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Prevalence of porcine cysticercosis and associated risk factors in smallholder pig production systems in Mbeya region, southern highlands of Tanzania

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ABSTRACT

Porcine cysticercosis (PC) caused by the larval stage of a zoonotic tapeworm *Taenia solium*, is known to pose serious economic losses and public health risk among smallholder pig production communities. The present study was conducted to determine prevalence and associated risk factors for PC in smallholder pig production systems in Mbeya region, the major pig rearing region of Tanzania. A cross-sectional survey employing a random sample of 300 pig keepers from 30 villages of Mbozi and Mbeya Rural districts, Mbeya region were used to evaluate pig production systems and practices. Concurrently, 600 male and female pigs of different age categories were randomly selected and examined for PC using lingual examination method and antigen enzyme-linked immunosorbent assay (Ag-ELISA). The overall pig level PC prevalence in Mbozi district was 11.7% (95% CI = 8.5–15.8%) and 32% (95% CI: 27–37.5%) based on lingual examination and Ag-ELISA, respectively. In Mbeya Rural district, the prevalences were 6% (95% CI: 3.8–9.3%) and 30.7% (95% CI: 25.8–36.1%) by lingual examination and Ag-ELISA, respectively. In Mbozi district 46% of the households were found infected (one or more infected pigs) and the corresponding figure was 45% for Mbeya Rural district. The agreement between lingual examination and Ag-ELISA was poor ($\kappa < 0.40$). There were no significant differences in the prevalence of PC in different sex categories of pigs. Significant risk factors associated with PC prevalence were free roaming of pigs (OR = 2.1; 95% CI = 1.3–3.6; $p = 0.006$), past experience of porcine cysticercosis in the household (OR = 2.6; 95% CI = 1.5–4.8; $p = 0.002$), increased age of pig (OR = 1.9; 95% CI = 1.2–3.0), slatted raised floor in pig pen (OR = 8.4; 95% CI = 1.0–70.0), in-house origin of the pig (OR = 1.6; 95% CI = 1.1–2.5) and sourcing of water from rivers (OR = 3.1; 95% CI = 1.6–6.3; $p < 0.001$) and ponds (OR = 5.0; 95% CI = 1.2–21.7; $p = 0.031$). This study has clearly revealed a high sero-prevalence of PC in the study area, which imposes a major economical and public health burden to the smallholder pig farmers. The study also points to a number of important risk factors in smallholder pig management that may be addressed (e.g. confinement, quality of pens and water sources) in future interventions and educational campaigns for control of *T. solium*.

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1. Introduction

Pig production in Tanzania is one of the fastest growing livestock sub-sectors involving over 7% of the smallholder farmers and 18% of livestock keeping households, based on low input–output management systems (URT, United Republic of Tanzania, 2006; FAOSTAT, 2009). The farmers have consistently increased the supply of pork, thus, increased availability and consumption of animal protein in rural and urban families. The predominance of smallholder production systems in the sub-sector and associated poor husbandry and limited biosecurity does, however, make it vulnerable to diseases, like African swine fever, and food safety threats, particularly porcine cysticercosis (PC). PC is an infection in pigs with the larval stage of the tapeworm *Taenia solium* (cysticercosis). It is an important parasitic zoonosis with humans harbouring the adult stage of the parasite (taeniosis). Human infection results from ingestion of infected pork, whereas pigs get infected by consuming human faeces or feed/water contaminated with taeniid eggs from humans. Occasionally humans ingest *T. solium* eggs, which develop into cysts in different body tissues with serious consequences resulting from cysts in the central nervous system, a condition termed as neurocysticercosis (NCC). PC is most prevalent in rural pig keeping communities of developing countries, Tanzania inclusive (Perry et al., 2002; Phiri et al., 2003; Zoli et al., 2003; Ngowi et al., 2004a; Boa et al., 2006). The disease has, since the first finding in a slaughter slab in Mbulu district in 1985 (Nsengwa, 1995), been reported as an emerging and increasing problem in smallholder production systems throughout the country (Boa et al., 1995). Subsequent studies based on ante-mortem lingual examination established prevalence in the Northern highlands (Ngowi et al., 2004a) and Southern highlands of Tanzania (Boa et al., 2006). It is however important to note that lingual examination method can detect only about 21% of truly infected pigs (Dorny et al., 2004). The disease has become a major barrier to local, regional and international trading of pigs and pork. Smallholder pig keepers have become the most vulnerable group along the pig production and marketing chain; both to income loss when their pig assets cannot be sold or are condemned at slaughter due to PC, and also when their lives are prone to *T. solium* taeniosis and cysticercosis. *T. solium* infections are, however, not limited to the rural pig producers but are also extended to urban pork consumers to whom the rural pig producers are among the suppliers (Mkupasi et al., 2011).

The need for controlling PC is fundamental for improving smallholder pig production, safe pork consumption and improvements in public health both in Tanzania and other PC endemic countries in Africa. However, lack of information on the PC prevalence and associated risk factors in the local setting has been an important limiting factor to that effect. Therefore, the current study was conducted in Mbozi and Mbeya Rural districts with the largest pig populations in the country, to determine the prevalence of PC and associated risk factors in order to provide inputs necessary for developing sustainable control strategies.

2. Materials and methods

2.1. Ethics statement

The study protocol was approved by the Postgraduate Studies Committee of the Faculty of Veterinary Medicine, Sokoine University of Agriculture, which is an institutional review board for studies related to the field of Veterinary Medicine and Public Health. The Committee approved obtaining verbal consents from pig farmers for their participation in the survey and allowing involving their pigs in the study. Verbal consents were purposely adopted as some respondents could not read or write. Sampling of blood from pigs was performed by qualified registered veterinarians. Following completion of the study feedback seminars were conducted in the study villages, which also involved training of the rural farmers on possible control measures of the disease.

2.2. Study area

This study was conducted in Mbozi and Mbeya Rural districts located in Mbeya region in southern highlands of Tanzania. The temperature in Mbeya region ranges between −6 °C in the highlands and 29 °C in the lowlands. Average rainfall per year is around 900 mm. The rainy season is from November to May with heaviest rainfall occurring during the months of December to March. Mbeya Rural district lies between latitudes 8° 38′ and 9° 20′ S and longitudes 33° 01′ and 33° 49′ E. It has 126 villages (URT, 1997), covering a total area of 2334 km^2 and 254,069 inhabitants (NBS, National Bureau of Statistics, 2003). In 2002 the district had a pig population of 33,535 (URT, 2006). Mbozi district is located in the south-western corner of Mbeya Region. It lies between latitudes 8°14′ and 9°24′ S and longitudes 32° 04′ and 33° 13′ E. It comprises of 152 villages (URT, 1997), covering a total of 9586 km^2 and 513,600 inhabitants (NBS, 2003). In 2006 it had a pig population of 57,898 (URT, 2006).

2.3. Study design and sample size

A cross-sectional survey was conducted between November 2007 and January 2008. A multistage sampling technique was used to sample villages, households (HH), and pigs. Sample size for HH was calculated based on formula by Bartlett et al. (2001). A total of 300 HH were involved (150 per district). In each district the households were picked from 15 randomly selected villages from lists of all pig keeping villages in the district (10 pig keepers' HH per village). An estimation of the sample size of the pigs required for the study was based on the formula by Martin et al. (1987), in which 300 pigs were examined in each of the two districts. In households with one or two pigs, all the pigs were examined while in households with more than two pigs; a proportion of the pigs were randomly selected for sampling. Sows that had recently farrowed or were in late pregnancy, and piglets less than two months old were excluded from the study.