Vol. 13(1), pp. 25-34, January-June 2021
DOI: 10.5897/JPVB2020.0395
Article Number: B0AD2A265938
ISSN: 2141-2510

http://www.academicjournals.org/JPVB

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Journal of Parasitology and Vector Biology

Full Length Research Paper

Prevalence and risk factor associated with *Taenia solium* cysticercosis among pig farmers in two districts (Amuru and Gulu) in Northern Uganda

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Received 1 August 2020 Accepted 30 November, 2020

Taenia solium **cysticercosis is a serious public health issue affecting humans in developing countries. The disease affects the rural economies due to the loss in productivity associated with human ill-health and condemnations of infected pork carcasses by the veterinarians. The aim of the study was to investigate the prevalence and risk factors for porcine cysticercosis in the districts of Amuru and Gulu in Northern Uganda. A cross sectional study was conducted among households rearing pigs in Amuru and Gulu districts in Northern Uganda from March to June, 2019. A total of 569 pigs and 300 households were studied. Data on prevalence and risk factors for *T. solium* cysticercosis was collected using lingual examinations and questionnaires, respectively. Data was analyzed using Pearson's Chi square. Bivariate and multivariate analyses were used to detect the independent factors associated with dependent variables. Variables with P< 0.05 were considered as statistically significant. The prevalence of *Cysticercus cellulosae* was at 13.6% (96% CI: 8.6-18.6). The risk factors associated with porcine cysticercosis transmission in Gulu and Amuru were sex (P=0.044, OR=5.41 (95%CI:1.04-15.24)), pig keeping, (P=0.00, OR=0.56 (95%CI: 0.012-0.25)), routine deworming (P=0.04,OR=1.13 (95%CI:0.032-0.35)) and pig free range (P=0.03, OR=3.843 (95%CI: 1.13-12.71)) and open defecation (P=0.003, OR=0.322(95%CI: 0.003-3.058)). The findings from the current study indicate that the prevalence of porcine *T. solium* cysticercosis is endemic in Gulu district. The porcine cysticercosis is being influenced by pig farmers, lack of deworming, free range pigs, and allowing pigs to feed on human faeces. There is need for the local to authorities to strengthen public health education on pig husbandry practices and routine meat inspection at these facilities by the health authorities in the region.**

Key words: Prevalence, *Taenia solium* cysticercosis, risk factors, Northern Uganda

INTRODUCTION

Porcine cysticercosis (PC) is a serious public health infection caused by the larval stage of cestode *Taenia solium* (Pajuelo et al., 2015; Ng-Nguyen et al., 2018). The disease poses an emerging threat to public health and economic well-being of resource limited communities of developing countries (Chacha et al., 2014; Chowdhury et

al., 2014). Humans acquire cysticercosis by autoinfection or consuming food/drinking water contaminated with the worm's egg (Chhabra and Singla, 2009; Dahourou et al., 2018; Ng-Nguyen et al., 2018). Pigs are the intermediate hosts and get infected when they ingest the infective eggs and/or proglottids which develop into cysticerci causing porcine cysticercosis (Maganira et al., 2019). In humans, when the cysticerci migrate through the intestinal mucosal wall into the blood circulation, they penetrate other striated muscles and eventually form cysts in the brain leading to neurocysticercosis (NCC) (Lescano et al., 2007; Chowdhury et al., 2014). NCC is the most common cause of adult-onset seizures in endemic regions worldwide (Chowdhury et al., 2014; Pajuelo et al., 2015).

Uganda has seen an increased pig population from 3.18 million in 2008 to 4.5 million in 2018 and is among the largest pork consumers in sub Saharan Africa (Greve, 2015). These have been attributed mainly to the population growth, urbanization and increasing households' income (Uganda Bureau of Statistics, 2009). A previous study showed that Uganda per capita consumption (3.43 kg) of pork in 2011 ranked the highest in East Africa (Atherstone et al., 2017) but current data from the study area is scanty. Though there is a positive development in pig farming in Uganda, challenges of *T. solium* porcine cysticercosis exist. Uganda is one of the countries in Africa with very limited data on human cysticercosis (Alarakol et al., 2017). Recent serological studies in Uganda showed that prevalence of porcine cysticercosis in pigs ranges from 8 and 12% (Kung et al., 2017). These showed that communities' exposure to *T. solium* infections were mainly through consumption of infected pork (Phiri et al., 2003). However, the risk of exposure to PC is closely associated with poor pig management systems (Kungu et al., 2019). Northern Uganda has experienced a protracted war from 1986 to 2006 with profound negative consequences (Ayiasi et al., 2019). The war resulted in serious social, economic, health and breakdown in agricultural systems. *T. solium* cysticercosis has emerged as one of the serious public health issues in the region (Phiri et al., 2003). While there is increased pig farming in Northern Uganda, PC has also been reported in the region (Ikwap et al., 2014; Kungu et al., 2019). The occurrence of PC is associated with many factors including those related to pig husbandry and management (Kungu et al., 2017). The aforementioned situations seriously affect the level of pig production and course grave economic losses to the farmers (Atawalna et al., 2015). Despite poor pig husbandry and management practices among many rural pig farmers, pork sales and consumption continue to increase in Northern Uganda (Chenais et al., 2017). The increase in pig farming has been attributed to the ready demand and the markets for pork in Gulu city. However, poor methods of pig farming and poor hygiene practices put the communities and pigs in the region at serious risks of infections by *T. solium*. PC especially those under free range management has been suggested as an indicator of occurrence of the infection in humans. This is true for the rural small holder pig farmers where pigs' movements are unrestricted and ingest contaminated materials (Morales et al*.,* 2008; Waiswa et al*.,* 2009; Pondja et al*.,* 2010). While the demands for pig production and pork sales have continued to increase, limited data on the prevalence and risk factors for the surge of PC in the region exists. This study aimed to investigate the prevalence and risk factors for PC in order to provide in-depth knowledge on the common modes of *T. solium* parasites of transmissions for sustainable management and control of the disease in the region.

MATERIALS AND METHODS

Study design

A cross sectional study was conducted between February and March 2019 among rural pig farmers in the two districts of Amuru and Gulu, Northern Uganda. The data for risk factors were collected using questionnaires and for PC were collected from visual inspection and examinations of cysts. All research participants consented to the study. The research protocol was approved by Gulu University, Research Ethics Committee (GUREC) and Uganda National Council of Science and Technology (UNCST).

Study setting

This study was conducted in two sub counties in each district of Amuru and Gulu, Northern Uganda. The two districts cover a total area of over 3000 km^2 with an estimated population of 600,000 inhabitants (Uganda Bureau of Statistics, 2016). Unyama Sub-County has four parishes and 16 villages with approximately 4000 households (population of 15,000). Lamogi Sub-County has five parishes and fourteen villages with 5000 households (population of 16,000). Amuru and Gulu were purposively selected because they are among the pig producing districts in Northern Uganda (Ikwap et al., 2014). The people in these areas depend on pig farming to supplement their livelihood and are the main suppliers of pigs to slaughter houses in Gulu city. The pigs are usually kept in pens at night and released in the morning to scavenge for foods in the surrounding environment. These areas have inadequate sanitary facilities as well as safe water for domestic use. The pit latrines coverage is estimated at 89% of the population and the main sources of water in these areas are: ground springs, wells, bore holes, tap-water and protected wells (Uganda Bureau of Statistics,

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2016).

Sample size determination

The sample size was determined based on the formula by Kish and Lislie (1965), $n=Z^2P(1-P)/L^2$, where *n* is the required sample size; *Z* is the multiplier from the normal distribution, *P* is the expected prevalence and *L* is the desired absolute precision. Since the prevalence of PC among pigs in the study areas is unknown, this study used the one of Moyo district, which was at 33% with allowable error of 10%, and at 95% confidence interval. Therefore, a total of 85 samples were required. In order to minimize the sampling error, this value was doubled and multiplied by the design effect at 1.5 to 254. Thus, the overall sampled size was 254. Additionally, a total of 300 households determined using formula by Kish and Lislie (1965) were included in the study.

Sampling procedures

A multi-stage cluster sampling technique was used to select the districts and the eligible study participants. A two-stage cluster sampling technique was used. First, Amuru and Gulu districts were purposely selected. Secondly, two parishes, 8 villages were randomly selected from list of villages obtained with the help of local administration of the Sub County in each district. In each district, one Sub County cluster, two parishes and 8 villages were randomly selected using lottery method. In the case of Gulu and Amuru, Unyama and Lamogi Sub-counties were selected, respectively. All eligible parishes and villages within each of the two districts were assigned a number and two numbers were chosen at random to select parishes and villages from each district for inclusion in the study as described by Ng-Nguyen et al. (2018). The study participants who were mainly households' head and/or persons involved in pig farming in the households were randomly selected from the list of households keeping pigs prepared with the help of district veterinary officer and local administration of the villages. The individuals selected were visited and consented prior to being included in the study.

Data collection

Self-administered semi-structured questionnaires were used to collect the data. The questionnaires were first pretested with a limited number of samples (20%) in Koro Sub County outside the study area to check for the quality and validity of the questions. The questionnaires collected data on demographic characteristics of the study participants, hygiene and sanitary practices including fecal disposals, routine hand washing after visiting pit latrines, sources of drinking water; un-boiled or untreated water. Additionally, other data collected included pig management systems including pig keeping, type of pigs, presence of piglets, free-range pig rearing and tethering, pork consumption, meat inspections, purpose for pig rearing, vaccination among others. For ethical purposes, the study protocol was explained to the participants prior to the administration of the questionnaires and all participants consented to participate in the study. The estimated time for administration of each questionnaire was 30 min.

Pig sampling and examinations

Pig sampling and examination was done in each sub-county of the district. Briefly, 231 pigs were examined by visual inspection of their tongues for the presence of cysts in the districts of Gulu and Amuru. We conducted pig examination with the assistance of experienced veterinary officers and village helpers. In each household, all pigs were included for random selection and those selected were examined for the presence of cysts. The numbers of pigs selected per household were based on the population size of pigs in the respective households with maximum numbers not exceeding five. In all cases, the proportion to size (PPS) approach was used to calculate the number of pigs in the two sub counties of the two districts. The selected pigs were restrained adequately and their mouths gagged with a suitable size wooden stick placed in between the jaws to avoid biting during palpation of the tongues. The tongues ventral surfaces were examined for the presence of cysts. Pregnant and suckling sows or piglets less than three months were not examined to avoid stress. The pigs found infected with cysts or not were recorded. The owners of infected pigs were advised to slaughter and burn the infected carcasses under the supervision of a veterinarian. Precautionary measures were made to avoid accidents arising from pigs handling and no accidents occurred during this study period. Additionally, we ensured that materials were not re-used during pig examinations to avoid transmissions of the diseases among pigs from different households.

Statistical analysis

The prevalence data are presented as mean, standard deviation and frequency. This study used bivariate logistic regression to assess the strength of association between independent and the outcome variables (PC). The Odds ratios (OR) at 95% Confidence interval (CI) was used to measure the strength of association between each independent variable and outcome variables of interest. Multivariate logistic regression model was used to establish independent factors associated with PC. All independent variables associated with the outcomes of being positive for PC at p-values less than 0.2 at bivariate level and those variables known to be associated with the outcomes were fitted in the logistic regression model. A statistical significance level was set at p-value of 0.05 at 95% CI. Pearson's Chi square was used to test for levels of significance between means of proportions. All values greater than statistical P-value 0.05 was considered as significant.

RESULTS

Households and pig population

A total of 597 pigs in 300 households were involved in the study in Amuru and Gulu districts. Two hundred fifty, 250 (36%, 95% CI: 31-42) and 347 (46%, 95% CI: 41-52) numbers of pigs in the households were examined in Amuru and Gulu districts, respectively. Two hundred and thirty one (39%, 95%CI: 34-44) was the overall numbers of pigs examined for porcine cysticercosis Table 1

Number of pigs from eleven villages in Amuru and Gulu districts

The structure of the study area is indicated in Table 2. A total of five hundred and ninety seven pigs were from

Table 1. Number of households rearing pigs in Gulu and Amuru districts.

District	Number of households	Number of pigs in households	Number of pigs examined	Percent (95%CI)
Gulu	150	250	116	46 (41-51)
Amuru	150	347	125	36 (31-41)
Total	300	597	231	39 (34-44)

**39% of the pigs in the households were examined for porcine cysticercosis.

Table 2. Total number of pigs from the eleven villages in Amuru and Gulu districts.

Category	Number	Mean	Range
Districts	2	-	-
Parishes	4	2	2
Villages	11	5	5
Households	300	150	10-150
Pigs	597	2	1-19

**A total of 597 pigs from the 11 villages. The mean number of pigs per households was 2 with a range of 1-19 pigs.

Table 3. Prevalence of porcine cysticercosis in Unyama Sub County, Gulu District **(n=250**).

Parish	Number of pigs in households	Number of pigs examined	Number of pigs infected	Prevalence 95%CI
Unyama	38	19	6	5.2 (0.2-10.2)
Lapeta	42	25	4	3.4 (1.6-8.4)
Akonyibedo	58	21	1	0.9 (0.3-4.9)
Oding	50	21	3	2.6 (1.1-7.1)
Angaya	62	30	1	0.9 (0.3-4.9)
Total	250	116	15	12.9 (7.9-17.0)

CI: Confident interval.

eleven villages included for the study in Amuru and Gulu districts. Up to 300 selected households were involved and each household had an average of four pigs selected in the study.

Prevalence of porcine cysticercosis in Unyama sub county, Gulu district

Of the 250 pigs involved in the study from Unyama sub-county, 116 (46.4%, 95% CI: 41.4-52.4) were examined for porcine cysticercosis. Fifteen pigs were positive for porcine cysticercosis. Unyama Centre, 6 (5.2%, 95% CI: 0.2-10.2), Lapeta 4 (3.4%, 95%: 0.1-7.4) and Oding villages, 3 (2.6%, 95%CI: 0.1-6.6) had more pigs infected with *T*. *solium* cysticercosis. The overall prevalence of porcine cysticercosis in Unyama sub-county was (12.9%, 95%: 7.5-17.9). Up to 45 (56%, 95%CI: 51-52) of the households visited had pigs positive for PC Table 3.

Prevalence of porcine cysticercosis in Lamogi sub-county, Amuru district

Of the 347 pigs involved in the study from Lamogi sub-county, Amuru district, 125 pigs were examined for porcine cysticercosis. One pig was positive for porcine cysticercosis with an overall prevalence of 0.1%. Pakure Parish was the only parish with one positive case of porcine cysticercosis. Forty six (58%, 95%CI: 53-63) of the households did not have pit latrines and pig pens Table 4.

Demographic characteristics and study population

Table 5 shows a total of 300 respondents interviewed on PC between February and April, 2019. The study participants' age ranged from between 17 and 71 with a mean age of 36 ± 13.2 years. Majority of the participants

Table 4. Prevalence of porcine cysticercosis in Lamogi Sub County, Amuru District (**n=347**).

Village	No. of pigs in households	No. of pigs examined	No. of pigs infected	Prevalence 95%CI
Amora	70	28	-	0.0
Odur	58	15	-	0.0
Kal	51	19		0.0
Pakure	24	11	1	0.1
Amilobo	83	22	-	0.0
Agwayugi	61	30	-	0.0
Total	347	125	1	0.1

Table 5. Demographic characteristics and study population.

Independent variable	Frequency	95% CI
Sex		
Male	146	49 (44-55)
Female	154	51 (46-56)
Age		
10-19	28	7 (2-12)
20-29	89	30 (25-35)
30-39	82	27 (22-32)
40-49	44	15 (10-20)
50-59	35	12 (7-17)
60+	22	7 (2-12)
Marital status		
Married	220	73 (68-78)
Single	51	17 (12-22)
Widowed	25	8 (3-13)
Religion		
Catholic	200	67 (62-72)
Protestant	66	22 (17-27)
Moslem	10	3 (0.2-4.4)
Jehovah	5	2 (0.1-4.4)
Pentecostal	15	5 (0.1-4.8)
Education level		
None	160	53 (48-58)
Primary	70	23 (18-28)
Secondary	35	12 (7-17)
Tertiary	35	12 (7-17)
Occupation		
Farmers	180	60 (55-65)
Business	50	17 (12-22)
Teachers	46	15 (10-20)
Others	24	8 (3-13)
Residency (year)		
< 1	75	25 (20-30)

Table 5. Contd.

>1	23	8 (3-13)
>4	47	16 (11-21)
>10	45	15 (10-20)
>30	110	37 (32-42)

CI: Confidence interval.

were in the age groups 20-29. One hundred and fifty, 154 (51%, 95%CI: 46-56) of the participants were females. Majority were Catholic, 200 (67%, 95%CI: 62-72) followed by Protestants 66 (22%, 95%CI: 17-27) and Pentecostal faith based organizations, 15 (5.1%, 95%CI: 0.1-10). More than half 160 (53%, 95%CI: 48-58) of the participants had no formal education and most were farmers, 180 (60%, 95%CI: 55-65). The majority, 110 (37%, 32-42) involved in the current study were married persons who had lived in the study area for more than thirty years.

Risk factors porcine cysticercosis in Amuru and Gulu district

Of the 300 respondents, 208 (69%, 95%CI: 64-74) practiced pig farming with more than half 154 (51%, 95%CI: 46-56) of their pigs farmed by free range system (Table 6). Sixty percent, 180 (60%, 95%CI: 55-65) of the pig farmers largely reared pigs for sale and more than 62%, 185 (62%, 95%CI: 90-100) of them knew pork tapeworms. Eighty percent, 240 (80%, 95%CI: 75-85) had heard about PC. Sixty two percent, 185 (62%, 95%CI: 57-67) of the pigs' farmers kept the local breed because they are fairly resistant to the disease. Equal numbers of, 135 (45%, 95%CI: 40-50) and 135 (45%, 95%CI: 40-50) pig farmers reported they conducted routine deworming and vaccination of their animals, respectively. Fifty three percent, 158 (53%, 95%CI: 48-58) reported they had piglets in the households. Forty four percent, 135 (44%) of the respondents reported they had pit latrines and used them frequently, 185 (62%). However, 131 (44%) of the respondents reported they practiced open defecation. At least 131 (44%) of the respondent agreed they allowed their animals to feed on human feces. Most of the respondents, 210 (70%, 95%CI: 65-75) reported the boreholes as their sources of water. Up to, 138 (46%, 95%CI: 41-51) of the pig farmers reported that Veterinary Assistants conducted routine pig inspections when pigs were slaughtered in their villages.

Association of demographic characteristics and risk factors with porcine cysticercosis

This study analyzed the association of independent variables sex, age group, marital status, religion, occupation, and residency and education level with PC. Further analyses were conducted on the association of the variables; pig keeping, allowing pigs to feed on human feces, routine vaccination, routine inspection during pigs' slaughter, keeping piglets, pork consumption, routine deworming, presence of pit latrines, use of pit latrines and open defecation with PC (Table 7). Variables data with P-value less than 0.2 in the bivariate analyses were included into multivariable logistic regression model for further investigation. The finding from multivariate logistic regression analysis indicated that there was no statistically significant difference between age groups, marital status, religion, and duration of residency in respect to PC. However, the independent variable of sex (P=0.044, OR=5.41 (95%CI: 1.04-15.241)) was significantly associated with PC. Similarly, multivariate regression analyses revealed that there was no significant statistical difference between, routine vaccinations, presence of pit latrines, use of pit latrines, presence of piglets and pork consumption. However, pig keeping, (P=0.00, OR=0.56 (95%CI: 0.012-0.249)), routine deworming (P=0.04, OR= 1.131 (95%CI: 0.032-0.351)) and pig free range (P=0.03, OR=3.843 (95%CI: 1.13-12.71)), open defecation (P=0.003, OR=0.322 (95%CI: 0.003-3.058)) were the variables predictors significantly associated with PC.

DISCUSSION

This study has shown that PC is a growing concern in the district of Gulu, Northern Uganda. This may be attributed to poor methods of pig farming where pigs are allowed to scavenge or forage for foods in the villages as the farmers are unable to feed them. Additionally, lack of pit latrines and open defecation by some members of the communities might be encouraging the occurrences of the disease. Furthermore, the inabilities of the pig farmers to routinely deworm their pigs and vaccinate the piglets are the other risk factors for the occurrences of PC in the region. In Unyama sub-county, a prominent pig farming hub in Gulu district, the inadequate hygienic and sanitation practices were evident as one travelled within the rural community. These provide suitable environment for *T. solium* cyticercosis in the area. The pit latrines and

Table 6. Data on risk factors for porcine cysticercosis in Amuru and Gulu districts (n=300).

Variable	Frequency	Percent (95%CI)
Keeping pigs in the homestead*		
Yes	208	69 (64-74)
No	92	31 (26-36)
Types of pigs kept		
Local	185	62 (57-670)
Local and foreign	80	38 (33-43)
Don't know	35	12 (7-17)
Purpose for keeping pigs		
Sale	180	60 (55-65)
Consumption	50	17 (12-22)
Reproduction	70	23 (18-28)
Deworming of pigs*		
Yes	135	45 (40-50)
No	165	55 (50-60)
Know pork tapeworm*		
Yes	180	60 (55-65)
No	120	40 (35-45)
Heard of porcine cysticercosis		
Yes	240	80 (75-85)
No	60	20 (15-25)
Routine vaccinations		
Yes	135	45 (40-50)
No	165	55 (50-60)
Free range pig rearing*		
Yes	154	51 (46-56)
No	146	49 (44-54)
Presence of piglets		
Yes	158	53 (48-58)
No	142	47 (42-52)
Source of drinking water		
Borehole	210	70 (65-75)
Protected spring wells	57	19 (14-23)
Tap water	30	10 (5-15)
Others	3	1 (0.1-4.5)
Presence of Pit latrine		
Yes	132	44 (39-49)
No	168	56 (51-61)
Use of pit latrine		
Always	152	51 (46-56)

Table 6. Contd.

Sometimes	102	34 (29-39)
Never	46	15 (10-20)
Feed pigs with human feces*		
Yes	17	6 (1-10)
No	283	94 (89-99)
Open defecation*		
Yes	131	44 (39-49)
No	169	56 (51-61)
Routine pig inspections		
Yes	138	46 (41-51)
No	162	54 (49-59)

Table 7. Risk factors associated with porcine cysticercosis in Amuru and Gulu districts.

Variable	Frequency	Wald	S.E.	Sig(P)	OR	(95%CI)
Gender						
Male	146	3.012	0.974	0.054	5.41	(1.04-15.241)
Female	154					
Keeping pigs						
Yes	208	14.247	0.766	0.00	0.056	(0.012-0.249)
No	92					
Deworming						
Yes	135	8.111	1.259	0.04	0.131	(0.032-0.531)
No	165					
Pigs free range						
Yes	154	0.496	1.259	0.042	2.427	(0.21-28.634)
No	146					
Open defecation						
Yes	17	0.982	1.153	0.003	0.322	(0.033-3.058)
No	283					
Constant	-	3.671	0.194	0.55	9.847	-

*Major risk factors for porcine porcine cysticercosis in the study. Significance, P<0.05.

pig pens are poorly constructed or non-existent in the area. Most of the PC was concentrated in the semi-urban areas of the sub-county where commercial activities occurred. It is clear, that the majority of the pigs' farmers reared pigs mainly for sales. Unlike, Unyama sub-county, *T. solium* cysticercosis was almost non-existent in Lamogi sub-county in Amuru district where only one positive case was identified. However, there was no clear correlation in the hygienic and sanitation practices between these two sub-counties since both exhibited poor social infrastructure. These areas had poor husbandry practices and lacked pit latrines and had poorly constructed pig pens. In the absence of these vital facilities, the possibility of PC is encouraged in the region. Therefore, the low prevalence of PC in Amuru district may be attributed to recent vaccination and deworming of pigs' population which was done after the outbreak of Swine fever from 2015 to 2016 in Northern Uganda. This outbreak depleted most pigs in the area. These findings are consistent with the studies done previously; Gweba et

al. (2010) conducted study on PC among live pigs in a Zuru area of Kebbi State, in Nigeria and reported 5.6% infections. Kavishe et al. (2017) in a similar study conducted in Babati district, Manyara region, Northern Tanzania, found 13% of pigs infected with PC. On the other hand, Praet et al. (2009) conducted a study among the rural communities, in Northern Cameroon and reported prevalence of 5.6%. However, higher prevalence of PC has been reported in sub Saharan Africa where up to 64% of pigs were reported with PC (Dorny et al., 2004). The high prevalence may be attributed to poor hygiene and sanitary practices in these areas.

Several risk factors have contributed to the increased PC in endemic areas. Kungu et al. (2017) found that people who did not routinely deworm their pigs were more likely to have PC. Praet et al. (2009) on the other hand reported that pigs' farmers with low level of education were 5 times more likely to have their pigs infected with PC. In this study, the factors found mostly associated with the presence of PC were pig keeping, lack of deworming, free range pigs and open defecation. Farmers, who owned pigs, practiced free range, did not deworm their pigs and those who practiced open defecations were more likely found to have pigs with PC. These are consistent with previous studies where access of free range pigs to human faeces, lack of pit latrines and open defecations had been identified as risk factors for PC (Openshaw et al., 2018; Ngowi et al., 2010, Carabin et al., 2015). Additionally, having pigs in households had been identified as a risk factor for cysticercosis and taeniasis in Africa and South America and higher risk of sero-positivity had been seen in households that consume pork, respectively (Openshaw et al., 2018; Nkouawa et al., 2015). Furthermore, most (53%) of the respondents interviewed were illiterate. Our findings indicate that only 23% of the respondents had primary education and 58% were able to read and write. Further analysis revealed that male pig farmers and those who had at least a secondary education level were more likely to have pigs with less infection. This may be attributed to males having more interest in pig farming compared to the female counterpart. These findings did not conform to other studies done previously. For examples, Kungu et al. (2017) reported that male famers were significantly associated with better knowledge about PC than their female counterpart. Additionally, Openshaw et al. (2018) argued that level of education is associated with increased risk of infections and prevalence of PC. Males were 4 times more likely to have pigs with fewer infections than their female counterparts because they were significantly associated with better practices towards PC (Dahourou et al., 2018). In the current study, the majorities (78%) of the pigs' farmers were deficient of good husbandry practices care and were unable to provide the required management practices to support the well-being of the pigs in the villages. Most of the pig farmers relied on the veterinary assistants who occasionally visited them on request.

Conclusion

The findings indicate that porcine cysticercosis is endemic in Gulu district. The porcine cysticercosis is being influenced by poor pig husbandry practices by pig farmers. There is need for the local authorities to strengthen public education and routine meat inspection to prevent the proliferation of porcine cysticercosis in Amuru and Gulu Northern Uganda.

Limitation of the study

This study used lingual examination to diagnose the PC in households rearing pigs. This method is unable to diagnose pigs with low cyst burdens and those with no visible cysts on the ventral surface of the pigs' tongues are usually declared not infected. A combination of this finding, the results from the serology and confirmation with PCR method would provide a better picture of PC in the region. However, we were unable to conduct the serology and PCR tests. This means that the prevalence rate could be much higher than what it is reported here. Despite this limitation, the finding from the current study is important as it brings into light the potential risk of PC in the region that requires urgent attention. Future research should focus on examining the influence of pig husbandry and management practices on pig production among pig farmers in the rural communities. Additionally, further study should establish the sero-epidemiology of *T. solium* cysticercosis among the pig population and the rural communities for better understanding level of the exposure or current infection among the population.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors thank Okello Charles, Mwaka, and Ochieng Ladiro Michael from the districts of Amuru and Gulu districts. Special thanks go to the statistician Mr. Onen Anthony for the impeccable work done. This work was supported through the DELTAS Africa Initiative grant # DEL-15-011 to THRiVE-2. The DELTAS Africa Initiative is an independent funding scheme of the African Academy of Sciences (AAS)'s Alliance for Accelerating Excellence in Science in Africa (AESA) and supported by the New Partnership for Africa's Development Planning and

Coordinating Agency (NEPAD Agency) with funding from the Wellcome Trust grant # 107742/Z/15/Z and the UK government. BSB receives salary support from DELTAS Africa grant # 107743 to MUII-plus.

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