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The prevalence of porcine cysticercosis in Eastern and Southern provinces of Zambia

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Abstract

The objective of this study was to determine the prevalence and importance of porcine cysticercosis in rural areas of Zambia. The study involved an abattoir survey of 1316 pigs at a slaughter slab in Lusaka and two field surveys in villages in Southern and Eastern provinces. Lingual examination of live pigs and visual inspection of their carcass as well as blood sampling for measuring circulating parasite antigen by enzyme-linked immunosorbent assay (Ag-ELISA) were used as parameters to measure infection. In the field surveys, a questionnaire was administered to every household whose pigs were examined to obtain information on pig husbandry practices and to study risk factors for the infection. Out of the 1316 pigs examined at the slaughter slab, 143 (10.9%) and 271 (20.6%) were positive by lingual examination and meat inspection, respectively. Most of the pigs were very heavily infected with predominantly live cysts. The field surveys revealed that eight (8.2%) out of 98 pigs from Southern province and eight (5.2%) out of 151 pigs from Eastern province were positive for cysticercosis by tongue palpation. Using the Ag-ELISA 20 (20.8%) and 14 (9.3%) pigs were positive in Southern and Eastern provinces, respectively. The questionnaire survey revealed poor pig husbandry practices, absence of meat inspection and control, poor knowledge of the disease and poor sanitation in the surveyed villages. The prevalence of pig cysticercosis found in this study ranks among the highest in the southern African region, in Africa and in the world. The current study suggests the presence of human tapeworm carriers and a high risk of human cysticercosis in the surveyed areas as

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well as in urban centres where pigs from rural areas are increasingly sold, slaughtered and consumed.

Keywords: Pig-cestoda; *Taenia solium*; Porcine cysticercosis; Enzyme-linked immunosorbent assay; Zambia

1. Introduction

Infection with *Taenia solium*, the pig tapeworm, is widely prevalent in human and swine hosts in many developing countries of Latin America, Africa, and Asia (Sarti et al., 1992). Man is the only natural definitive host while pigs are the intermediate hosts. Occasionally man becomes an intermediate host from ingestion of eggs of the adult tapeworm, resulting in a condition known as human cysticercosis. The cysticerci of *T. solium* may lodge in the brain causing cerebral cysticercosis (neurocysticercosis), a very serious zoonosis causing headache, epileptic seizures, epilepsy, mental disturbance and death. The *T. solium* taeniosis/cysticercosis complex is associated with poor sanitation and hygiene, poor methods of pig husbandry and poor meat inspection and control. Ingestion of larvae (cysticerci) in raw or inadequately cooked pork results in human tapeworm infection (taeniosis). Porcine cysticercosis represents one of the most important constraints to increased pig production in the developing world especially affecting the economic and nutritional well-being of the rural poor. While this infection has an economic impact due to meat condemnation, the main interest is on public health (Anonymous, 1995).

Data collected during the last decade show that *T. solium* cysticercosis in pigs and man is more widely distributed in sub-Saharan Africa than previously assumed (for a review, see Geerts et al., 2002). However, precise data on the prevalence and importance of this zoonotic disease in southern Africa are scarce.

Pig farming in Zambia is practised mainly in two provinces, Eastern and Southern. These provinces constitute 70% (54 and 16%, respectively) of the pig population in the country (MAFF, 1998). Pigs are mainly raised by resource-limited farmers. In the Eastern province, pigs are raised mainly for home consumption, while most of the pigs raised in the Southern province are transported to Lusaka where they are sold and slaughtered at an illegal slaughter slab. Recent (unpublished) observations showed a high prevalence of *T. solium* cysticercosis in pigs presented at this slaughter slab.

The main objective of the presented study was to investigate the prevalence and importance of porcine cysticercosis in Zambia, and specifically, to establish the prevalence of *T. solium* metacestodes in pigs in Sinda and Kalomo districts in the Eastern and Southern provinces, respectively, and to investigate the possible risk factors associated with the spread of *T. solium* infection in these areas.

2. Materials and methods

2.1. Study site

The first study was conducted at the Chibolya slaughter slab in Lusaka, the country's capital city. At this slaughter slab, only animals from resource-poor farmers in the rural areas,

mainly the Southern province, are slaughtered. Approximately 100 pigs are slaughtered every day, 7 days a week, under very rudimentary conditions. Tongue palpation is routinely done before slaughter, but no meat inspection is conducted as the slaughter slab is not an official slaughtering establishment. The carcasses are processed at the slaughter slab where the meat is also sold; when cysticerci are found in the carcass the meat is sold at a reduced price.

The second phase involved two field surveys, one in the Kalomo district in the Southern province, and the other in Sinda district (between Katete and Petauke districts) in the Eastern province.

In Kalomo, the main agricultural activities are cattle breeding and crop production. However, due to very severe outbreaks of Corridor disease in this region the cattle population has dramatically decreased in the last 10 years. This has resulted in increased interest in pig keeping. Pigs are mainly raised for commercial reasons and on average a household keeps about seven pigs, mostly fatteners. The breeds reared in this area are Large White, Landrace or crosses. Villages, often consisting of only one extended household, are quite isolated from each other.

In Sinda, pig breeding is a well-established agricultural practice and the pig breeds reared are small local breeds. Due to the endemicity of African swine fever, the transport of live pigs or pork to the capital and other provinces is prohibited; however, a lot of pigs are transported to urban centres within the Eastern province. Pigs are mainly raised for home consumption. Villages in the Eastern province are much larger than in the Southern province. Most households keep pigs; the pig population in these villages can be several hundreds. However, the average pig population per household is the same as in Kalomo (7.2 pigs).

2.2. *Study design*

Between March and June 2000, 1316 pigs were examined at the Chibolya slaughter slab in Lusaka. All pigs presented for slaughter on the days of sampling were included in the study. The estimated age varied between 6 months and several years; pigs of both sexes were sampled. Before slaughter each pig was examined for the presence of cysticerci on the ventral side of the tongue and at slaughter the presence of cysticerci was assessed by examining cyst predilection sites in the carcass including the masseter muscles, hind leg muscles, tongue, heart and psoas muscles.

The field surveys were conducted in August 2000 (Kalomo) and February 2001 (Sinda). An area was selected from each district after obtaining information from veterinary assistants indicating the presence of *T. solium*-infected pigs and the willingness of the community to participate in the study. A cluster of households to be surveyed was randomly selected from each study area. In the Kalomo area, where villages are small, a total of 98 pigs from 21 households were sampled. In the Sinda district, three large villages (Sewa, Chikwendo and Chinkhumba) were selected in which 151 pigs belonging to 66 randomly selected households were sampled.

An attempt was made to sample all pigs belonging to each household; however, due to free-roaming management of the pigs this was not always possible. Unweaned piglets were not included in the survey. Pigs were examined for the presence of cysticerci by tongue palpation (Gonzales et al., 1990) and blood was collected by puncture of the cranial vena

cava or the jugular vein into plain vacutainer tubes. Serum was separated by centrifugation and dispensed into aliquots and stored at −20 °C until analysis.

Information on the environmental, demographic and risk factors associated with transmission of *T. solium* within the community was recorded on questionnaires.

2.3. Enzyme-linked immunosorbent assay for the detection of circulating antigen (Ag-ELISA)

The Ag-ELISA was performed as described by Dorny et al. (2000) with a few modifications: incubation steps were reduced from 1 h to 30 min (coating) or 15 min (other steps); all incubations were done on a shaking plate except for the last step (substrate); streptavidin–horseradish peroxydase (Jackson Immunoresearch Lab, Inc.) diluted 1/10,000 was used as the conjugate. The optical density of each serum sample was compared with a sample of negative pig serum samples ($N = 8$) at a probability level of $P = 0.001$ to determine the result of the test (Sokal and Rohlf, 1981).

2.4. Hospital records review

Previous records of taeniosis and/or epilepsy or other neurological disorders were reviewed in the rural clinics and hospitals from the study areas. Also assessed was the degree of *T. solium* taeniosis/cysticercosis awareness among the medical personnel in the study area.

2.5. Data analysis

The effect of pig management practices (husbandry, slaughter age), sanitary facilities and hygiene (pork consumption, home slaughter, meat inspection, presence of latrine, use of latrine), and knowledge of *T. solium* taeniosis/cysticercosis in humans and pigs, on cysticercosis (tapeworm carrier, skin nodules, neurological disorders, cysts in pork) was done by means of logistic regression, taking into account the effects of the complex design of the survey (StataCorp, 2001). The survey at hand consisted of sampling pigs from randomly selected villages. In each village, a random selection of households was performed. The design effects due to clustering within a village are taken into account in this analysis by using the village as the primary sampling unit (StataCorp, 2001).

3. Results

3.1. Abattoir survey

Of the 1316 pigs examined at the slaughter slab 143 pigs (10.9%) were considered to be positive by lingual examination. From these suspected animals, 116 pigs (79.4%) were confirmed after slaughter; only 17 animals found positive at lingual examination could not be confirmed at post-mortem. A total of 271 (20.6%) out of the 1316 pigs were found

Table 1
Prevalence of *T. solium* cysticercosis in pigs in Eastern (Sinda district) and Southern (Kalomo district) provinces of Zambia

District	n^a	Tongue palpation		Ag-ELISA	
		No. of positive	Positive (%)	No. of positive	Positive (%)
Sinda	151	8	5.2	14	9.3
Kalomo	98	8	10.3	20	20.8
Total	249	16	6.4	34	13.7

[a] Number of pigs.

positive at post-mortem examination. This suggests that 155 pigs (57%) with cysticercosis were not detected by lingual examination. Most infections were massive with predominantly live cysts.

3.2. Field surveys

From the 98 animals sampled in Kalomo district, eight pigs were found positive by tongue palpation (Table 1). The Ag-ELISA detected circulating parasite antigen in 20 (20.8%) of these 98 pigs. However, only three of the eight tongue-palpation-positive animals were seropositive. Based on serology evidence of porcine *T. solium* infection was found in 12 (57%) of the villages and in eight (38.1%) of the households (Table 2).

In eight of the 151 pigs sampled in Sinda district, cysticerci were detected by tongue palpation (Table 1). The Ag-ELISA detected circulating parasite antigen in 14 (9.3%) of the 151 sampled pigs. Circulating antigen was detected in only four (50%) of the eight tongue-palpation-positive pigs. Based on serology, there was evidence of infection in pigs from 14 (21%) households. Infected pigs were found in all three of the villages.

Table 2 presents the prevalence of *T. solium* cysticercosis in both provinces, according to each household from which pigs were sampled.

3.3. Questionnaire survey

While important differences in socio-economic and demographic conditions exist between the villages visited in Southern and Eastern provinces, results from the questionnaire survey were very similar in both areas. It was demonstrated that in these rural areas, pigs are generally maintained under extensive circumstances and allowed to freely roam among

Table 2
Prevalence of porcine cysticercosis in households in Eastern (Sinda district) and Southern (Kalomo district) provinces

District	n^a	No. of positive	Positive (%)
Petauke	66	14	21.2
Kalomo	21	8	38.1

[a] Number of pigs.

the households to scavenge for food. Seventy-six percent and 50% of the households in the Kalomo and Sinda districts, respectively, had no latrines and even in households with a latrine not all family members used it due to cultural taboos. There is little or no meat inspection performed on carcasses of pigs slaughtered in the villages and in the few cases where cysts are detected at slaughter, the meat is eaten or sold for consumption due to ignorance. Pork is consumed in most households of both districts. Cysts in pork are considered by villagers to be the result of feeding the pigs on grain husks obtained from local breweries. Awareness of the *T. solium* disease condition is virtually absent. Most interviewed persons had complaints of chronic headache. In the Kalomo district, epilepsy, madness and skin nodules were very rarely reported. In Sinda, skin nodules were also rarely reported, however, epilepsy and madness were reported to occur more frequently than in the Southern province.

No significant associations ($p > 0.1$) between pig husbandry practices, sanitary conditions and infection of pigs could be found.

3.4. Hospital records review

One hospital and one health centre were visited in the Kalomo district. In these medical centres, there were no records of human cysticercosis cases and medical staff exhibited very little knowledge of neurocysticercosis. However, there was awareness of tapeworm infection in humans although the link between tapeworm infections and epileptic seizures in humans and cysticercosis in pigs was not made.

In the Sinda district, the situation was similar. Out of three hospitals visited none had records of any cysticercosis cases and only one hospital had a medical doctor aware of neurocysticercosis and epileptic seizures. None of the medical centres visited currently has the capacity for diagnosis of neurocysticercosis by neuro-imaging techniques such as computed tomography or magnetic resonance.

4. Discussion

This is the first community-based survey of *T. solium* cysticercosis in pigs in Zambia. Previous abattoir records obtained from the Ministry of Agriculture Food and Fisheries suggested an annual prevalence from 0.05 to 5% (MAFF, 1998). This is in contrast to the 9.3–20.8% found in this study. However, the records from the ministry are based on official abattoir reports where mainly commercially reared pigs are slaughtered, while in the present study traditionally reared pigs were examined. These findings suggest a higher prevalence than that reported by Boa et al. (1995) from a survey of slaughter slabs in districts of northern Tanzania, but similar to that found in recent community-based studies in Mbulu district in northern Tanzania (Ngowi et al., 2001) and in Tete province, Mozambique (Afonso et al., 2001).

Three different methods were used for the diagnosis of cysticercosis: tongue palpation, meat inspection and the detection of circulating parasite antigen. In the abattoir survey, the sensitivity of tongue palpation, when compared to visual inspection of the carcass, was only 43%. It was shown that tongue palpation is a very specific method to demonstrate cysticercosis in pigs, but that it has a sensitivity not exceeding 70% (Gonzales et al., 1990). In

lightly infected pigs, however, both the sensitivity and the specificity are low (Sciutto et al., 1998). Therefore, the value of tongue palpation in community-based studies is questionable. Alternative methods for diagnosis in live animals are serological tests. Antibody-, as well as antigen-detecting tests have been developed (Sciutto et al., 1998; Subahar et al., 2001). However, most tests have not yet been fully validated in pigs. The Ag-ELISA used in this study was originally designed for the diagnosis of *T. saginata* cysticercosis in cattle (Dorny et al., 2000). Preliminary results have shown that this assay is also very sensitive and specific for the diagnosis of *T. solium* cysticercosis in humans and pigs (Erhart et al., 2002; Phiri et al., 2001). Validation of this assay is currently underway and will consequently allow assessing its potential in epidemiological studies.

In both surveyed areas only eight pigs were found positive for cysticercosis by tongue palpation, while ELISA demonstrated circulating parasite antigen in 20 and 14 pigs in Kalomo and Sinda districts, respectively, apparently confirming the higher sensitivity of the latter technique. However, most intriguing was the fact that several tongue positive records could not be confirmed by Ag-ELISA. This, however, is similar to studies by Diaz et al. (1992) in Peru, who failed to confirm tongue positive findings by the enzyme-linked immunoelectrotransfer blot (EITB) assay. Possible reasons why the tongue palpation findings could not be confirmed by the Ag-ELISA might be that observed or palpable 'cyst' could have been scars or that the number of live cysts was too small to be detected by ELISA. However, in a recent experimental study in pigs the minimum number of living cysts, which could be detected using this Ag-ELISA, was 1 (Nguekam et al., submitted). In the same study circulating antigen first appeared between 2 and 6 weeks post-infection and remained present during almost the whole observation period of 6 months, even in pigs carrying only 5–8 living cysts, although strong fluctuations of the level of CA were observed in some pigs.

There are a number of factors in the surveyed villages contributing to optimal conditions for transmission of this cestode. Such factors include the free-roaming management of pigs, the lack of latrines in most households or their use, the absence of meat inspection in villages and nearby urban centres, and the lack of awareness of the local population, including physicians, of the risks involved in eating meat with *T. solium* cysts. Statistical analysis failed to show associations between infection in pigs and various epidemiological factors, which were considered possible risk factors. However, the study population was fairly homogeneous in terms of most of these factors and the pigs appear to be equally and permanently at risk of coming into contact with the parasites. The small sample size may also have weakened the statistical significance of any relationship.

One of the most striking results of this survey is the almost complete absence of data on human cysticercosis in the surveyed areas and the general lack of knowledge on the *T. solium* taeniosis–cysticercosis complex among medical doctors and other health workers. The high prevalence of cysticercosis in pigs strongly suggests that many people are carriers of the pig tapeworm and consequently contaminate their direct environment with eggs containing oncospheres that are infective for man. In regions where cysticercosis in pigs is common, human cysticercosis prevalence is usually high. Results from other endemic areas in Africa (Newell et al., 1997) have indicated a strong relationship between cysticercosis and epilepsy. Therefore, there is an urgent need to collect baseline data on human cysticercosis in Zambia for a better understanding of the local epidemiology and the transmission risks.

Although the pig population is significantly larger in the Eastern province compared to the Southern province and pig husbandry conditions are fairly identical in both provinces, the prevalence of cysticercosis was highest in the Southern province. However, all samples from the Eastern province were collected from three large villages within walking distance of each other, while in the Southern province the survey was done on 21 households covering a much wider area. It is clear that more in-depth studies covering a larger area and more districts should be done to determine the true prevalence in both provinces.

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