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ORIGINAL RESEARCH

Prevalence of gastrointestinal nematodes in growing pigs in Kabale District in Uganda

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Abstract During the last 30 years, pig production in Uganda and neighbouring counties has increased markedly. Pigs are mainly kept as a source of income for small-scale farmers; however, the pig production is subject to several constraints, one of them being worm infections. A study was carried out in rural communities in Kabale District in the South Western part of Uganda in September and October 2007 in order to estimate the prevalence of gastrointestinal nematode parasites in pigs based on coprological examination. Fifty-six households were randomly selected and visited. Housing system and deworming history were recorded. Faeces was sampled from rectum of one to five pigs (age, 3–12 months) per household. A total of 106 pigs were examined coprologically of which 91% excreted nematode eggs. The following prevalences of nematode eggs were recorded: strongyles (89%), *Ascaris suum* (40%), *Trichuris suis* (17%) and spiruroid eggs (48%). On household level, rearing pigs on slatted floors in pens significantly reduced the faecal egg excretion of strongyle eggs with almost 80% (p=0.010) and a significant interaction between floor type and anthelmintic treatment was found for spiruroids (p=0.037). Fifteen *T. suis* egg positive pigs were selected for post-mortem examination of the gastrointestinal tract. The post-mortem examinations revealed that 93% pigs were infected with *Oesophagostomum* spp. (worm burden, min–max 10–2,180), 73% with *A. suum* (1–36), 67% with *T. suis* (6–58), and 20% with *Hyostrongylus rubidus* (worms not quantified). In general, nematode infections were widespread and polyparasitism common in pigs in Uganda. However, worm burdens were moderate which may be related to recent deworming or to the practice of rearing pigs on slatted floors in wooden elevated pens.

Keywords *Ascaris suum* · Nematode prevalence · *Oesophagostomum* spp. · Pig management · Spiruroids · *Trichuris suis* · Uganda

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Introduction

Livestock production is vital for the livelihood of poor people throughout the world. While ruminants and poultry are the most important groups of domestic animals in tropical production systems, pig production is becoming increasingly more important in many African countries, particularly in peri-urban farming (Perry et al. 2002). From 1985 to 2005, the production of pig meat more than doubled in the sub-Saharan countries (FAOSTAT 2010). This trend was very pronounced in Uganda; here, the pork production increased tenfold within the same period (FAOSTAT 2010). Pig production provides a good potential for high economic gain for the farmer given factors like high feed conversion efficiency, high fecundity and short generation intervals (Lekule and Kyvsgaard 2003). In order for smallholder farmers to benefit fully from pig production, a number of obstacles must be overcome, these being high mortality, low rates of weight gain as compared to industrialized production systems and absence of even minimal health care (Lekule and Kyvsgaard 2003). Better weight gains have been obtained following regular anthelmintic treatments of growing pigs on farms in tropical settings (Kumaresan et al. 2009) and even in well-fed pigs, gastrointestinal nematode infections may account for 3–13% reductions in weight gain and feed conversion efficiency (Stewart and Hale 1988). In pig production among smallholder farmers in low income countries, where the diet is often insufficient, the impact of intestinal nematodes is expected to be bigger. Nematodes and other parasites are therefore an important limiting factor to smallholder livestock production in most low income countries (Perry et al. 2002) and are indeed perceived as such among smallholder farmers (Kagira et al. 2010). The range of gastrointestinal nematodes species in pigs in the tropics includes *Oesophagostomum* spp., *Ascaris suum*, *Trichuris suis*, *Hyostrongylus rubidus*, *Ascarops strongylina* and *Physocephalus sexalatus* (Roepstorff and Nansen 1998).

The present paper provides information on the prevalence and species composition of infections with gastrointestinal nematodes and on management practices among smallholder farmers in a rural setting in South Western Uganda.

Materials and methods

Study area and population

The study was carried out in small villages located along a 30-km stretch between Kabale and Katuna in the South Western part of Uganda in September and October 2007. The households were picked randomly within 11 different villages scattered on the hill side in the area. Kabale District lies at an altitude of about 1,500 m above sea level. The climate is tropical highland and the district has an average minimum and maximum temperature of 10°C and 23°C, respectively. The annual rainfall is about 1,000 mm varying from 20 mm per month in the dry season to 130 mm per month within the two wet seasons: March–June and September–December. The sampling was carried out at the end of the dry season since the wet season fell late in 2007.

The study population consisted of 106 domestic pigs, crossbred of local breeds, from 56 randomly selected households in the area. Pigs aged 3–12 months were sampled—boars and sows were excluded from the study. The age, sex and weight were noted, and all sampled pigs were ear tagged in order to find the pigs again for possible post-mortem study. Management practices, including stabling, anthelmintic treatments within the last 3 months and type of feed were recorded for all households visited.

Faecal examination and necropsy procedure

Four grammes of faeces was used to determine eggs per gramme of faeces (epg) by a concentration McMaster technique with a lower detection limit of 20 epg (Roepstorff and Nansen 1998). The flotation fluid was saturated NaCl with 500 g glucose–monohydrate per litre (ρ=1.27 g/ml). As no centrifuge was available, the 10 ml faeces–water suspension was left in the tubes to sediment for 30 min. Thereafter, the supernatant was removed and the samples were stored at 5°C over the night. The following day, the samples were examined at 400× magnification in a light microscope, and the different types of nematode eggs were identified according to Thienpont et al. (1986).

Among pigs with *Trichuris* positive faecal egg counts (FEC), 15 positive pigs were selected for post-mortem examination of the gastrointestinal tract, as described by Roepstorff and Nansen (1998) with the following modifications: The stomach was cut open and the content discarded. The mucus on the stomach wall was examined for the presence of macroscopic worms. All the contents from the small intestine were sieved in a kitchen sieve (1 mm mesh size) and macroscopic worms were recovered. The caecum and colon were cut open and rinsed gently in physiological saline (0.9%), the intestinal wall was carefully examined and the *T. suis* attached to the mucosa were picked up manually. A 10% subsample of the content was sieved in a 212-µm sieve. Macroscopic worms were collected and enumerated. All worms collected were rinsed in saline and stored directly in 70% ethanol. The worms were identified to species level and for *Oesophagostoum* spp. to genus level.

Statistical analysis and calculations

Descriptive statistics (mean, median and standard deviation) on FECs of all pigs were calculated for the different egg types found by faecal examination. The parameter k of the negative binomial distribution, which is a measure of the degree of aggregation, was estimated as $k=\text{mean}^2/(\text{variance} - \text{mean})$. After testing for aggregation of infections within households having more than one pig, the prevalence of infection (positive FEC) was analysed for all individual pigs with respect to floor type (slatted/non-slatted) and treatment, using a χ^2 test. Furthermore, statistical analyses were performed at household level for prevalence (a household was considered positive if one or more pigs had a positive FEC) using a Fisher exact test and for mean FECs by analysis of variance (ANOVA) using the statistical software programme SAS. The latter was performed on logarithmically transformed (log (x+1)) data and with independent variables as mentioned above. All tests was considered statistical significant if $p<0.05$.

Results

Management

The 56 households visited had one to five pigs each, and the majority of the households kept goats and chickens as well. The farmers grew crops either close to their houses or in the valley below the hills. Many of the households were having pit latrines close to their houses. These latrines were not used when the people worked in the fields in the valley during the day. The pigs were housed in close proximity to the dwelling houses. Four different housing systems were found in the area. Thirty-three (59%) households kept their pigs in pens with wooden (slatted) floors elevated above the ground. Fifteen households (27%) kept their pigs tethered, typically on a small pasture close to the house. Nine households (16%) kept the pigs in pens made of wood or stone placed directly on the ground with dirt floors. Two households kept both a tethered pig and a pig in a pen with wooden, slatted floor elevated above the ground. A single household had a pen with concrete floor. Free roaming pigs were observed by the authors in several villages but when asked, no households let their pigs roam freely at all times. The pigs were mainly fed different kinds of kitchen leftovers, grass, potato vines, yams leaves, and sorghum. Commercial feed was not used. Deworming by means of regular use of anthelmintics was performed on some farms; twenty (36%) households had dewormed their pigs within the last 3 months. The types of drugs used were not recorded.

Faecal examination

A total of 106 pigs from 56 farms were sampled (23 farms had one pig; 20 farms two pigs, ten farms had three pigs, two farms had four pigs and one farm had five pigs). FEC showed that 91% of the animals excreted nematode eggs and that strongyle eggs were dominating with a prevalence of 89% (Table 1). The highest egg count found in an individual pig was 56,560 *Ascaris* epg.

All pigs (aged 3 to 7 months old) found negative for strongyles ($n=12$) and negative for all four kinds of eggs ($n=10$) were reared on wooden floors elevated above the ground (slatted floors). Due to too small pig numbers within the farms, the test for aggregation within households was formally not valid. However, the numbers indicated no or little aggregation within the households. An analysis based on 104 pigs (two pigs on concrete were left out) showed significantly lower prevalence of strongyle infections ($\chi^2=9.02$, $p=0.011$) when pigs were reared on slatted floors compared to dirt floors or tethering (non-slatted floors; 81.7% vs. 100%). Any effects on other egg types or effect of recent anthelmintic treatment were not significant

Table 1 Prevalence and intensity of gastrointestinal nematode infections in 106 growing pigs in Kabale District of Uganda, based on faecal examination

Nematode egg		Intensity (based on positive pigs; epg)			
Type	Prevalence (%)	Median	Min–max	Mean	SD
Strongyle[a]	88.7	780	20–7,760	964	1,097
Spiruroid [b]	48.1	200	20–20,040	1,258	3,395
Ascaris suum	39.6	1,860	20–56,560	4,673	9,180
Trichuris suis	17.0	150	40–900	264	271

[a] The following pig nematodes have eggs of the strongylid type: *Oesophagostomum* spp., *Hyostrongylus rubidus*, and *Trichostrongylus axei*

[b] The following nematodes have eggs of the spiruroid type: *Ascarops strongylina* and *Physocephalus sexalatus*

The parameter k of the negative binominal was less than 1 (0.06–0.6) for all four kinds of eggs found by the faecal examination indicating a high degree of aggregation in pigs (Fig. 1). Of the 106 pigs, 9% excreted no eggs, 23% excreted one, 37% excreted two, 23% excreted three and 8% excreted all four types of eggs.

Mean strongyle FECs were significantly lower in households with wooden, slatted floors in pens compared to non-slatted floors (137 vs. 667 epg (back transformed means) ANOVA, $p=0.010$); a reduction of nearly 80%. A significant interaction between slatted floors and treatment was found for mean spiruroid FECs ($p=0.037$), indicating that households combining treatment with pens with slatted floors had almost no egg excretion (1 epg, back transformed mean) compared with any other combination of factors (37 epg). However, in general FECs were low for spiruroids except for two individuals excreting more than 10,000 egp.

Post-mortem examination

Four different nematode species/genera were identified in the 15 necropsied pigs. Fourteen pigs (93%) harboured *Oesophagostomum* spp. (402 (10–2,180); mean (min–max)), 11 pigs (73%) harboured *A. suum* (9 (1–36)), ten pigs (67%) harboured *T. suis* (23 (6–58)) and three pigs (20%) harboured *H. rubidus*, which were not quantified. The frequencies from the post-mortem study should be taken with precaution, since the pigs slaughtered were not selected randomly. However, the necropsied pigs had levels of egg excretion that covered the range (equal medians) of all the pigs examined by coprological methods. *A. strongylina* and *P. sexalatus*, which are the two species in tropical areas with

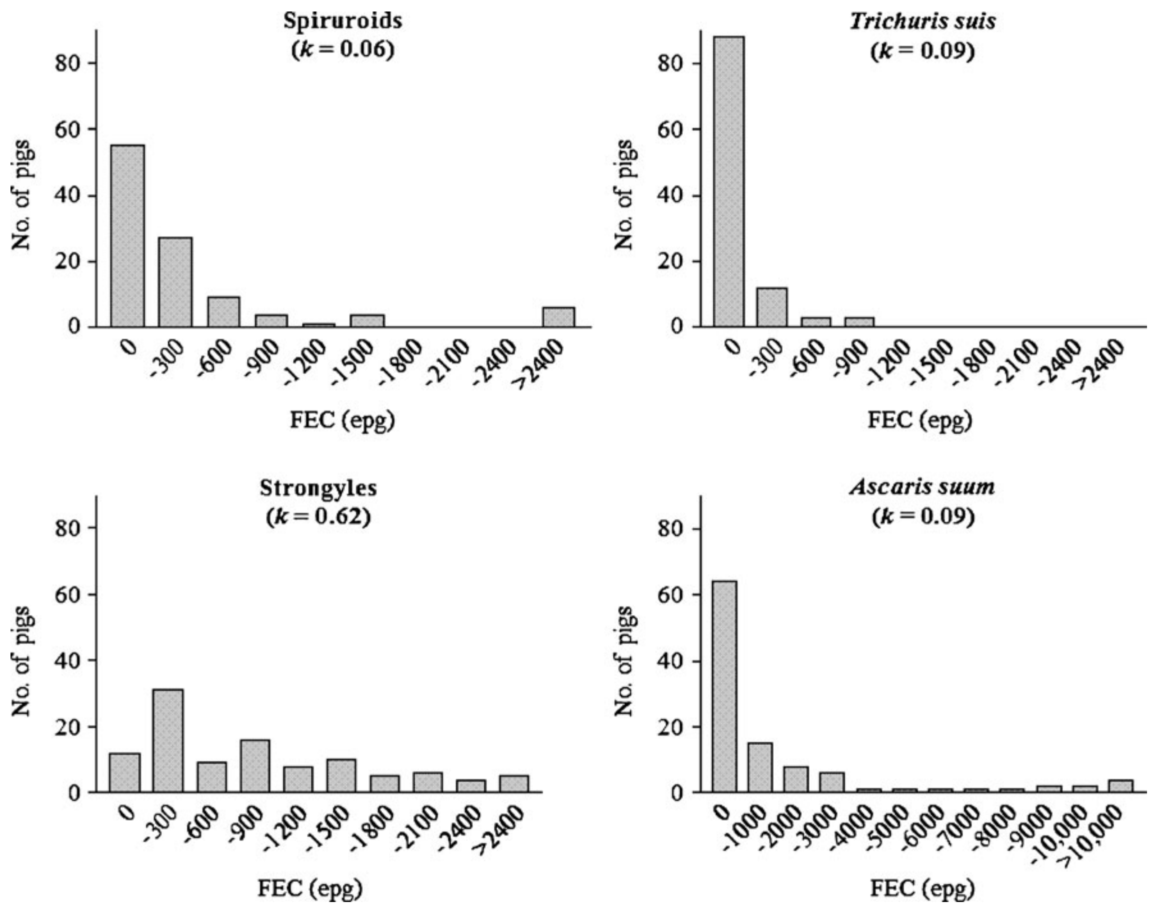

Fig. 1 Frequency distributions of faecal egg counts (FEC) in eggs per gramme (epg) of faeces from *Ascaris suum*, *Trichuris suis*, strongyles and spiruroids in 106 growing pigs from Kabale District, Uganda. The parameter *k* of the negative binomial distribution is given for each egg type

spiruroid egg types, were not found in the post-mortem examinations, despite that 12 of the slaughtered pigs excreted spiruroid eggs.

Discussion

This study is the first to report the prevalence of gastrointestinal nematodes in pigs and the management practices in South Western Uganda. It was found that nematode infections were very common in pigs kept in the mountainous South Western part of the country. The overall prevalence of gastrointestinal nematodes of 91% found in this study is of similar magnitude as other studies in Africa, e.g. Ghana (91%), Burkina Faso (93%) and Nigeria (87%) (Permin et al. 1999; Tamboura et al. 2006; Weka and Ikeh 2009). In contrast, the prevalences found in the neighbouring countries, Kenya and Tanzania, were much lower; 68% in Kenya (Nganga et al. 2008) and 53% in Tanzania (Esrony et al. 1997). The management practices within Kabale District in Uganda are quite different from the practices in Kenya and Tanzania where the majority of the pigs are reared in indoor systems (Nganga et al. 2008; Esrony et al. 1997). Rearing pigs in semi-intensive, indoor systems may explain the lower prevalence of *T. suis*, *A. suum* and *Oesophagostomum* spp. found in Tanzania and Kenya compared with the present study.

The most prevalent gastrointestinal nematodes found in the present study were strongyles. *Oesophagostomum* species are favoured by high faecal egg excretion, and the free-living stages thrive particularly well in humid and unhygienic conditions like many other parasites with faecal–oral transmission cycle. However, the high prevalence can also be due to the fact that *Oesophagostomum* is only lightly immunogenic and therefore can be found in all age groups of pigs (Nansen and Roepstorff 1999). Spiruroids were found in pigs in Nigeria in an older survey (Ajayi et al. 1988), Ghana (Permin et al. 1999), and to a small extent in Kenya (Nganga et al. 2008) as well as in the present study in Uganda. Because coprophagous beetles, which are the intermediate host for spiruroids, are restricted to outdoor conditions, pigs reared indoor do rarely have the spiruroids (Nansen and Roepstorff 1999). Probably due to this fact, spiruroids were present in moderate numbers in Nigeria and to lesser extend in Ghana, where the study populations were scavenging pigs, while they were not recorded in Tanzania (Esrony et al. 1997) and Botswana (Nsoso et al. 2000) and only had a very low prevalence (2.6%) in Kenya (Nganga et al. 2008).

In the present study, pigs that had been treated within the last 3 months and were reared on the wooden slatted floors elevated above the ground had a high reduction in spiruroid FEC. This interaction could be a result of pigs not becoming re-infected with spiruroids. If the piglets acquire the infection early in life, when they roam freely, but are kept confined later in life, elevated above the ground with limited access to faecal material and thereby also limited contact with the intermediate host, this interaction makes good sense.

The pigs of the post-mortem study were selected among pigs with positive *T. suis* egg counts (epg min–max, 40–900). However, the selected pigs were co-infected with other nematodes in most cases. The reason for this selection was a need for obtaining established *T. suis* worms for genetic studies (Nissen 2009). The frequency distribution of the nematodes in this group does therefore not represent prevalences for the entire study population of pigs, but the worm burdens are probably representative. No spiruroids were found in the necropsied pigs despite the fact that some of the selected pigs excreted spiruroid eggs. This is probably due to the fact that the gastric mucosa was not examined thoroughly for tiny, white worms, like the spiruroids. Some of the slaughtered pigs did not harbour *T. suis* worms, despite they were coprologically positive. This was the case for five out of the 15 pigs. Previous studies have shown that false-positive egg counts are quite common in pigs due to coprophagy or geophagy (Boes et al. 1997, 1998a). Findings of false-positive egg counts may therefore indicate that pigs have access to pig (or human) faeces containing eggs, and if the pigs are free-roaming, such passage of non-embryonated eggs may facilitate the spreading of the eggs within the local environment.

The distribution of eggs of *T. suis*, *A. suum*, the strongyles and the spiruroids within the pig population of the present study was moderately to highly aggregated, meaning that a few pigs excreted many parasite eggs, while the majority of the pigs excreted no or few parasite eggs. This has been described in many other studies with both experimentally and naturally infected pigs (e.g. Boes et al. 1998b, 2000) and may be explained partly by variation in exposure and partly by host genetics (Nejsum et al. 2009). Locating the high egg excreters before treating would be a part of an optimal control strategy; however, this is hardly applicable in a rural setting in a low income country: Even in industrialized countries, this is hardly feasible due to low prizes of drugs compared to veterinary services.

The finding of high prevalences and moderate worm burdens shows that there is a need for control of gastrointestinal nematodes. The control measures should integrate improved hygiene and better nutrition with anthelmintic treatments. This will result in healthier and faster growing pigs and thereby increase the income for the pig farmer. In Kabale District, the pig farmers have come a long way already if they keep the pigs confined at all times. Recommendations to smallholder farmers could be to keep the pigs confined in pens with wooden slatted floors elevated above the ground since it significant lowers the level of infection with regard to strongyles and to spiruroids, when combined with treatment. A caveat is that poorly constructed or maintained elevated pens may lead to animal welfare problems. Of course a proper cleaning of the pens is also a prerequisite for obtaining lower infections levels and avoiding reinfection. Confinement of pigs has the added benefit of keeping pigs from eating human faeces and thereby limiting the transmission of cysticercosis (Lekule and Kyvsgaard 2003). Regular deworming has been shown to result in higher weight gain (Kumaresan et al. 2009) but treatment cannot stand alone when it comes to controling worms. The feed used in Uganda resembles what smallholder farmers feed their pigs in Kenya (Kagira et al. 2010) and in other parts of the world like India (Kumaresan et al. 2009) and Vietnam (Lemke and Zarate 2008). Simulations with a more optimal composition of amino acids in the feed using more green feed (Lekule and Kyvsgaard 2003) and experimental addition of minerals (Kagira et al. 2010) gave positive results. By exploiting locally available resources better, faster and higher weight gain of pigs might be reached.

Our study clearly showed that gastrointestinal nematodes are common in pigs in the tropical highland area of Uganda and that there is a lack of knowledge of cost-efficient control. Since pig production is becoming increasingly important for the livelihood of smallholder farmers in Uganda and other low income countries, information and education on appropriate and sustainable management is urgently needed to improve the pig production in the future.

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