Some risk factors for *Taenia solium* cysticercosis in semi-intensively raised pigs in Zuru, Nigeria

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Summary

The prevalence of *Taenia solium* cysticercosis in live pigs and at post mortem was determined in the Zuru area of Kebbi State, Nigeria. Prevalence rates of 5.85% ($n = 205$) and 14.40% ($n = 118$), respectively, were obtained from live pigs examined by lingual palpation and post-mortem examination. There was a significant ($p<0.05$) association between sex and infectivity for meat inspection and a positive non-significant ($p>0.05$) relationship between age and infectivity. Human taeniosis was assessed by direct microscopy of stool samples from volunteers; a prevalence of 8% ($n = 50$) was obtained. Environmental (soil, water and water from washed vegetables) samples were analysed; one of the water samples and some soil samples were positive for taeniid ova. Of the pig-rearing households that responded to the questionnaire survey 93% ($n = 100$) allow their pigs to scavenge freely around residential areas and refuse dumps, 2% had epileptic patients and over 80% did not have knowledge on how *T. solium* infection is acquired and its public health significance. To obtain baseline data for effective control and possible eradication, there is the need for a serological and epidemiological survey of this significant parasitic zoonosis in the study area and other parts of Nigeria where pigs are reared and/or pork is consumed.

Keywords

Cysticercosis, Environment, Inspection, Nigeria, Pig, Post mortem, Public health, *Taenia solium*.

Fattori di rischio per cisticercosi da *Taenia solium* in una popolazione suina di allevamento semintensivo a Zuru, Nigeria

Riassunto

Questo studio ha valutato in vivo e post-mortem la prevalenza di cisticercosi da Taenia solium *in una popolazione di suini dell'area di Zuru, Stato di Kebbi, Nigeria. Alla palpazione linguale in vivo e all'esame post-mortem sono state osservate percentuali di prevalenza, rispettivamente, del 5,85%* (n = *205) e del 14,40%* (n = *118). Per la carne di suino è stata riscontrata l'associazione significativa* ($p<0,05$) *tra sesso e infettività e relazione positiva, ma non significativa* ($p<0,05$), *tra età e infettività. Mediante esame microscopico diretto di campioni di feci di soggetti volontari è stata valutata la presenza di teniasi umana, pari alla prevalenza dell'8%* (n = *50). Sono stati esaminati campioni ambientali (suolo e acqua). Un campione di acqua e alcuni campioni di suolo sono risultati positivi alle uova di tenia. Il 93%* (n = *100) dei proprietari dei suini, sottoposti a questionario,*

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ha permesso di rilevare come gli animali fossero liberi di grufolare in aree abitate e discariche, il 2% dei proprietari stessi fosse epilettico e oltre l'80% non fosse a conoscenza delle modalità con cui si contrae l'infezione da Taenia solium *né della sua rilevanza per la salute pubblica. Questo studio siero-epidemiologico è stato necessario al fine di ottenere dati utili per attuare un controllo efficace dell'infezione e, possibilmente, eradicarla.*

Parole chiave
Ambiente, Cisticercosi, Ispezione, Nigeria, Salute Pubblica, Suino, *Taenia solium*.

Introduction

Taenia solium is an important parasite that causes serious public health and socio-economic problems in endemic regions of the world. It has been demonstrated in endemic areas that *T. solium* infection is associated with poverty, absence of latrines and free access by scavenging pigs to human faeces deposited indiscriminately on fields, farmlands and backyard premises (5, 31, 32). Human cysticercosis is pronounced in areas where people eat pork and traditional husbandry is practised. Poor hygiene, inadequate sanitation and the use of untreated or partially treated wastewater in agriculture also facilitate the spread of infection. Cysticercosis can occur in individuals who do not raise pigs or consume pork (20). Humans are the definitive hosts while pigs act as an intermediate host, thus pigs are the source of human taeniosis and cysticercosis (33). *T. solium* is the most important parasite of the nervous system in humans and leads to neurocysticercosis which is characterised by late onset epilepsy, intra-cranial hypertension associated with seizures, dementia and hydrocephalus that is related to arachnoiditis (10, 22). The environment is of importance in the transmission and maintenance of the disease, especially through drinking water, vegetables and soil. Infected humans disseminate the eggs into the environment as long as the worm is active in the intestine which may be for up to 30 years. Such eggs in the environment can remain viable for months (1).

In Africa, the prevalence of these conditions in humans and animals is undermined because of a lack of documentation. Some countries in Africa have reported high prevalence of *T. solium* cysticercosis/taeniosis whereas limited or no information is available on this infection in other parts (15). Surveys in pigs have contributed to increase the awareness of this zoonotic infection in many developing countries where it is believed to be endemic, for example in East and southern Africa (21, 29). Nigeria has an estimated pig population of 5 million (16) which are distributed mainly among the rural communities in the six geopolitical zones. These pigs are raised mainly semi-intensively as is the case in most parts of Africa and they have direct access to human faecal matter as they scavenge around.

This cross-sectional survey was conducted to investigate the prevalence of *T. solium* cysticercosis in free-ranging pigs in the Zuru area of Kebbi State, Nigeria. In addition, the role of environmental factors, such as soil, water and vegetables was assessed as these factors contribute to the transmission and maintenance of the disease.

Materials and methods

Study area

The study was conducted in the Zuru local government area of Kebbi State, north-western Nigeria which lies between latitudes 11°15′ to 11°30′N and longitude 5°to 5°30′E.

Determination of sample size

The study was conducted between January and August 2008. A pig census was conducted in the eight pig-rearing locations and households of Amanawa, Jarkasa, Rikoto, Senchi, Unguwan Zuru, Bedi, Dabai and Tudun Wada. There was lack of data on the prevalence of cysticercosis in the study area to serve as basis for the estimation of the sample size. The sample size was calculated using the formula:

$n = Z^2PQ/L^2$ (21)

where:

n is the number of individuals, Z is the score for a given confidence interval and P is a known or estimated prevalence

Q = (1–P), and L the permissible error of estimation.

In this study, the desired confidence interval was 95% with an allowable error of estimation of 0.05 and P was estimated at 10%. Therefore, $n = 1.96^2 \times 0.1 \times 0.9/0.05^2 = 138$. The sample size was adjusted to $n = 205$ pigs from the eight locations. A physical randomisation selection technique using card shuffling was employed to select the households and pigs to be sampled. This technique involved card numbering from 1 to 50, shuffled to select the representative households in each area and pigs in each household (2). The age of the pigs was determined by observation of teeth (17).

Tongue palpation

Households rearing pigs managed semi-intensively in each location were visited early in the morning before the pigs were released to go scavenging. Each selected pig was restrained adequately with the aid of ropes on lateral recumbency. The mouth was gagged with a wooden bar twisted across the upper and lower jaws, the tongue pulled out and examined for the presence of *Cysticercus* cysts on its entire ventral surface (8, 21, 25).

Meat inspection

Two pig slaughter slabs at Unguwan Zuru and Bedi were used for the study. After the evisceration of the carcasses, the tongue, heart, liver and lung were examined for the presence of *Cysticercus* cysts (8, 38). Live cysts were identified as fluid-filled, translucent with invaginated visible scolices, while the dead cysts were bluish green in colour and calcified (25).

Examination of environmental and human faecal samples

Environmental samples (soil, water and water from washed vegetables) were collected and analysed to determine the presence of taeniid eggs. Thirty-two soil samples were collected from prominent refuse dumps in the study area. These refuse dumps are primarily areas in which pigs scavenge and humans defecate. Four top-soil samples were collected two metres apart from the chosen refuse dump in each of the locations. The soil samples were analysed using centrifugation and sedimentation techniques and taeniid eggs were identified based on morphological characteristics (5). Water samples were collected from four streams in the study area (Rafin Mose, Rafin Dakarkari, Rafin Kwakwa and Rafin Dambu). One litre of water was collected each from three different spots in each stream four metres apart and analysed for taeniid eggs (5, 8). Twenty samples of water from washed vegetables were collected from two locations at the Zuru central market and analysed for taeniid eggs.

Fifty human faecal samples were collected from 18 men, 15 women and 17 children volunteers in the study area. The faecal samples were analysed using the formol ether concentration technique (3). Taeniid eggs were also identified according to their morphological characteristics.

Questionnaire survey

A structured questionnaire was designed and circulated to 100 pig raisers in the eight locations of the study area. The questionnaire was structured to ascertain the knowledge, attitude and behavioural practices of pig raisers in relation to their awareness of the mechanisms of transmission, maintenance and public health significance of cysticercosis/taeniosis.

The data obtained were analysed using percentages, chi square test (χ^2) and Pearson's product moment correlation coefficient (r).

Results

From the eight pig-rearing locations identified in Zuru, 131 households were found rearing pigs. Tudun Wada had the most households that raised pigs (29.0%) and the highest total number of pigs (53.9%) while Senchi area had the lowest of 3.05% for households rearing pigs and 1.44% for the number of pigs reared, respectively (Table I).

A total of 4 208 pigs were estimated from the census conducted in the course of this study

out of which 205 live pigs were examined orally for the presence of *Cysticercus* cysts from which a prevalence rate of 5.85% was obtained. The sex distribution revealed a higher percentage of infection in females (3.41%) while the group affected most was the three years of age and above (14.28%) (Tables I, II and III).

At post-mortem inspection, of 118 carcasses examined at the two unofficial pig slaughter slabs, 17 (14.40%) were positive for cysticerci cysts (Table IV).

Table I
Pig population structure in the eight pig-rearing locations of the study area

Area	No. of houses rearing pigs (%)	Adult males (%)	Adult females (%)	Male piglets (%)	Female piglets (%)	Total
Amanawa	10 (7.63)	78 (11.0)	80 (8.0)	67 (5.5)	72(5.6)	297
Bedi	11 (8.39)	27 (3.8)	33 (3.3)	31 (2.5)	42 (3.2)	133
Dabai	10 (7.63)	22 (3.1)	38 (3.8)	30 (2.5)	41(3.2)	131
Jarkasa	23 (17.55)	62 (8.8)	111 (11.1)	102 (8.4)	180(13.9)	455
Rikoto	27 (20.6)	81 (11.5)	113 (11.3)	267(21.9)	253 (19.6)	714
Senchi	4 (3.05)	10 (1.4)	13 (1.3)	11(0.9)	14(1.1)	48
Tudun Wada	38 (29)	394 (55.8)	563 (56.4)	674(55.5)	641(49.7)	2 272
Unguwan Zuru	8 (6.10)	32 (4.5)	46 (4.6)	33(2.7)	47(3.6)	158
Total	131	706	997	1 215	1 290	4 208

Table II
Households sampled and pigs per location in the study area

Location	No. of households rearing pigs (%)	No. of households sampled (%)	No. of pigs sampled (%)
Amanawa	10 (7.63)	5 (50.0)	25 (8.4)
Bedi	11 (8.39)	5 (45.5)	20 (15.0)
Dabai	10 (7.63)	6 (60.0)	20 (15.3)
Jarkasa	23 (17.55)	8 (34.8)	30 (6.6)
Rikoto	27 (20.61)	9 (33.3)	30 (4.2)
Senchi	4 (3.05)	2 (50.0)	10 (20.8)
Tudun Wada	38 (29.00)	10 (26.3)	50 (2.2)
Unguwan Zuru	8 (6.10)	5 (62.5)	20 (12.7)
Total	131 (100)	50 (38.2)	205 (100)

Table III
Age and sex distribution of live pigs examined by tongue palpation for *Cysticercus* cysts

Age (years)	No. of pigs sampled	No. of males sampled	No. of females sampled	Males positive (%)	Females positive (%)	Total positive (%)
<1	98	50	48	1	1	2 (2.04)
1-2	76	35	41	3	3	6 (7.89)
2-3	24	6	18	1	2	3 (12.5)
≥3	7	–	7	–	1	1 (14.28)
Total	205	91	114	5 (2.43)	7 (3.41)	12 (5.85)

χ^2 1.027
degree of freedom 3=7.815
p<0.05
r 0.418

The tongue and heart contained the highest number of cysts (28.12%, $n = 32$) while the lungs had the lowest (3.12%, $n = 32$). A total of 71.87% ($n = 32$) of the detected cysts were viable and the tongue and heart also had the highest number of viable cysts (26.08%, $n = 23$) (Table V).

Results from the environmental assessment revealed that one of the four soil samples from Amanawa and Unguwan Zuru and two of the four samples from Tudun Wada were positive for taeniid eggs. Only water samples from Rafin Mose were positive while none of the water from washed vegetables was positive for taeniid eggs.

Out of the 50 faecal samples collected from volunteers from pig-raising households, 4 (8.0%) (all male) were positive for taeniid eggs.

Other incidental parasites, ova and cysts encountered in the course of this study in the environmental samples include: *Trichuris* spp., *Toxocara* spp., *Ascaris* spp., *Strongyloides* spp., *Eimeria* spp., *Dipylidium* spp., *Ancylostoma* spp., *Entamoeba* spp. and *Schistosoma* spp.

Table VI shows the various responses obtained from the questionnaire. Significantly, a majority of the households raised their pigs semi-intensively and most of the pigs were allowed to scavenge with unrestricted access to human faeces deposited indiscriminately on farmland, uncompleted building sites, refuse dumps and fringes of bush.

Discussion

Of the eight pig-rearing locations in the study area, 131 households were identified as raising pigs. A total of 632 households from seven locations in the same study area of which 105 households raising pigs were estimated earlier (2006) (39). Likewise, a total of 4 208 pigs were counted in this study; this represents an increase compared to the total of

Table IV
Sex and age distribution of pigs slaughtered at the two slaughter slabs in Bedi and Unguwan Zuru revealing the presence of cysts

Age (years)	Unguwan Zuru slaughter slab		Bedi slaughter slab		Number of infected carcasses (%)		Total infected (%)
	Male	Female	Male	Female	Male	Female	
<1	28	14	7	2	1	3	4 (7.84)
1-2	20	6	5	2	4	–	4 (12.12)
2-3	11	6	2	3	2	2	4 (18.18)
≥3	3	7	1	1	–	5	5 (41.66)
Total	62	33	15	8	7 (5.93)	10(8.47)	17 (14.40)

χ^2 9.799
degree of freedom 3=7.815
p>0.05
r 0.698

Table V
Distribution of cysts in pig offal examined at the two slaughter slabs in Bedi and Unguwan Zuru

Site of cyst	Carcasses with cysts (%)	No. of cysts(%)	No. of viable cysts (%)	No. of dead cysts (%)
Tongue only	5 (29.41)	8 (25.00)	5 (21.23)	3 (33.33)
Heart only	3 (17.64)	3 (9.37)	2 (8.69)	1 (11.11)
Liver only	2 (11.76)	3 (9.37)	3(13.04)	–
Lung only	1 (5.88)	1 (3.12)	1 (4.34)	–
Tongue and heart	3 (17.64)	9 (28.12)	6 (26.08)	3 (33.33)
Tongue and liver	2 (11.76)	5 (15.62)	3 (13.04)	2 (22.22)
Tongue and lung	1 (5.88)	3 (9.37)	3 (13.04)	–
Total	17	32	23	9

Table VI
Knowledge and practices related to *Taenia solium* cysticercosis transmission based on questionnaire, interviews and observations in the Zuru area

Factors	Outcome (*n* = 100)
Knowledge	
On how a person acquires human taeniosis	18
On how pigs acquire porcine cysticercosis	16
On how to prevent human taeniosis human taeniosis	15
On how to prevent porcine cysticercosis	13
On porcine cysticercosis – human taeniosis relationship	9
On the public health significance of *Taenia solium*	8
Reported practices	
Sex of pig owners	
Male	68
Female	32
Marital status of pig owners	
Married	93
Single	7
Occupation of pig owners	
Trading	15
Farming	54
Civil service	31
Household with a toilet system	91
Household that practices thorough hand-washing after toilet	26
Household source of drinking water	
Tap	–
Well/borehole	81
Stream	19
Household that boils drinking water	7
Household with members eating pork	35
Household that deworms family members	14
Household that deworms pigs	31
Household with a case of epilepsy	2
Practices observed	
System of management	
Traditional (extensive)	16
Semi-intensive	77
Intensive	7
Location of pigsty	
Backyard	58
Within the compound	5
In front of the house	14
Beside the house	23
Pigs roam freely	93
Pigs have access to human faeces as they roam	72

3 199 pigs obtained in 1992 by the Federal Department of Livestock and Pest Control Services (9) and 3 895 pigs obtained in 2007 by Yatswako *et al.* (39) obtained from the same study area. This increase in the number of households involved in pig rearing and the number of pigs being reared may be attributed to the rapid economic gain associated with pig rearing, the high fertility rate of pigs, high feed conversion efficiency, early maturity, short generation interval and relatively small space requirements (16). Pig rearing is also a secondary occupation and an additional source of income as shown in Table VI where the majority of the respondents were involved in farming, trading and government office works. As mentioned above, of the eight locations studied, Tudun Wada had the highest number of pig-rearing households and total pig population; this area is known to be populated by people whose religions do not forbid the rearing of pigs and consumption pork. Apart from religious beliefs, pork consumption is also based on individual preference in the study area.

There were more adult female pigs estimated in this survey compared to the 2007 survey by Yatswako *et al.*; this may be due to the periodic sale of adult male pigs (which are often castrated to reach market weight early) to meet the economic and nutritional needs of the pig-rearing households. Furthermore, the females are kept for breeding purposes and their high fertility rate accounts for large litter sizes which in turn explain the high populations of piglets recorded. From the tongue examination technique used on live pigs in this study; a prevalence rate of 5.85% ($n = 205$) was recorded. This is higher than 4.2% ($n = 96$) in Ibadan, south-west Nigeria (8) and 5.5% ($n = 1300$) in Enugu, south-east Nigeria (25). The sensitivity of the tongue palpation technique in detecting porcine cysticercosis varies widely, especially when compared with the conventional meat inspection technique. There are reports of high sensitivity, such as 70% in Peru (11), 43% in Zambia (28) and 17.4% and 14% in Tanzania and Kenya, respectively (21). Due to the wide variation in the sensitivity of this technique, it has been described as not very efficient but has the advantage of rapid and easy performance and is an inexpensive way of rapidly monitoring the presence and burden of porcine cysticercosis (21).

The age group bracket most affected was that between <1 and 2 years (Table IV); this age bracket is the most active of all the age groups and consists mainly of growers that need a higher nutritional requirement for rapid growth and, consequently, tend to scavenge more than others and are thus more exposed to parasites. The high incidence obtained among this age group is in agreement with the observations made by Onah and Chiejina (25).

During meat inspection, it was observed that the Unguwan Zuru slaughter slab slaughtered more pigs than that in Bedi. This was explained by the fact that pigs are slaughtered three days each week in Unguwan Zuru while at Bedi, pigs are slaughtered on Sundays only (market day), with an average slaughter of two pigs a day. A prevalence rate of 14.40% ($n = 118$) was obtained in this study using the meat inspection technique. This is higher than the prevalence of 2.57% ($n = 389$) (8), 13.53% ($n = 1300$) (25) and 9.5% ($n = 317$) (4) observed in Ibadan, Nsukka and northern Nigeria, respectively. However, higher prevalence levels have been recorded elsewhere in Africa, such as Zambia (20.6%) (27).

Meat inspection is considered to be a more reliable technique for the identification of cysticercoid pigs than the lingual examination. This is due to several predilection sites examined at meat inspection compared to just the tongue examined during lingual palpation. There was no provision for the slaughter of pigs within the municipal slaughterhouse in the study area neither were ante-mortem and post-mortem inspections conducted in the two unofficial slaughter slabs in Bedi and Unguwan Zuru, respectively. In addition, many pigs were slaughtered within homesteads for family consumption, sale and, occasionally, for festivities. A lack of comprehensive and satisfactory meat inspection, coupled with clandestine marketing and slaughtering of pigs, have been recognised as important risk factors in the transmission of

cysticercosis to humans (20). The uncooperative attitude of butchers during the course of this study in the two slabs made it difficult to examine the whole carcasses and explained why only offal was examined. The butchers forbid multiple incisions on carcasses as they claimed that it lowered the value of the carcasses. Furthermore, there is a degree of urgency in getting the meat to the market place by the middlemen. Uninspected pork is sold fresh and is cooked in homesteads and market places; this practice may expose the consumers to taeniosis through consumption of raw or undercooked meat and can also maintain the transmission of the parasite (7, 23, 26). The highest number of detected cysts was found on the tongue and heart (28.12%, $n = 12$). This concurred with the observations of Gracey *et al.* (13) who reported that the cyst has a greater affinity for the muscle of the heart and tongue. In this study, cysts were also found in the liver and lungs, which contradicts the findings of Onah and Chiejina (25). Due to the under-reporting that may result from tongue palpation and meat inspection procedures, it is imperative therefore to compliment these techniques with serological tests, especially in epidemiological studies. Using an enzyme-linked immunosorbent assay (ELISA), a sero-prevalence rate of 46.0% ($n = 63$) in live pigs kept semi-intensively was obtained in Jos, Plateau State, Nigeria (37).

Statistically, there was no significant association between sex and infectivity and but there was a positive correlation between age and infectivity at tongue examination. At meat inspection, however, there was a significant relationship between sex and infectivity and a negative correlation between age and infectivity. It was revealed that age and sex did not have significant influence on infectivity of *Cysticercus* cysts (25), as the pigs were exposed to similar poor sanitary conditions and stress. The pigs in this study always roamed together, regardless of age differences and were thus likely to be affected irrespective of age or sex.

The few households (9%) in the study area in which members had knowledge of the significance of *T. solium* might have acquired this knowledge either through informed family members, veterinary staff treating their stock or from other educated pig farmers. The higher number of pig-rearing households without any knowledge on how human taeniosis and porcine cysticercosis are acquired, prevented and the public health significance of *T. solium* suggests a lack of awareness of the public on the serious health and economic consequences of the parasitic infection. More extensive education campaign on the risks and prevention of cysticercosis are essential in the study area, as recommended by the International Task Force for Disease Eradication (ITFDE) (20).

Although most of the households surveyed had toilet facilities 93% ($n = 100$), the majority of the household members defecate on undeveloped land areas and farmlands that are within the immediate outskirts of the study area. The farmers spent most of their day on farmlands and defecate there. The pigs, which were mostly managed semi-intensively in the study area, roamed about freely during the day and had direct access to human faecal matter. It has been established that there is a significant association between porcine cysticercosis and accessibility of pigs to human faecal matter (30). Pigs are allowed to roam freely in most parts of Africa as a result of inadequate feed and the ability of pigs to utilise waste products and convert such to meat (22).

The number of people who consumed pork in this study provided an indication that it is a popular delicacy in the area. However, the consumption of under-cooked or ill-prepared pork can lead to the spread and maintenance of the parasite. Human behaviour, which includes eating habits, lack of sanitation and close intimacy with animals, is among some of the most important factors that influence the transmission of parasitic diseases (18). The lower number of households that embark on periodic deworming is of serious concern as a single carrier of the worm will continue to shed millions of eggs into the environment through defecation for up to a period of 30 years, as long as the worm remains active and the person remains untreated (13).

The lack of a pipe-borne water supply to Zuru means that most households depend on water from wells, boreholes and streams. Water from these alternative sources is likely to be contaminated on account of the direct exposure to environmental factors. Taeniid eggs can survive in the environment for several months (13) and can be washed off during the rainy season into streams and wells from refuse dumps and farmlands. The egg can survive in stagnant and flowing water for a relatively long period of time (14).

The 2% ($n = 100$) households that had a case of epilepsy each may not provide the true picture of the condition in the study area. Family members and close associates of epileptic patients tend to hide information concerning this condition from the public because of stigmatisation. Epilepsy has profound social, physical and psychological consequences on the affected individuals. It also places particular demands on health, dramatically increasing the burden of disease as a result of social stigmatisation and discrimination (20). Serological tests were not conducted in this study and consequently neurocysticercosis cannot be truly established. It is said that immunodiagnostic tools for cysticercosis have greatly contributed to a better understanding of the prevalence and epidemiology of the infection (6).

The environmental samples collected revealed small numbers of taeniid ova. The low incidence of the egg in the environment does not necessarily reflect the true status of the density of eggs in the environment as physical changes, such as distortion and/or loss of identifiable morphological features, can result in non-identification of taeniid eggs in water, soil and water from washed vegetables, and consequently under-reporting of the positive cases (34).

Prevalence of taeniid eggs in human faecal samples from volunteers in this study 8% ($n = 50$) is higher than 3.5% ($n = 57$) (8) but slightly lower than 8.6% ($n = 1525$) obtained by Onah and Chiejina (25). Repeated sampling of stools is needed for each patient to be able to establish the presence of gravid segments/ proglottids or taeniid eggs.

Some ova and cysts in environmental samples are zoonotic in nature. The environment is known to be an importance source of transmission of protozoa and helminth parasites (with water, soil and food having particular significance). Many parasites have the potential to produce large quantities of transmissible stages and can survive in moist microclimates for prolonged periods of time and hence pose a persistent threat to public health (34).

Ascaris and *Trichuris* ova were the predominant species encountered in the samples. *Ascaris* spp. is a common roundworm which has larvae that can migrate into the tissues of many animals including humans (24). *Toxocara* and *Ancylostoma* spp. are of significant zoonotic importance and constitute a public health risk due to the frequent contact between humans, pets and soil (35, 36). The detection of *Toxocara* spp. in soil is of serious concern, especially for children who are fond of playing with soil (1). Humans are known to be the most important definitive host for *Schistosoma* spp. *Entamoeba* spp., *Giardia* spp. and, occasionally, *Strongyloides* spp. are also zoonotic in nature (3, 13, 19).

Conclusion

The parasite investigated in this work was *T. solium*, which is zoonotic and humans are the only definitive host. This study revealed that both porcine cysticercosis and human taeniosis are prevalent in the Zuru area of Kebbi State, Nigeria. The prevalence rate obtained through tongue examination and meat inspection for the presence of *Cysticercus* cysts was indicative of environmental contamination with the infective ova of *T. solium* and, consequently, a high risk of human cysticercosis (12). The risk factors which could probably have influenced the transmission and distribution of porcine cysticercosis in the area are defecation by humans in the environment, pigs that roamed freely (21) and a contaminated environment.

Considering the public health and economic significance of the parasite, it is necessary that adequate, appropriate and urgent measures be taken to effectively control the parasite, not only in Zuru, but in Nigeria as a whole. These measures should include a nationwide study on the epidemiology of the disease in humans and pigs, community-based public health education, improvement to pig husbandry, the promotion of high standards of personal and environmental hygiene (8, 25) and the prevention of pigs having access to human faeces (21).

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