



Short communication

## Feedstuff and poor latrines may put pigs at risk of cysticercosis — A case-control study



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### ABSTRACT

Attempts to control *Taenia solium* in low-income countries have been unsuccessful or unsustainable. This could indicate a 'missing link' in our understanding of the transmission dynamics of the parasite and possibly the magnitude of environmental contamination. We aimed to identify risk factors associated with porcine cysticercosis using a case-control study design, utilising known information on persistent or multiple infections of porcine cysticercosis. The study, a combination of questionnaire interviews and observational surveys, was conducted in July 2014 in the two districts Mbeya and Mbozi, Tanzania. Study households were identified based on their status regarding porcine cysticercosis prevalence and allocated into cases or controls based on previous porcine cysticercosis presence. This resulted in 43 farmers in the case group and 50 farmers in the control group, from 20 villages. Potato peels were said to be given to pigs either raw or boiled by 46% of the farmers. Based on logistic regression porcine cysticercosis could be associated with absence or a completely open latrine ( $p=0.035$ , OR 5.98, CI: 1.33–43.02) compared to an enclosed latrine. Feeding potato peels to pigs was also associated with increased risk of infection ( $p=0.007$ , OR 3.45, CI: 1.43–8.79). Logistic analysis including the pig management system indicated pigs kept in elevated pens ( $p=0.049$ , OR 5.33, CI: 1.08–32.27) and on a dirt floor ( $p=0.041$ , OR 9.87, CI: 1.29–114.55) were more likely to be infected compared to a cemented floor. Whether potato peels are contaminated with *Taenia* eggs before they reach the household or whether the contamination is from water or dirty hands during the process of peeling, remains to be confirmed. This study suggests that detailed assessment of a number of areas of pig management is essential for designing effective control programmes.

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### 1. Introduction

The zoonotic tapeworm *Taenia solium* causing taeniosis/cysticercosis is a serious threat to both the public health and agricultural sector of countries where the parasite is endemic (Karesh et al., 2012). Attempts to control *T. solium* in developing countries have so far been unsuccessful or unsustainable, although a number of interventions including health education (Ngowi et al., 2008), treatment of humans (Sarti et al., 2000), treatment of pigs (Pondja et al., 2012), vaccination of pigs (Molinari et al.,

1997), and treatment of pigs and humans combined (Garcia et al., 2006), have been trialled. Despite these attempts to break the life cycle and control the parasite, *T. solium* remains highly prevalent in many low and middle income countries. Failure to control *T. solium* could indicate a 'missing link' in our understanding of the transmission dynamics and perhaps an underestimation of the effect of environmental contamination in the transmission of this parasite. Known risk factors for porcine cysticercosis have been identified to be insufficient number or usage of latrines (Ngowi et al., 2004), free-range production systems (Komba et al., 2013; Pondja et al., 2010), keeping pigs in elevated pens (Komba et al., 2013), increasing age (Komba et al., 2013; Pondja et al., 2010), and source of water (Komba et al., 2013). Increased risk with certain water sources indicates that some types of water sources could

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be contaminated with *Taenia* eggs, but studies confirming water contamination with *T. solium* eggs are still missing.

Free-range allowing pigs access to human faeces, appear to be the most prominent risk factor for porcine cysticercosis. However, recent data have shown that confinement of pigs can be insufficient in preventing transmission, indicating that pigs might become infected while being confined (Braae et al., 2014). We therefore, hypothesised that pigs are infected with porcine cysticercosis through environmental contamination while being confined. To explore this, we used a case-control design, utilising known information on persistent or multiple infections of porcine cysticercosis in pigs, to identify risk factors responsible for transmission of *T. solium* from humans to pigs relating to human behaviour.

## 2. Methods

### 2.1. Study area

The study was conducted in July 2014 in the two districts Mbeya and Mbozi in Tanzania. Both districts are rural areas where pig production is almost exclusively on a smallholder level, with 31,190 pigs in Mbeya district and 117,483 pigs in Mbozi district according to the 2007/2008 census (URT, 2012), making it the most important pig producing region in Tanzania.

### 2.2. Study design and sample size

Households were identified based on participation in a previous study investigating porcine cysticercosis prevalence using Ag-ELISA (Brandt et al., 1992) at three time points over an approximate period of 14 months among all pig keeping households from 22 villages (Braae et al., 2014). Households were allocated into two different groups—case and control. Households allocated to the control group had been visited at least twice during the 14-month period with no cysticercosis positive pigs detected. Households allocated to the case group had one or more cysticercosis positive pigs on at least two occasions during the 14-month period. Households that had only been visited once ( $n=959$ ) or had one or more positive pigs on only one occasion ( $n=82$ ) were excluded from the study. This resulted in 107 households from 20 villages, 10 villages from each of the two districts, identified as suitable candidates for the study.

### 2.3. Data collection

Data collection comprised of a questionnaire survey and an observational survey. The questionnaire was double blinded and interviews were performed by the same person and administered to a member of each household (preferably the person responsible for the pigs) present at the time of visit. The questionnaire was constructed to capture information about household characteristics, drinking water, sanitation, pork consumption, pig production, and pig management. The observational survey gathered information on latrine presence and usage, and presence and type of pig pen. Latrines were categories based on whether pigs could gain access to the latrine; (1) completely enclosed (latrine with a locked door and no entry points for pigs), (2) partially enclosed (latrine with door, but not closed and pigs could possibly enter), and (3) latrine missing or open (door or latrine missing, easy access for pigs).

### 2.4. Ethical considerations

Permission to conduct the study was sought through Sokoine University of Agriculture in Morogoro, Tanzania, and regional, district, and local village authorities. Oral and written informed consent was also sought from all participating farmers after they

were informed about the aim, risks, and benefits of the study. After the questionnaire had been administered the farmers were informed about ways to improve their pig management. The study was approved by the Imperial College Research Ethics Committee (ICREC), reference no. ICREC\_11\_3.6.

### 2.5. Statistical methods and analysis

Data were analysed in the statistical programme R (<http://www.r-project.org>). Univariate comparison of the groups was done using Student's *t*-test, Chi<sup>2</sup> test, or Fishers Exact test, depending on the variables. Logistic regression was performed with case-control as the dependent variable to control for association with the independent variables in a multivariate analysis. Odds ratios (OR) were calculated for all significant independent variables in the logistic regression models.

## 3. Results

From the 107 identified households, farmers participated from 93 households covering 20 villages in the survey area. Hence, fourteen farmers did not participate, 11 were unavailable at the time of visit, one declined to participate, one had moved to a neighbouring district, and one had passed away. This resulted in 43 farmers in the case group and 50 farmers in the control group. There was no significant difference between the two groups in terms of household characteristics (Table 1).

Confinement of pigs was practised throughout the year by the majority of farmers according to their own statements (Table 2). However, more than half of the farmers said they left piglets to roam. Neither the production system ( $p=0.81$ ) or farmers attitude towards letting their piglets roam ( $p=0.51$ ) differed significantly between cases and control. Maize bran was the most common source of food within the area, but kitchen waste was used as pig feed by 91% of the farmers, and potato peels were said to be given to pigs by 46% of the farmers. Significant more farmers among the cases gave potato peels to their pigs compared with the controls (Chi<sup>2</sup>,  $p=0.019$ ). Potato peels were given to the pigs either raw or boiled. There was no significant difference between the two groups in terms of giving boiled potato peels (Chi<sup>2</sup>,  $p=0.91$ ), but more farmers from the cases group gave raw potato peels compared with farmers from the control group (Chi<sup>2</sup>,  $p=0.067$ ). Potatoes were harvested from local fields and night soil was not commonly used in the region. However, the plough used for weeding and harvest is sometimes also used to dispose of children's faeces if defecation has taken place indiscriminately close to the household. Once harvested, potatoes, if moist, are laid out on the ground to dry within the household compound in close proximity to the latrine, before being stored in large bags. When peeled it is either done dry or wet, with the water leftover used for livestock.

All farmers, with the exception of one, had latrines near their houses. The types of latrine differed significantly between cases and controls (Fishers exact test,  $p=0.043$ ). Most latrines had signs of recent usage, with no significant difference between the two groups (Chi<sup>2</sup>,  $p=0.486$ ). Pigs were more likely to be kept in elevated pens if they belonged to the cases group (Chi<sup>2</sup>,  $p=0.019$ ) and type of flooring within the pens also differed significantly between cases and controls (Fishers exact test,  $p=0.024$ ).

Multivariate logistic regression associated the absence/open type latrines ( $p=0.035$ , OR 5.98, CI: 1.33–43.02) compared with completely enclosed latrines and the use of potato peels as feeds for pigs ( $p=0.007$ , OR 3.45, CI: 1.43–8.79) compared to none provided, as risk factors for porcine cysticercosis. The same model, but inclusive of boiled and raw potato peels, revealed that both raw ( $p=0.011$ , OR 7.76, CI: 1.80–46.05) and boiled ( $p=0.049$ , OR 2.65CI:

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