

Full Length Research Paper

Animal health constraints in dairy goats kept under smallholder farming systems in Kongwa and Mvomero Districts, Tanzania

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This study was conducted to determine animal health constraints for dairy goats kept by small-scale farmers in Kongwa and Mvomero districts, Tanzania. A total of 129 dairy goats belonging to 108 farmers were screened for gastrointestinal nematode (GIN) infection, coccidiosis, haemoparasites, brucellosis and contagious caprine pleuropneumonia (CCPP) over a period of 11 months. Other clinical diseases and mortalities were recorded. The goats used were Norwegian crosses and Toggenburg crosses. The mean prevalence of GIN infection and coccidiosis in all goats were 54.8 and 57.4%, respectively. Prevalence of GIN infection was higher ($P \leq 0.05$) during the rainy months than in the dry months, but the prevalence of coccidiosis did not differ ($P > 0.05$) between the dry and rainy seasons. The EPG in goats did not differ ($P > 0.05$) between Kongwa (169.79 ± 0.03 EPG) and Mvomero (171.51 ± 0.04 EPG) districts, but the OPG differed significantly ($P \leq 0.05$) with values of 793.15 ± 0.04 (Kongwa) and 364.02 ± 0.05 (Mvomero). The prevalence of CCPP in the goats was 26.4%. Other clinical diseases included respiratory diseases, infectious keratoconjunctivitis and orf (scabby lesions around mouth and nostrils). Both tests for haemoparasites and brucellosis indicated negative results for all goats tested. Mortality rate during the study period was 15.5% and the major causes of deaths were respiratory diseases, bloat and food poisoning. In conclusion, gastrointestinal nematodes are prevalent in both districts, but the burdens are relatively low to justify mass treatment. The Norwegian goats are more susceptible to GIN infection and coccidiosis compared to Toggenburg goats.

Key Words: Coccidiosis, diseases, gastrointestinal nematodes, mortality, Norwegian goats, Toggenburg goats.

INTRODUCTION

In Tanzania, promotion of small-scale dairy goat production for poverty alleviation and combating malnutrition

malnutrition started in early 1980s. Since then the number of dairy goats in the country has increased mainly

through the goat-in-trust schemes promoted by non-governmental organisations (NGOs), church organisations and research institutions/Universities. At the moment, the number of dairy goats in the country is estimated at 419,533 (United Republic of Tanzania (URT), 2012) and are predominantly kept by smallholder farmers in rural areas, especially women. The common dairy goat breeds include Toggenburg, Saanen, Norwegian, Anglo-Nubian and Alpine (Ministry of Livestock Development (MLD), 2006). The introduction of dairy goats in rural areas has provided an alternative source of milk to poor households, which cannot afford keeping dairy cattle.

Dairy goat production under smallholder production system is constrained by many factors, including poor husbandry practices, inadequate nutrition and disease challenges. The most common diseases affecting small ruminants in different parts of Tanzania are gastrointestinal parasitism, respiratory infections (especially pneumonic pasteurellosis and contagious caprine pleuropneumonia (CCPP)) and contagious ecthyma (Mtenga and Kusiluka, 1997; Kusiluka, 2002; Magona and Musisi, 2002). Some vector-borne diseases such as Rift valley fever (RVF) and bluetongue are associated with epidemic episodes (Sindato et al., 2011; Swai and Schoonman, 2009).

Gastrointestinal nematode (GIN) infection in small ruminants is of considerable significance in a wide range of agro-climatic zones and affects production through losses resulting from mortalities, reduced weight gain, milk yield and reproduction efficiency (Fabiya, 1987; Bekele et al., 1992; Singla, 1995). The effects of GIN on production depend mostly upon the age of the animals, breed, parasite species involved and the worm burden in the affected animal (Wadhwa et al., 2011). Gastrointestinal nematode infection is the most serious health challenge that limits goat production, especially in rural areas of developing countries (Kusiluka and Kambarage, 1996; Githiori et al., 2006). This is mainly because most developing countries located in the warm tropical zone, which has favourable climate for the survival and development of GINs, have poor management practices and inadequate animal health control programmes (Akhtar et al., 2000). The impact of GINs is manifested by morbidity, mortality, cost of treatment and control measures against the syndrome (Mahusoon et al., 2004; Nwosu et al., 2007). However, most of the economic losses caused by GINs are mainly due to production losses rather than mortality (Waller, 2004) because the more prevalent subclinical infections cause sub-optimal productivity and insidious losses with negative impact on long-term animal productivity. Most cases of GINs infection rarely get veterinary attention due to their chronic and insidious nature (Sanyal, 1998; Dimander et al., 2000) and clinical signs may be evident only during terminal stages (Valentine

et al., 2007).

Another important disease is coccidiosis, caused by different species of *Eimeria*. This is the most common form of coccidial infections in small ruminants, often occurring concurrently with GINs (Kusiluka, 1995; Kambarage et al., 1996; Kusiluka et al., 1998). Clinical coccidiosis is less common under traditional smallholder production system, except where poor hygiene leads to gross contamination of the environment that favours the build up of heavy oocyst burdens. This precipitates a clinical disease in young and animals with concurrent infections (Assoku, 1981; Barger et al., 1994). Most species of *Eimeria* affecting small ruminants have limited pathogenicity, however, in the presence of pathogenic GINs, their additive parasitic effect may lead to a clinical disease. The environmental factors that favour the establishment, survival and development of GINs and coccidiosis are very similar and quite often animals have mixed infections (Kusiluka, 1995), making it difficult to quantify the pathogenic effects of the individual parasite. Because of this, it is often advisable to study the epidemiology of both groups of parasites concurrently.

Contagious Caprine pleuropneumonia is another important disease affecting goats in Tanzania. The disease has been suspected to be in the country since early 1980s and was confirmed by isolation of *Mycoplasma capri pneumoniae* by Msami et al. (1998) and then Kusiluka et al. (2007). Hence, the disease has been in the country for over three decades and probably a longer time. Symptoms such as high fever, anorexia, laboured breathing, productive coughing, purulent nasal mucous emanating from the nose and reluctance to walk are considered as being indicative of CCPP and the predisposing factors include animal contact when sharing water and pasture (Swai and Neselle, 2010). Brucellosis is a disease with important effects on both public health and animal health. In goats, it is mainly caused by *Brucella melitensis*. The organisms persist in the genital system of the males and the disease is transmitted to the females at the time of service. The disease is of economic importance because it causes loss of milk production and abortion. The disease is characterized by abortion after third month of gestation and birth of weak kids.

In order to develop sustainable strategies for control of small ruminant diseases, there is a need to determine the most important diseases affecting the animals in different areas. This can be achieved by undertaking longitudinal studies to determine the spatial and temporal patterns of diseases of socio-economic importance with the aim of identifying appropriate intervention strategies. The present study was intended to establish the diseases of socio-economic importance in Toggenburg and Norwegian crossbred dairy goats kept under smallholder farming systems in Kongwa and Mvomero districts of

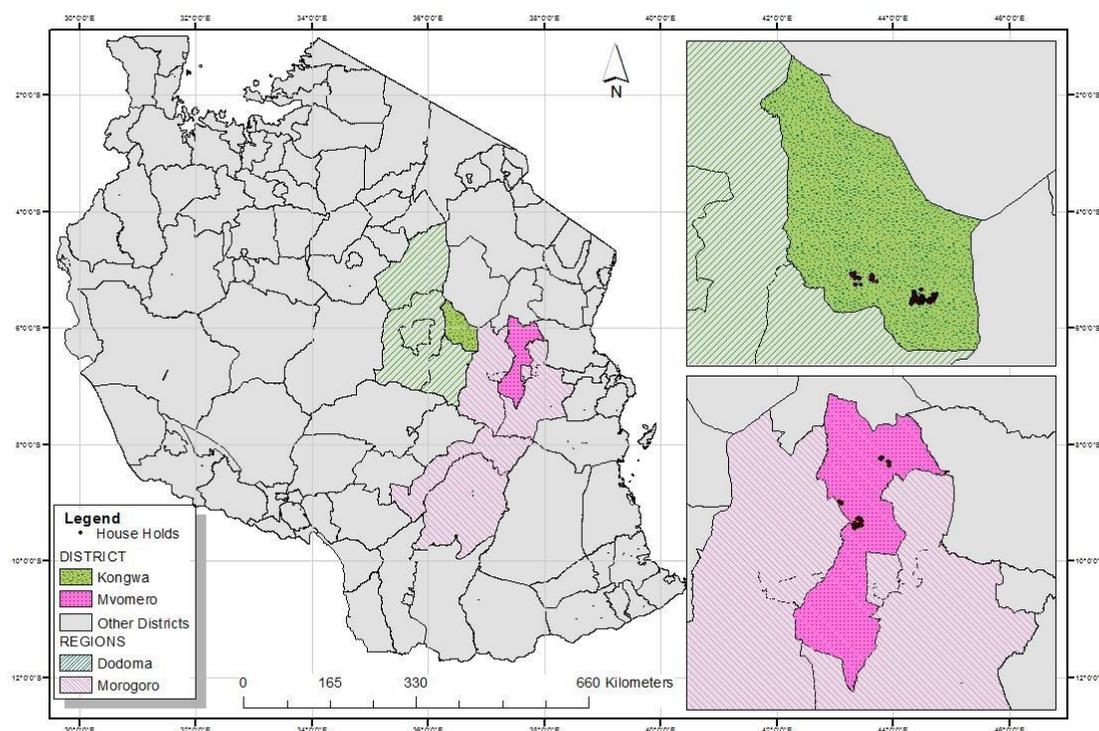


Figure 1. Map of Tanzania showing the study areas in Kongwa and Mvomero districts.

Tanzania. Toggenburg and Norwegian goats are the predominant dairy breeds in Tanzania. The animals were introduced in the rural areas of the two districts in order to improve human food and nutritional security and income of the resource-poor families. More specifically, the study was undertaken to: (i) determine the causes of mortality of dairy goats in semi-arid and sub-humid environments; (ii) determine seasonal patterns of nematode and eimeria infections and, (iii) compare the tolerance to common diseases between Toggenburg and Norwegian crossbred dairy goats introduced in the study areas. The epidemiological data gathered through the study could form the basis of designing disease control strategies in the study areas.

MATERIALS AND METHODS

Description of the study areas

The present study was conducted in Masinyeti and Ihanda villages of Kongwa district located in northeast of Dodoma region and Kunke and Wami-Luhindo villages of Mvomero district located in the north-eastern part of Morogoro region (Figure 1). Kongwa district is located in the semi-arid area and has an altitude ranging from 900 to 1000 m above sea level (asl), mean annual temperature of 26.5°C and rainfall of 400 to 800 mm per annum. Mvomero is

located in the sub-humid tropical zone at an altitude of 600 to 2000 m asl, has temperatures that range from 18 to 30°C and receives annual rainfall of 600 to 2000 mm. Crosses of Toggenburg with the Small East African (SEA) goats were obtained from Babati district, Manyara region in northern Tanzania, which has a drier climate while the crosses of Norwegian goats with the SEA goats were obtained from Mgeta division, which is located on the slopes of the Uluguru Mountains in Morogoro region and has a cool mountain climate. The two types of crossbred goats were introduced in the study areas in order to improve food and nutritional security status of the communities.

Experimental animals

A total of 72 Norwegian (65 females; 7 males) and 57 Toggenburg (52 female; 5 males) crossbred goats were distributed between March and April, 2012 to 108 small-scale farmers willing to participate in the project in the four project villages (Table 1). In each village, half of the farmers received Norwegian crosses and the remaining farmers received Toggenburg crosses. For both breeds, the proportion of dairy goat blood was 75% while that of SEA goats was 25%. Before distribution to the project farmers, all animals were ear-tagged for identification and screened to know their health status with regard to GINs and coccidia burdens. Before the beginning of data collection, all goats were treated with an anthelmintic drug (Ivomec®) to control endoparasites and sprayed with acaricides to control ectoparasites. In both breeds, the animals were classified as young if they were below one year and adult if they were above one year of age.

Table 1. Number of dairy crossbred goats distributed to farmers in the study areas.

District	Village	Breed	Does	Bucks	Total
Kongwa	Ihanda	Norwegian	19	3	22
		Toggenburg	16	1	17
	Masinyeti	Norwegian	15	1	16
		Toggenburg	15	2	17
Mvomero	Kunke	Norwegian	16	2	18
		Toggenburg	16	1	17
	Wami	Norwegian	15	1	16
		Toggenburg	5	1	6
Total			117	12	129

Screening for gastrointestinal nematode eggs and coccidia oocysts

Screening of goats for GINs, coccidiosis and haemoparasites and general health monitoring of the animals was done from June, 2012 to April, 2013. During this period, field visits were made every month to the study areas and faecal samples were collected from rectum of each animal. Each faecal sample was placed in a separate polythene bag and then all samples were packed and stored in a cool box and transported within 24 h to the laboratory at Sokoine University of Agriculture (SUA) where they were stored at 4°C until when analysis was done. The presence of gastrointestinal nematode eggs and coccidia oocysts in faeces were determined using the McMaster counting technique using saturated salt solution with specific gravity of 1.200 as the floating medium (Hansen and Perry, 1994). The number of eggs and oocysts counted in the McMaster slide was multiplied by 100 and expressed as nematode eggs per gram of faeces (EPG) and oocysts per gram of faeces (OPG), respectively. The nematode egg load of each animal was graded as low (≤ 500 EPG), medium (500 to 1,000 EPG) and high ($> 1,000$ EPG). Similarly, the oocyst burdens were graded as low ($\leq 50,000$ OPG), medium (50,000 to 100,000 OPG) and high ($> 100,000$ OPG) according to Soulsby (1982). Animals with medium to high rate of infections were treated. For each village, faecal samples from all positive samples were pooled and cultured. Nematode larvae were harvested using sedimentation technique and species of the nematodes were identified using standard keys (Soulsby, 1982; Uhlinger, 1991; Foreyt, 2001). For identification of *Eimeria* species, faecal samples were allowed to sporulate and species identification was performed according to Duszynski and Wilber (1997).

Other clinical diseases, conditions and symptoms observed in dairy goats kept by small-scale farmers

Blood sample for each animal was collected from jugular vein using 10 ml vacutainer tubes containing Ethylenediaminetetraacetic acid (EDTA). The blood samples were stored in a cool box containing ice during the field work and were transported to the laboratory for analysis within 24 h. A thin blood smear was prepared for each sample, air dried, fixed in methanol and stained with Giemsa. The smears were examined for the presence of parasites (Quinn et al.,

1994). The parasites of interest were *Trypanosoma*, *Babesia* and *Anaplasma*. Also packed cell volume (PCV) and haemoglobin concentration (HB) were determined as complementary tests for parasitism. Collection of blood samples was done every month concurrently with the collection of faecal samples. Blood samples for serological screening were collected in vacutainer tubes containing heparin as anticoagulant. Serum samples were screened for brucellosis using the Rose Bengal test with the *Brucella abortus* as an antigen (Alton et al., 1988; Robinson, 2003). Presence of antibodies against *Mycoplasma capricolum* subspecies *capri pneumoniae* (*M. capri pneumoniae*), the causative agent for CCPP in serum samples was screened using the *M. capri pneumoniae* Antibody Test Kit (c-ELISA kit) developed based on the method by Thiaucourt et al. (1994). Farmers reported any clinical sign of diseases in the study animals to the village extension officers who then visited the respective farmers, verified and recorded the symptoms such as diarrhoea, rough hair coat, coughing, nasal and ocular discharges and skin lesions. Deaths and their causes (if established) were also recorded as they occur by the village extension workers.

Statistical analyses

Data on EPG, OPG, PCV and HB were analysed using the General Linear Model procedures of SAS (2009) to determine the effect of location (village), season, breed, sex, age of the goats and their interactions on EPG, OPG, PCV and HB. Before conducting statistical analysis, the EPG and OPG values were logarithmically transformed using $\log_{10}(\text{EPG} + 100)$ and $\log_{10}(\text{OPG} + 100)$ to normalize the distribution. No transformation was done for HB and PCV. Data on prevalence of various diseases and mortality rate were analysed using the chi-square test to test the significance of the differences between the breeds and among the villages.

RESULTS

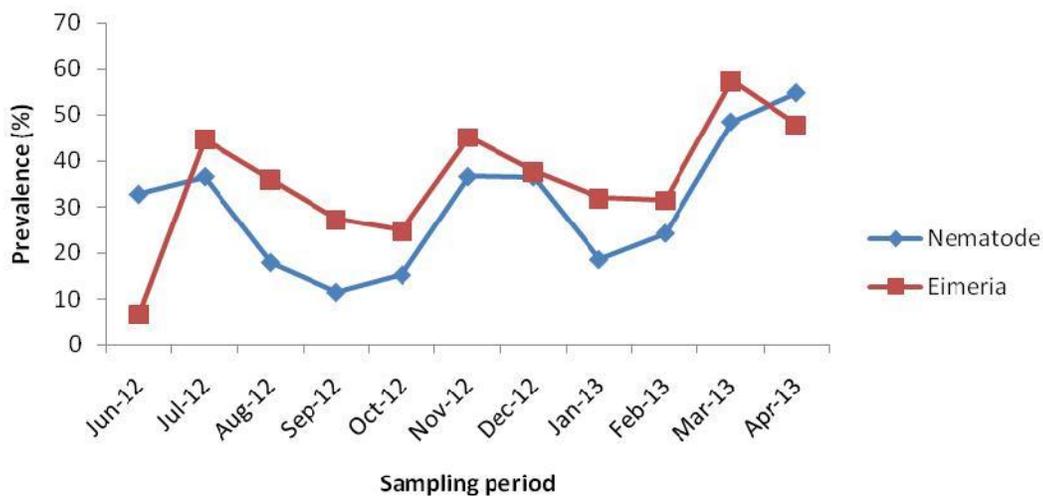
Gastrointestinal nematode and coccidia infections

Goats purchased from Babati and Mgeta were screened for nematode and *Eimeria* infections before being

Table 2. Least squares means \pm SE for EPG, OPG, HB and PCV of Toggenburg and Norwegian crosses before being transported to the study villages.

Factor	Parameter	Variable			
		EPG	OPG	HB (g/dl)	PCV (%)
Breed	Toggenburg	465.41 ^d \pm 0.07	5561.78 ^a \pm 0.1057	9.22 ^a \pm 0.38	27.87 ^a \pm 1.15
	Norwegian	792.35 ^a \pm 0.06	722.62 ^b \pm 0.089	7.91 ^b \pm 0.36	23.67 ^b \pm 1.08
	P-value	0.0008	0.0480	0.0008	0.0004
Age group	Adult	501.50 \pm 0.09	1172.47 ^b \pm 0.13	8.54 \pm 0.36	25.80 \pm 1.07
	Young	756.26 \pm 0.11	5111.93 ^a \pm 0.15	8.59 \pm 0.42	25.74 \pm 1.27
	P-value	0.6822	0.0361	0.9120	0.9640
Sex	Female	281.61 \pm 0.06	2985.62 \pm 0.08	8.76 \pm 0.23	26.48 \pm 0.70
	Male	976.16 \pm 0.16	3298.79 \pm 0.23	8.38 \pm 0.63	25.07 \pm 1.91
	P-value	0.0820	0.2690	0.5928	0.5133

^{a,b}The means with different letters in the same column within a factor differ significantly ($P \leq 0.05$). PCV = packed cell volume; HB = haemoglobin concentration; EPG = nematode eggs per gram of faeces; OPG = *Eimeria* oocysts per gram of faeces; n = Number of animals observed; P = Probability value.

**Figure 2.** Prevalence of nematode and *Eimeria* infections in dairy goats during the experimental period in the study areas.

transported to the study sites. The prevalence of nematode and *Eimeria* infections in Toggenburg crossbred goats ($n = 57$) was 32.6 and 63.0%, respectively. In Norwegian crosses ($n = 72$), the prevalence was 54.7% for nematodes and 62.5% for *Eimeria*. Table 2 shows the effects of breed, age and sex of the animals on the nematode egg and coccidia oocyst burdens. Toggenburg crossbred goats from Babati had lower EPG ($P \leq 0.001$) and higher OPG ($P \leq 0.05$) than the Norwegian crossbreds from Mgeta. The Toggenburg crosses had higher HB ($P \leq 0.001$) and PCV ($P \leq 0.001$)

values than the Norwegian crosses. The difference between young and adult goats was not significant ($P > 0.05$) for EPG, HB and PCV, but it was significant ($P \leq 0.05$) for OPG. The values of EPG, OPG, HB and PCV did not differ significantly ($P > 0.05$) between male and female goats. However, males had slightly higher EPG and OPG and lower HB and PCV values compared to females.

The overall trend for the prevalence of GIN and *Eimeria* infections in Norwegian and Toggenburg crosses after being taken to the study areas is presented in Figure 2.

Table 3. Comparison of EPG, OPG, HB, and PCV of Norwegian and Toggenburg crossbred goats during the study period in the project villages.

Village	District	Breed	Variable			
			EPG	OPG	HB (g/dl)	PCV (%)
Ihanda	Kongwa	Norwegian	280.55 ± 0.03	707.91 ± 0.04	7.23 ± 0.48	24.73 ± 1.33
		Toggenburg	87.73 ± 0.03	655.82 ± 0.04	7.31 ± 0.48	26.31 ± 1.33
		P-value	0.1437	0.8661	0.8901	0.3278
Masinyeti	Kongwa	Norwegian	175.26 ± 0.04	878.33 ± 0.05	6.67 ± 0.59	22.14 ± 1.66
		Toggenburg	135.59 ± 0.03	930.52 ± 0.05	7.56 ± 0.49	27.45 ± 1.38
		P-value	0.8067	0.8907	0.2052	0.2711
Kunke	Mvomero	Norwegian	86.94 ± 0.03	279.22 ± 0.04	6.68 ± 0.48	24.73 ± 1.28
		Toggenburg	106.15 ± 0.03	276.60 ± 0.04	6.49 ± 0.48	24.05 ± 1.31
		P-value	0.8831	0.9932	0.7449	0.6729
Wami-Luhindo	Mvomero	Norwegian	304.37 ± 0.05	791.47 ± 0.06	7.06 ± 0.69	24.12 ^b ± 1.94
		Toggenburg	188.55 ± 0.05	108.79 ± 0.07	6.98 ± 0.80	29.04 ^a ± 2.25
		P-value	0.5332	0.1172	0.9193	0.0363

^{a,b}The means with different letters in the same column within a factor differ significantly ($P \leq 0.05$). PCV = packed cell volume; HB = haemoglobin concentration; EPG = nematode eggs per gram of faeces; OPG = *Eimeria* oocysts per gram of faeces; n = Number of animals observed; P = Probability value.

The prevalence of GIN infection in all goats was below 40% while that of *Eimeria* was below 50% for the most part of the study period. At the start of the experiment in June 2012 less than 30 and 10% of the animals were infected with nematodes and *Eimeria*, respectively. During the study period peak infections occurred in March (57% of the animals were infected) for *Eimeria* and April (55% of the animals were infected) for GINs. The levels of infection for both parasites were lower during the main dry season (July - October) and short dry spell (January - February). There was a slight increase in the levels of infections during November - December and March - April, during which the study areas experienced short rains and the main rain season, respectively.

Table 3 shows the least squares means for EPG, OPG, HB and PCV of each breed in each village during the study period. In all the villages there were no significant ($P > 0.05$) differences between the breeds for all parameters observed. However, the Norwegian crosses had slightly higher values for EPG and OPG compared to Toggenburg crosses in all villages, except Kunke for EPG and Masinyeti for OPG. On the other hand, the Norwegian crosses had slightly lower HB and PCV values in Ihanda and Masinyeti and higher values in Kunke and Wami-Luhindo villages. The effects of location (village) and breed on EPG, OPG, HB and PCV observed in goats during the study period is shown in Table 4. Location did not significantly ($P > 0.05$) influence EPG, HB and PCV,

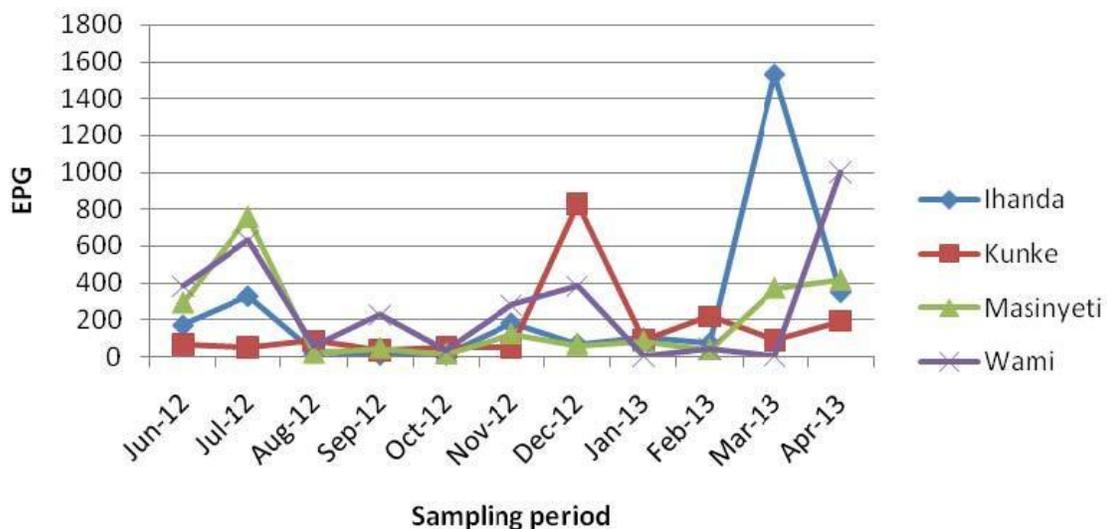
but had significant ($P \leq 0.05$) influence on OPG. Goats in Ihanda (681.86 ± 0.04) and Masinyeti (904.43 ± 0.04) had higher OPG values than those in Kunke (277.91 ± 0.03) and Wami-Luhindo (450.13 ± 0.06). With regard to EPG, goats in Wami-Luhindo (246.46 ± 0.06) had the highest value while those in Kunke had the lowest value (96.55 ± 0.02), though the differences among the villages were not statistically significant. Goats in Ihanda (7.27 ± 0.38 g/dl) had the highest HB value while those in Kunke (6.59 ± 0.36 g/dl) had the lowest. For PCV, goats in Wami-Luhindo ($26.58 \pm 1.75\%$) had the highest value while those in Kunke ($24.39 \pm 1.01\%$) had the lowest. Breed had no significant effects ($P > 0.05$) on EPG, OPG and HB, but significantly influenced ($P \leq 0.05$) PCV. The Norwegian crosses had slightly higher values for EPG (211.78 ± 0.02) and OPG (664.23 ± 0.03) than the Toggenburg crosses (129.51 ± 0.02 EPG and 492.93 ± 0.03 OPG), while the Toggenburg crosses had higher HB (7.09 ± 0.35 g/dl) and PCV ($26.71 \pm 0.99\%$) values than the Norwegian crosses. The monthly values of EPG observed in goats in the study areas are presented in Figure 3.

In all villages, the initial EPG values in June, 2012 were low but raised tremendously in July in Masinyeti and Ihanda villages. For the most part of the study period, the mean EPG was below 400. The highest mean EPG was recorded in March, 2013 in Ihanda village and April in Wami-Luhindo village. This corresponded to the rainy

Table 4. Effects of location and breed on EPG, OPG, HB and PCV of goats during the study period.

Factor	Variable				
	EPG	OPG	HB (g/dl)	PCV (%)	
Village	Ihanda	184.14 ± 0.03	681.86 ^a ± 0.04	7.27 ± 0.38	25.52 ± 1.06
	Kunke	96.55 ± 0.02	277.91 ^b ± 0.03	6.59 ± 0.36	24.39 ± 1.01
	Masinyeti	155.43 ± 0.03	904.43 ^a ± 0.04	7.12 ± 0.41	24.79 ± 1.16
	Wami-Luhindo	246.46 ± 0.06	450.13 ^{ab} ± 0.06	7.02 ± 0.62	26.58 ± 1.75
	P - value	0.6776	0.0401	0.3630	0.5706
Breed	Norwegian	211.78 ± 0.02	664.23 ± 0.03	6.91 ± 0.34	23.93 ^b ± 0.96
	Toggenburg	129.51 ± 0.02	492.93 ± 0.03	7.09 ± 0.35	26.71 ^a ± 0.99
	P - value	0.2638	0.3209	0.5856	0.0023

^{a,b}The means with different letters in the same column of the same factor differ significantly ($P \leq 0.05$). PCV = packed cell volume; HB = haemoglobin concentration; EPG = nematode eggs per gram of faeces; OPG = *Eimeria* oocysts per gram of faeces; n = Number of animals observed; P = Probability value.

**Figure 3.** Monthly burdens of EPG for goats from Ihanda, Kunke, Masinyeti and Wami-Luhindo villages

season in all the study villages (March to May). The lowest EPG values in all the villages were recorded during the driest period of the year (August to November). A slight rise in EPG values was recorded in December, 2012, a month, which is within the short rainy period. The mean monthly OPG values observed in goats in the four study villages are presented in Figure 4. The OPG values were below 500 for the most part of the study period. The peak OPG values were recorded in July, 2012 in Wami-Luhindo and Masinyeti villages. For the rest of the period, the OPG values remained below 2000, even during the rain season, except in Masinyeti village in which the OPG was about 2,500 in January, 2013.

The distribution of the GIN genera in the study villages did not differ significantly ($P > 0.05$), though there were slight variations of the dominant species in each village. In Masinyeti village the most predominant genus was *Haemonchus* (47.83%), followed by *Bunostomum* (34.78%) and *Strongyloides* (17.39%). In Ihanda village the main genera were *Bunostomum* (69.23%), *Haemonchus* (15.38%) and *Strongyloides* (15.38%) while in Wami-Luhindo village *Bunostomum*, *Haemonchus* and *Strongyloides* accounted for 66.67, 16.67 and 16.67%, respectively. In Kunke village *Bunostomum* (60%) was the most predominant genus, followed by *Haemonchus* (20%) and *Strongyloides* (20%).

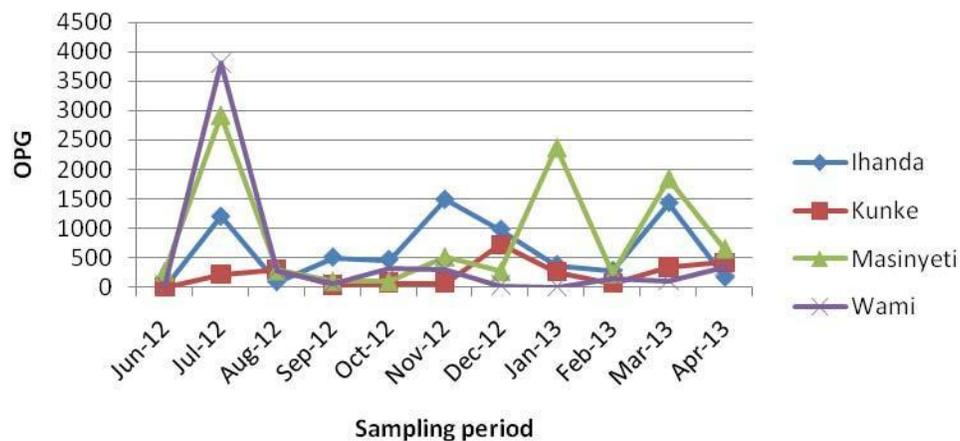


Figure 4. Monthly burdens of OPG in goats from Ihanda, Kunke, Masinyeti, and Wami-Luhindo villages

Moreover, at Wami-Luhindo village *Moniezia expansa* and *Moniezia ben* were also observed in four and two animals, respectively. *M. expansa* was also observed in two animals at Masinyeti villages.

The *Eimeria* species observed in the goat faecal samples from the study villages were *Eimeria arloingi*, *Eimeria parva*, and *Eimeria ninakohlyakimovae*. At Masinyeti village *Eimeria arloingi* (66.67%) was the most abundant species, followed by *E. parva* (20%) and *E. ninakohlyakimovae* (13.33%). At Ihanda village the predominant species was *E. arloingi* (63.64%), followed by *E. parva* (27.27%) and *E. ninakohlyakimovae* (9.01%). At Kunke village the most predominant species was *E. arloingi* (62.5%), followed by *E. parva* (25%) and *E. ninakohlyakimovae* (12.5%). No *Eimeria* species were observed after faecal culture of samples collected from goats of Wami-Luhindo village.

Other clinical diseases, conditions and symptoms observed in dairy goats kept by small-scale farmers

Of the 129 dairy goats screened for CCP in all project villages, 26.4% of the goats were seropositive. Screening for brucellosis and haemoparasites (*Trypanosoma*, *Babesia* and *Anaplasma*) revealed negative results for all goats. A total of 284 cases of clinical diseases, conditions and symptoms were observed and treated in the study goats and these included diarrhoea (27.46%), coughing (13.73%), worm infection (39.08%), orf (16.55%), heartwater (2.82%) and abdominal hernia (0.35%). A total of 20 goats died during the study period due to various reasons and the overall mortality rate was 15.5%.

The causes of mortality are shown in Table 5. The causes for most (55%) of the deaths could not be established because of lack of veterinary services in the study villages. The lack of timely provision of veterinary services and poor communication system in the study villages contributed to the observed high mortality.

DISCUSSION

The present study has demonstrated that dairy goats in the study areas are infected with gastrointestinal nematodes throughout the year, despite the fact that they are kept indoors. This is contributed by the fact that some farmers allow their goats to graze in natural pastures around the homesteads and the majority of the farmers collect forages for feeding goats from communal lands in which local goats and other ruminant animals graze. This predisposes the dairy goats to infection with gastrointestinal parasites. The observation that most nematode egg and coccidia oocyst counts were highest during the rainy and humid months indicates that rainfall, humidity and temperature play a significant role in the epidemiology of gastrointestinal parasites as it has been reported by others (Regassa et al., 2006; Mbuh et al., 2008). Climatic conditions during the rainy season are favourable for the development, survival and translocation of pre-parasitic stages of gastrointestinal nematodes. In this study, nematode burdens declined during the dry season with the lowest values being observed in the driest months of August, September and October. This concurs with Nwosu et al. (2007) who reported that the climatic conditions in the dry period are not favourable for the survival of the free-living stages of

Table 5. Causes of death of dairy goats in the study villages.

Cause of death	Breed		Total
	Norwegian crosses	Toggenburg crosses	
Pneumonia	-	1	1
Plastic bag impaction	-	1	1
Starvation	-	1	1
Excessive consumption of cassava leaves	-	1	1
Consumption of insecticide treated maize grain	-	1	1
Abscess	-	1	1
Cowdriosis	2	-	2
Bloat of unknown origin	1	-	1
Cause of death not well established	10	1	11
Total	13	7	20

the parasites. The nematode genera observed in the present study have been reported in previous studies in Tanzania (Kusiluka, 1995; Kusiluka et al., 1996, 1999) and in neighbouring countries. Ng'ang'a et al. (2004) and Odoi et al. (2007) reported that in Kenya, the widely reported nematode genera of small ruminants include *Haemonchus*, *Trichostrongylus*, *Cooperia* and *Oesophagostomum*.

The prevalence of coccidiosis in dairy goats from the four villages observed in this study is similar to what has been reported in other sub-Saharan African countries (Kanyari et al., 2009; Kanyari et al., 2010). In this study, the dairy goats were infected with *Eimeria* throughout the year in all four villages, suggesting that the environmental conditions were conducive for the survival and development of the *Eimeria* species throughout the year. Most of the dairy goats in the study villages are kept indoors under the cut-and-carry system. This system increases the risk of goats for being infected with coccidiosis. The finding that both prevalence and loads of coccidia in this study were higher in young goats compared to adult goats agrees with the findings reported by several authors (Abo-Shehadeh and Abo-Ferieha, 2003; Regassa et al., 2006; Mbuh et al., 2008). This is due to the fact that coccidiosis is mainly a disease of young goats that have not yet developed immunity against coccidia (Matijala and Penzhorn, 2003). It is possible that the mixed infection of nematodes and *Eimeria* increased the susceptibility of young goats to coccidiosis.

The proportion of animals infected with nematodes and *Eimeria* and the respective EPG and OPG values were very low at the beginning of the study in June, 2012, simply because the animals were given treatment against gastrointestinal parasites before being distributed to the farmers. The high burdens of both EPG and OPG

recorded in July, 2012 indicates that the animals got new infections after being introduced in the research villages, implying that the project villages are infested with nematodes and *Eimeria*. The higher OPG values observed during the month of July compared to EPG reflect the resistance of coccidia oocysts to desiccation. Kanyari (1993) observed that sporulated oocysts are more resistant to desiccation compared to helminth eggs or larvae and consequently oocyst counts in goats during the dry season are higher than the nematode egg counts. The overall low prevalence and burdens of nematodes and *Eimeria* in goats during the entire study period in all villages and both breeds may be due to the low stocking rate of goats which did not favour a build up of high nematode egg and oocyst burdens because on average, each household had one or two goats. Moreover, presence of few animals per household coupled with zero grazing minimized the risk of goats for being infected with the nematodes.

The persistently higher levels of EPG and OPG among the Norwegian crossbred goats compared to Toggenburg crosses may suggest that the Norwegian goats are more susceptible to gastrointestinal nematodes than the Toggenburg goats. Breed differences with respect to nematode infection in dairy goats have been reported by other studies (Richard et al., 1990; Costa et al., 2000). The Toggenburg goats have been in the country for longer time (since early 1960s) compared to the Norwegian goats, which were introduced in the late 1980s. Hence, the Toggenburg goats may have adapted better to the local conditions and developed traits for tolerance to endemic diseases compared to the Norwegian goats.

Screening for *M. capripneumoniae* revealed that a significant proportion of goats in the project villages were infected with CCPP. The observation in the present study supports the findings of previous studies which have

reported the existence of CCPP in Tanzania (Noah et al., 2011). CCPP infection in goats was confirmed for the first time in late 1990s (Msami et al., 1998). The disease is one of the major limiting factors for improved goat production in Eastern Africa (Eshetu et al., 2007). The disease causes direct economic loss due to high mortality, reduced milk and meat production, costs of diagnosis, treatment, vaccination and surveillance. Also it causes indirect loss resulting from trade restrictions. Therefore, there is a need to develop sustainable disease control strategy for CCPP in order to promote commercial goat production. Apart from CCPP, a peste des petits ruminants (PPR) has emerged in recent years as the major threat to the small ruminant industry in the country (Karimuribo et al., 2011, 2012). However, it was not encountered in this study. Similarly, trypanosomosis and tick-borne diseases, which are the major haemoparasitic diseases of small ruminant in sub-Saharan Africa (Kusiluka and Kambarage, 1996), were not observed in the current study.

The main cause of animal death in the present study was poor management practices. Some of the causes of deaths encountered in this study such as excessive eating of cassava leaves and insecticide-treated maize, plastic bag impaction and starvation could have been prevented if the farmers had the relevant skills required for provision of adequate care of dairy goats. This underlines the need for educating the farmers on improved animal husbandry practices, in addition to animal health control programmes. The fact that the causes of death for most of the animals were not determined reflects the unavailability of veterinary services and underscores the need for improvement of extension service delivery system in rural areas. It is possible that even the deaths reported to be caused by cowdriosis were erroneous because of the difficulty in field diagnosis of this disease. The introduction and sustainability of dairy goat keeping in the study villages will be successful if the farmers acquire basic animal husbandry and health management skills so that appropriate interventions can be made before losses are encountered. The situation can be improved by introducing community animal health workers in the study villages who will be responsible for early diagnosis and treatment of diseases in the villages.

Conclusion

It can be concluded that gastrointestinal parasites are widespread among dairy goats in the study areas and that the rainy season is the major factor, which influences the epidemiology of these parasites. The most predominant nematode genera in the study villages are *Bunostomum* (57.67%), *Haemonchus* (24.97%) and *Strongyloides* (17.36%) while for *Eimeria* the most

common species are *E. arloingi*, *E. parva* and *E. ninakohlyakimovae*. Although nematodes and coccidia were found in the study sites throughout the year, their burdens were relatively small to justify mass treatment. Therefore, treatment of individual clinically sick animals that are suspected to be highly affected by GINs or coccidiosis may be a rational option. Control of other diseases such as CCPP by vaccination is also recommended in view of its potential impact on goat mortality. Moreover, the study has revealed that the Toggenburg goats are relatively tolerant to helminthosis and coccidiosis compared to the Norwegian goats.

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Conflict of interest

The authors have no conflict of interest.

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