

Taenia solium cysticercosis survey at a slaughterhouse in Kampala, Uganda

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Keywords

Swine, *Taenia solium*, pork, meat inspection, abattoirs, zoonoses, Uganda

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Summary

A survey was conducted at Wambizi slaughterhouse in Kampala City, Uganda, to ascertain the prevalence of *Taenia* species infection in pigs via serology, as well as the role of meat inspection in control of these parasitic conditions in carcasses of slaughtered pigs. A total of 620 pigs were sampled using simple random selection during three months. Individual pig data including sex, breed, district of origin, antemortem clinical signs and postmortem lesions were recorded. Blood samples were collected for serological assays. A questionnaire was used to capture perceptions of meat inspectors and pig traders on *T. solium* cysticercosis. Of the 620 pig inspected carcasses, only four were observed with *T. solium* cysts and none had *T. hydatigena* cysts. Up to 67 (10.8%) pigs tested positive by B158C11A10/B60H8A4 Ag-ELISA serology. Seroprevalences were significantly different between districts ($\chi^2 = 45.98$; $p < 0.001$) with pigs from the Eastern districts having the highest seroprevalence. The two meat inspectors at the slaughterhouse had knowledge of pork inspection protocol for *Taenia* spp. infections, although they did not follow it properly because of the high number of carcasses to be inspected daily. All the 15 traders interviewed had heard about porcine cysticercosis but only five had ever seen cystic pork. *T. solium* cysticercosis is still prevailing in pigs in Uganda. Meat inspection is not a reliable diagnostic tool for efficient detection of *T. solium* cysticercosis.

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■ INTRODUCTION

Pigs play a key role in maintaining the transmission cycle of some zoonotic parasitic infections such as *Taenia solium* infection or cysticercosis (Thomas et al., 2016). The importance of cysticercosis led to its inclusion on the World Health Organisation roadmap for the control of neglected tropical diseases (Murrell et al., 2005). This condition has high public health and economic implications which have undermined growth of the pig industry where detection and strict condemnation of infected carcasses are implemented (Ngowi et al., 2010). The tremendous growth of the pig industry reportedly resulting from the increased demand for pork with consumption up to 3.4 kg/person/year in Uganda could therefore be threatened by the occurrence of *T. solium* cysticercosis (FAOSTAT, 2014).

Although no significant clinical signs may be exhibited in live pigs, evidence of porcine cysticercosis could suggest the occurrence of the infection in humans. Some of the risk factors of the disease to humans have been reported as ingestion of undercooked infected pork meat and free-range pig rearing. Such practices are common in the various smallholder pig-keeping communities of Uganda (Pondja et al., 2010; Waiswa et al., 2009; Willingham et al., 2010).

In order to obtain a countrywide baseline understanding of the *T. solium* cysticercosis burden in pigs in Uganda, a survey was conducted at Wambizi abattoir, an important marketing outlet of pigs reared in the country, to determine the prevalence of *Taenia* spp. infections via serology, and to assess the use of meat inspection as a detection tool. Located in Kampala, Uganda's capital and central business district, the abattoir is strategically positioned as a market hub for the urban consumers' high demand for pork (Dione et al., 2014; Ouma et al., 2014). Infection detection was carried out using gross meat inspection and serology (Winskill et al., 2017; Lightowers et al., 2016). The results of this study are expected to form a basis for in-depth epidemiological studies on the *T. solium* condition in the country and inform policy-makers and pig value chain actors on how to reduce best the burden of *Taenia* spp. infections on the agricultural economy and public health.

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MATERIALS AND METHODS

The study received approval from the Research and Ethics Committee of the College of Veterinary Medicine, Animal Resources and Biosecurity of Makerere University (Ref. No.: VAB/REC/17/08). Prior to the study, formal consent was obtained from the Manager of Wambizi abattoir. Participants verbally consented after clear explanation of the purpose of the study.

Study design

This survey was conducted at Wambizi abattoir from April to June 2017. The abattoir is located in Nalukolongo, Rubaga Division, Kampala District, and operates under ownership and management of the Wambizi Cooperative Society. It is the only gazetted pig slaughter place in Uganda. It was founded by pig farmers in 1971 to enable profitable marketing of their pigs and pig products. The pigs slaughtered at the abattoir are supplied by traders from various pig farming communities in the country. The pigs arrive in the evening and undergo slaughter process starting at 5.00 am the next day. Every carcass is then inspected for presence of lesions, especially those of zoonotic importance, and those without lesions are stamped to certify that they are safe for human consumption. The inspected pork is then traded through the formal and informal market outlets in urban and periurban Kampala and Wakiso districts. By-products such as offal, limbs, heads and fat are marketed by vendors on and off the premises.

Sample size determination

The sample size for this study was calculated using the following formula for an infinite population (Dohoo et al., 2009): $n = [Z^2 P(1-P)]/D^2$ where n is the required sample size, Z the multiplier from a standard normal distribution (1.96) at a probability level of 0.05, P the likely prevalence estimated to be 50% considering that there is no reliable abattoir prevalence data in the country for *Taenia* spp. infections, and D the desired precision for the estimate ($\pm 5\%$). A minimum sample size of 384 pigs was calculated. However, a total of 620 pigs were sampled to increase precision.

Sampling strategy

A minimum of 40 pigs were sampled by simple random selection on the most active two days of the week (Friday and Saturday when 70–100 pigs were slaughtered daily) for three months. Individual pig data on sex, breed, visible clinical signs and district of origin were recorded, and a blood sample was collected from the anterior vena cava using BD Vacutainer plain tubes (10 ml) during slaughter. Blood samples were kept standing in an icebox at about +4°C and taken to Makerere University, College of Veterinary Medicine, Animal Resources and Biosecurity (Mak-COVAB) where blood was centrifuged to separate the serum from blood clots. The serum was harvested into barcoded 2-ml vials that were stored at -20°C until serological analysis.

Postmortem inspection of carcasses

Following antemortem examination and slaughter, each carcass of the bled pigs was examined by the researcher and the government resident meat inspector according to inspection guidelines including visual examination, palpation and incision of the head viscera and carcass (Murrell et al., 2005). Evidence of cysts of *T. solium*, *T. hydatigena* and other lesions were noted. Pictures of predilection sites with prospective lesions were used as aiding tools during the assessment.

Briefly, predilection sites which included tongue, masseter, muscles of the thigh, liver, lungs and heart were inspected. These sites are known

to be highly sensitive and specific for detection of *T. solium* cysts (Herenda et al., 2000). On the other hand, the entire pluck, abdominal viscera and peritoneal cavity were examined for “*T. hydatigena* cysts with emphasis on the omentum and the mesentery examined *ex situ*” (OIE, 2008). Cysts were to be considered of “*T. hydatigena* metacestodes if they were singular, transparent and filled with clear fluid, with a discrete white spot denoting a scolex” (Herenda et al., 2000). The number of cysts, size and anatomic location were recorded on a data sheet.

Traders and meat inspectors' survey

Key informant interviews were conducted with 15 traders and two resident meat inspectors at the abattoir to assess their perceptions on *T. solium* infection. The following topics were addressed in the interview: knowledge about *T. solium* cysticercosis, transmission cycle and its control.

Serological analysis

Serological analysis for *Taenia* spp. antigen was carried out at Mak-COVAB pathology laboratory with the commercially available B158C11A10/B60H8A4 Ag-ELISA (apDIA Cysticercosis) (sensitivity = 100%; specificity = 99.6%) following the manufacturer's instructions. This test detects the secretory and excretory products of viable cysticerci of endemic *Taenia* spp. (Cortez Alcobedes et al., 2010).

Data analysis

Data collected was entered, cleaned and analyzed in Stata Statistical software (version 11.0, Stata Corp., 2020). Measure of associations between variables were determined by the Chi-square test. Logistic regression analysis was used to test for association between possible putative risk factors and seroprevalence of *T. solium* infection in pigs.

RESULTS

Pig biodata

In total 620 pigs were sampled at Wambizi abattoir with the majority (444) originating from the Central region. The slaughtered pigs were predominantly crossbred (97.3%), over 24 months of age (65.2%), and female (51.6%) (Table I).

Clinical signs at antemortem

The main antemortem clinical signs included diarrhea, coughing, nasal discharges, skin bruises, mange, scabs, reddened skin around

Table I: Pig characteristics at the slaughterhouse by region of origin, Uganda // *Caractéristiques des porcs à l'abattoir selon la région d'origine, Ouganda*

Characteristic	Central	Eastern	Northern	Total
Breed type				
Local	11	1	5	17 (2.7)
Crossbreed	433	116	54	603 (97.3)
Age group				
8–24 months	177	39	0	216 (34.8)
> 24 months	267	78	59	404 (65.2)
Sex				
Female	224	37	59	320 (51.6)
Male	220	80	0	300 (48.4)

the ears and ventral abdomen. No cardinal clinical sign associated with *T. solium* cysticercosis was observed among the 620 pigs studied.

Taenia spp. infection detection by Ag-ELISA

Out of the 620-pig serum samples, 67 tested positive for *Taenia* spp. antigen by B158C11A10/B60H8A4 Ag-ELISA (10.8%; 95% CI: 5.6–18.8%). The highest prevalence was recorded in pigs originating from Eastern Uganda. The seroprevalence significantly differed between districts ($\chi^2 = 45.98$; $p < 0.001$; Table II).

Demographic factors such as the breed type, sex, and age group of pigs were measured for potential association with the seroprevalence of *T. solium* cysticercosis using conditional logistic regression analysis with variables grouped by region (Table III). None of the factors explored were significantly associated with the infection in pigs.

Meat inspection for detection of *Taenia* spp. infections

Out of the 620 pig carcasses inspected postmortem, only four were observed with *T. solium* cysts and none had *T. hydatigena* cysts. All the samples from pigs observed with cysts during meat inspection tested positive by serology. Comparison with the prevalence showed that the results were significantly different ($\chi^2 = 33.23$; $p < 0.001$). The point estimates of meat inspection as a diagnostic tool for *T. solium*, using serology as a reference test, are summarized in Table IV.

Table II: *Taenia solium* cysticercosis seroprevalence in pigs at the slaughterhouse by region of origin, Uganda // *Séroprévalence de la cysticercose à Taenia solium chez les porcs à l'abattoir selon la région d'origine, Ouganda*

Region	N	Seroprevalence (%)	χ^2 , P
Central	444	25 (5.6)	45.98, 10^{-10}
Eastern	117	31 (26.5)	
Northern	59	11 (18.6)	
Total	620	67 (10.8)	

Table III: Conditional logistic regression of pig characteristics and seroprevalence of *Taenia solium* cysticercosis, Uganda // *Régression logistique conditionnelle des caractéristiques des porcs et séroprévalence de la cysticercose à Taenia solium, Ouganda*

Variable	Z	P	95% Confidence interval
Breed type	0.65	0.51	1.40–2.79
Sex	1.85	0.06	1.82–0.06
Age group	0.46	0.25	1.01–0.78

Table IV: Point estimates of diagnostic characteristics following pork inspection for *Taenia solium* detection, Uganda // *Valeurs estimées des caractéristiques diagnostiques consécutives à l'inspection de viande de porc pour la détection de Taenia solium, Ouganda*

Diagnostic characteristics	Point estimate (95% confidence interval)
Sensitivity	0.06 (0.02–0.15)
Specificity	1.00 (0.99–1.00)
Positive predictive value	1.00 (0.40–1.00)
Negative predictive value	0.90 (0.87–0.92)

Meat inspectors and traders' perceptions on *Taenia* spp. infections

The two meat inspectors interviewed regarding detection of *Taenia* spp. infections in pigs had been working in the abattoir for the past 18 years. They noted that cysticercosis infection was the most prioritized condition during the routine meat inspection process. They estimated porcine cysticercosis prevalence to be lower than 1%, with about 150 kilograms of pork condemned per year as a result.

The 15 pig traders interviewed were mostly men (12), 20–40 years of age (12) and 46% had attained secondary education. Although all 15 traders had heard about porcine cysticercosis and referred to it as *akacere* in local Luganda language, meaning pork with rice spots, only five had ever seen cystic pork. All the respondents noted that their pork had never been condemned because of cysticercosis.

DISCUSSION

The overall seroprevalence of *T. solium* infection observed in this study (10.8%) was lower than that reported in other abattoir surveys (Braae et al., 2015; Porphyre et al., 2015). The seroprevalence of *T. solium* cysticercosis in slaughtered pigs varied significantly according to the district of origin, those from Eastern Uganda being most affected. According to a previous study in Soroti, Eastern Uganda, the high prevalence of porcine cysticercosis was attributed to poor sanitation and exposure of roaming pigs to human feces (Zirintunda and Ekou, 2015). The lower seroprevalences in the districts of the Central region could be due to improved systems of management whereby pigs are in most cases confined, as well as the high level of sanitation in the region, especially better covering of latrines compared to other regions of the country (Dione et al., 2014; Muhanguzi et al., 2012). Although previous studies have reported demographic factors such as breed, age and sex to be predictors of *T. solium* cysticercosis seroprevalence in pigs (Kungu et al., 2017), this was not the case in this study.

The antemortem findings in this study agree with other works in Masaka, Kamuli and Mukono which reported a trend of occurrence of conditions similar to the clinical signs observed in this study (Kungu et al., 2017). Diarrhea associated conditions, skin scabs (mange, swine erysipelas) have been perceived by farmers to be the commonest signs along with reddened ventral abdominal area and ears (Dione et al., 2014). However, these reported clinical signs are not cardinal in diagnosis of *T. solium* cysticercosis, which is usually characterized by abnormal behavior such as seizures, trembling, twisting and walking in circles (Trevisan et al., 2016).

Meat inspection is mandatory in gazetted abattoirs as stated in the Public Health Act of Uganda. This is to ensure proper inspection and certification of pork before sale to retail outlets (Anon., 1964). In this study, only a few pigs were detected with cysts by postmortem meat inspection which is attributed to the poor sensitivity of meat inspection (only 6%), as previously reported (Dermauw et al., 2016; Thomas et al., 2016). Since its sensitivity and objectivity are dependent on the expertise and vigilance of meat inspectors, there is a possibility that the sensitivity of inspection may drop even further when many pigs are slaughtered in a day.

Unlike the occurrence of *T. hydatigena* infection reported in pork inspection studies in Burkina Faso (8.8%) and Tanzania (6.6%) (Dermauw et al., 2016; Braae et al., 2015), none was observed in this study. This could still be attributed to the poor sensitivity of the meat inspection method.

The current study further noted that the two designated meat inspectors at Wambizi abattoir were well informed about porcine

cysticercosis. The inspectors indicated that porcine cysticercosis was among the most prioritized conditions for control in the country. However, we observed laxity among the inspectors when the number of slaughters was high, which could result in some of the carcasses being stamped and exiting the abattoir without proper inspection. Such a tendency has been reported in other abattoir studies. It was also observed that traders had heard about porcine cysticercosis with one-third (5/15) of respondents having seen cystic pork. This level of awareness could have been created by the fact that *T. solium* cysticercosis occurs in many parts of the country.

■ CONCLUSION

This study provides evidence that *Taenia solium* cysticercosis is endemic in Uganda. Differing seroprevalences in pigs originating from different regions may point to the need to control *T. solium* infection in Uganda through improved husbandry and sanitation practices. Although meat inspection has a role in minimizing the zoonotic risk of porcine cysticercosis to consumers, the method is not an efficient detection tool when used alone. This can also be aggravated by the fatigue of the few inspectors at Wambizi abattoir when there is a high number of pigs slaughtered in a day. Since no *T. hydatigena* cysts were observed in this study, it is likely that the seroprevalence estimates of *Taenia* spp. infections obtained in this study and in previous works in the country could be caused by *T. solium*. Based on the present findings, it is recommended that the abattoir should improve disease detection by using both gross inspection and laboratory diagnosis.

Author contributions statement

JMK conceived and designed the study, collected, analyzed and interpreted the data, drafted and critically reviewed the manuscript; MA analyzed and interpreted the data, drafted and critically reviewed the ms.; MMD designed the study, collected, analyzed and interpreted the data, drafted and critically reviewed the ms. All authors gave final approval for submission of the ms.

Conflicts of interest

The authors declare that there is no conflict of interest.

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Résumé

Kungu J.M., Afayoa M., Dione M.M. Enquête sur la cysticercose à *Taenia solium* dans un abattoir de Kampala en Ouganda

Une enquête a été menée à l'abattoir Wambizi dans la ville de Kampala, en Ouganda, afin de déterminer la prévalence sérologique des infections par les *Taenia* chez les porcs et l'efficacité de l'inspection sanitaire pour identifier ces infestations parasitaires dans les carcasses de porcs abattus. Au total, 620 porcs ont été échantillonnés aléatoirement pendant trois mois. Des données individuelles sur les porcs, notamment le sexe, la race, le district d'origine, les signes cliniques *ante mortem* et les lésions *post mortem* ont été enregistrées. Des échantillons sanguins ont été prélevés pour des tests sérologiques. Un questionnaire a permis de déterminer les connaissances des inspecteurs chargés de l'examen des viandes et des négociants qui la commercialisaient à propos de la cysticercose à *T. solium*. Sur les 620 carcasses de porcs inspectées, seules quatre avaient des kystes de *T. solium* et aucune n'avait de kystes de *T. hydatigena*. En revanche, 67 porcs (10,8 %) ont été positifs par la sérologie Ag-ELISA B158C11A10/B60H8A4. Les séroprévalences étaient significativement différentes entre les districts d'origine ($\chi^2 = 45,98$; $p < 0,001$), les porcs venus des districts de l'est du pays ayant eu la séroprévalence la plus élevée. Les deux inspecteurs sanitaires de l'abattoir ont affirmé connaître le protocole d'inspection des carcasses de porc pour les infections à *Taenia* spp., bien qu'ils n'aient pas pu le suivre correctement en raison du trop grand nombre de carcasses à inspecter quotidiennement. Les 15 commerçants interrogés avaient entendu parler de la cysticercose porcine, mais seuls cinq d'entre eux avaient déjà vu un porc kystique. La cysticercose à *T. solium* reste une pathologie répandue chez les porcs en Ouganda. Toutefois, l'inspection des viandes n'est pas un outil de diagnostic fiable pour la détection efficace de la cysticercose à *T. solium*.

Mots-clés : porcine, *Taenia solium*, viande porcine, inspection des viandes, abattoir, zoonose, Ouganda

Resumen

Kungu J.M., Afayoa M., Dione M.M. Encuesta sobre la cisticercosis por *Taenia solium* en un matadero de Kampala, Uganda

Se llevó a cabo una encuesta en el matadero de Wambizi en la ciudad de Kampala, Uganda, para corroborar mediante serología la prevalencia de infecciones por especies de *Taenia* en cerdos, así como el papel de la inspección de carne en el control de esta condición parasitaria en carcacas de cerdos de matadero. Un total de 620 cerdos fueron muestreados utilizando una simple selección aleatoria durante tres meses. La información individual de los cerdos incluyó sexo, raza, distrito de origen, signos clínicos *ante mortem* y lesiones registradas *post mortem*. Se colectaron muestras de sangre para estudios serológicos. Se utilizó un cuestionario para capturar las percepciones de los inspectores de carne y de los comerciantes de cerdos sobre la cisticercosis por *T. solium*. De las 620 carcacas de cerdo inspeccionadas, solamente cuatro presentaron quistes de *T. solium* y ninguna presentó quistes de *T. hydatigena*. La serología de 67 (10,8%) de los cerdos fue positiva para B158C11A10/B60H8A4 Ag-ELISA. Las seroprevalencias fueron significativamente diferentes entre distritos ($\chi^2 = 45,98$; $p < 0,001$), con seroprevalencias más elevadas en los cerdos provenientes de los distritos de este. Los dos inspectores de carne en el matadero conocían los protocolos de inspección de cerdos para infecciones por *Taenia* spp., sin embargo, no los siguieron adecuadamente debido al gran número de carcacas a inspeccionar diariamente. Todos los 15 comerciantes entrevistados habían oído sobre la cisticercosis porcina, pero solo cinco habían visto un quiste en cerdos. La cisticercosis por *T. solium* es todavía prevalente en cerdos en Uganda. La inspección de carne no es una herramienta de diagnóstico fiable para la detección eficiente de infecciones por *T. solium*.

Palabras clave: cerdo, *Taenia solium*, carne de cerdo, inspección de la carne, mataderos, zoonosis, Uganda

