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Assessment of routine inspection methods for porcine cysticercosis in Zambian village pigs

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Abstract

The value of tongue and meat inspection as diagnostic tools for porcine cysticercosis was assessed in 65 Zambian village pigs by comparing the results with carcass dissections. In addition, the intensity of infections, distribution and viability of cysts in infected pigs were measured. Five pigs (7.7%) were positive on tongue examination, while routine meat inspection showed 12 (18.5%) positives. However, carcass dissections detected cysticerci in 31 (47.7%) pigs. The range in number of cysticerci was 1 to 14,662 per carcass. Cysticerci were distributed throughout the carcass with the highest concentration in the heart, tongue and hind legs. In one animal 13 viable cysts were detected only in the brain. Fourteen pigs had more than 100 viable cysts, six between 2 and 100, and four had single cyst infections. Seven animals harboured only calcified cysts. These findings demonstrate the serious shortcomings of routine detection methods for porcine cysticercosis. While the specificity of tongue palpation and meat inspection was 100%, these tests failed to detect the infection in 83.9% and 61.3% of infected pigs, respectively.

Introduction

Taenia solium cysticercosis, the pork tapeworm, is a serious livestock and public health problem in many communities in developing countries (Engels *et al.*, 2003; Phiri *et al.*, 2003). In man *T. solium* causes neurocysticercosis, the greatest cause of acquired epilepsy worldwide (Anon., 1994). Economic losses due to cysticercosis are mainly measured in terms of losses to farmers or families resulting from the loss of or depreciation in infected pig meat, and in terms of the impact of cysticercosis on pig productivity (Engels *et al.*, 2003).

Tongue examination in live pigs and meat inspection of pig carcasses have been the main methods for identifying infected pigs. If carried out correctly (both palpation and visual inspection throughout the base) the specificity of

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tongue palpation is close to 100% (Gonzalez *et al.*, 1990; Dorny *et al.*, 2004). The sensitivity of the technique, however, depends very much on the degree of infection in the pig. Although in heavily infected pigs tongue inspection might detect up to 70% of infected pigs, in lightly infected animals the sensitivity is much lower (Gonzalez *et al.*, 1990). Several studies have shown that none of the pigs experimentally or naturally infected harbouring less than 100 cysts could be detected by tongue inspection (Nguekam *et al.*, 2003; Dorny *et al.*, 2004). Meat inspection at slaughterhouses to detect *T. solium* cysticerci depends largely on visual examination of different sites in the carcass, considered to be predilection sites for the parasite, such as the heart, masseter, tongue and shoulder muscles (Gracey, 1986). However, this selective inspection of muscles during meat inspection, although reported to be specific, is not very sensitive, especially the carcasses of pigs with low cyst burdens (Gonzalez *et al.*, 1990; Sciutto *et al.*, 1998; Boa *et al.*, 2002; Dorny *et al.*, 2004).

Although it is accepted that a rather high and variable number of pigs infected with *T. solium* cysticercosis are not detected by tongue palpation and/or meat inspection, very few studies have been conducted in endemic countries to define the sensitivity and specificity of both methods. Therefore, a study was conducted to assess the value of tongue and meat inspection as diagnostic tools for porcine cysticercosis in 65 village pigs by comparing the results with total carcass dissection. In addition, the intensity of infections, distribution and viability of cysts in infected pigs were measured. The study was done in two provinces of Zambia, known to be endemic for *T. solium*. Both provinces practice free-range pig production with different breeds, so cyst numbers and viability in relation to pig breeds were also compared.

Materials and methods

The study was conducted between April 2002 and March 2003. Pigs were randomly purchased from the Chibolya small livestock association market in Lusaka ($n = 30$) where mostly pigs from the Southern province are sold, and from villages in the Katete and Petauke districts in the Eastern Province ($n = 35$). The estimated ages of pigs ranged from one to five years covering both sexes. All the pigs from the Lusaka market were crosses of Large white and Landrace breeds. Pigs from the Eastern province were all of a smaller local breed.

Tongue examination

Tongue inspection was performed before slaughter. Each pig was placed in left recumbence and held by the neck and firmly restrained with the help of three people. The mouth of the pig was opened using a wooden rod and a mutton cloth. The tongue was gently pulled for examination and palpation on the ventral surface, especially the base. Pigs were considered positive for cysticercosis if cyst-like nodules were either seen or felt (Gonzalez *et al.*, 1990).

Routine meat inspection

Immediately following slaughter and opening of the carcass, routine meat inspection was done by a member of the research team, to assess the presence of *T. solium* cysticerci in predilection sites (i.e. the masseter muscles, triceps brachial muscle, tongue, psoas muscles and heart), according to Boa *et al.* (2002). In the head two longitudinal incisions were made into the external masseter muscles and one incision into the internal masseter muscles on both sides of the lower jaw and the presence of the cysts noted. The tongue was detached from the head, the surface inspected and a deep longitudinal incision was made on the ventral surface, covering the entire length of the tongue, and examined. After visual examination, the heart was incised into both ventricles and septum followed by visual inspection. Three deep incisions were made through the triceps muscles into the shoulder and the incised surface inspected. Both psoas muscles were incised longitudinally and examined for the presence of cysticerci.

Carcass dissection and cyst counts and viability assessment

The muscle groups were excised from the half carcasses together with the complete heart, tongue, head and neck muscles, psoas muscles, diaphragm, lungs, kidneys, liver, brains and eyes. Slicing was done in such a way that all fully developed cysts could be revealed and enumerated (i.e. each slice was less than 0.5 cm thick). The total number of cysticerci for those muscle groups where cysts were only counted in half of the carcasses was calculated by multiplying the detected unilateral number by two. Additionally, cysticerci were macroscopically classified as either viable or calcified according to their macroscopic appearance. Viable cysticerci had well-limited thin-walled cystic structures containing clear vesicular fluid and a visible whitish protoscolex. Calcified cysticerci were non-cystic but rather had semi-solid caseous masses with no discernible parasite structures. All doubtful cases were considered negative.

Statistical analysis

The Pearson's chi-square (Fisher's exact test and Yates corrected chi-square test) was used to determine the associations of origin of pigs on the prevalence of cysticercosis. Cysticerci medians of viable and calcified cysts from the Southern and Eastern provinces were compared using the Mann-Whitney U test. The SPSS (Version 11) and Epi-info 2002 software were used for statistical analyses.

Results

Number of infected animals according to the parasitological tests

Taenia solium cysticerci were found in 5 (7.7%) pigs at tongue examination, in 12 (18.5%) pigs after routine meat inspection and in 31 (47.7%) pigs after total carcass dissection of the 65 pigs examined (table 1). Tongue examination was unable to detect any infected pigs in the

Table 1. The prevalence (%) of cysticercosis in 65 pigs from the Southern ($n = 30$) and Eastern ($n = 35$) provinces of Zambia assessed by tongue examination, meat inspection and carcass dissection.

	Diagnostic methods		
Province	Tongue palpation (%)	Meat inspection (%)	Dissection (%)
Eastern	0 (0)	2 (5.7)	17 (48.6)
Southern	5 (16.7)	10 (33.3)	14 (46.7)
Total	5 (7.7)	12 (18.5)	31 (47.7)

Eastern province but detected 16.7% of infected pigs from the Southern province (table 1). The prevalence of *T. solium* cysticerci in pigs from the Southern province was significantly higher than that in the Eastern province after tongue examination ($\chi^2 = 6.22$, $P = 0.01$) and meat inspection ($\chi^2 = 6.45$, $P = 0.01$), but there was no difference when the infection was measured by carcass dissection (table 1).

After carcass dissection, cysticerci were found distributed throughout the carcass. The numbers of cysts were highly variable among the organs and muscle groups. Cysts were found in shoulder muscles (20 pigs), the tongue (18 pigs), heart (16 pigs), psoas muscles (16 pigs) and masseter muscles (14 pigs). Recovery of cysts from the so-called predilection sites was not different when compared to their presence in non- (routinely) inspected muscles and organs.

Distribution of cysticerci in infected pigs

Most of the pigs harboured low numbers of cysticerci with only a few pigs exhibiting a high numbers of parasites. The number of cysticerci per carcass ranged from one to 24,662. Fourteen pigs had more than 100 viable cysts, six had between two and 100, and in four pigs a single cyst was found (table 2). Pigs from the Eastern province had light infection with mean viable cysts per carcass of 105 ± 58 SEM, while from the Southern province this was 5440 ± 2349 SEM. Lightly infected animals had cysts in only some muscles/organs whereas the heavily infected pigs had cysts all over the carcasses.

The majority (76.5%) of infected pigs from the Eastern province had less than 50 cysts per carcass, and only (17.6%) had over 100 cysts per carcass. In contrast, in infected pigs from the Southern province only 14.3% harboured less than 50 cysts and 76.6% had more than 100 cysts (table 2). This difference was significant ($P = 0.001$). There were no age specific differences in cyst burden.

Table 2. The number of cysts in 31 pigs from the Eastern ($n = 17$) and Southern ($n = 14$) provinces of Zambia assessed by carcass dissection.

	Number of cysts per carcass		
Province	1–50 (%)	51–100 (%)	>100 (%)
Eastern	13 (76.47)	1 (5.88)	3 (17.65)
Southern	2 (14.28)	1 (7.14)	11 (76.57)
Total	15 (48.39)	2 (6.45)	14 (45.16)

Viability of cysticerci

From a total of 31 pigs found positive at carcass dissection, ten pigs harboured only viable cysticerci, 14 pigs had both viable and calcified cysticerci and seven pigs had only calcified cysts. Six of these seven pigs with only calcified cysts were from the Eastern province (table 3).

Discussion

An important issue raised by this work is the failure of long-established and considered reliable parasitological diagnostic procedures for pig cysticercosis. While the specificity of tongue palpation and meat inspection in this study was 100%, these tests were unable to exclude *T. solium* infected pork from the food chain since they failed to detect infections in 83.9% and 61.3% of infected animals, respectively. Thus, the two commonly used methods are unsuitable for use in epidemiological surveys and cannot be applied to monitor control programmes of *T. solium*. The low sensitivity of these parasitological tests was also demonstrated using a Bayesian analysis on a dataset of Zambian village pigs (Dorny *et al.*, 2004), which estimated the sensitivity of tongue inspection and routine meat inspection at 21% and 22%, respectively. Light infections especially were not detected by tongue palpation and carcass inspection.

The number of parasites harboured by each of the 17 infected pigs from the Eastern province indicated that most animals (82%) harboured less than ten parasites. In six pigs only calcified cysts were found. In contrast, 11 (76.6%) of the 14 infected pigs from the Southern province had more than 100 cysts, and in all but one infected animal viable cysts were found. The number of pigs examined in the present study is too small to speculate on these differences, but it may be interesting to investigate whether pig breeds display different susceptibilities to cysticercosis. In the Eastern province a small local breed is reared while in the Southern province larger improved breeds are kept. Differences in intensity of infection may also reflect a distinct epidemiological situation: In the Eastern province, villages are larger with more

Table 3. Viability of cysticerci found in pigs from the Eastern and Southern provinces of Zambia.

Province	Status of cyst	Infected pigs (%)
Eastern ($n = 35$)	Only viable	3 (8.6)
	Viable and calcified	8 (25.8)
	Only calcified	6 (17.1)
	Subtotal	17 (48.6)
Southern ($n = 30$)	Only viable	7 (23.3)
	Viable and calcified	6 (19.3)
	Only calcified	1 (3.3)
	Subtotal	14 (46.7)
Total positive ($n = 65$)	All	31 (47.7)

inhabitants and the number of pigs reared is much higher than in the Southern province.

Cysticerci were recovered from the heart, tongue, internal masseter, external masseter, triceps brachii, diaphragm, brain, head muscles, psoas and muscles of the forelimbs, hind limbs, head, oesophagus, trunk and abdomen. Cysts were not recovered from the kidneys, livers, spleen and lungs. Similar findings were reported from Nigeria by Onah & Chiejina (1995) and Boa *et al.* (2002) in Tanzania.

The existence of light infections in Zambian village pigs together with the low sensitivity of currently used parasitological techniques may result in a serious underestimation of the true prevalence of the infection. Therefore, to control the parasite effectively in endemic areas more sensitive and specific diagnostic methods should be used, such as immunodiagnostic tools (Dorny *et al.*, 2004).

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