Trop Anim Health Prod (2012) 44:657–664
DOI 10.1007/s11250-011-9951-9

ORIGINAL RESEARCH

Risk factors associated with occurrence of nematodes in free range pigs in Busia District, Kenya

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Accepted: 2 August 2011 / Published online: 11 August 2011

Abstract Nematode infections are a serious constraint to pig production, especially where free range pig keeping is practiced. This study investigated the epidemiology of nematodes in free range pigs in Busia District, Kenya. Three hundred and six pigs from 135 farms were sampled for faeces that were analysed for nematode eggs per gram (EPG) of faeces using the McMaster technique. The nematode eggs were also identified to genus and species based on morphology. A questionnaire on risk factors was also administered to the pig owners. The overall prevalence and mean nematode EPG were 84.2% and 2,355, respectively. The nematode eggs were identified as those belonging to *Oesophagostomum* spp. (75%), *Strongyloides ransomi* (37%), *Ascaris suum* (18%), *Metastrongylus* spp. (11%), *Trichuris suis* (7%) and *Physocephalus sexalatus* (3%). The prevalence of nematodes was positively correlated ($p<0.05$) with the amount of rainfall in the division of the pigs' origin (all nematodes except *S. ransomi*). The prevalence of nematodes was also associated with the age of the pigs. A lower burden of nematodes was associated ($p<0.05$) with a history of deworming (*A. suum*) and the provision of night housing (*S. ransomi* and *Metastrongylus* spp.). In conclusion, this study has provided information on nematode infections and the associated risk factors for free range pigs in Busia District, which can be used when implementing integrated control measures.

Keywords Associations · Kenya · Pigs · Nematodes · Risk factors

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Introduction

Free range pig production has gained importance in parts of Kenya due to its requirements for low inputs and space and is an important income generating activity amongst the resource-poor farmers (Kagira et al. 2010). However, pig farming in free range and semi-intensive production systems is faced with several constraints, chief among them being parasitic diseases (Nissen et al. 2011; Marufu et al. 2008). The occurrence of parasites in pigs and other livestock has been associated with several risk factors that can be categorised as parasite (epidemiology of different species), host (resistance, age, sex) and environment related factors (climate, stocking density and management) (Tamboura et al. 2006; Roepstorff and Nansen 1994). Environmental factors are bound to significantly affect nematodosis in free range pigs as is the case in grazing ruminants, and the importance of these parasites may vary between geographical locations depending on the prevailing local climatic conditions. The host-related characteristics have been associated with the occurrence of porcine parasites, where some groups of pigs have higher burdens of parasites than others (Tamboura et al. 2006; Kagira et al. 2008). Such associations are mainly due to interactions between the parasites and the immune system of the host.

The determination of the association between risk factors and the occurrence of parasites in the host is important not only in understanding the epidemiology but also in devising effective control strategies for the parasites. Most of the current known associations between occurrence of nematodes and risk factors are based on studies in pigs kept indoors. The current study examined the association between host, environmental and husbandry factors and the prevalence and intensity of nematode infections in free range pigs on smallholder farms in Busia District, Kenya.

Materials and methods

Study area

The study was conducted in Busia District, which is situated in the Western Province of Kenya. The district is located approximately 500 km from Nairobi and lies between latitudes 0°136′ and 0° North of the equator and longitude 33°54′ and 34°25′ East of Greenwich meridian. The district covers an area of 1,261.3 km^2 and is made up of six administrative divisions, which are Budalangi, Funyula, Matayos, Township, Nambale and Butula. It lies within the Lake Victoria basin and has an altitude of 1,130–1,375 m above sea level. Most parts of the district receive mean annual rainfall of 1,270–1,790 mm, which is bimodal and generally decreases from north to south. The temperature in the district ranges between 14 and 30°C.

The most recent census (GoK 2010) puts the total human population in the district at 488,075, most of whom were smallholder farmers. The district is one of the poorest in Kenya with high absolute poverty levels and majority of the population earns less than a 1 US dollar per day (GoK 2010). The livestock population was estimated at 102,377 cattle, 22,449 sheep, 46,317 goats and 31,585 pigs (GoK 2010).

Study farms

The cross-sectional study was undertaken between April and May 2007 on pig farms selected from the six administrative divisions of the district. The study farms were selected with the assistance of field extension officers from the Ministry of Livestock and Fisheries Development. Administrative officers in charge of the sub-locations were also involved, especially in offering logistics. The sampling unit of interest was individual smallholder pig farms and all the pig farms in the area were regarded as being smallholder with herd sizes of less than 10 pigs. Two administrative villages per division were purposively selected based on the presence of a high number of pigs. Since no recent census of livestock has been undertaken in the district, the study relied on advice from the veterinary officers in charge of divisions to indicate villages having at least 10 pig farmers. At village level, households with pigs were established using the "snowballing and sampling to redundancy methods" that have been used previously in studies on *Taenia solium* cysticercosis in pigs (Sikasunge et al. 2006). The village chairman identified the first few pig farmers, who helped in identifying the others until all the farmers in the village were covered. An estimation of the sample size of the pigs required for the study was done using the formula given by Martin et al. (1987). A total of 306 pigs from 135 farms in all the six divisions of the district were sampled.

Collection and analysis of faecal samples

Faecal samples were collected per rectum using plastic gloves, put into faecal pots, labelled, kept cool and transported to the laboratory for analysis. The samples were quantitatively analysed for nematode eggs per gram (EPG) using a McMaster faecal floatation technique (MAFF 1986). The samples were also cultured and nematode larvae recovered and identified as described in the MAFF (1986) manual.

Host variables and questionnaire

The host related attributes that were recorded when sampling each pig included sex and age categories. Samples were obtained from piglets (23), growers (135), finishers (53), sows (84) and boars (11). It was very common to find piglets aged 2 months or more that were still suckling but grazing at the same time. The growers were those pigs that were already weaned but less than 16 weeks (4 months) old. The finishers were pigs aged between 4 and 10 months. Sows were regarded as the breeding females that were either pregnant or had previously farrowed. The very few boars (11) were excluded from the statistical analysis on the relationship between occurrence of parasites and age categories of pigs.

A structured questionnaire regarding the husbandry and management practices was administered to the farmers. The farmers were questioned on history of anthelmintic usage, anthelmintics used and provision of housing. Data on the rainfall amount for April 2007 was also collected from the divisions where it was available, which were Budalangi (125 mm), Funyula (197 mm) and Township (223 mm).

Data management and analysis

Data was entered into Ms Excel spreadsheets before being exported to the Statview® statistical package for analysis. Associations between the categorical variables (sex, age, divisions, deworming history, anthelmintic used and housing) and continuous variables (prevalence, nematode EPG (log transformed)) were examined by one-way analysis of variance (ANOVA). Associations between the categorical variables and the prevalence of parasites were examined using chi-square (χ^2) statistic. Pearson correlations (r) were calculated between the amount of rainfall and the measures of parasite burdens. A multivariate logistic regression using a backward stepwise analysis was subsequently undertaken on the significant factors. The significance of association between factors was considered at $p<0.05$. The strength of association between independent and dependent variables was estimated by odds ratios (OR) that were directly derived from the estimates of logistic regression.

Results

The prevalence of various nematodes in the sampled pigs and study farms based on identification of eggs in faecal samples is shown in Table 1. The nematode eggs identified included those of *Oesophagostomum* spp., *Strongyloides ransomi* and *Ascaris suum*. Only 3% of the pigs shed eggs of *Fasciola* spp.

The percentage of farms with pigs infected with any of the nematodes (single or mixed species) was 89.6%. There was a positive correlation between the prevalence of *Oesophagostomum* spp., *A. suum*, *Trichuris suis* and *S. ransomi* at animal level. However, this correlation was only significant when the prevalence of *Oesophagostomum* spp. was compared with that of *S. ransomi* (r^2=0.58, $p<0.001$).

Table 1 The prevalence of various nematodes in 306 free range pigs sampled on 135 farms in Busia District, Kenya, based on identification of eggs in faecal samples

Nematode	Prevalence (%) of infected pigs	Prevalence (%) of infected[a] farms
All nematodes	84.2	89.6
Oesophagostomum spp.	74.8	84.4
Strongyloides ransomi	36.6	56.3
Ascaris suum	17.6	30.4
Metastrongylus spp.	9.8	18.5
Trichuris suis	6.5	14.1
Physocephalus sexalatus	3.6	5.2

[a] At least one pig on a farm with an infection

The overall mean EPG of all (one or mixed species) nematodes was 2,355 and ranged from 0 to 35,000 EPG in individual pigs. The highest mean EPG was that for *Oesophagostomum* spp. (mean=1,060, range=0–22,800) followed by *S. ransomi* (840, 0–26,600) and *A. suum* (345, 0–15,200). The lowest mean and range of EPG was for *Physocephalus sexalatus* (16, 0–1,200) followed by *Metastrongylus* spp. (39, 0–2,000) and *T. suis* (57, 0–4400). The percentage distribution of numbers of EPG in the study pigs is shown in Table 2. Fifty-two percent (52%) of pigs were excreting nematode eggs (single or mixed species) at less than 1,000 EPG. However, 10% of the pigs were found to be excreting more than 5,000 nematode eggs.

Thirty-four percent (34%) of the pigs had monospecific infections with *Oesophagostomum* spp. It was only in a few animals (7.5%) that monospecific infections of *S. ransomi*, *A. suum* or *P. sexalatus* were observed. Of the multiple nematode infections (58%) observed, the highest combination was that of *Oesophagostomum* spp. and *S. ransomi* (16.7%). Only 2 pigs were infected with five types of nematodes, and none were infected with all types of nematodes.

The relationship between the mean EPG of the nematodes and management factors is shown in Table 3. The mean EPG for *A. suum* was significantly ($p<0.05$) associated with deworming, being lower on farms with a history of deworming. Piperazine and levamisole were the anthelmintics used previously by farmers but the use of either drug was not significantly ($p>0.05$) associated with mean EPGs for any of the nematodes. The mean EPGs for *S. ransomi*, *Metastrongylus* spp., and total nematodes were significantly lower ($p<0.05$) in pigs from farms where housing was provided than those from farms where housing was not provided. The prevalence of any of the nematodes was not significantly ($p>0.05$) associated with any of the other management practice studied.

The relationship between the prevalence of various genera of nematodes and division of origin of the pigs is shown in Table 4. Among the divisions, there were significant ($p<0.05$) differences in the prevalence of pigs infected with mixed nematodes, *Oesophagostomum* spp., *T. suis* and *P. sexalatus*. The mean EPG of *Oesophagostomum* spp. and *T. suis* varied significantly across the divisions being highest in Matayos and lowest in Budalangi Division.

The relationship between the rainfall and prevalence of the nematodes is shown in Fig. 1. There was a positive correlation between the amount of rainfall in a given division and prevalence of *Oesophagostomum* spp. (r= 0.99, $p<0.05$), *A. suum* (r=0.98, $p<0.05$), *Metastrongylus* spp. (r=0.58, $p<0.05$) and *P. sexalatus* (r=0.71, $p<0.05$). However, there was negative correlation between the amount of rainfall and prevalence of *S. ransomi* (r= −0.448, $p<0.05$). The mean EPGs for *Oesophagostomum*

Table 2 The distribution (number and proportion) of 306 free range pigs sampled in Busia District, Kenya that had various levels of nematode infections based on eggs per gram of faeces (EPG)

Range of EPG counts	Number of pigs infected with a given nematode (proportion)					
	All nematode	*Oesophagostomum* spp	*Strongyloides ransomi*	*Ascaris suum*	*Trichuris suis*	*Metastrongylus* spp.
<200	48 (16%)	77 (25%)	193 (63%)	252 (82%)	286 (94%)	275 (89%)
200–900	103 (34%)	95 (31%)	74 (24%)	38 (12%)	16 (5%)	27 (9%)
1,000–1,900	64 (21%)	70 (23%)	13 (4%)	4 (1%)	2 (1%)	2 (1%)
2,000–2,900	31 (10%)	22 (7%)	3 (1%)	5 (2%)	0 (0%)	1 (<1%)
3,000–3,900	8(3%)	8 (3%)	5 (2%)	1 (<1%)	0 (0%)	0 (%)
4,000–4,900	15 (5%)	8 (3%)	4 (1%)	0 (0%)	2 (1%)	0 (0%)
5,000 and more	30 (10%)	6 (2%)	13 (4%)	1 (<1%)	2 (1%)	0 (0%)

spp., *Metastrongylus* spp. and *P. sexalatus* were also significantly correlated ($r>0.80$, $p<0.05$) with the abundance of rainfall.

The relationship between the occurrence of nematode infections and either sex or age of the pigs is shown in Table 5. The prevalence of total nematodes and *P. sexalatus* were significantly ($p<0.05$) higher in male than female pigs. The mean EPG *S. ransomi* were significantly ($p<0.05$) higher in males than female pigs. All the other relationships were not significant ($p>0.05$). The prevalences of *Oesophagostomum* spp. and *T. suis* were highest in sows and finishers/growers, respectively, while the prevalence of the rest of the nematodes was highest in piglets. The differences attributable to the age of the pigs that were statistically significant ($p<0.05$) were those for the prevalences of *S. ransomi*, *P. sexalatus* and *Metastrongylus* spp. infections. The mean EPG of any nematode (single or mixed species), *S. ransomi* and *Metastrongylus* spp. differed significantly ($p<0.05$) in pigs of different ages.

Table 6 shows the multivariate association between variables (division, host and farm) and the prevalence of nematodes. Division of origin was the only variable that was significantly associated with prevalence of *Oesophagostomum* spp. Thus, pigs originating from Nambale, Township, Matayos, Butula and Funyula divisions were 26.8, 18.7, 12.3, 9.9, and 4.9 times more likely to have an *Oesophagostomum* spp. infection than those from Budalang'i Division.

For *Metastrongylus* spp., age category was the only statistically significant ($p<0.05$) variable associated with the prevalence of the nematode. Thus, piglets were 3.2 times more likely to have *Metastrongylus* spp. compared to adults, while growers were approximately 2 times less likely to have *Metastrongylus* spp. compared to adults.

For *S. ransomi*, age was the only significant ($p<0.05$) variable associated with the prevalence of the nematode. Thus, growers and piglets were 38 and 7 times, respectively, more likely to have an *S. ransomi* infection than adult pigs.

Discussion

The current study documents the occurrence of nematode parasites in free range pigs in Busia District and their relationship with host and environmental factors. The recorded occurrence of the six nematode species was higher than that reported in indoor kept pigs in Kenya (Kagira et al. 2008) and Scandinavian countries (Haugegaard 2010) but was close to that reported in semi-intensively kept pigs

Table 3 The relationship between mean nematode eggs per gram of faeces (EPG) for various genera of parasites and management factors for 306 pigs sampled in Busia District Kenya

Parasites	Deworming history		Drugs used		Housing	
	Yes	No	Levamisole	Piperazine	Provided	Not provided
All nematodes	2,248	2,612	1,975	1,950	772	1,229
Oesophagostomum spp.	995	1,173	937	1,667	251	424
Ascaris suum	198	624	249	57	28	31
Trichuris suis	62	55	25	29	372	1,011
Strongyloides ransomi	924	712	697	104	23	69
Metastrongylus spp.	38	41	41	0	22	13
Physocephalus sexalatus	20.3	7	25	0	1,528	2,730

Table 4 The relationship between the prevalence of various genera of nematodes and division of origin of 306 pigs sampled in Busia District, Kenya

Division	Prevalence (%) of nematodes						
	All nematodes[a]	*Oesophagostomum* spp.	*Strongyloides ransomi*	*Ascaris suum*	*Metastrongylus* spp.	*Trichuris suis*	*Physocephalus sexalatus*
Nambale	92.4	89.4	39.4	16.7	6.1	10.6	6.1
Matayos	91.8	86.5	37.8	23	8.1	2.7	0
Township	89.3	78.9	38.6	21.1	21.1	7	12.3
Butula	77.5	75	27.5	7.5	5	2.5	0
Funyula	74.4	61.5	33.3	17.9	7.7	15.4	0
Budalang'i	60	23.3	40	13.3	10	0	0
All divisions	84.2	74.8	36.6	17.6	9.8	6.5	3.6

[a] Single or mixed species of nematodes

in Uganda (Nissen et al. 2011). This can be attributed to the higher risk of parasite infection in pigs kept under the traditional system where animals are often kept tethered or allowed to scavenge for feed in environments that may be contaminated with parasite eggs and larva. Further, there is minimal control of worms by farmers keeping pigs under free range and semi-intensive production systems (Nissen et al. 2011; Kagira et al. 2010). Levamisole and piperazine were the most widely used anthelmintics in the study but as reported previously the drugs were used irregularly (Kagira et al. 2010). A study should be carried out to determine the most effective deworming regime for the free range pigs in the study area.

The observation that *Oesophagostomum* spp. was the most common nematode parasite in the pigs was similar to that reported in indoor kept pigs in Kenya (Kagira et al. 2001), and outdoor and semi-intensively kept pigs in other African countries (Marufu et al. 2008; Nissen et al. 2011). The prevalence of *Oesophagostomum* spp. in the current study was high despite the low stocking rate on most farms. The infective L_3 stages of *Oesophagostomum* spp. may survive in the environment for prolonged periods, thus exposing outdoor kept pigs to continuous infection (Roepstorff and Nansen 1994). The pigs in the current study were also tethered, often in one spot for prolonged periods, which may have made them graze and root the

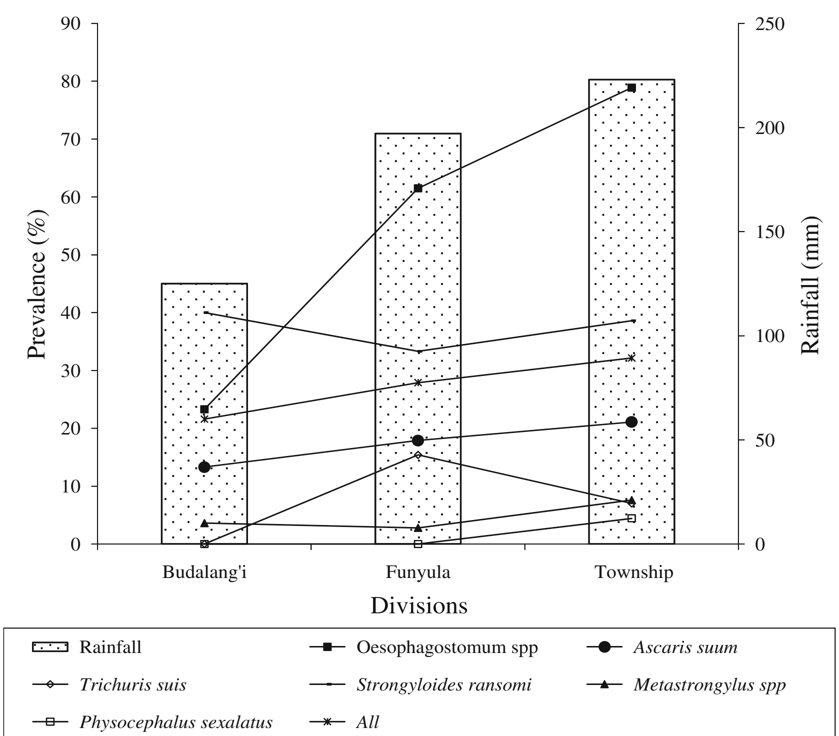

Fig. 1 The relationship between prevalence of various genera of nematodes in 306 pigs sampled in Busia District, Kenya and the amount of rainfall received (April 2007) in the division of the pigs' origin

Table 5 The relationship between prevalence or mean nematode eggs per gram of faeces (EPG) for various genera of nematodes in 306 pigs sampled in Busia District, Kenya and the age and sex of the pigs

Parasite	Variable	Age				Sex	
		Piglets	Growers	Finishers	Sows	Male	Female
All nematodes	Mean prevalence (%)	91.3	86.5	81	79.2	90.7	81.2
	Mean EPG	6,078	2,510	1,407	2,060	2,694	2,208
Oesophagostomum spp.	Mean prevalence (%)	79.8	73.9	73.3	69.8	78	73.2
	Mean EPG	1,058	1,444	994	1,064	913	1,127
Ascaris suum	Mean prevalence (%)	21.7	17.9	17	16.3	18.6	17.2
	Mean EPG	800	248	366	339	239	394
Trichuris suis	Mean prevalence (%)	9.4	7.4	4.8	4.3	6.2	6.7
	Mean EPG	53	93	24	9	110	33
Strongyloides ransomi	Mean prevalence (%)	78.3	47.4	35.8	11.9	44.3	33
	Mean EPG	3,617	1,039	528	48	1,357	598
Metastrongylus spp.	Mean prevalence (%)	30.4	9.4	8.3	5.2	9.3	10
	Mean EPG	70	45	33	16	39	38
Physocephalus sexalatus	Mean prevalence (%)	21.7	3.7	1.9	0	7.2	1.9
	Mean EPG	139	10	4	0	35	7

heavily infested vegetation cover (Kagira et al. 2010). To avoid this problem, it would be important to encourage the farmers to rotate the tethering of pigs in different areas of pastures. Studies on the survival of *Oesophagsotomum* spp. and other parasites in soil and herbage should be carried out to determine the feasibility of a rotation scheme for the tethered pigs.

Infections with *Oesophagostomum* spp. stimulate only limited immunity, which moderately regulates the intestinal worm burdens (Roepstorff and Nansen 1994). Thus, as observed in this study, sows had the highest worm burdens and similar observations have been reported in other studies (Tamboura et al. 2006; Haugegaard 2010). Effective control strategies against this worm should be targeted towards sows since they are kept for several years on a farm (Kagira et al. 2010) and may act as source of infection for piglets.

S. ransomi was the second most prevalent nematode in this study. The prevalence in the animals was higher than that reported in indoor reared pigs in Kenya (Kagira et al. 2001). The observed differences could be due to management as well as the different age groups of pigs sampled in the two studies. In the current study, the prevalence of *S. ransomi* was highest in piglets but lowest in sows, which is similar to what has been reported in other studies (Kagira et al. 2008; Tamboura et al. 2006). This pattern seems to be closely related to the fast development of acquired

Table 6 Results of multivariate analysis showing the association between variables (division of origin and, age category of pigs) and the prevalence of *Oesophagostomum* spp., *Metastrongylus* spp. and *Strongyloides ransomi* in 306 pigs sampled in Busia District, Kenya

Variable	Levels	OR (95%CI) *Oesophagostomum* spp.	OR (95%CI) *Metastrongylus* spp.	OR (95%CI) *Strongyloides ransomi*
Division of origin	Township	12.3 (4.2–36.1)	–	–
	Butula	9.9 (0.17–30)	–	–
	Funyula	4.9 (1.6–15)	–	–
	Matayos	18.7 (6.35–55.1)	–	–
	Nambale	26.8 (8.4–85)	–	–
	Budalangi	1	–	–
Age category	Grower	–	0.51 (0.22–1.2)	38 (8.3–174.6)
	Piglet	–	3.2 (0.94–10.9)	7 (2.8–17.7)
	Adult	–	1	1

OR odd ratios in the final model, *95% CI* 95% confidence intervals resistance and possible transcolostral transmission from sow to piglets (Roepstorff and Nansen 1994). The fact that the prevalence of *S. ransomi* was highest in Budalangi Division, a relatively dry division confirms that this parasite is readily transmissible in areas with low rainfall as a result of the direct host to host transmission.

The prevalence of *A. suum* reported in this study was higher than that reported in indoor reared pigs in Kenya (Kagira et al. 2001) but was lower than that reported in outdoor reared and semi-intensively kept pigs from Burkina Faso (Tamboura et al. 2006) and Uganda (Nissen et al. 2011). The differences in prevalence may be attributed to different production systems in pigs in the different studies. Further, in this study, the prevalence was higher in the wetter divisions such as Township and the prevalence and reinfection levels of *Ascaris* have been positively correlated with rainfall in other studies (Marufu et al. 2008). In the current study, the prevalence of *A. suum* was highest in piglets and lowest in growers. In other studies, the prevalence of *A. suum* has been reported as being highest in weaners and growers, but lowest in adults; this being associated with a strong acquired immunity that results in the expulsion of immature parasites from the small intestine 17–21 days postinfection (Roepstorff and Nansen 1994; Kagira et al. 2008).

This study reports the occurrence of *Metastrongylus* spp. in pigs in Kenya for the first time. Other previous studies in the country (Kagira et al. 2001; Wabacha et al. 2006) have focussed on pigs kept indoors that did not have access to the intermediate hosts of lungs worms. These lungworms have an indirect life cycle with earthworms as true intermediate hosts. Eggs in the soil and L_3 larvae within the earthworms may remain viable for several years, thus continuously exposing the free range pigs. The prevalence of *Metastrongylus* spp. reported in this study was lower than that reported in Uganda (61%) (Waiswa et al. 2007). The prevalence of *Metastrongylus* spp. was highest in pigs from Township Division that had high rainfall and lowest in Budalang'i Division, which was relatively drier. In USA, Forrester et al. (1982) reported that the prevalence of *Metastrongylus* spp. in pigs in Florida was higher during the wet compared to dry seasons. This may have been related to the favourable development of earthworms, the intermediate hosts of *Metastrongylus* spp., in an area of high rainfall (Forrester et al. 1982). In the current study, the higher prevalence and intensity of *Metastrongylus* spp. in piglets compared to other categories of pigs could be associated with the development of immunity, as this has been reported to occur elsewhere (Foata et al. 2006).

The prevalence of *T. suis* in this study was close to that reported previously in Kenya (Kagira et al. 2001) and Zimbabwe (Marufu et al. 2008) but was lower than that reported in Uganda (17%) (Nissen et al. 2011). The age pattern of infection whereby growers and finishers had the highest levels of infection has been reported previously in indoor reared pigs in Kenya (Kagira et al. 2008) and is probably related to the development of immunity in adult animals. The prevalence of *P. sexalatus* in this study was lower than that reported in Ghana (17%) by Permin et al. (1999). The prevalence of *P. sexalatus* was highest in Township Division, which as observed above, has a high rainfall that can lead to an abundance of coprophagous beetles, the intermediate host of this parasite (Roepstorff and Nansen 1994). In this study, the parasite was significantly more common in male animals than females, while piglets had a relatively higher prevalence and intensity compared to other age categories of pigs. This may be indicative of an age-related occurrence, not previously reported in literature.

In the current study, 3% of the pigs were found to shed *Fasciola* spp. eggs. A prevalence of this trematode ranging from 1 to 6% has been reported in other countries (Boes et al. 2000; Capucchio et al. 2009). Fasciolosis is highly endemic in cattle in Busia District, with one study reporting a prevalence of 22% (Karanja 2005) and thus free ranging pigs could also be exposed to the infection. The McMaster technique used in the current study has a low sensitivity for detecting trematode eggs and future studies should use either a sedimentation method or a more appropriate floatation method for the detection of trematode eggs.

The present study demonstrated that a substantial proportion of sampled pigs had monospecific infections with *Oesophagostomum* spp., which is similar to findings reported in earlier studies (Marufu et al. 2008; Kagira et al. 2001). The highest association of concurrence of nematodes in indoor pigs has previously been found between *Oesophagostomum* spp. and *A. suum* (Kagira et al. 2001), which differs from the observations in the current study where concurrent infections of *Oesophagostomum* spp. and *S. ransomi* were most common. Apart from *Oesophagostomum* spp., the distribution of other nematodes probably followed a negative binomial distribution since they were only parasitizing a few hosts. Such observations have previously been made for a number of nematodes in pigs such as *A. suum*, *H. rubidus*, *M. apri*, *P. sexalatus* and *T. suis* (Boes et al. 2000; Nejsum et al. 2009). The major factors thought to contribute to this distribution include heterogeneity in the host behaviour and the development of immunity to specific parasitic infection (Boes et al. 2000; Nejsum et al. 2009).

In conclusion, this study has shown that free range pigs in Busia District have a high prevalence of nematodes and their occurrence was mainly associated with host (age and sex) and division of origin of the pigs. These factors should be taken into consideration when implementing control strategies for pig nematodes in this study area.

Acknowledgements The study was funded by World Bank through the Kenya Agricultural Productivity Program (KAPP). The authors are grateful for the cooperation given by participating farmers and extension officers in Busia District, Kenya. The assistance provided by the technical staff at KARI-TRC is highly appreciated.

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