Ghana Journal of Science, Technology and Development
Vol. 7, Issue 1. July 2020
available online at ***www.gjstd.org***
e-ISSN: 2343-6727

Science | Technology | Development

Abattoir-based prevalence and distribution of porcine cysticercosis in northern Ghana inferred from Kumasi Abattoir

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ABSTRACT

Taenia solium cysticercosis is a cosmopolitan foodborne disease that is neglected in many endemic tropical societies. The disease situation is less understood in parts of sub-Saharan Africa including Ghana, meanwhile useful surveillance data are needed from all endemic localities for designing effective intervention strategies. The present study estimated abattoir-based prevalence and distribution of T. solium cysticercosis in pigs from northern Ghana. A survey was carried out at the Kumasi abattoir to screen for cyst infection and localization sites, and evaluate the handling of infected carcasses. Taenia solium cysticercosis infection was noted in pigs at the abattoir, drawn from all five Regions of northern Ghana. Generally, porcine cysticercosis had 9.73% prevalence across the Regions with the Upper East Region (10.10%) being noted as a key focus of the cestode. Animals from the Upper West, Savannah, Northern and North East Regions also recorded a prevalence range of 8.25 – 12.12%. The results indicate considerable prevalence of T. solium cysticercosis that was in wide distribution in pig in northern Ghana and point to a public health threat in cities where such infected pigs are slaughtered.

Keywords: *Porcine cysticercosis, Taenia solium, Ghana, prevalence, distribution, food-borne zoonosis*

INTRODUCTION

Porcine cysticercosis (PCC) is an important parasitic disease in many pig rearing societies globally. Its impact is more common in poor communities where it affects pig production and poses public health challenge in human population (Torgerson *et al*., 2015). Porcine cysticercosis is caused by the pork tapeworm, *Taenia solium*, that is transmitted between pigs and humans. The cestode uses humans as definitive host where adult worm resides in the small intestine causing taeniasis, and pigs as intermediate host in which it develops into cysticerci. Eggs shed by adult worms are distributed in the environment through human faeces. Pigs get infected by ingesting *T. solium* eggs from contaminated food materials, water or direct ingestion of infected human stool when scavenging. Humans become infected when they consume raw or undercooked pork containing cysticerci. Humans can also suffer cysticercosis when eggs are accidentally ingested where cysts develop and can affect muscles, eyes and skin, and the central nervous system (neurocycsticercosis) to cause neurological symptoms including

epilepsy seizure (Zoli *et al*., 2003). *Taenia solium* cysticercosis and taeniasis are foodborne zoonotic infections common among pig keeping societies with poor sanitation standards and poor pig husbandry practices (Bimi *et al*, 2012; Carabin *et al*., 2015; Singh *et al*., 2018; Zammarchi *et al*., 2013).

Globally, PCC is recognized as a major neglected tropical disease that warrants effective control/elimination strategies (WHO, 2010). In 2015, WHO estimated human cysticercosis to be the most important foodborne parasitic disease among 10 others, causing 2.8 million DALYs (Torgerson *et al*., 2015). Zoli *et al*. (2003) estimated economic loss due to PCC to be 25 million in endemic west and central African countries. *Taenia solium* is hitherto of wide spread following the distribution of pigs, however, recent reports indicate its frequency mainly from pig rearing localities in Africa, Asia and southern America. Reports of *T. solium* is an indication of 'broken' sanitation standards and poor pig husbandry practices where pigs have easy access to human faeces.

In sub-Saharan Africa, many countries have long been known to be endemic to *T. solium* cysticercosis but useful data on the disease situation are available only from few countries (Assana *et al*., 2013; Melki *et al*., 2018; Winkler, 2012). West Africa is one such under-researched sub-regions; meanwhile the cestode is endemic in Benin, Burkina, Ghana, Côte d'Ivoire, Nigeria, Senegal, Togo, the Gambia, Cape Verde, Guinea Bissau, Mali (Melki *et al*., 2018). Impact of *T. solium* in humans in Ghana was long noted (Proctor *et al*., 1965) and recent studies indicate the persistence of the cestode in different localities across the country. Adu-Gyasi *et al*. (2018) and Bimi *et al*. (2012) found 1.50% and 13.15% taeniasis prevalence in the middle-belt and Northern Region of Ghana, respectively, while Atawalna *et al*. (2015) reported 2.31% PCC from the Kumasi Metropolis. The present study describes abattoir-based prevalence and distribution of porcine cysticercosis and localization sites of cysts in pigs from the northern zone of Ghana.

MATERIALS AND METHODS

Study Area

A two-month slaughterhouse survey was conducted at the Kumasi abattoir company limited for the period, December 2018 – January 2019, to screen pigs brought from the northern zone of Ghana for slaughter for *Taenia solium* cysticercosis. Pigs at slaughter originated from the Upper East, Upper West, Savannah, North East and Northern Regions of Ghana (Figure 1).

Sample collection and storage

All pigs (987) brought from the northern zone of Ghana for slaughter during the period were considered for the study. Prior to slaughter of animals, age, sex and origin of pigs were noted. Age of pigs was estimated based on tooth eruption and wear (Clarke *et al.*, 1992) with the help from veterinary staff, coupled with estimated age provided by middlemen. After slaughter, the tongue, diaphragm, heart, shoulders and thigh were carefully examined by the 'eye and knife' method by veterinary officers. The 'eye and knife' method involved visual examination and/or incision of localization sites to detect cysticercosis (Dorny *et al*., 2005). Cysts were identified as *T. solium* based on morphology: fluid filled translucent vesicles (0.5 – 1 cm) with small whitish spots indicating invaginated scolex. Cysts were sampled by cutting portions of affected muscles or whole organs and fixed in 70 % ethanol.

Statistical analysis

The data was summarised into frequencies and presented as tables and bar chart using the IBM SPSS software. Prevalence was estimated as number of animals infected per total number of animals screened.

RESULTS

Distribution and prevalence of porcine cysticercosis (PCC)

At the Kumasi abattoir, a total of 987 pigs at various ages from the northern zone of Ghana, thus Northern, North East, Upper

East, Upper West and the Savannah Regions were screened for porcine cysticercosis (PCC) (Figure 1). *Taenia solium* cysts were identified in pigs from all five Regions. On the average, northern Ghana as determined here showed a prevalence of 9.73% (96/987) PCC (Table 1, Figure 1). The Upper East and Upper West Regions where substantive number of pigs originated revealed prevalence of 10.10% (50/495) and 8.25% (25/303), respectively. The Savannah, North East and Northern Regions were yet as one administrative Region, the Northern Region, as at the time of the survey. Meanwhile, the dataset has been partitioned to reflect current demarcations, thus; North East, Northern and Savannah Regions with PCC prevalence in the respective order, 12.12%, 11.43% and 10.84%. The number of animals drawn from these three Regions were however considered too small for a statistical power of inference, hence the estimated prevalence values may not reflect the true PCC situation in such localities.

FIGURE 1. **Map of Ghana indicating the origin of pigs (area in red rectangle) in northern zone and point of slaughter (Kumasi, Ashanti Region) and estimated prevalence of porcine cysticercosis (in parenthesis) in the present study. North East, Northern and Savannah Regions were together as Northern Region as at the time of sample collection. Map adapted from The Huans in Africa (https://haunsinafrica.com/).**

TABLE 1. **Prevalence of porcine cysticercosis (PCC) from the Upper East, Upper West, North East, Northern and Savannah Regions of Ghana**

Regions (town)	n (M/F)	n infected (M/F)	Prevalence (%) (M/F)
Upper East (Bawku, Bongo, Bolgatanga, Bougosonye, Chiana, Garu, Namoo, Navrongo, Widana)	495 (129/366)	50 (24/26)	10.10 (18.60/7.10)
Upper West (Wa)	303 (124/179)	25 (10/15)	8.25 (8.06/8.38)
*Savannah (Damongo)	83 (35/48)	9 (5/4)	10.84 (14.29/8.33)
*Northern (Yendi)	73 (16/57)	8 (5/3)	11.43 (31.25/5.56)
*North East (Nalerigu)	33 (10/23)	4 (0/4)	12.12 (-/17.39)
Total	987 (314/673)	96 (44/52)	9.73 (14.01/7.73)

**These were all together as the Northern Region as at the time of slaughterhouse survey. n = number of animals, M: male, F: female.*

Male and female pigs were infected with cysticercosis alike; the difference in prevalence values observed here may be artificial since more female than male

animals were brought for slaughter. The town origin of pigs recorded here was provided by middlemen that supplied animals to the abattoir. These towns should be considered as assembling point or marketing centres where animals from surrounding villages/communities were brought for sale to such middlemen and/or shipment to southern cities for slaughter. The infections were thought to be primarily autochthonous to the Regions.

Away from the alimentary canal, *T. solium* cysts could be isolated from skeletal and smooth muscles of pig carcasses (Figure 2). The thigh makes the most common localization site of the cestode, as was the case in 64/96 animals, followed by the shoulders in 24/96 animals and the heart in 7/96 animals. The tongue, diaphragm and the striated longissimus of pigs could be regarded as less common places to isolate *T. solium* cyst. There were six animals of the 96 that had the entire carcass heavily infested with cysts; these carcasses were totally condemned. Whole and affected parts of those partially infected were condemned and subsequently incinerated by the veterinary staff.

Localization sites of *Taenia solium* cysticercosis

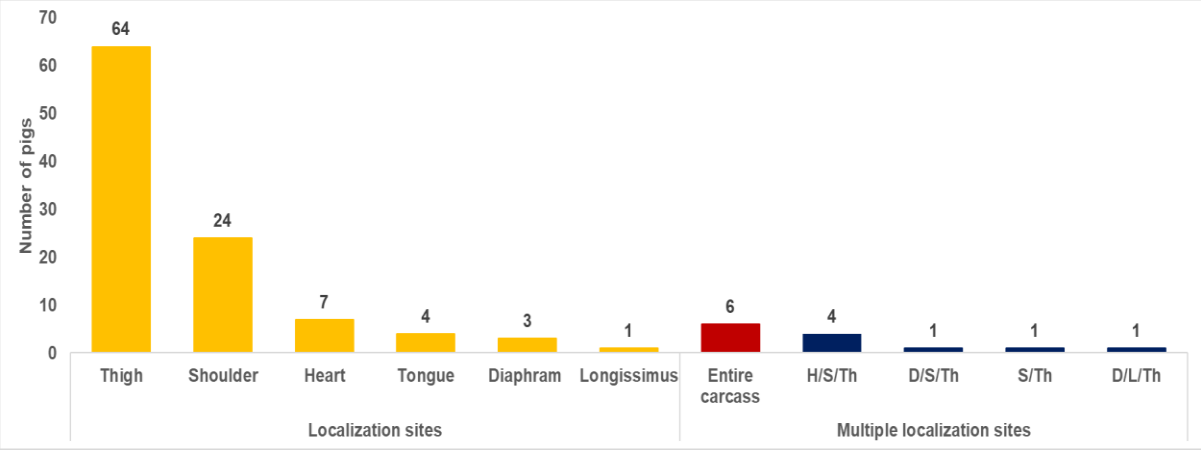

FIGURE 2. **Taenia solium cysticercosis localization sites in pigs. D: diaphragm, H: heart, L: longissimus, S: shoulder, T: tongue and Th: thigh.**

DISCUSSION

Porcine cysticercosis (PCC) is widely distributed in West Africa and has been shown to have varied prevalence/incidence from country to country and among endemic localities within countries (Adu-Gyasi *et al.*, 2018; Bimi *et al.*, 2012; Carabin *et al.*, 2015; Melki *et al.*, 2018). Generally, it is thought to be common in pig raising and pork consuming, rural poor societies, and less frequent or absent in societies where pork consumption is prohibited such as in Islamic societies (Melki *et al.*, 2018). Meanwhile data on *Taenia solium* cysticercosis and taeniasis disease situations are only available from few places which reveals only limited understanding of its dispersal and transmission dynamics. The present work discusses the prevalence and distribution of *T. solium* cysticercosis in pigs from northern Ghana.

Porcine cysticercosis could be reported in pigs from all five Regions of northern

Ghana. This observation confirms the occurrence of the cestode in Ghana (Atawalna *et al*., 2015; Bimi *et al*., 2012; Permin *et al*., 1999) and indicates its wide geographical distribution in the country than previously regarded. Our observations also indicate persistent transmission systems of the disease in the endemic localities.

Prevalence of PCC in Ghana has been noted to be in the range of 2.31% to 11.70% (Atawalna *et al*., 2015; Permin *et al*., 1999) while Bimi *et al*. (2012) reported of 13.15% in taeniasis in human subjects based on taeniid eggs identification (authors acknowledged possible inclusion of *T. saginata* eggs in this value). Over a two decade period, prevalence values of PCC in northern Ghana, particularly in the Upper East Region has not significantly changed; thus 10.10% in the present study vs. 11.70% in the accounts of Permin *et al*. (1999). Though previous records of the disease from the other four regions were unavailable for comparison, the average prevalence of 9.73% clearly indicates endemicity to the area. Our observations are not extreme to those ever known in the western Africa subregion; higher prevalence were once reported from the Nsukka area in Nigeria – 20.50% in a post-mortem survey (Onah and Chiejina, 1995) and from Burkina Faso – 32.50 – 39.60% by ELISA (Ganaba *et al*., 2011). On the account of post-mortem examinations, the present and previous prevalence values reveal Ghana to be an important foci of PCC in the West Africa (Adu-Gyasi *et al*., 2018; Atawalna *et al*., 2015; Bimi *et al*., 2012; Melki *et al*., 2018; Permin *et al*., 1999) and perhaps in whole of sub-Saharan Africa (Assana *et al*., 2013). For instance, the high PCC prevalence in the 1990s in Nsukka area of Nigeria had been shown to have reduced in recent years to 2.40% (Idika *et al*., 2017) whereas the case of the Upper East Region of Ghana about the same time period remains relatively unchanged thus 11.70% in 1997 (Permin *et al*., 1999) vs 10.10% in the present study.

In *T. solium* cysticercosis highly endemic regions, inspection of the tongue of live animals is one of the easiest diagnostic approach. From this study, the tongue is clearly shown not to be a very reliable part to diagnose *T. solium* cyst infection in the pigs. The striated muscles of the thigh and the shoulder proved to be the most reliable predilection sites. This observation probably explains why post-mortem inspection usually gave higher prevalence values than tongue inspection (Assana *et al*., 2013). Following the various or multiple predilection sites recorded here, meat inspectors may pay attention to all muscular parts of carcass and visual inspection should be accompanied by incision and palpation (Komba *et al*., 2013).

It is common that pigs raised in Ghanaian rural communities are usually transported to urban areas for slaughter as seen in the present study where animals raised in rural communities in the northern zone were slaughtered in Kumasi city. This phenomenon poses a public health threat to pork consuming population in the city, whereby unnoticed cysts in pork may infect humans and cause taeniasis. Such introduced *T. solium* taeniasis infection if not managed well may result in cysticercosis in humans via accidental ingestion of taeniid eggs. It is worth mentioning that the six carcasses noted to be wholly infected and all infected parts of the rest of cysticercosis positive carcasses were condemned (incinerated). Considering the limited slaughtering facilities in Ghana, home/elicit slaughter without veterinary inspection is still common in rural settings (MoFA, 2016). Such informal slaughter activities will promote easy transmission of taeniasis (Melki *et al*., 2018).

Prevalence or incidence of *T. solium* cysticercosis is an indication of poor

hygiene standards where pigs have access to infected human faecal matter. Various risk factors common in developing countries are known to support the wide distribution and persistent of cysticercosis: 1) open air defaecation by humans, 2) lack of household toilet facility, 3) extensive/semi-intensive pig rearing system, 4) wide movement of pigs (Assana *et al*., 2013; Bimi *et al*., 2012; Komba *et al*., 2013; Melki *et al*., 2018; Nonterah *et al*., 2015). These factors were not investigated in the present study, nevertheless, presence of *T. solium* in the intermediate host is an indication that such pigs had access to infective eggs of the cestode from scavenging on sewage or human faeces or drinking contaminated water. These pigs may have been raised under extensive or semi-intensive systems which are the commonest livestock husbandry systems in rural Ghana (MoFA, 2004, 2016).

CONCLUSION AND RECOMMENDATIONS

The present study showed considerable prevalence but wide spread of *Taenia solium* cysticercosis in pigs (porcine cysticercosis (PCC)) in northern Ghana. The cestode infection was recorded in pigs from Northern, North East, Upper East, Upper West and Savannah Regions. The Upper East Region was shown to be a major focus of the cestode infection in pigs. The findings here indicate a wide circulation of PCC in pig raising societies in northern Ghana and slaughter of such infected pigs at far away urban centres may results in extensive distribution of the zoonosis.

It will be beneficial to investigate the disease situation and associated risk factors for transmission and distribution of *T. solium* taeniasis and cysticercosis in human (and pig) populations at the endemic localities reported here and in Ghana cities such as in Kumasi where pork is consumed. In addition, evaluation of the genetic characteristics and population structure of local *T. solium* population in Ghana will be essential to understand its evolutionary trajectories and dispersal routes. Finally, the economic importance of *T. solium* diseases need to be estimated to draw local attention to its burden and possible intervention.

ACKNOWLEDGMENTS

We are grateful to Mr Kwesi Kumah, Mr Kwame Anane and all other staff of the Veterinary Service at the Kumasi abattoir who facilitated the survey and collection of samples.

Competing Interest

Authors declare no competing interest.

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