of the study area

This study was conducted in Mbeya (rural) and Mbozi districts of Mbeya and Songwe regions, respectively in the southern highlands of Tanzania. The regions are located between latitudes 8°14′ and 9°24′S and longitudes 32°04′ and 33°49′E. In 2012, human population was estimated to be 2,707,410 (NBS, 2013). The climate is generally subtropical with dry and rainy seasons sharply defined, rainy season extending from November to May, followed by a dry spell. Annual rainfall ranges from 600 mm in the lowlands to 2600 mm in the highlands. In 2012 human populations were recorded to be 305,319 in Mbeya (rural) district and 446,339 in Mbozi district (NBS, 2013). Pig production is almost exclusively on a small scale and pig populations were estimated to be 16,935 in Mbeya (rural) and 26,930 in Mbozi district (Unofficial data, District Livestock Offices).

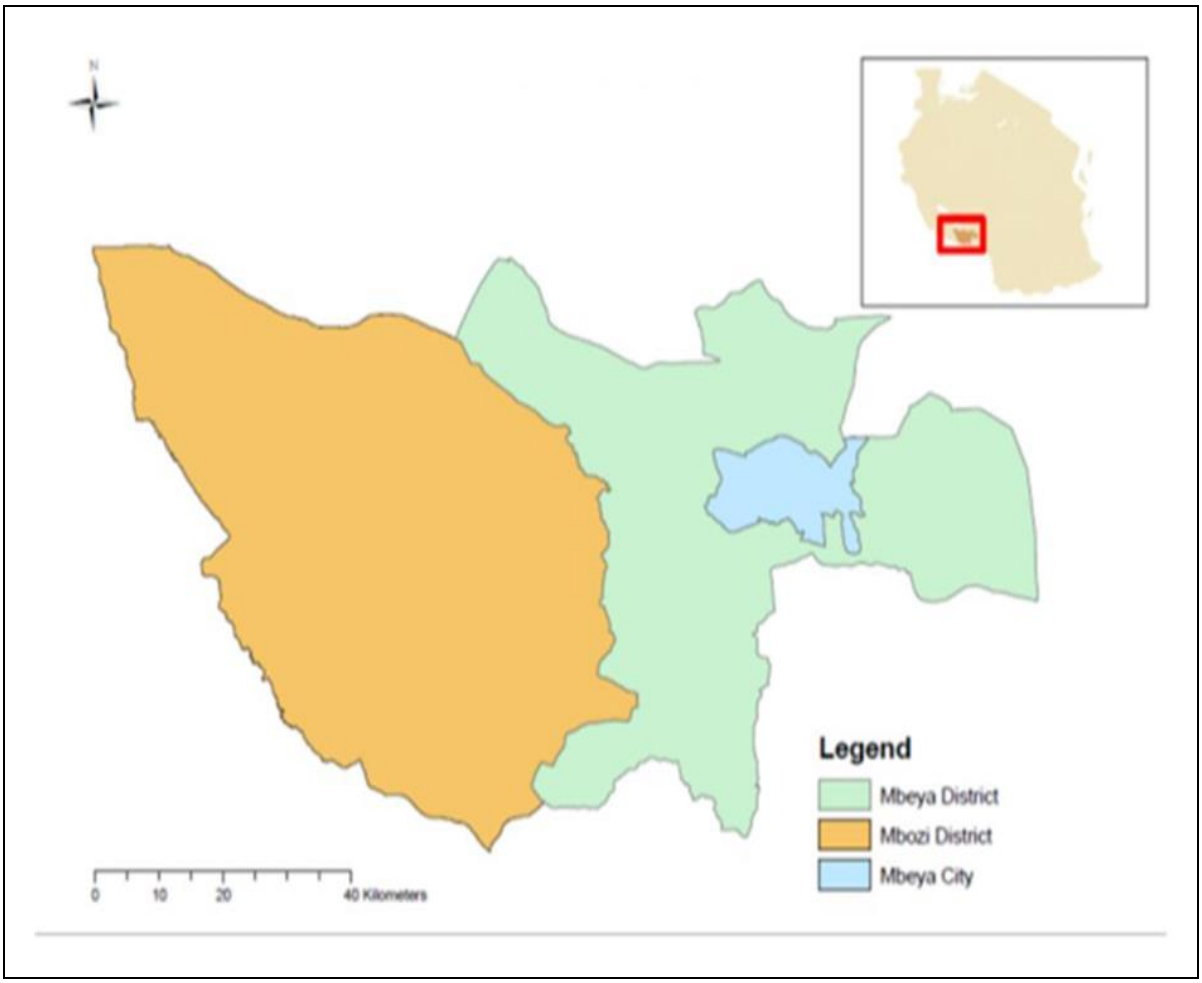

Figure 1: Map of Tanzania showing location of the study districts of Mbeya Rural and Mbozi of Mbeya and Songwe regions, Tanzania

Study design

This was a cross-sectional study where questionnaire survey and pig necropsies were conducted between October and December 2016. Seven wards were included for the study, three in Mbeya (rural) and four in Mbozi. From the seven wards, eleven villages were selected (seven in Mbeya and four in Mbozi). In each village all farmers willing to participate in the study were included. Farmers were identified and located by the help of village leaders and by using a snowball technique. Households from where slaughter pigs would be purchased were selected randomly. The number of pigs to be slaughtered was calculated for the intervention study and based on a likelihood ratio test for an odds ratio.

Household survey

Data was collected by using structured standard hard copy questionnaires which were filled during personal interviews by trained local extension officers. The interviews were conducted in Kiswahili. In each household a respondent was a household head or a person owning/taking care of the pigs or any other person who could provide the required information. Farmers provided written consent to participate. Household particulars including family name and GPS coordinates were recorded. Information gathered was about pig management practices, and farmers' knowledge and practices, which are likely to influence

occurrence/transmission of *T. solium* in pigs and humans.

Pig slaughter and carcass slicing procedures

Slaughter pigs were bought from owners and were transported to Tanzania Livestock Research Institute (TALIRI) Uyole. Slaughtering and carcass processing was done at Nsalaga slaughter slab, which is the nearest to TALIRI-Uyole. After slaughter, the heart and diaphragm were separated and transferred into labelled containers, and they were, together with the carcasses, transported to the post mortem facility at TALIRI-Uyole. The tongue, brain and masseter muscles werethen extracted from the head.

The carcasses were longitudinally partitioned into two halves. The muscles from the right half of the carcass were excised from bones, muscles of the forelimb separated from muscles of the rest of the carcass. Then all muscles/organs were sliced with sagittal cuts of less than 0.5 cm in thickness. The cut surfaces were examined macroscopically for presence, viability and number of *T. solium* cysticerci. A cyst was recorded as viable if it was a translucent vesicle with a visible scolex inside floating in transparent fluid. A non-viable cyst was smaller, non-translucent, filled with caseous (calcified) material. Total cyst count for a pig was estimated as double the number for half carcass musculature plus numbers for the tongue, brain, masseter muscles, diaphragm, and heart. Infection burden was classified as light if total cyst count was less than 100; moderate if it was between 101 and 1000; and heavy if it was more than 1000.

Ethical clearance

The study protocol was approved by Research, Publications and Ethics committee of the College of Veterinary Medicine and Biomedical Sciences (CVMBS) of Sokoine University of Agriculture (Reference number: SUA/CVMS/016/32). Permission to conduct the study was secured from the Director of Veterinary Services (DVS), of the ministry of Livestock and Fisheries. Further, permission was sought from authorities in the study districts and villages. Farmers gave a written/verbal consent to participate in the study.

RESULTS

Description of pig management practices

A total of 890 households were surveyed, which were keeping a total of 3094 pigs, most of them (80.7%) being non-descript crossbreeds of indigenous breeds and exotic breeds mainly landrace and large white. Majority of the households (80.4%) kept one to five pigs. Maize bran was the most common feed for pigs, followed by food wastes. Rivers and wells were the main sources of drinking water for pigs as they contributed about 60% of water provided to pigs. About 60% of the households were confining their pigs in pens and about 20% let their pigs to roam. The rest were either tethering their pigs or were partially confining their pigs (penning/tethering them for part of the day). Selling pigs when in need of cash was almost the sole reason for keeping the pigs, as it was mentioned by 98.4% of the respondents.

Farmers' knowledge, attitudes and practices related to *T. solium* transmission

Awareness about the disease was low. Only 5.7% of the respondents mentioned cysticercosis to be among important diseases affecting their pigs and 18.5% were aware of the tapeworm infection in humans (Table 1). About a third (32%) of the people who knew of tapeworm infection in humans did not know how the infection is acquired but 53.4% of them associated it with consumption of raw/undercooked pork. About 86% of respondents said that they (and their families) were consuming pork and the major (98%) source of the pork was local butchers/pork outlets which are situated around community gathering areas. About a half of the respondents (49%) had seen cysts in pig meat; of them61.2% were not aware that consumption of the meat could cause disease in people.

Table 1: Knowledge and practices of farmers in Mbozi districts and Mbeya (rural) on occurrence and transmission of *Taenia solium* cystcercosis

Question	Response	Number of households	%
Do you have a latrine?	Yes	840	95.4
	No	41	4.6
Do household members use it?	Always	831	99.1
	Sometimes	7	0.8
	Never	1	0.1
Do pigs have access to the latrine?	Yes	376	45.1
	No	457	54.9
Do you know of tapeworms infections in humans	Yes	163	18.5
	No	717	81.5
Have you seen cysts in pig meat?	Yes	431	49
	No	448	51
Are you aware the meat can cause disease in humans?	Yes	167	38.8
	No	264	61.2

Latrine coverage was high (>95%) but most of the latrines (>90%) were not enclosed as they had no doors or had doors which were open or were not closing properly. Nearly half (45%) of the latrines could be accessible to pigs. Quite a few households had hand washing facilities by their latrines indicating that washing hands after latrine use was not a common practice.

Postmortem results

A total of 282 pigs were slaughtered and examined and*T. solium* cysticerci were found in 27 (9.6%) pigs. Out of the 27 parasitized pigs, four had non-viable cysts, three having both viable and non-viable cysts and one having non-viable cysts only. Total number of cysts and distribution in the organs/muscle groups are shown in Table 2. Fourteen (51.9%) of the infected pigs had light infections, four (14.8%) had moderate infections and nine (33.3%) had heavy infections. Frequency of infection (predilection), mean number of cysts and maximum counts of cysts in different organs/muscles are shown in Table 3.

Table 2: Numbers of *Taenia solium* cysticerci in 27 parasitized pigs out of 282 slaughtered pigs in Mbozi and Mbeya rural districts of Songwe and Mbeya regions. The counts were made in predilection organs and musculature of right half of carcasses

Animal Id	Brain	Tongue	Masseter uscles	Heart	Diaphragm	Forelimb	Remaining half carcass	Total cyst count	% viable
5	1	1	6	10	10	36	52	116	100
19	0	0	0	0	0	2	0	2	100
21	2	1	2	5	3	26	58	97	94.8
25	0	1	0	1	0	0	8	10	80
31	1	0	0	0	1	2	8	12	100
44	8	57	41	141	42	576	2070	2935	100
71	0	0	0	1	0	0	0	1	0
130	0	0	0	0	0	0	2	2	100
149	12	329	369	69	515	430	1504	3228	100
150	148	1846	851	20	0	1980	14758	19603	100
157	1	167	245	138	113	1174	2484	4322	100

Table 2. Continue..

162	2	16	62	35	2	222	98	437	100
169	17	94	112	48	17	1076	798	2162	100
170	0	0	1	3	0	0	2	6	100
184	0	4	0	8	0	18	12	42	100
188	3	3	6	1	3	32	36	84	100
192	2	96	143	167	2	430	274	1114	100
194	9	201	118	346	213	810	1416	3113	100
195	0	13	14	8	5	94	112	246	100
200	0	0	0	0	0	6	20	26	100
202	0	0	0	0	0	0	4	4	100
210	24	241	247	366	313	1968	1986	5145	100
218	0	0	0	6	0	0	0	6	100
222	433	2750	6800	336	635	17928	9848	38730	100
224	0	8	3	3	2	34	60	110	97.3
226	0	0	0	4	0	0	0	4	100
236	0	2	0	0	0	0	0	2	100

Table 3: Frequency of infection, mean number of cysts and maximum counts of cysts in organ/muscle groups of 27 pigs which were found to be parasitized with *T. solium* cysts out of 282 slaughtered pigs in Mbozi and Mbeya rural districts of Songwe and Mbeya regions

Organ/muscle group	Frequency of infection		Mean number of cysts	Std. Dev.	Max
	Number	%			
Brain	14	51.9	24.6	86.4	433
Tongue	18	66.7	215.9	619.2	2750
Masseter	16	59.3	334.1	1304.7	6800
Heart	21	77.8	63.6	113.2	366
Diaphragm	15	55.6	69.5	163.7	635
Forelimb	21	77.8	994.2	3433.3	17928
Remaining half carcass	22	81.5	1318.9	3323.7	14758

DISCUSSION

The results reported in this studypresent a reliable estimate of the prevalence of the disease in rural pigs within the most important pig production area in Tanzania.Higher prevalence has been reported in more or less similar studies in Zambia (56%), Cameroon (19.6%),Peru (16.8%) and Mexico (15.8%) (Assana *et al.,* 2010; Chembensofu *et al.,* 2017; Huerta *et al.,* 2001; Jayashi *et al.,* 2012; Sah *et al.,* 2017). However, lower prevalence (5.5%) was recorded in another study in Peru (Garcia *et al.,* 2016). The results of this study showed that PC is still a public health threat in the study area and that more control measures are needed.

Parasite over-dispersion has been demonstrated in this study where a few pigs harbor massive infections and most of the infected pigs have light/moderate infections. Eighteen of the 27 infected pigs (66.7% 95% CI 46-83%) had light to moderate infection burdens.This spells a public health threat as studies have shown that lightly infected carcasses may not be detected by

tongue palpation and routine meat inspection and they may consequently enter the food chain (Boa *et al.,* 2002; Dorny et al., 2004; Nguekam *et al.,* 2003).

Low level of knowledge/awareness on the disease and its transmission has been reported in this study and it possibly contributes to the observed risk practices. This underscores the importance of health education. Proper knowledge of pig farmers and communities on *T. solium* cysticercosis/taeniasis has been found to influence proper practices and is therefore crucial for control of the disease complex (Kungu *et al.,* 2017; Mwidunda *et al.,* 2015; Ngowi *et al.,* 2008; Rajshekhar *et al.,* 2003).

Although high levels of latrine coverage and use was reported in this study, precarious latrines still present a potential risk factor. Earlier studies within the present study area had highlighted the role of absence/poor latrines in the transmission of the disease (Braae *et al.,* 2015; Komba et al., 2013). The present findings therefore reemphasize not only the importance of having and using latrines, but also the importance of using latrines with closing doors. Washing hands (with soap) most importantly after latrine also needs to be emphasized, not only for controlling*T. solium*, but also other hygiene related diseases.

Using drinking water from surfaces sources (rivers, wells, ponds and springs) for pigs (and humans) might be responsible for perpetuation of the disease transmission in the study area. Such sources are said to be at a higher risk of contamination(Gwimbi, 2011; Morris *et al.,* 2003). The extent to which the environment (including water sources) in the study area is contaminated with *Taenia* eggs is not yet reported, but earlier studies have associated use of the unsafe water with higher sero-prevalence in pigs (Komba *et al.,* 2013) and in humans (Mwanjali *et al.,* 2013). Information on the environment contamination with *Taenia* eggs is needed in planning for control measures.

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