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Occurrence of cysticercosis in pigs slaughtered at three abattoirs in Wukari town, Taraba State, Nigeria

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Abstract

Porcine cysticercosis is a parasitic zoonotic disease of economic and public health importance. This study evaluated the occurrence of cysticercosis in pigs slaughtered in Wukari town, Taraba State Nigeria. A cross-sectional survey design was used, and the sample size was 390, made up of 109 females and 281 males. Post-mortem examination of the carcasses were carried out by visual examination, systematic palpation and cutting into organs. Results showed that 9 out of the 390 pigs sampled (2.3%) had cysticercosis. Out of the 281 male pig carcasses examined, 7 (2.5%) had cysticercus cysts while 2 (1.8%) out of the 109 females had the cysts. Prevalence was higher in male pigs, though sex was not significantly ($p > 0.05$) associated with the prevalence. Out of the total pigs examined, 241 were between 6 – 12 months of age, out of which 3 (1.3%) were infected with cysticerci. Six out of the 149 pigs that were > 12 months of age (4.03%) had cysticerci. Significantly ($p < 0.05$) higher prevalence was observed in older pigs (> 12 months). The cysts detected were found in the shoulder muscle, masseter, thigh muscle, heart and tongue, and were immature and viable except one. It was concluded that the occurrence of cysticercosis in pigs in the study area was 2.3%. It was recommended that open-field defecation should be avoided, intensive management of pigs should be adopted, and that veterinary care and effective meat inspection and public awareness campaign on the risk of consumption of raw or undercooked pork be undertaken.

Keywords: Cysticercosis; Occurrence; *Taenia solium*; Pigs; Cysts; Wukari, Taraba State, Nigeria.

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Introduction

Pig production is experiencing rapid expansion worldwide, particularly in developing nations where there is a transition from ruminant livestock production to monogastric production. This change is driven by the shorter life cycles of pigs compared to ruminants (FAO, 2020). The production of pigs has multiple benefits, such as generating cash, providing a source of protein, and serving as valuable assets for traditional ceremonies (Kagira *et al.,* 2003). Pigs has a distinctive capacity to adjust and thrive in many environments, making them a valuable resource for addressing inadequate protein supply, serving as an investment option, and generating income for the human population, particularly women (Ajala *et al*., 2007). Nigeria's pig population is approximately 3.5 million, accounting for 4% of the country's overall domestic livestock (Bourn *et al*., 2014).

The pig production industry is confronted with public health risks as a result of the occurrence of certain zoonotic illnesses. Cysticercosis in pigs is a parasitic zoonotic disease that is of economic and public health importance. Porcine cysticercosis is a condition where the tissues of pigs are infected by metacestodes (cysticerci) of the cestode *Taenia solium* (*T. solium*). *Taenia solium* is a parasitic tapeworm that can be transmitted between pigs and humans in an ecosystem. Pigs contract the disease by either consuming human faeces that contain infectious eggs of *T. solium* or by grazing on pastures that are infected with *T. solium* eggs (Carrique-Mas *et al*., 2001). Subsequently, these eggs develop into oncospheres within the pig's gastrointestinal tract. The oncospheres migrate through the circulatory system and settle in various organs of the body, where they undergo development into the larval form of the tapeworm known as *Cysticercus cellulosae*. The *Cysticercus cellulosae* is a cystic formation filled with fluid. It is composed of a thin bladder wall that is found within the tissues of pigs. These structures are usually 5 – 15 mm in length, but can occasionally grow up to 5 cm (Flisser *et al.,* 2004). Defining the clinical manifestations of the disease in pigs is exceedingly challenging, because pigs may have numerous cysticerci in their muscles, yet they exhibit no signs of distress (Garcia *et al.,* 2003). Pigs with a high number of larvae in their brain may exhibit a calmer demeanour compared to others and spend longer periods of time lying down (Garcia *et al.,* 2003).

Consuming raw or undercooked pork from infected pigs can lead to the development of larval cysts into adult tapeworms in the intestines. Gravid proglottids, which contain infective eggs, detach from the adult tapeworm and are expelled in the faeces (Garcia *et al.,* 2003). In regions where open-field defecation is prevalent, pigs consume the excrement containing these infectious eggs either directly or from contaminated pastures, thus perpetuating the life cycle (Ito *et al*., 2006). Humans can serve as an intermediate host for *T. solium* if they come into contact with infective eggs through faecal-oral contamination. The larval stage can be present in several parts of the human body, including muscle, heart, eyes, skin, or central nervous system, resulting in human cysticercosis (Flisser *et al*., 2004). Neurocysticercosis (NCC) is the most severe manifestation of human cysticercosis, associated by the development of the larval form in the brain. Human NCC can manifest several clinical symptoms, including headache, blindness, hydrocephalus, chronic meningitis and dementia (Carabin *et al*., 2005). Neurocysticercosis has been linked to epilepsy in areas where pigs feed on carcasses and sanitation conditions are sub-standard (Rottbeck *et al.,* 2013). According to White (2009), more than 10 million individuals are estimated to come into contact with the immature form of *Taenia solium*, which often leads to neurocysticercosis and epileptic seizures in those affected.

The parasite does not occur in areas where there is sufficient sanitation and proper animal care methods. Nevertheless, these areas remain susceptible due to the migration of individuals from heavily infected regions, who carry diseases of the mature stage (taeniasis). These new pathogens contribute to a higher prevalence of the disease, particularly in poorer nations. These individuals can spread the parasite to the surroundings of others, resulting in subsequent infections (Pawlowski and Murrel, 2000). Research has shown that in regions where the disease is common, the occurrence of swine cysticercosis and *T. solium* infections in humans is linked to poverty, lack of latrines and unrestricted access of scavenging pigs to human faeces. Additionally, the feeding of pigs with contaminated feed containing infected human faeces has been identified as a contributing factor (Mutua *et al*., 2007). Currently, pig production in Nigeria is commonly done by extensive or semi-extensive management systems, which can make them more susceptible to some zoonotic infections due to their scavenging behaviour.

Diagnosis of cysticercosis is made by conducting post-mortem examinations in slaughterhouses or abattoirs to identify *Cysticercus cellulosae* cysts in the carcasses of pigs. This is accomplished through a methodical process of visually inspecting, palpating, and making cuts into organs such as the tongue, masseter muscles, myocardium, triceps, thigh muscles, diaphragm, liver, spleen, and intestinal mucosa, following the techniques outlined by Anosike (2000). This approach has been utilized in multiple researches that investigated the occurrence of cysticercosis (Ngowi *et al*., 2004). The ELISA test, which identifies the presence of antibodies produced by a pig's immune system against *Cysticercus cellulosae*, is highly sensitive but also costly. It has been utilised in numerous studies (Krecek *et al*., 2012).

Additionally, there have been reports of economic losses by pig farmers resulting from the condemnation and disposal of carcasses infected with cysticerci (Ito *et al*., 2006). In West and Central Africa, as well as Latin America, the disease leads to yearly economic losses valued at approximately 25 million Euros and 164 million US dollars.

Porcine cysticersosis is widespread in several regions of the world, particularly in Latin American, African, and Asian countries (Sarti *et al*., 1992). The worldwide occurrence of swine cysticercosis is approximately 8% according to Zoli *et al.* (2003). The condition is common in Nigeria (Waiswa *et al*., 2009). Earlier studies in Nigeria reported a prevalence rate of 3.2% in Adamawa State (Biu and Ijudai, 2012), 6.25% in Ibi, Taraba State (Karshima *et al*., 2013), and 7.6% in Jos, Plateau State (Bata *et al.,* 2020). Although there have been recorded incidences of the disease in Nigeria, there is a lack of information specifically about the disease in Wukari, Taraba State. The present investigation was carried out to evaluate the occurrence of *Cysticercus cellulosae* in pigs that were slaughtered at abattoirs in Wukari, Taraba State, Nigeria.

Materials and Methods

Study Area: The study was conducted in the town of Wukari, which is the administrative headquarters for Wukari Local Government Area in Taraba State, Nigeria. The city is situated in the north-eastern region of Nigeria, lying between latitude 70.52' 48'N to 70.87' N and longitude 90.43' 38''E to 90.77''E. It is positioned at an elevation of 189 metres above sea level (Elechi *et al*., 2013). The town's population, as recorded in the 2006 population census conducted by the NPC (2006), is around 241,546. Taraba State has a tropical climate with two distinct seasons: the wet season, which spans from March to October, and the dry season, which spans

from November to March or April (TSGD, 2018)

Sample Size Determination and Ethical Clearance: In the absence of published reports on the occurrence of porcine cysticercosis in Wukari, the sample size was estimated using the Thrusfield formula (N= Z2P (1-P)/d2). This was done by taking into account an expected prevalence of 50% (P), a 95% confidence interval (CI) (Z = 1.96), and a desired absolute precision of 5% (d) (Thrusfield, 2007). The calculated sample size obtained using this equation was 384, but 390 was adopted as the sample size. Ethical approval for the study was obtained from Federal University Wukari Ethical Committee for Animal Research with Approval Number CAR/FUW/EL/020.

Source of Research Pigs: The pigs used for the study were local breeds of pigs kept and slaughtered within Wukari town. Abattoirs within the town covered for this study are Ajiduku, Pwadzu and Hospital area abattoirs.

Study Design and Sampling Technique: The study was carried out in all the abattoirs in the study area. The study used a random sampling technique.

Data Collection: The abattoirs were visited thrice every week for a period of three months (September – December, 2023). Data on the ages of the slaughtered pigs was gathered from the butchers through either oral interviews or by estimating the age based on the appearance of the permanent incisor, utilizing dentition ageing. The pigs were categorised into two age categories: young (6 – 12 months) and adults (> 12 months), based on the age categorization system of Kumsa *et al*. (2014). The female pigs were distinguished by the noticeable vulva in the perineal area and the udder in the inguinal area. The presence of the male reproductive organ (scrotal sac) situated in the inguinal region was utilised to identify the males (boars). Data regarding the location, shape and viability of the cysts observed were also collected.

Carcass Examination for the Presence of Cyst: The method described by Anosike (2000) involving a comprehensive and systematic examination of slaughtered pig carcasses, was followed for the carcass examination. This included visually inspecting the carcasses, palpating them for abnormalities, and making incisions into various organs such as the tongue, masseter muscles, shoulder muscles, myocardium, triceps, thigh muscles, diaphragm, liver, spleen, and intestinal mucosa. Any carcasses found to have *Cysticercus cellulosae* was identified and documented as positive for porcine cysticercosis. According to Thornton and Gracey, (1974), cysts were classified as viable if the fluid was transparent, and as non-viable if there were apparent bluish green caseous masses or necrotic (dark) patches. The cyst samples were carried to the Parasitology Laboratory at the National Veterinary Research Institute, Vom, Nigeria, to identify if the cysts were mature or immature. They were placed in sample vials containing 10% formalin.

Statistical Analysis: The prevalence was determined by dividing the number of animals that tested positive by the total number of animals that were evaluated and then multiplying the result by 100. Chi-square test (χ^2) was utilized to examine the relationship between the existence of cysts and risk factors such as sex and age. This analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 25. Throughout the analysis, a confidence level of 95% was maintained, and a significance level of $p < 0.05$ was used. Summary results were presented as percentages in Tables.

Results

Out of the 390 pig carcasses examined, 9 were infected with cysts, giving an overall prevalence of 2.3%. Pig carcasses examined at Hospital area abattoir had the highest

prevalence of 3.5% (6 out of 171), followed by Ajiduku area abattoir with prevalence of 1.7% (2 out of 121), and the least was observed in Pwadju area abattoir with a prevalence of 1.02% (1 out of 98) (Table 1).

Seven out of the 281 male pig carcasses examined (2.5%) had cysts, while two out of the 109 females (1.8%) had cysts (Table 2). Though the prevalence was higher in male pigs, there was no significant ($p > 0.05$) association between prevalence and sex of pigs in this study.

Two hundred and forty-one out of the total of 390 pigs examined were aged 6 – 12 months, and 1.3% (3) had cysticerci (Table 3). One hundred and forty-nine of the pigs were > 12 months of age old, of which 6 (4.03%) had cysticerci (Table 3). Significantly ($p < 0.05$) higher prevalence was observed in older pigs (> 12 months) when compared with the younger (6 – 12 months of age) ones. (Table 3).

Table 4 shows the number of cysts found at different sites on the carcasses, their form and viability. Out of 9 cysts found in this study, 3 (33.3%) were found in the shoulder muscle, 2 (22.2%) from the masseter, 2 (22.2%) from the thigh muscle, 1 (11.1%) from the heart, and 1 (11.1%) from the tongue. All the cysts detected were immature and viable except one which is not viable. Pictures of the cysts in the body organs are shown in Figures 1 and 2.

Table 1. Prevalence of porcine cysticercosis based on abattoir location in Wukari, Taraba State Nigeria.

Abattoir	Number of pigs examined	Number of pigs with cysticercus cysts (%)
Hospital area abattoir	171	6 (3.5%)
Ajiduku area abattoir	121	2 (1.7%)
Pwadju area abattoir	98	1 (1.02%)
Total	**390**	**9 (2.3%)**

Table 2. Prevalence of porcine cysticercosis based on sex of the pigs in Wukari, Taraba State Nigeria.

Sex	Number of pigs examined	Number of pigs with cysticercus cysts (%)
Females	109	2 (1.8%)
Males	281	7 (2.5%)
Total	**390**	**9 (2.3%)**

[$\chi^2 = 0.15$; $p = 0.699$]

Table 3. Prevalence of porcine cysticercosis based on age of the pigs in Wukari, Taraba State Nigeria.

Age (months)	Number of pigs examined	Number of pigs with cysticercus cysts (%)
6 – 12 months	241	3 (1.3%)
> 12 months	149	6 (4.03%)
Total	**390**	**9 (2.3%)**

[$\chi^2 = 3.89$; $p < 0.05$]

Table 4. Prevalence of porcine cysticercosis in Wukari, Taraba State Nigeria, based on predilection site of the cysts in the pigs.

Predilection site	Number of Cysts observed	Percentage of the total number of cysts (%)
Shoulder muscle	3	33.3%
Masseter muscle	2	22.2%
Thigh muscle	2	22.2%
Heart muscle	1	11.1%
Tongue	1	11.1%
Total	**9**	**100 %**

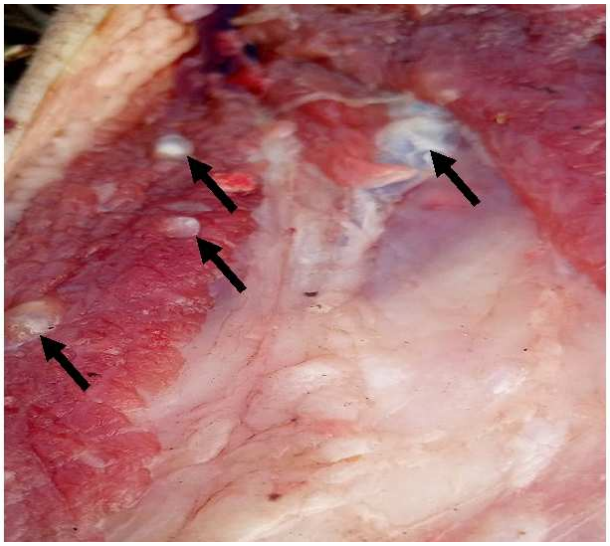

Figure 1. *Taenia solium* cysts on the masseter muscle. The black arrows are pointing at fluid-filled sacs (*Cysticercus cellulosae*) on the masseter muscles of one of the infected pigs examined at Wukari, Taraba State, Nigeria.

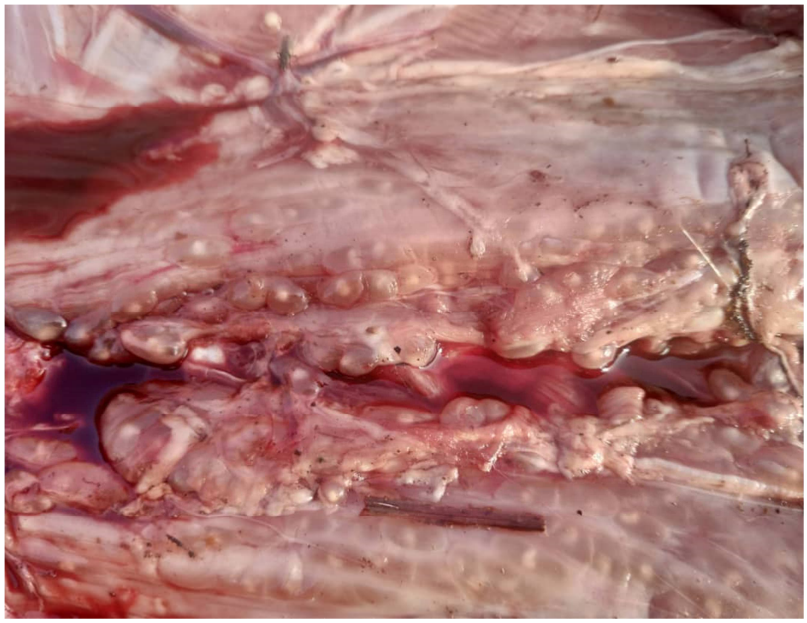

Figure 2. *Taenia solium* cysts on the shoulder muscle. Multiple fluid-filled sacs (*Cysticercus cellulosae)* found embedded on the muscle of one of the infected pigs examined.

Discussion

The overall 2.3% prevalence recorded in this study is lower than what was previously reported in various parts of Nigeria, such as 14.4% reported in Zuru, North-western Nigeria (Gweba *et al*., 2010), 7.6% in Jos, North-central Nigeria (Bata *et al*.,2020), 6.26% in Ibi, North-eastern Nigeria (Karshima *et al*.,2013), 13.53% in Enugu, South-eastern Nigeria (Onah and Chiejina, 1995), 2.57% in Ibadan South-western Nigeria (Falake and Ogudipe, 2003); and 4.44% in a neighbouring African country, Cameroon (Shey-Njila *et al*., 2003). There could be many reasons for the lower prevalence observed in this study. It could be due to improved hygiene and/or reduced open-field defaecation, which reduces the chances of exposure of pigs to human faeces. Secondly, attempt at elaborate examination of the whole carcasses through multiple and deep incisions into the carcass to search for embedded cyst was resisted by the butchers. The butchers rejected multiple and deeper incisions on carcass, with the claim that it will reduce the market value of the meat. This uncooperative attitude of the butchers during the course of this study made it difficult for the whole carcass to be comprehensively examined; this may partly account for the lower prevalence recorded. There has also been a rise in the population of scavenging dogs in the study area. As dogs are known to have a greater number of olfactory lobes, they are more likely to identify and consume human faeces more efficiently and quickly compared to pigs. As a result, the odds of pigs getting infected during scavenging are reduced. This fact and its role in reducing infection in pigs has earlier been reported by Sikasunge, (2006).

The wrong behaviour of some hospitalized patients who find it more convenient to defaecate on the open environment close to the hospital than using the hospital toilet facility makes it easier for scavenging pigs to have access to such human faeces and therefore predispose them to infection. This could contribute to the higher prevalence of *cysticerci* in Hospital area abattoir than the two other abattoirs.

Prevalence distribution based on sex was higher in male pigs than the females, but the difference was not significant in this present study. This implies that both sexes have nearly equal chances of exposure to the infection. This is in line with the report of Adesokan and Adeoye (2019) and Garcia *et al.* (2003). Contrary to our findings, Khaing *et al.* (2015) reported significant relationship of porcine cysticercosis with sex and gave a reason that male pigs are capable of roaming further than the female, and could have higher chances of coming in contact with human faeces. The higher number of male pigs examined could be due to the fact that more male pig carcasses were examined compared to the female. Male pigs are usually sold by the farmers for income while the females are mostly kept longer for the purpose of breeding and this may explain the reason for the high number of male pigs examined.

Age-based prevalence distribution in the present study showed that older pigs (> 12 months of age) had a significantly higher occurrence of cysticercosis, when compared to the younger ones (6 – 12 months of age). This finding concurs with earlier reports of Ngowi *et al.* (2004) that showed that the occurrence of porcine cysticercosis increases with the age of the pigs, because of the fact that older animals might have had longer exposure period than the young ones. The finding that older pigs had significantly higher occurrence in the present study however contrasts with the reports of Gweba *et al.* (2010), Weka *et al.* (2013), and Boa *et al*. (2006) who found that age and sex of pigs were not significantly associated with the prevalence of porcine cysticercosis, based on the assumption that the pigs were exposed to the same poor sanitary conditions irrespective of age and sex when they roam about in search for feed.

Prevalence distribution based on predilection sites of the cysts in this study showed that the shoulder muscle harboured the highest number of cysts, followed by the masseter and thigh muscle, while lower numbers were found in the heart and the tongue. Previous studies in Nigeria also reported that cysts were most common in the shoulder and masseter muscle (Biu and Ijudai, 2012; Bata *et al*., 2020). Boa *et al*. (2006) in Tanzania also reported high prevalence of cysts in the shoulder muscle (24.4%) and masseter (8.1%) than either the tongue (7.0%) or the heart (3.6%). In contrast to this finding, Khaing *et al.* (2015) observed that all the cysts found in their study were located in the tongue except one located in the heart. Agere *et al.* (2016*)* observed high load of cysts in the heart with few in the shoulder muscle and tongue. The observation of cysts in different sites of the carcasses reported by different authors shows that cyst could be found in any muscle or organ of the body (OIE, 2022)

Conclusion and Recommendation: This study recorded a low prevalence (2.3%) of *Cysticercus cellulosae* cysts in pigs slaughtered for human consumption in Wukari town, Nigeria. The distribution of the occurrence of the cysts was not significantly associated with age or sex. It is recommended that meat inspection at the abattoirs should be strengthened. Open defecation and extensive pig husbandry should be discouraged.

Conflict of Interest

The authors declared no conflict of interest.

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