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ORIGINAL RESEARCH

Prevalence of extra-intestinal porcine helminth infections and assessment of sanitary conditions of pig slaughter slabs in Dar es Salaam city, Tanzania

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Abstract A study was carried out to establish the prevalence of extra-intestinal porcine helminth infections and to assess the pig slaughter slab sanitary conditions in Dar es Salaam city, Tanzania. A total of 24 privately owned pig slaughter slabs were assessed. All slaughter slabs were substandard; wrongly located, poorly designed and constructed and lacked most basic requirements for a slaughter house. Because of inadequate slaughtering, disposal and cleaning facilities, the slaughter slabs were under unhygienic condition with questionable safety, soundness and wholesomeness of the pork produced. Routine meat inspection procedures were used to detect extra-intestinal porcine helminth infections. Of the 731 examined pigs; 8.1%, 5.9% and 0.4% were infected with ascariosis, porcine cysticercosis and hydatidosis, respectively. It was noted that almost all slaughter pigs in Dar es Salaam originated from different regions. Based on the region of origin, the status of porcine cysticercosis was 8.2% for Dodoma (n=98), 8.2% for Manyara (n=260) and 6.9% for Mbeya (n=116). This study disclosed the unhygienic sanitary condition prevailing in Dar es Salaam pig slaughter slabs and recommends that strategies should be devised to improve the situation. Porcine ascariosis and cysticercosis were widely prevalent and caused economic losses due to condemnations. Because of their zoonotic nature, the observed extra-intestinal porcine helminth infections in pig pose a public health risk among consumers. Thus, there is a need to introduce appropriate control measures of parasitic infections in pigs.

Keywords Pig slaughter · Sanitary conditions · Cysticercosis · Echinococcosis · Ascariosis

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Introduction

Like in many other developing countries, livestock productions in Tanzania largely depend on the traditional sector which constitutes more than 98% of the total livestock population (MAFs 2002). The traditional livestock keeping faces several challenges which include poor animal genetic make-up, poor management and diseases. Animal diseases seriously affect the productivity of livestock population. As a result of devastating outcome of livestock diseases, animal protein output of livestock has not been able to keep up with the national demand. Indeed, control of livestock diseases remains a mystery because of inadequate veterinary services extended to livestock keepers particularly in rural areas. Concomitantly, animals brought for slaughter into urban areas come from villages where disease control regimens are limited. Veterinary services are rarely extended to villages because of shortage of veterinary staff, poor transport facilities, and limited diagnostic facilities and drugs. The lack of veterinary services to these livestock-rearing areas suggests a possible widespread occurrence of diseases in livestocks. This further suggests that most slaughter animals brought to the abattoir may harbour chronic or subclinical infections which are rarely detected during ante-mortem examination.

Under normal circumstances, many abattoir and slaughter slabs in developing countries are poorly constructed, have poor slaughter and meat inspection facilities and qualified

meat inspectors are always inadequate (Biu et al. 2006). However, in most abattoirs, it is standard practice to condemn diseased carcasses or organs wholly or partially, for health and aesthetic reasons. The level of such practices varies from place to place and sometimes unmarketable meat may escape and is supplied for public use. When this is coupled with the poor animal management practiced by most livestock keepers, may ease the distribution of infected and or contaminated carcasses and offals to the public. This practice may pose not only eating unsound, unwholesome but also unsafe meat. There are many published zoonotic diseases like cysticercosis, trichinellosis, toxoplasmosis, hydatidosis, campylobacteriosis, rift valley fever and tuberculosis that are transmissible to humans through consumption of infected meat (Gracey et al. 1999).

Consumption of pig meat has increased dramatically in recent years in urban areas of Tanzania which has lead to increased production and transportation of pigs from rural communities to large urban areas (Boa et al. 2006). Similarly, the possibilities of transporting infected and diseased pigs into urban areas for slaughter are also high. This may pose a high risk to the public if slaughtered pigs are not properly examined during meat inspection (Phiri et al. 2003; Sikasunge et al. 2008). Among the endemic pig infections in Tanzania include extra-intestinal helminthes include porcine cysticercosis, hydatidosis and ascariosis (Ngowi et al. 2004; Boa et al. 2006).

Porcine cysticercosis is an infection caused by the larval stage of *Taenia solium*. In the life cycle of this parasite, humans are the definitive hosts which harbour the adult tapeworm in small intestine, whereas pigs are the common intermediate hosts. The disease is prevalent in areas with traditional pig production systems, poor sanitation and inadequate or absent of meat inspection (Flisser et al. 2003; Sikasunge et al. 2007). In East and Southern Africa, the prevalence is reported to be as high as 20–40% (Phiri et al. 2003). In Tanzania, prevalence of porcine cysticercosis in slaughter pigs ranges from 0.3 to 17.4% (Boa et al. 1995, 2006).

Moreover, hydatidosis is a condition of livestock and humans that arises from eating infective eggs of cestode *Echinococcus granulosus*. Dogs are the primary definitive hosts for this parasite, with livestock acting as intermediate hosts and human as aberrant intermediate hosts. The distribution of *E. granulosus* is considered worldwide but higher in developing countries especially in rural communities where there is close contact between dogs and various domestic animals (Eckert and Deplazes 2004). Studies in East African countries by Macpherson et al. (2004), Nonga and Karimuribo (2009) and Kebede et al. (2008) showed evidences of its existence in domestic animals. Human infections have also been reported in pastoral communities in Tanzania (Ernest et al. 2009). The role of pigs in transmission of echinococcosis increases in areas where pigs are raised under free range system. However, the extent of *E. granulosus* infection in pigs is not extensively investigated in Tanzania.

Ascariosis is another common infection of pigs caused by *Ascaris suum* and is among the leading causes of liver condemnation during post-mortem meat inspection. The pathological effects of adult worms in the small intestine are less dramatic compared to the larval migrations in the animal tissues such as the liver and lungs. A study carried out in the northern highlands of Tanzania recorded a prevalence of 44.3% of *A. suum* infection in pigs (Ngowi et al. 2004). *A. suum* was formally considered to be a parasite of pigs only but recent studies have reported the occurrence of cross-infection to human in Denmark (Nejsum et al. 2005, 2006).

Therefore, the present study was carried out to establish the prevalence of porcine extra-intestinal porcine helminth infections and assess the pig slaughter slab sanitary conditions in Dar es Salaam city, Tanzania.

Materials and methods

Study area and animals

This study was conducted in Dar es Salaam city of Tanzania which, administratively is divided into Kinondoni, Ilala and Temeke municipalities (Fig. 1). It is the highly populated city in the country having a population of 2,497,940 people (NBS 2002). Geographically the city is located between latitude 6°46′ and 6°51′ S and longitude 39°14′ and 39°18′ E. It experiences generally tropical climatic conditions, typified by hot and humid weather throughout the year. Annual rainfall is approximately 1,100 mm/year with two distinct rainy seasons: the long rain season, which fall between April and May, and the short rain season between October and November.

Management of pigs in the areas where they keep pigs is variable ranging from intensive, semi-intesive to extensive system with minimal veterinary services. Majority of pigs slaughtered were landrace and large white crossed with local breeds. Laboratory examination of samples was carried out at Sokoine University of Agriculture (SUA) in Morogoro region, located approximately 200 km west of the city.

Distribution mapping of pig slaughter slab and sanitary conditions assessment

A hand held geographical positioning system, made in Taiwan, was used to locate all official slaughter places visited during the study. The information recorded were the

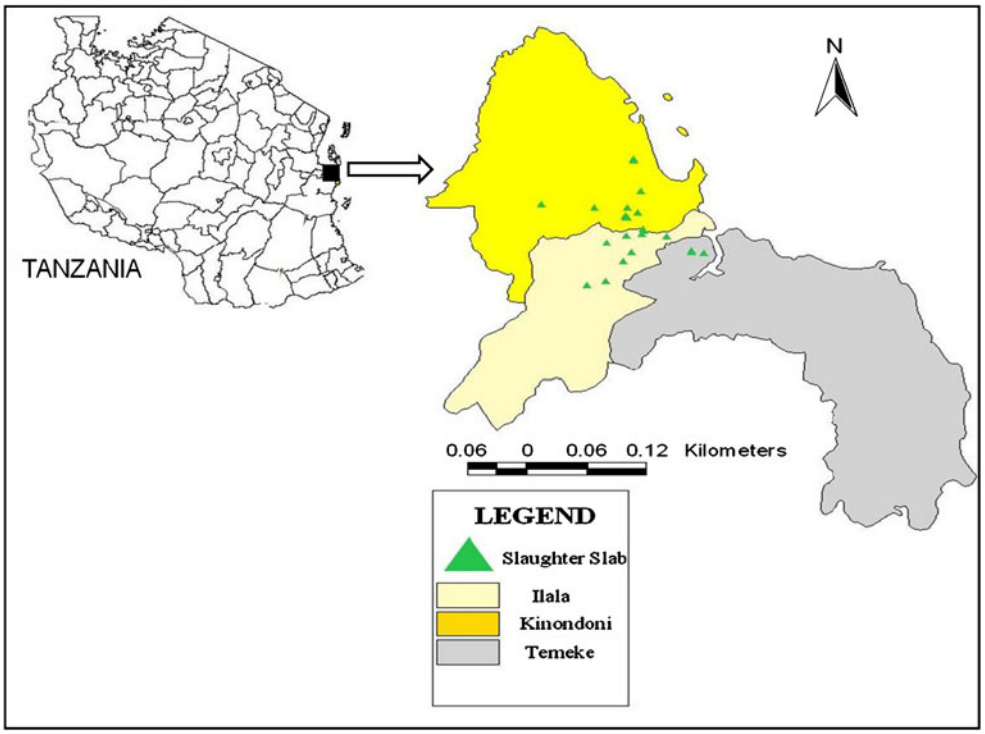

Fig. 1 Map of Tanzania showing Dar es Salaam city and distribution of pig slaughter slabs in its three municipalities

altitudes, latitudes and longitudes. Sanitary parameters assessed in the slaughter slabs included; location, presence of a fence, source and availability of water, slaughter place layout and availability of basic facilities, waste disposal, presence of toilet and bathroom, protective gears, hygiene of workers and the surroundings.

Pig data collection

During this cross-sectional epidemiological study conducted in 24 slaughter slabs in the city from November 2007 to January 2008; each slaughter slab was visited for 12 days. All pigs slaughtered during each visiting day were thoroughly inspected for extra-intestinal helminthes infection. During inspection, important information like number of animals slaughtered, sex, origin and general post-mortem meat inspection results were recorded. In addition, pig inspection records between January 2006 and Septemper 2007 in each municipal veterinary office were retrieved and assessed.

Post-mortem examination of pig carcasses and laboratory confirmation of extra-intestinal helminthes infection

T. solium cysts Thorough inspection of the carcass was done through visual inspection and palpation. Sharp incisions were made on tongue, external and internal masseter, intercostals, psoas, triceps brachii and heart muscles according to the Tanzania general guidelines for inspection of pig carcasses and as described by Gracey et al. (1999). In cases which were found to have *Cysticercus cellulosae*, two to three 50 g pieces of infected muscles were collected from different muscles and stored in cool box with ice pack. The samples were subsequently transported to the laboratory at the Faculty of Veterinary Medicine, Sokoine University of Agriculture, for microscopic confirmation of *T. solium* cysts. In the laboratory, the cysts were immersed in Berlese mounting medium (Den kgl. Veterinaer-og Landbohøjskoles apotek) for 24 h, and then each pressed between two glass slides and examined under the microscope (Olympus-Taiwan) at ×4, ×10 and ×40 magnification.

Cystic echinococcosis Visual examination, palpation and where necessary incision of livers, lungs, spleens and kidneys were performed. Two of the suspected hydatid cysts from each positive case were collected and preserved in 70% alcohol for laboratory examination. In the laboratory, individual cyst was carefully opened and examined to identify whether it was a hydatid cyst and whether it was fertile, sterile or calcified. After opening, the cyst fluid was aspirated by using a 20 ml syringe. A drop of the cyst fluid was placed on the microscope glass slide and covered with cover slip and observed for presence of protoscolices on light microscope with ×10 to ×40 objective. For clear vision, a drop of 0.1% aqueous eosin solution was added to equal volume of cyst fluid on microscope slide with the principle that viable protoscolices should completely or partially exclude the dye while the dead ones take it up. Presence of protoscoleces looked like white dots on the germinal epithelium. Identification of hydatid protoscoleces was done as described by Craig et al. (2003).

Examination for ascariosis The entire liver was visually examined for presence of focal interstitial hepatitis appearing as whitish fibrous foci on the liver surface and parenchyma (milk spots) which were up to 1-cm diameter. The lesions were used as an indicator of *A. suum* infection. Milk spot lesions were identified as described by Gracey et al. (1999) and Herenda et al. (2009).

Data analysis

Data were analysed using Statistical Package for Social Sciences version 11.5. Descriptive statistics were computed to determine the prevalence of porcine cysticercosis, hydatidosis and ascariosis infections in examined pigs. Cross-tabulation was performed to assess the association between infected pigs and important variables such as the region of origin. Data from the retrospective study were analysed in Microsoft Excel to determine the prevalence of the conditions. Locations of the slaughter places were mapped using ArchView 3.2 mapping software.

Results

The number and distribution of authorized pig slaughter slabs in Dar es Salaam city

There were a total of 24 pig slaughter slabs in Dar es Salaam city of which 13 were in Kinondoni, seven in Ilala and Temeke had four (Fig. 1). There is overlapping of the locations of some slaughter slabs on the map (Fig. 1) because such slabs were in close proximity to each other.

Sanitary situation of the slaughter slabs

All the slaughter slabs were privately owned not fenced and were built within areas crowded with residential houses. The slaughter slabs had scarce availability of water and lacked drainage infrastructures. Butchers reported that carcasses were not washed and similarly, the slaughter houses were not regularly cleaned because of water shortage. Arriving pigs to the slaughter slabs were being slaughtered directly as there was no resting places (lairage). The slaughter slab buildings were small in size (3×5 m) made of rough concrete walls and floors such that proper cleaning was impossible. The slabs were roofed with corrugated iron sheet. They were poorly ventilated and had no electrical supply. All the processes of carcass dressing from bleeding, scalding, dehairing, evisceration and portioning were done manually on the floor. Because of the small size of the buildings, physical demarcation between clean and dirty places was not possible. This necessitated the same personnel to perform all processing activities from bleeding to carcass dressing at the same working place. Workers lacked necessary working gear and their personal hygiene as well as sanitary condition of the surroundings was poor. The slabs also had no toilets and bathrooms which further compromised good hygienic practices of a food industry. No cold room storage and the meat was distributed to the market on the day of slaughter. All the slaughter slabs had inadequate waste disposal facilities and no decomposition pits, the situation which attracted cats, flies, craws and stray dogs. The slabs were rampant with filth and scattered rubbish which were left uncollected, apart from the effluent draining trenches through which the filth was scattered. In addition, some slaughter places were inaccessible because of lack of roads.

Extra-intestinal helminths in pigs

A total of 731 carcases of pigs were examined in the three municipalities of Dar es Salaam city namely, Kinondoni (578), Ilala (111) and Temeke (42) between November 2007 and January 2008. All the slaughtered pigs were adult of which 309 were male and 422 were female. The overall prevalence of the three extra-intestinal helminths infections in pigs is summarized in Table 1. Laboratory examination of porcine cysticerci confirmed that the observed cysts were due to *T. solium*. All the hydatid cysts examined were sterile.

The pigs slaughtered in Dar es Salaam city during the study period originated from nine regions of Tanzania which were Manyara, Mbeya, Rukwa, Kilimanjaro, Dodoma, Morogoro, Singida, Dar es Salaam and Tanga (Table 2). It was found that pigs from Manyara and Dodoma regions had the highest infection rates (8.2% each) of cysticercosis. Pigs from Morogoro region had a significantly ($P< 0.05$) higher prevalence of ascariosis (14.3%) compared to pigs from other regions. Hydatidosis was recorded at a lower level in pigs from all regions.

Table 1 Prevalence of extra-intestinal helminths infection in pigs slaughtered in Dar es Salaam city

Condition	Total number of pigs examined	Number of positive pigs	Prevalence
Cysticercosis	731	43	5.9
Hydatidosis	731	3	0.4
Ascariosis	731	59	8.1

Table 2 Origin of pigs slaughtered in Dar es Salaam city and their infection rates

Region of origin	Number of pigs examined	Number (%) of extra-intestinal helminths		
		Cysticercosis	Hydatidosis	Ascariosis
Manyara	328	27 (8.2)	1 (0.3)	29 (8.8)
Mbeya	116	8 (6.9)	1 (0.9)	8 (6.9)
Rukwa	8	0 (0.0)	0 (0.0)	0 (0.0)
Kilimanjaro	12	0 (0.0)	0 (0.0)	0 (0.0)
Dodoma	98	8 (8.2)	0 (0.0)	8 (8.2)
Morogoro	14	0 (0.0)	0 (0.0)	2 (14.3)
Singida	57	0 (0.0)	1 (1.8)	6 (10.5)
Dar es Salaam	90	0 (0.0)	0 (0.0)	6 (6.7)
Tanga	8	0 (0.0)	0 (0.0)	0 (0.0)
Total	731	43 (5.9)	3 (0.4)	59 (8.1)

Retrospective results on extra-intestinal helminths in pigs

A total of 23,212 pigs were slaughtered and inspected between January 2006 and September 2007. The records showed that 149 (0.6%) and 3,668 (15.8%) of slaughtered pigs had cysticercosis and ascariosis, respectively.

Discussion

An abattoir or slaughterhouse as a building for butchering is a food factory whose primary aim is to produce healthy, wholesome and clean products which are safe for human consumption. For this purpose to be achieved, proper construction, layout and equipment must all be geared to promote efficient and hygienic operations (Gracey et al. 1999). Failure to meet the specifications and standards may become hazardous to human and his environment. The most important issue in all meat-processing plants is maintenance of proper hygiene and adequate sanitary conditions. While the slaughtering of animals result in meat supply and useful by-products, livestock waste spills can introduce enteric pathogens and excess nutrients into surface and ground waters (Akinro et al. 2009). The slaughter slabs examined in Dar es Salaam during this study were all in sub-standards; wrongly located, poorly designed and constructed and lacked most basic requirements for a slaughter house. With inadequate slaughtering and disposal facilities, the slaughter slabs were likely to become sources of infection, nuisance to the community and pollution to the environment. Poor town planning, inefficient regulation enforcement by Tanzania Food and Drug Authority on slaughterhouse specifications, requirements and sanitary-hygienic measures; caused pig traders and butchers to identify sites for pig slaughter based on their convenience.

Results from this study indicate that cysticercosis, ascariosis and hydatidosis are common extra-intestinal helminths which may affect the pig industry and pose health risks to the meat consumers. This merits for more extensive epidemiological investigations to better determine the prevalence, economic impact and the public health importance of the diseases. Although abattoir surveys have limitations, they are an economical way of gathering information on livestock diseases. It is suggested that an efficient meat inspection services and proper recording should function as an important monitor of animal disease, being particularly valuable to chronic and ill-defined conditions which are not apparent to either the stock owner or his veterinary surgeon but are of great significance to public health, animal health and of considerable economic value as it has been with exra-intestinal helminthes infections (Ansari-Lari 2005). For example there are no reliable tests for diagnosis of hydatidosis in live animals and so, the reliable diagnosis is through post-mortem examination (Njoroge et al. 2000). Detection of such diseases which are of public health importance at meat inspection safeguards the public from possibilities of zoonosis and foodborne disease infections. Also, a feed-back from the slaughterhouse to the individual farm is of great value in the field of preventive medicine.

It has been found that cysticercosis had a prevalence of 5.9% with the highest infection rates detected in pigs from Manyara and Dodoma regions. Abattoir survey done in 1995 in northern Tanzania (Manyara region inclusive) showed a prevalence to range from 4.5% to 37.7% (Boa et al. 1995). Moreover, a lingual cysticercosis survey conducted in southern part of Tanzania reported a prevalence to range from 5.5% in Chunya, 8.8% in Iringa to 16.9% in Songea (Phiri et al. 2003). The observed differences in prevalence may probably be due to mixed origins of pigs. The fact that traders are more aware of the disease and its economical implication at slaughter therefore they conduct their own antermortem tongue inspection in rural communities and reject infected pigs as reported by Ngowi et al. (2004).

During this survey, most of the infected pigs originated from rural areas of the country, some of which have been previously reported to be endemic for the parasite. However, this study could not confirm the actual absence of the infection in the other regions, including Dar es Salaam, because of the small number of pigs from these regions that were slaughtered during the study. The observed prevalence of porcine cysticercosis in slaughter pigs in Dar es Salaam city indicate a high risk to public health because of the zoonotic nature of the disease and posses a greater economic losses to the pig farmers and traders. However, considering the low sensitivity of the meat inspection method, the observed prevalence should be regarded as a gross underestimation of the actual prevalence.

One of the important findings from this study is the observed high prevalence of porcine cysticercosis in pigs originating from Dodoma, the central region of Tanzania. This region had not previously been investigated for porcine cysticercosis. This initial evidence suggests another area in the country to consider for more epidemiological studies and later institution of control measures. In addition, it suggests that porcine cysticercosis might be a nation-wide problem. The present study, like other studies elsewhere, shows that porcine cysticercosis is widely prevalent, becoming an obstacle to the pig industry. The disease causes losses to smallholder farmers and pig traders and poses a serious health risk to the pork consumers. In Uganda, a survey by Kisakye and Masaba (2002) reported a prevalence of 9.4% in pigs slaughtered in Kampala city while Phiri et al. (2002) reported a prevalence of 20.6% in Zambia.

The low prevalence (0.4%) of hydatidosis in the slaughtered pigs in this study should be considered as an indication that the disease may be endemic in pigs. A higher hydatidosis prevalence of 4.3% was reported by Ngowi et al. (2004) in slaughter slabs in northern Tanzania, where most pigs slaughtered were from Mbulu district. In Kenya, a study by Ndirangu et al. (2004) reported hydatidosis prevalence of 2.4% in pigs based on abattoir records. The low prevalence observed in this study may suggest a low interaction between stray dogs (the definitive host of *E. granulosus*) and the pigs. This is because in most areas of Tanzania, pigs are managed under intensive system and this may reduce the predisposition to *E. granulosus* infection. However, the low prevalence of *E. granulosus* in dogs in Tanzania reported by Ernest (2004) further supports the current results. Moreover, higher incidences of human cases of hydatidosis have recently been reported in Northern Tanzania (Ernest et al. 2009). Apart from the risk to human health, the organs that were condemned as a result of hydatid cyst infection necessarily results in the deprivation of people of much needed protein and monetary losses.

The prevalence of *A. suum* was lower in this study (8.1%) than that of 44.3% reported in northern Tanzania (Ngowi et al. 2004) and 40% in Burkina Faso (Tamboura et al. 2006). Increased uses of anthelmintics and mixed origins of the slaughter pigs in the present study may partly explain these differences. Nevertheless, the observed prevalence is of economic and public health importance as now there is a report of cross-infection to human (Nejsum et al. 2005). However, the 8.1% liver condemnation rate due to ascariosis is of great economic losses to pig meat traders and the farmers at large. Further epidemiological studies are needed to establish factors responsible for the prevalence and transmission of ascariosis in the country, evaluate the economic losses caused by the parasite and to elucidate the possibility of cross-infection to human in Tanzania.

It is concluded that livestock for slaughter, although by no means constitute a representative sample of the resident livestock population, provide a useful source of information complementary to data acquired from surveys of disease incidence in breeding herds and, in many aspects, are more easily and thoroughly examined than the latter. The study has disclosed the poor sanitary conditions of pig slaughter slabs and reported the status of pig cysticercosis, hydatidosis and ascariosis in Dar es Salaam city. The pathetic conditions of slaughter slabs and presence of zoonotic helminth diseases may pose a health risk to meat consumers and the general public. This suggests a need for immediate slaughter slab sanitary measures, regulation enforcement and a rigorous meat inspection procedure to minimize the chance of consumers acquiring infection through contact with and/or consumption of infected pig meat.

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