



International Journal of Veterinary Sciences and Animal Husbandry



ISSN: 2456-2912

VET 2022; 7(2): 07-16

© 2022 VET

www.veterinarypaper.com

Received: 09-11-2021

Accepted: 13-12-2021

JW Magona

Formerly at National Livestock
Resources Research Institute
(NaLIRRI), P.O. Box 96,
Tororo, Uganda

J Walubengo

Formerly at National Livestock
Resources Research Institute
(NaLIRRI), P.O. Box 96,
Tororo, Uganda

G Musisi

Formerly at National Livestock
Resources Research Institute
(NaLIRRI), P.O. Box 96,
Tororo, Uganda

DK Kakaire

Formerly at National Livestock
Resources Research Institute
(NaLIRRI), P.O. Box 96,
Tororo, Uganda

Variation in response of Mubende, Boer and Boer x Mubende goat breeds to gastrointestinal nematode infection under field conditions in Uganda

JW Magona, J Walubengo, G Musisi and DK Kakaire

DOI: <https://doi.org/10.22271/veterinary.2022.v7.i2a.406>

Abstract

More productive exotic Boer goats are increasing replacing indigenous Mubende goats in Uganda in a crossbreeding program, yet Boer goats easily succumb to gastrointestinal nematode (GIN) infection to which indigenous Mubende goats are more tolerant. Hence, a cross-sectional study was conducted in Ssembabule, Mpigi, Masaka and Mubende districts in Uganda to understand whether variation in susceptibility to GIN infection exists among Mubende, Boer and Boer x Mubende goats under field conditions. A total of 2423 goats, consisting of Mubende ($n=1,667$), Boer ($n=87$) and Boer x Mubende ($n=669$) goats were randomly sampled. Faecal Egg Count (FEC) and Packed Cell Volume (PCV) were determined and data on factors: gender, age, location, flock size and management were collected. The findings revealed that age and location had a significant ($p<0.05$) negative effect, while flock size had a significant ($p<0.05$) positive effect on FEC. In addition, age, location, and flock size had a significant ($p<0.05$) negative effects on PCV. Boer x Mubende goats had a highly significant ($p<0.001$) positive effect on FEC. While Mubende goats had a highly significant ($p<0.001$) negative effect and Boer had a significant ($p<0.05$) negative effect on FEC. In addition, Boer x Mubende had a significant ($p<0.05$) negative effect on PCV values. While Mubende had a significant ($p<0.05$) positive effect on PCV values. In conclusion, the findings suggested Boer x Mubende crosses were more susceptible to GIN infection than Mubende goats. Meanwhile, Boer x Mubende crosses and Mubende goats were less susceptible to GIN infection than Boer goats. Follow-up studies are recommended to confirm the level of susceptibility among Mubende, Boer and Boer x Mubende goats to GIN infection under experimental conditions.

Keywords: Response, Mubende, Boer x Mubende crosses, Boer goats, gastrointestinal nematode infection, Uganda

1. Introduction

Gastrointestinal nematode (GIN) infections pose the greatest challenge to commercial goat production worldwide. In the tropics, GIN infections are the principal cause of mortality, retarded growth and general production losses in goats (Baker *et al.*, 2001) ^[1]. Indigenous Mubende breed of goats in Uganda, a product of centuries of selection for traits adapted to harsh conditions, is increasingly being replaced by a more productive exotic Boer breed (Rege, 1999; Sewannyana, Oluka and Masaba, 2004) ^[2, 3]. However, the Boer breed easily succumbs to the overwhelming disease challenge, especially gastrointestinal nematode infections to which the Mubende breed is adapted. Disease resistance is arguably one of the important traits possessed by indigenous breeds and is an important attribute of livestock in low-input livestock production systems (Gibson and Bishop, 2005) ^[4]. Such traits if identified are useful in breed improvement programs involving crossbreeding of productivity exotic breeds with indigenous breeds. The goat population in Uganda is currently estimated at 12.4 million goats. Goats are important in Uganda as producers of meat, as it is generally preferred over other meats. Socio-economically, goats play a traditional role as dowry and financial assets (Okello and Obwolo, 1984) ^[5]. In addition, goats provide resource-poor farmers, especially women, with income, manure, and animal protein in form of meat and milk.

Corresponding Author:

JW Magona

Formerly at National Livestock
Resources Research Institute
(NaLIRRI), P.O. Box 96,
Tororo, Uganda

However, the productivity of goats is constrained by parasitic infections, the most important of all being gastrointestinal nematode infections that cause production losses and the death of infected animals. Control of gastrointestinal nematode infections in goats in Uganda hugely relies on anthelmintic treatments (Magona and Musisi, 2002) [6]. However, anthelmintic treatments are prohibitively costly to many smallholder goat farmers. Moreover, present control strategies for ruminant parasitic nematodes worldwide are complicated by the problem of anthelmintic resistance, particularly in *Haemonchus contortus* (Van Wyk and Malan, 1988; Waller *et al.*, 1996; Nsereko *et al.*, 2012) [7, 8, 9]. This necessitates designing of alternative low-cost control strategies relying on breed resistance. However, little or no information has been documented about disease resistance among goat breeds in Uganda. A study was, therefore, conducted to understand whether variation in susceptibility to gastrointestinal nematode infections existed among Mubende, Boer and Boer x Mubende goats under field conditions.

2. Materials and Methods

2.1 Study area

The study was conducted in Ssembabule, Mpigi, Masaka and Mubende districts on commercial goat farms. All farms enlisted in the project for enhancing goat export in Uganda were selected for the study. The farms undertook crossbreeding of imported Boer goats with the indigenous Mubende goats. A total of 30 farms were visited including, seven in Ssembabule, nine in Mpigi district, eight in Masaka and six in Mubende district.



Fig 1: Photo of Mubende Goats (Courtesy of Buyana Farm, Makerere University <https://www.bing.com/images/>)

2.2.2 Boer x Mubende crosses

Boer x Mubende crosses (see Figure 2) are reported to have the advantage of combining ability of the adaptation genes from Mubende breed and meat producing ability from the Boer breed (Sewannyana, Oluka and Masaba, 2004) [3]. Under experimental conditions, F₁ (50% Boer) Boer x Mubende crosses are reported to have birth weight of 1.91 Kg, weaning weight of 8.94 Kg at 16 weeks and daily pre-weaning growth rate of 62.77 Kg, and F₂ (75% Boer) Boer x Mubende crosses are reported to have birth weight of 2.06 Kg, weaning weight of 7.16 Kg at 16 weeks and a daily pre-weaning growth rate of 47.15 g/day (Sewannyana, Oluka and Masaba, 2004) [3].



Fig 2: Photo of Boer x Mubende crosses (Courtesy of Buyana farm, <https://www.bing.com/images/>)

The main vegetation type in the study area is savannah grassland. The area receives 1200-1500 mm of rainfall annually, which is bimodal in distribution. There are two wet seasons (March to June and September to November) and two dry seasons (December to February and July to August). The daily mean minimum and mean maximum temperatures are 15 °C and 27 °C, respectively.

Goats are kept under extensive grazing in rangelands in South-western Uganda in often well-fenced farms. They graze freely on pastures during the day and are housed in wooden structures with raised floors during the night.

2.2 Goat breed characteristics

2.2.1 Mubende goats

The Mubende goat (see Figure 1) is found in humid southern and central Uganda. It is adapted to Sub-humid and warm tropical Savannah climatic conditions (Sewannyana, Oluka and Masaba, 2004) [3]. The breed has promising meat and skin characteristics (Gall, 1981; Devendra and Burns, 1983) [10, 11]. It has good reproductive and growth characteristics with a twinning rate of 30%; adult male live weights of 40 Kg; adult female live weight of 30 Kg; fecundity rates of 1.5 young per litter; and kidding intervals of 300 days (Mason and Maule, 1960; Sacker and Trail, 1966; Sewannyana, Oluka and Masaba, 2004) [12, 13, 3]. Birth weight of 1.98 Kg, weaning weight of 8.27 Kg at 16 weeks and daily pre-weaning growth rates of 56.11 Kg for Mubende goats have been reported under experimental conditions (Sewannyana, Oluka and Masaba, 2004) [3].

2.2.3 Boer goats

The South African Boer goat has been selected for high meat production and quality (Devandra and Burns, 1983; Jindal, 1984; Sewannyana, Oluke and Masaba, 2004) [11, 14, 3]. Boer goats have been introduced in Uganda for upgrading indigenous breeds by farmer communities and organization as an alternative way for improving the low output of meat and milk among indigenous goats (Sewannyana, Oluke and Masaba, 2004; Babigumira *et al.*, 2011; Onzima *et al.*, 2014) [3, 15, 16].



Fig 3: Photo of Boer goats (Courtesy of Buyana Farm, Makerere University, <https://www.bing.com/image>)

2.3 Sampling

A sample size of at least 384 goats was required per district based on an estimated prevalence of 50% and a 95% confidence interval (CI) at a 5% desired precision. The sample size was calculated using the formula $n = 1.96^2 P (1-P)/d^2$ derived from Thrusfield (1995) [17] with $P = 0.5$ and $d = 0.05$. Faecal samples were collected from a minimum of 384 goats per district. Goats were selected from identified farms, using systematic sampling strategy. Every second animal in the flock was sampled. For each animal sampled, its district, location, farm owner, farm flock size, breed, age, management and gender were recorded.

2.4 Collection and handling of faecal samples

The faecal sample was collected per rectum. Using gloved fingers, about 10 grams of sample were obtained from each goat and placed immediately in a plastic bag. The plastic bag was tightly held close to the faecal sample to keep off air. For identification, each sample was labelled with the details of the

individual goat and farm before being put in a cold box containing ice packs. The samples were transported for laboratory analysis at the National Livestock Resources Research Institute (NaLIRRI), Tororo, Uganda within 12 hours. All samples were collected between 9-10 hours just before the goats were released for grazing each morning.

2.5 Detection of nematode eggs and estimation of faecal egg counts

Flotation method as described by Hansen and Perry [18] was used in the detection of nematode eggs. Parasitological identification of nematode eggs was performed using morphological features as described by Soulsby (1982) [19]. Using a modified McMaster technique, FEC was determined as number of eggs per gram (EPG) for each sample (Kaplan and Miller, 2006) [20]. A detection level of 100 EPG for the McMaster method was used.

2.6 Statistical Analysis

Descriptive statistics on the data were generated using the frequency functions of Excel. t-tests were used to compare mean values for faecal egg counts using GENSTAT (GENSTAT®, Version 13). P-values < 0.05 were considered significant. Multivariate linear regression was performed to assess which factors: breed, gender, age, district, flock size and level of management did influence the variance in faecal egg count and PCV values.

3. Results

The distribution of Mubende ($n = 1667$), Boer ($n = 87$) and Boer-Mubende ($n = 669$) goats sampled disaggregated by gender, age, district, flock size and management is shown in Table 1. Of all goats sampled ($n = 2423$), 1,919 (79.2%) were females and 504 (20.8%) were males. In terms of age, 1039 (42.9%) goats were below 1 year, and 1384 (57.1%) goats were above 1 year. In terms of areas, 520 (21.5%), 628 (25.9%), 777 (32.0%) and 498 (20.6%) goats were sampled in Ssembabule, Mpigi, Masaka and Mubende districts, respectively. Of all goats sampled, 851 (35.1%), 853 (35.2%) and 719 (29.7%) belonged to small flocks (<100 goats), medium flocks (100-300 goats) and large flocks (>300 goats), respectively. In terms of management, 1092 (45%) goats were sampled from farms with good management, while 1331 (55%) goats were from farms with poor management.

Table 1: Distribution of Mubende ($n = 1667$), Boer ($n = 87$) and Boer x Mubende ($n = 669$) goats sampled disaggregated by gender, age, district, flock size and management

Factors	Levels	Mubende Goats		Boer x Mubende Crosses		Boer Goats		Total
		Sample size	Proportion %	Sample size	Proportion %	Sample size	Proportion %	
Gender	Female	1352	70.5	503	26.2	64	3.3	1,919
	Male	315	62.5	166	32.9	23	4.6	504
Age	< 1yr	651	62.7	362	34.8	26	2.5	1,039
	>1yr	1016	73.4	307	22.2	61	4.4	1384
District	Ssembabule	352	67.7	137	26.3	31	6.0	520
	Mpigi	491	78.2	137	21.8	-	-	628
	Masaka	573	73.7	170	21.9	34	4.4	777
	Mubende	314	63.0	162	32.5	22	4.4	498
Flock size	< 100	674	79.2	167	19.6	10	1.2	851
	100-300	682	80.0	120	14.1	51	5.9	853
	> 300	311	43.3	382	53.1	26	3.6	719
Management	Good	875	80.1	166	15.2	51	4.7	1092
	Poor	792	59.5	503	37.8	36	2.7	1331

The multivariable linear regression model indicated that district had a highly significant effect ($p < 0.001$), while age and flock size had significant effect ($p < 0.05$) on FEC. The

regression equation was: $FEC = 178.8 - 27.6 \text{ AGE} - 29.23 \text{ DISTRICT} + 22.06 \text{ FLOCKSIZE}$. Age and district had negative effect while flock size had positive effect on FEC.

The overall regression fit was highly significant ($p < 0.001$). In addition, multivariable linear regression model indicated Boer x Mubende had highly significant ($p < 0.001$) effect on FEC, but Boer did not ($P = 0.17$). Boer and Boer x Mubende were responsible for 60% of the variance in FEC. The regression equation was: $FEC = 92.3 + 47.4 \text{ Boer} + 52.7 \text{ Boer-Mubende}$, suggesting the factors, Boer and Boer x Mubende had positive effect on FEC. The overall regression fit was highly significant ($p < 0.001$).

Furthermore, the multivariable linear regression model indicated Mubende had highly significant ($p < 0.001$) effect, while Boer had a significant ($p < 0.05$) effect on FEC. Both factors, Mubende and Boer were responsible for 60% of the variance in FEC. The regression equation was: $FEC = 145 - 52.7 \text{ MUBENDE} - 100.2 \text{ Boer}$, suggesting both factors, Mubende and Boer had negative effect on FEC. The overall regression fit was highly significant ($p < 0.001$).

In addition, district and flock size had highly significant effect ($p < 0.001$), while age had significant effect ($p < 0.05$) on PCV. The regression equation was: $PCV = 31.6 - 0.6 \text{ AGE} - 0.5 \text{ DISTRICT} - 1.2 \text{ FLOCKSIZE}$. The factors had negative effect on PCV values. The overall regression fit was highly significant ($p < 0.001$).

The multivariable linear regression model indicated Boer x Mubende had highly significant ($p < 0.001$) effect on PCV values, but Boer had no significant effect on PCV ($P = 0.562$). Boer x Mubende was responsible for 30% of the variance in PCV values. The regression equation was: $PCV = 27.346 -$

$0.369 \text{ BOER} - 0.760 \text{ BOER-MUBENDE}$. The factors had negative effects on PCV values, implying that presence of the breed factors influenced reducing PCV values. The overall regression fit was highly significant ($p < 0.001$).

Regarding Mubende and Boer, the multivariable linear regression model indicated Mubende had a significant ($p < 0.05$) effect on PCV values, but Boer had no significant effect on PCV ($P = 0.553$). Mubende was responsible for 30% of the variance in PCV values. The regression equation was: $PCV = 26.6 + 0.4 \text{ BOER} + 0.8 \text{ MUBENDE}$. The factors had a positive effect on PCV values, implying that presence of the breed factors influenced increasing PCV values. The overall regression fit was significant ($p < 0.05$).

The distribution of worm infection intensity (EPG) among Mubende, Boer and Boer x Mubende goats in Uganda is shown in Figure 4. Most goats of either Mubende (80%), or Boer (84%) or Boer x Mubende (70%) breed sampled were free from gastrointestinal nematode infections. Boer x Mubende crosses had the highest proportion of individuals (25%) with EPG of 100-1000, followed by Boer goats (16%) and Mubende goats (14%). In addition, Mubende goats had the highest proportion of individuals (5%) with EPG of 1001-2000, followed by Boer x Mubende crosses (3%). EPG of above 2000, which are quite pathogenic and may lead to clinical infection, were rare among Mubende goats (1%) or Boer x Mubende crosses (2%). It is noteworthy that Boer goats did not have EPG of 1000 and above.

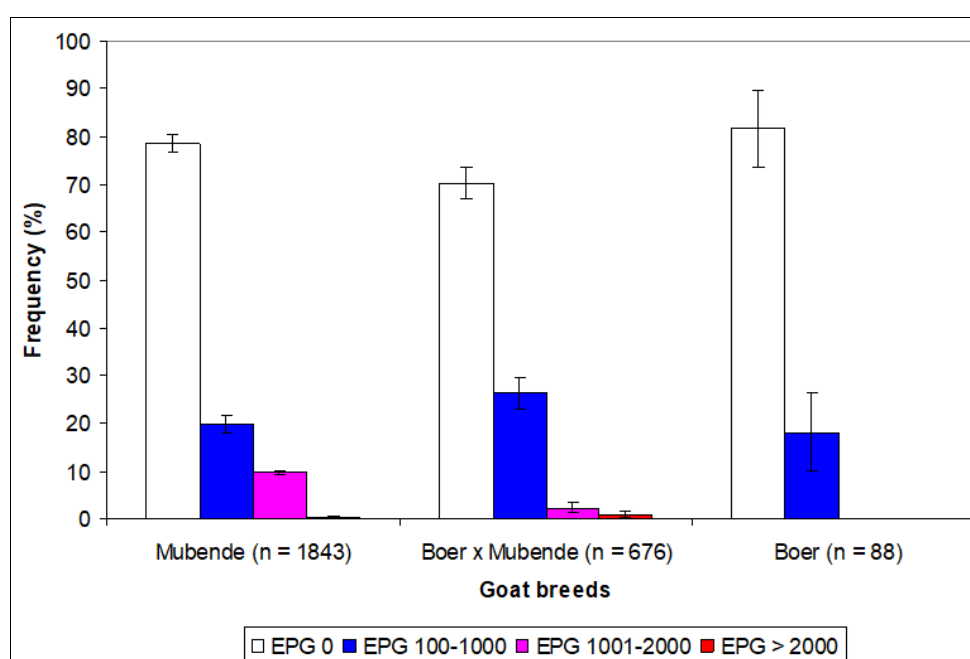


Fig 4: Distribution of worm infection intensity (EPG) among Mubende, Boer and Boer x Mubende goats in Uganda

Figure 5 shows the distribution of packed cell volumes of goats of Mubende, Boer and Boer x Mubende crosses on selected farms visited in Uganda. Most Mubende and Boer goats had mean PCV of 26-30%, while most Boer x Mubende

Crosses had a mean PCV of 21-25%. Low PCV of 15% and below, normally denoting anaemic animals, were rare amongst Boer goats but limited among Mubende goats and Boer x Mubende crosses.

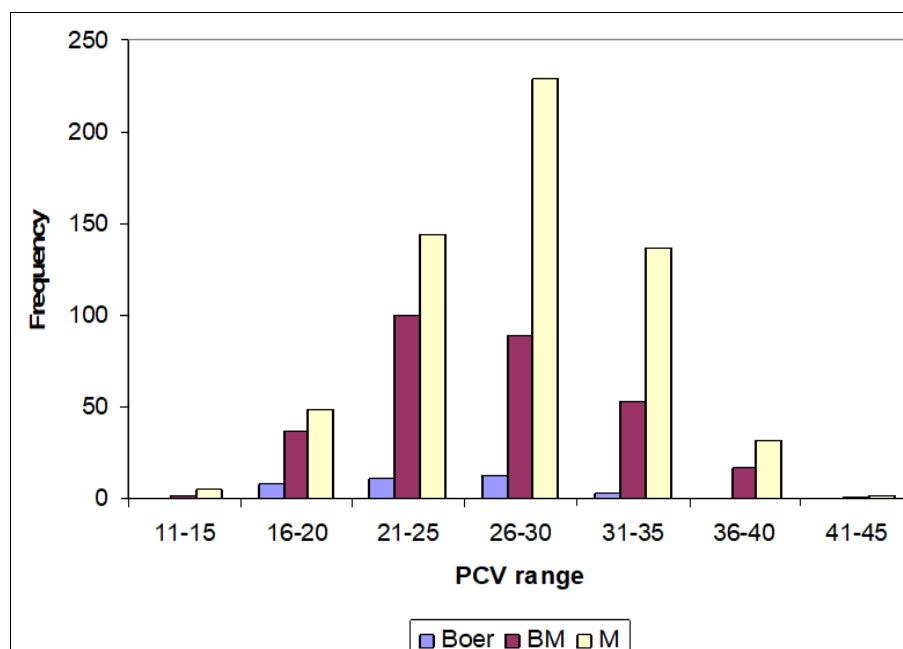


Fig 5: Distribution of packed cell volumes of Mubende, Boer and Boer x Mubende goats in Uganda

In Table 2, Mubende goats are compared to Boer x Mubende crosses in terms of mean faecal egg counts and mean Log faecal egg counts disaggregated by gender, age, district (location), flock size and management. Female Boer x Mubende crosses had significantly higher ($p < 0.05$) mean faecal egg counts than female Mubende goats. Equally, male Boer x Mubende crosses had significantly higher ($p < 0.05$) mean faecal egg counts than male Mubende goats.

In addition, Boer x Mubende crosses younger than one year had significantly higher ($p < 0.001$) mean faecal egg counts than their counterparts among the Mubende goats. Furthermore, Boer x Mubende crosses in Ssembabule, Mpigi and Mubende districts had significantly higher ($p < 0.05$) mean faecal egg counts than Mubende goats. Boer x Mubende crosses from large flocks (> 300) had significantly higher ($p < 0.001$) mean faecal egg counts than Mubende goats.

Table 2: Comparison of Mubende goats and Boer x Mubende crosses regarding mean faecal egg counts and mean Log faecal egg counts disaggregated by gender, age, area (district), flock size and management

Factors	Levels	Mubende Goats			Boer x Mubende Crosses			P-value
		Sample size (n)	FEC $\pm$ 95% CI	Log FEC $\pm$ 95% CI	Sample size (n)	FEC $\pm$ 95% CI	Log FEC $\pm$ 95% CI	
Gender	Female	1352	97.3 $\pm$ 15.6	1.89 $\pm$ 0.02	503	128.8 $\pm$ 28.2	1.95 $\pm$ 0.04	0.008
	Male	315	69.8 $\pm$ 22.0	1.86 $\pm$ 0.04	166	194.0 $\pm$ 89.2	1.98 $\pm$ 0.07	0.004
Age	< 1yr	651	93.4 $\pm$ 21.4	1.89 $\pm$ 0.03	362	180.7 $\pm$ 50.3	2.00 $\pm$ 0.05	< 0.001
	> 1yr	1016	91.3 $\pm$ 17.0	1.88 $\pm$ 0.02	307	102.9 $\pm$ 30.3	1.90 $\pm$ 0.04	0.336
District	Ssembabule	322	183.2 $\pm$ 48.9	2.01 $\pm$ 0.05	137	295.6 $\pm$ 115.0	2.12 $\pm$ 0.09	0.037
	Mpigi	491	49.7 $\pm$ 15.2	1.81 $\pm$ 0.03	137	97.0 $\pm$ 36.1	1.91 $\pm$ 0.05	0.001
	Masaka	573	69.6 $\pm$ 15.5	1.86 $\pm$ 0.03	170	68.2 $\pm$ 33.7	1.84 $\pm$ 0.05	0.352
	Mubende	281	107.8 $\pm$ 34.8	1.91 $\pm$ 0.05	162	157.4 $\pm$ 52.8	2.00 $\pm$ 0.07	0.028
Flock size	< 100	674	78.8 $\pm$ 15.8	1.88 $\pm$ 0.03	167	127.5 $\pm$ 48.9	1.93 $\pm$ 0.07	0.067
	100-300	682	110.4 $\pm$ 25.7	1.89 $\pm$ 0.03	120	110.8 $\pm$ 61.2	1.89 $\pm$ 0.07	0.939
	> 300	311	81.0 $\pm$ 26.7	1.87 $\pm$ 0.04	382	163.4 $\pm$ 45.4	1.99 $\pm$ 0.05	< 0.001
Management	Good	875	32.1 $\pm$ 9.0	1.77 $\pm$ 0.02	166	29.5 $\pm$ 23.9	1.76 $\pm$ 0.03	0.474
	Poor	792	158.5 $\pm$ 25.4	2.00 $\pm$ 0.03	503	183.1 $\pm$ 39.5	2.02 $\pm$ 0.04	0.474

Table 3 shows comparison of Mubende goats to Boer goats regarding mean faecal egg counts and mean Log faecal egg counts disaggregated by gender, age, district (location), flock size and management. Female Mubende goats had significantly higher ($p < 0.05$) mean faecal egg counts than female Boer goats. In addition, Mubende goats younger than 1 year had significantly higher ($p < 0.001$) mean faecal egg counts than their Boer counterparts. Likewise, Mubende goats

in Masaka district had significantly higher ($p < 0.001$) mean faecal egg counts than Boer goats. Furthermore, Mubende goats from large flocks (100-300) had significantly higher ($p < 0.001$) mean faecal egg counts than Boer goats. Independent of the level of management whether good or poor, Mubende goats had significantly higher ($p < 0.001$) mean faecal egg counts than Boer goats.

Table 3: Comparison of Mubende goats and Boer goats regarding mean faecal egg counts and mean Log faecal egg counts disaggregated by gender, age, area (district), flock size and management

Factors	Mubende goats				Boer goats			P-value
	Level	Sample size (n)	FEC $\pm$ 95% CI	Log FEC $\pm$ 95% CI	Sample size (n)	FEC $\pm$ 95% CI	Log FEC $\pm$ 95% CI	
Gender	Female	1352	97.3 $\pm$ 15.6	1.89 $\pm$ 0.02	64	40.6 $\pm$ 25.7	1.81 $\pm$ 0.07	0.050
	Male	315	69.8 $\pm$ 22.0	1.86 $\pm$ 0.04	23	56.5 $\pm$ 68.4	1.86 $\pm$ 0.13	0.961
Age	< 1yr	651	93.4 $\pm$ 21.4	1.89 $\pm$ 0.03	26	3.8 $\pm$ 7.5	1.72 $\pm$ 0.04	< 0.001
	> 1yr	1016	91.3 $\pm$ 17.0	1.88 $\pm$ 0.02	61	62.3 $\pm$ 36.1	1.87 $\pm$ 0.08	0.86
District	Ssembabule	322	183.2 $\pm$ 48.9	2.01 $\pm$ 0.05	31	157.1 $\pm$ 117.5	2.10 $\pm$ 0.23	0.502
	Mpigi	491	49.7 $\pm$ 15.2	1.81 $\pm$ 0.03	-	-	-	-
	Masaka	573	69.6 $\pm$ 15.5	1.86 $\pm$ 0.03	34	2.0 $\pm$ 3.8	1.71 $\pm$ 0.02	< 0.001
	Mubende	281	107.8 $\pm$ 34.8	1.91 $\pm$ 0.05	22	72.7 $\pm$ 55.0	1.92 $\pm$ 0.15	0.869
Flock size	< 100	674	78.8 $\pm$ 15.8	1.88 $\pm$ 0.03	10	130.0 $\pm$ 87.9	2.09 $\pm$ 0.26	0.067
	100-300	682	110.4 $\pm$ 25.7	1.89 $\pm$ 0.03	51	2.0 $\pm$ 3.8	1.71 $\pm$ 0.02	< 0.001
	> 300	311	81.0 $\pm$ 26.7	1.87 $\pm$ 0.04	26	96.2 $\pm$ 72.5	1.95 $\pm$ 0.15	0.283
Management	Good	875	32.1 $\pm$ 9.0	1.77 $\pm$ 0.02	51	2.0 $\pm$ 3.8	1.71 $\pm$ 0.02	< 0.001
	Poor	792	158.5 $\pm$ 25.4	2.00 $\pm$ 0.03	36	105.6 $\pm$ 57.4	1.99 $\pm$ 0.02	< 0.001

Table 4 depicts comparison of Boer x Mubende crosses to Boer goats regarding mean faecal egg counts and mean Log faecal egg counts disaggregated by gender, age, district (location), flock size and management. Female Boer x Mubende crosses had significantly higher ($p < 0.05$) mean faecal egg counts than female Boer goats. Boer x Mubende crosses younger than 1 year had significantly higher ($p < 0.001$) mean faecal egg counts than their Boer counterparts.

Boer x Mubende crosses in Masaka district had significantly higher ($p < 0.001$) mean faecal egg counts than Boer goats. Boer x Mubende crosses from large flocks (> 300) had significantly higher ($p < 0.001$) mean faecal egg counts than Boer goats. Independent of the level of flock management, whether good or poor, Boer x Mubende crosses had significantly higher ($p < 0.05$) mean faecal egg counts than Boer goats.

Table 4: Comparison of Boer x Mubende crosses and Boer goats regarding mean faecal egg counts and mean Log faecal egg counts disaggregated by gender, age, area (district), flock size and management

Ti	Boer x Mubende Crosses				Boer goats			p-value
	Level	Sample size (n)	FEC $\pm$ 95% CI	Log FEC $\pm$ 95% CI	Sample size (n)	FEC $\pm$ 95% CI	Log FEC $\pm$ 95% CI	
Gender	Female	503	128.8 $\pm$ 28.2	1.95 $\pm$ 0.04	64	40.6 $\pm$ 25.7	1.81 $\pm$ 0.07	0.002
	Male	166	194.0 $\pm$ 89.2	1.98 $\pm$ 0.07	23	56.5 $\pm$ 68.4	1.86 $\pm$ 0.13	0.101
Age	< 1yr	362	180.7 $\pm$ 50.3	2.00 $\pm$ 0.05	26	3.8 $\pm$ 7.5	1.72 $\pm$ 0.04	< 0.001
	> 1yr	307	102.9 $\pm$ 30.3	1.90 $\pm$ 0.04	61	62.3 $\pm$ 36.1	1.87 $\pm$ 0.08	0.546
District	Ssembabule	137	295.6 $\pm$ 115.0	2.12 $\pm$ 0.09	31	157.1 $\pm$ 117.5	2.10 $\pm$ 0.23	0.901
	Mpigi	137	97.0 $\pm$ 36.1	1.91 $\pm$ 0.05	-	-	-	-
Flock size	Masaka	573	69.6 $\pm$ 15.5	1.86 $\pm$ 0.03	34	2.0 $\pm$ 3.8	1.71 $\pm$ 0.02	< 0.001
	Mubende	281	107.8 $\pm$ 34.8	1.91 $\pm$ 0.05	22	72.7 $\pm$ 55.0	1.92 $\pm$ 0.15	0.445
	< 100	674	78.8 $\pm$ 15.8	1.88 $\pm$ 0.03	10	130.0 $\pm$ 87.9	2.09 $\pm$ 0.26	0.244
Management	100-300	682	110.4 $\pm$ 25.7	1.89 $\pm$ 0.03	51	2.0 $\pm$ 3.8	1.71 $\pm$ 0.02	< 0.001
	> 300	311	81.0 $\pm$ 26.7	1.87 $\pm$ 0.04	26	96.2 $\pm$ 72.5	1.95 $\pm$ 0.15	0.283
	Good	875	32.1 $\pm$ 9.0	1.77 $\pm$ 0.02	51	2.0 $\pm$ 3.8	1.71 $\pm$ 0.02	0.026
	Poor	792	158.5 $\pm$ 25.4	2.00 $\pm$ 0.03	36	105.6 $\pm$ 57.4	1.99 $\pm$ 0.02	0.011

Table 5: Comparison of Mubende goats and Boer goats regarding the mean PCV values disaggregated by gender, age, district, flock size and management

Factors	Mubende goats			Boer goats		p-Value
	Level	Sample size (n)	PCV $\pm$ 95% CI	Sample size (n)	PCV $\pm$ 95% CI	
Gender	Female	1352	27.2 $\pm$ 0.3	64	27.9 $\pm$ 1.3	0.353
	Male	315	28.1 $\pm$ 0.6	23	24.5 $\pm$ 2.3	0.004
Age	< 1yr	651	27.7 $\pm$ 0.4	26	29.7 $\pm$ 2.0	0.08
	> 1yr	1016	27.1 $\pm$ 0.4	61	25.8 $\pm$ 1.3	0.079
District	Ssembabule	322	29.4 $\pm$ 0.6	31	26.5 $\pm$ 2.4	0.041
	Mpigi	491	24.8 $\pm$ 0.5	-	-	-
	Masaka	573	29.1 $\pm$ 0.5	34	28.7 $\pm$ 1.6	0.784
Flock size	Mubende	281	25.9 $\pm$ 0.5	22	23.3 $\pm$ 1.6	0.009
	< 100	674	27.5 $\pm$ 0.4	10	29.1 $\pm$ 2.6	0.37
	100-300	682	27.9 $\pm$ 0.4	51	28.5 $\pm$ 1.5	0.486
Management	> 300	311	25.9 $\pm$ 0.6	26	23.2 $\pm$ 1.5	0.013
	Good	875	26.7 $\pm$ 0.4	51	28.5 $\pm$ 1.5	0.039
	Poor	792	28.1 $\pm$ 0.4	36	24.9 $\pm$ 1.6	< 0.001

Table 5 shows comparison of Mubende to Boer goats regarding the mean PCV values disaggregated by gender, age, district (location), flock size and management. Male Mubende goats had significantly higher ($p<0.05$) mean PCV values than male Boer goats. In addition, Mubende goats in Ssembabule and Mubende districts had significantly higher ($p<0.05$) mean PCV values than Boer goats. Interestingly, Mubende goats from large flocks (>300) had significantly higher ($p<0.05$) mean PCV values than Boer goats. Boer goats under good management had significantly higher ($p<0.05$) mean PCV values than Mubende goats. Contrastingly, Mubende goats under poor management had

significantly higher ($p<0.05$) mean PCV values than Boer goats.

In Table 6, Boer x Mubende crosses are compared to Boer goats regarding mean PCV values disaggregated by gender, age, district (location), flock size and management. Boer goats younger than 1 year had significantly higher ($p<0.05$) mean PCV values than Boer x Mubende crosses. While Boer x Mubende crosses in Ssembabule district had significantly higher ($p<0.05$) mean PCV values than Boer goats. Boer goats under good management had significantly higher ($p<0.05$) mean PCV values than Boer x Mubende crosses.

Table 6: Comparison of Boer x Mubende crosses and Boer goats regarding mean PCV values disaggregated by gender, age, district, flock size and management

Factors	Boer x Mubende crosses			Boer goats		p-Value
	Level	Sample size (n)	PCV $\pm$ 95% CI	Sample size (n)	PCV $\pm$ 95% CI	
Gender	Female	503	26.6 $\pm$ 0.5	64	27.9 $\pm$ 1.3	0.084
	Male	166	28.1 $\pm$ 0.6	23	26.7 $\pm$ 0.9	0.122
Age	< 1yr	362	27.0 $\pm$ 0.6	26	29.7 $\pm$ 2.0	0.028
	> 1yr	307	26.1 $\pm$ 0.6	61	25.8 $\pm$ 1.3	0.743
District	Ssembabule	137	29.8 $\pm$ 0.9	31	26.5 $\pm$ 2.4	0.023
	Mpigi	137	24.0 $\pm$ 0.6	-	-	
	Masaka	170	29.3 $\pm$ 1.0	34	28.7 $\pm$ 1.6	0.569
Flock size	Mubende	162	24.2 $\pm$ 0.6	22	23.3 $\pm$ 1.6	0.323
	< 100	167	29.5 $\pm$ 0.9	10	29.1 $\pm$ 2.6	0.832
	100-300	120	27.6 $\pm$ 1.1	51	28.5 $\pm$ 1.5	0.369
Management	> 300	382	25.0 $\pm$ 0.5	26	23.2 $\pm$ 1.5	0.076
	Good	166	26.6 $\pm$ 0.9	51	28.5 $\pm$ 1.5	0.045
	Poor	503	26.6 $\pm$ 0.5	36	24.9 $\pm$ 1.6	0.078

Comparison of Mubende goats to Boer x Mubende crosses regarding mean PCV values disaggregated by gender, age, district (location), flock size and management is shown in Table 7. Female Mubende goats had significantly higher ($p<0.05$) mean PCV values than female Boer x Mubende crosses. In addition, Mubende goats older than 1 year had significantly higher ($p<0.05$) mean PCV values than Boer x Mubende crosses. Likewise, Mubende goats in Mubende

district had significantly higher ($p<0.001$) mean PCV values than Boer x Mubende crosses. Interestingly, Boer x Mubende crosses in small flocks (<100) had significantly higher ($p<0.001$) mean PCV values than Mubende goats. While Mubende goats under good management had significantly higher ($p<0.001$) mean PCV values than Boer x Mubende crosses.

Table 7: Comparison of Mubende goats and Boer x Mubende crosses regarding mean PCV values disaggregated by gender, age, district, flock size and management

Factors	Mubende goats			Boer x Mubende crosses		p-Value
	Level	Sample size (n)	PCV $\pm$ 95% CI	Sample size (n)	PCV $\pm$ 95% CI	
Gender	Female	1352	27.2 $\pm$ 0.3	503	26.6 $\pm$ 0.5	0.004
	Male	315	28.1 $\pm$ 0.6	166	28.1 $\pm$ 0.6	0.011
Age	< 1yr	651	27.7 $\pm$ 0.4	362	27.0 $\pm$ 0.6	0.095
	> 1yr	1016	27.1 $\pm$ 0.4	307	26.1 $\pm$ 0.6	0.004
District	Ssembabule	322	29.4 $\pm$ 0.6	137	29.8 $\pm$ 0.9	0.357
	Mpigi	491	24.8 $\pm$ 0.5	137	24.0 $\pm$ 0.6	0.062
	Masaka	573	29.1 $\pm$ 0.5	170	29.3 $\pm$ 1.0	0.784
Flock size	Mubende	281	25.9 $\pm$ 0.5	162	24.2 $\pm$ 0.6	< 0.001
	< 100	674	27.5 $\pm$ 0.4	167	29.5 $\pm$ 0.9	< 0.001
	100-300	682	27.9 $\pm$ 0.4	120	27.6 $\pm$ 1.1	0.593
Management	> 300	311	25.9 $\pm$ 0.6	382	25.0 $\pm$ 0.5	0.02
	Good	875	26.7 $\pm$ 0.4	166	26.6 $\pm$ 0.9	0.786
	Poor	792	28.1 $\pm$ 0.4	503	26.6 $\pm$ 0.5	< 0.001

4. Discussion

We present findings of a cross-sectional study conducted in Uganda intended to understand variation in susceptibility amongst Mubende, Boer and Boer x Mubende goats to gastrointestinal nematode infection under field conditions.

Goats sampled exhibited natural demographic characteristics in Uganda: Largely females (79.2%) with few males (20.8%); More adult goats (above 1 year) (57.1%) than young goats (below 1 year) (42.9%); Similar proportions of goats sampled in the different districts: Ssembabule (21.5%), Mpigi (25.9%), Masaka (32.0%) and Mubende (20.6%); Similar proportions

of goats sampled from small flocks (< 100) (35.1%), medium flocks (100-300) (35.2%) and large flocks (> 300) (29.7%); and A larger proportion of goats originated from farms with poor management (55%) than from farms with good management (45%). This was explained by the fact that male goats experienced a high off take than female goats, hence male goats were fewer than female goats. Generally, adult goats were more than young goats in the natural goat population. All districts selected (Ssembabule, Mpigi, Masaka and Mubende) are goat-rearing districts, hence similar proportions of goats were sampled once the same sampling strategy was applied across the different districts. Given similar distribution of different flock sizes; small, medium and large in the natural goat population, different flock sizes were equally represented in the final sample. The fact that good management involved more resources and expenses to implement made it was more difficult for most farmers to practise, leading to poor management practice to predominate.

Age and district had negative effect on FEC, while flock size had positive effect. Worm infection or re-infection has been reported to decrease with age of goats due to increasing resistance with age as goat immunity to worm infection or re-infection develops further (Assoku, 1981; Magona and Musisi, 2002; Sohail *et al.*, 2017; Poddar *et al.*, 2017) [21, 6, 22, 23]. Variation of worm infection risk according to districts or locations has been reported by others (Ratanapob *et al.* 2012) [24]. This has been attributed to variations in temperature and rainfall patterns in different locations that negatively influence patterns of parasite infective stages and their severity (Ratanapob *et al.*, 2012) [24]. This as well concurred with other reports by Kantzoura *et al.* (2011) [25], Mushonga *et al.* (2018) [26] and Namutosi *et al.* (2020) [27]. Increasing flock size has been reported to increase worm egg shedding on pasture as stocking density and level of intensification increases on such farms (Magona and Musisi, 2002; Namutosi *et al.*, 2020) [6, 27].

Boer x Mubende goats and Mubende goats had highly significant negative effect on worm infection while Boer goats exhibited significant negative effect on FEC, suggesting that different goat breeds exhibited varying levels of host resistance to worm infection. This is in line with previous reports by others (Makun *et al.*, 2008; Nsereko *et al.*, 2015) [28, 29].

Location (district) and flock size had highly significant negative effect, while age had significant negative effect on PCV values. This was attributed to variation in worm infection intensity on pasture caused by variation in temperature and rainfall in different locations and increasing worm egg shedding on pasture as flock size increases. Increasing severity in gastrointestinal nematode infection in goats manifests anaemia associated with lower PCV values. Younger goats with lower immunity to worm infection experienced higher worm burden and hence lower PCV values and anaemia. Goat infection with *Haemonchus contortus* has been reported to cause a significant reduction in the erythrocyte counts, haemoglobin concentrations and PCV values (Alam *et al.*, 2020) [30].

Most goats of either Mubende or Boer or Boer x Mubende crosses on the farms visited, were free from gastrointestinal nematode infections, suggesting regular worm control was being practised on the farms sampled. More pathogenic EPG of above 1000 was rare among Mubende goats and Boer x Mubende crosses, suggesting that Mubende goats and Boer x Mubende crosses had host resistance against gastrointestinal

nematode infection. A phenomenon described previously by others (Baker *et al.*, 2003; Kusiluka and Kambarage, 2006; Okwee-Acai *et al.*, 2010) [31, 32, 33]. However, at EPG higher than 1000, Boer goats could only be maintained healthy using regular worm control. Interestingly, Boer goats sampled did not have EPG of 1000 and above, suggesting regular worm control targeting the highly susceptible Boer goats was undertaken on farms visited.

Generally, Boer x Mubende crosses were more susceptible to worm infection than Mubende goats, given significantly higher FEC exhibited compared to their counterpart Mubende goats. This is in line with earlier reports (Nsereko *et al.*, 2015) [29]. Data suggested Mubende goats exhibited higher host resistance against gastrointestinal nematode infection than Boer goats. Indigenous East African goat breeds to which Mubende goats belong have been reported to be more tolerant to gastrointestinal nematode infection than the South African Boer goats (Baker *et al.*, 2003; Kusiluka and Kambarage, 2006; Okwee-Acai *et al.*, 2010) [31, 32, 33].

Female Boer x Mubende crosses had significantly higher mean FEC than female Boer goats. Boer x Mubende crosses younger than 1 year had significantly higher mean FEC than their Boer counterparts. Boer x Mubende crosses in Masaka district had significantly higher mean FEC than Boer goats. Boer x Mubende crosses from large flocks (>300) had significantly higher mean FEC than Boer goats. Independent of the level of flock management, whether good or poor, Boer x Mubende crosses had significantly higher mean FEC than Boer goats. The findings suggested Boer x Mubende goats exhibited higher host resistance against gastrointestinal nematode infection than Boer goats. Previous studies have reported Boer x Mubende goats to exhibit a response to gastrointestinal nematode infection comparable to indigenous Mubende goats in Uganda (Nsereko *et al.*, 2015) [29].

Boer x Mubende goats exhibited highly significant negative effect, while Mubende goats exhibited a significant positive effect on PCV values. PCV of 15% and below, normally denoting anaemic animals, were rare amongst Boer goats but limited among Mubende goats and Boer x Mubende crosses. Suggesting worm control was practised especially against clinical cases of gastrointestinal nematode infection amongst the goats in line with previous reports (Magona and Musisi, 2002) [6].

Generally, Mubende goats had significantly higher mean PCV values than Boer goats. Suggesting Mubende goats, an indigenous goat breed, had host resistance against gastrointestinal nematode infection (Gibson and Bishop, 2005; Nsereko *et al.*, 2015) [4, 29]. Host resistance allowed Mubende goats cope with gastrointestinal nematode infection. On contrast, Boer goats largely relied on good management and regular worm control for survival in the face of gastrointestinal nematode infection. Worm control hugely relies on anthelmintic treatment in Uganda (Magona and Musisi, 2002) [6].

Data suggested that Boer x Mubende crosses exhibited breed resistance to gastrointestinal nematode infection and better minimized associated anaemic effects. Contrastingly, Boer goats largely relied on less exposure to worm infection or good management and worm control to cope with anaemic conditions.

Mubende goats had significantly higher mean PCV values than Boer x Mubende crosses. Suggesting Mubende goats were less susceptible to gastrointestinal nematode infection and were more tolerant to the associated anaemic effects than Boer x Mubende crosses. This was attributed to the adaptation

gene of the Mubende goat (Sewannyana, Oluka, Masaba, 2004)^[3].

5. Conclusion

The increasing age of goats had a suppression effect on faecal worm egg counts. Different areas or districts had different worm infection intensity on pastures that dictated different levels of worm infection risk to the goats. The increasing size of goat flocks led to increasing worm egg shedding on pasture and increased faecal worm egg counts. Variation in age, area-based risk of infection, and flock size negatively affected PCV values.

Findings on faecal worm egg counts and PCV values suggested that Boer x Mubende goats were more susceptible to gastrointestinal nematode infection than Mubende goats. In turn, Boer x Mubende crosses and Mubende goats were less susceptible to gastrointestinal nematode infection than Boer goats. Follow-up studies are recommended to confirm the level of susceptibility among Mubende, Boer, and Boer x Mubende goats to gastrointestinal nematode infection under experimental conditions.

6. Acknowledgements

We thank Joseph Muboli and Patrick Odyek for their technical assistance. We thank Dr. Charles Peter Otim, the former Director of Livestock Health Research Institute, Tororo, Uganda for his support during the study. In addition, we thank the District Veterinary staff from Ssembabule, Mpigi, Masaka, and Mubende districts for their incredible support during the study.

7. References

- Baker RL, Audho JO, Aduda EO, Thorpe W. Genetic resistance to gastro-intestinal nematode parasites in Gala and small East African goats in the sub-humid tropics. *Animal Science*. 2001 Apr;73(1):61-70.
- Rege JEO. The state of African cattle genetic resources I. Classification framework and identification of threatened and extinct breeds. *Animal Genetic Resources Information*. 1999 Apr;25:1-25.
- Sewannyana E, Oluka J, Masaba JK. Growth and performance of indigenous and crossbred goats. *Uganda Journal of Agricultural Sciences*. 2004;9(1):537-42.
- Gibson JP, Bishop SC. Use of molecular markers to enhance resistance of livestock to disease: A global approach. *Revue Scientifique et technique (International Office of Epizootics)*. 2005 Apr 1;24(1):343-353.
- Okello KL, Obwolo MJ. Uganda: Review of the potentialities of goat production. *World Animal Review*. 1984;53:27-32.
- Magona JW, Musisi G. Influence of age, grazing system, season and agroclimatic zone on the prevalence and intensity of gastrointestinal strongylosis in Ugandan goats. *Small Ruminant Research*. 2002;44:187-192.
- Van Wyk JA, Malan FS. Resistance of field strains of *Haemonchus contortus* to ivermectin, closantel, rafoxanide and the benzimidazoles in South Africa. *Vet. Rec*. 1988;123:226-228.
<http://www.tropentag.de/2011/abstracts/full/1166.pdf>
- Waller P, Echevarria F, Eddi C, Macial S, Nari A, Hansen JW. The prevalence of anthelmintic resistance in nematode parasites of sheep in Southern Latin America: general overview. *Veterinary Parasitology*. 1996;62:181-187.
- Nsereko G, Emudong P, Magona JW, Odoch T, Okwee-Acai J. Anthelmintic efficacy of Albendazole, Levamisole and Ivermectin against gastrointestinal nematode (GIN) infections in goats on natural pastures in Gomba District, Uganda. *Uganda Journal of Agricultural Sciences*. 2013;14(1):75-85.
- Gall C. Goat production Academics Press, UK; c1981.
- Devandra C, Burns M. Goat production in the tropics, Farnham, UK. Commonwealth Agricultural Bureau, UK; c1983, p. 183.
- Mason IL, Maule JP. The indigenous livestock of Eastern and Southern Africa. Technical Communication No. 14 Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh, UK; c1960, p. 112-123.
- Sacker GD, Trail JCM. Production characteristics of a herd of East African Mubende goats. *Tropical Agriculture*. 1966;43:43-51.
- Jindall SK. Goat Production, Rosmo Publications, New Delhi; c1984, p. 61-225.
- Babigumira BM, Galukande E, Nakimbugwe H, Kifudde W, Semambo DNK. Comparison between Mubende and Boer x Mubende goat crosses based on biometric measurements and weight-for-age in Uganda, 2011. <https://www.tropentag.de/2011/abstracts/full/1166.pdf>
- Onzima R, Ahesibwe AR, Katali BK, Kanis E, van Arendonk JAM. Economic analysis of cross breeding programs for indigenous goat breeds in Uganda. *Proceedings, 10th World Congress on Genetics Applied to Livestock Production*. Vancouver, Canada, 17th-22nd, 2014.
- Thrusfield M. *Veterinary Epidemiology*. Second Edition, Blackwell Sciences Ltd; c1995.
- Hansen J, Perry B. The epidemiology, diagnosis and control of gastrointestinal parasites of ruminants in Africa. *International Livestock Centre for Africa*, Nairobi, Kenya; c1994. p. 121.
- Soulsby EJW. *Helminths Arthropods and protozoa of Domesticated Animals*, 7th edition. Lea and Febiger, Philadelphia, Bailliere, Tindall, London, UK; c1982. p. 212-258, 579-624, 765-766.
- Kaplan RM, Miller JE. Modified McMaster egg counting for quantification of nematode eggs; c2006. www.sheepandgoat.com/ACSRPC/Resources/PDF/modmcmaster.pdf
- Assoku RKG. Studies of parasitic helminths of sheep and goats in Ghana. *Bulletin of Animal Health and Production in African*. 1981;29(1):1-0.
- Sohail M, Nauman-ul-Islam M, Shah SSA, Shah IA, Raziq A, Khan MI. Incidence of gastrointestinal parasites in beetal goats at District Peshawar, Pakistan. *Advances in Animal and Veterinary Sciences*. 2017;5(5):205-7.
- Poddar PR, Begum N, Alim MA, Dey AR, Hossain MS, Labony SS. Prevalence of gastrointestinal helminths of sheep in Sherpur, Bangladesh. *Journal of Advanced Veterinary and Animal Research*. 2017;4(3):274-280.
- Ratanapob N, Arunvipas P, Kasemsuwan S, Phimpraphai W, Panneum S. Prevalence and risk factors for intestinal parasite infection in goats raised in Nakhom Pathom Province, Thailand. *Tropical Animal Health Production*. 2012 Apr;44(4):741-5.
- Kantzoura V, Kouam MK, Theodoropoulou H, Feidas H, Theodoropoulos G. Prevalence and Risk Factors of Gastrointestinal Parasitic Infections in Small Ruminants in the Greek Temperate Mediterranean Environment.

- Journal of Veterinary and Animal Science. 2012;2(1):25-33. <https://doi.org/10.4236/ojvm.2012.21005>.
26. Mushonga B, Habumugisha D, Kandiwa E, Madzingira O, Samkange A, Segwagwe BE, *et al.*, Prevalence of *Haemonchus contortus* infections in sheep and goats in Nyagatare District, Rwanda. *Hindawi Journal of Veterinary Medicine* 2018 (9). Article ID 3602081 <http://doi.org/10.1155/2018/3602081>.
 27. Namutosi W, Higienyi J, Elizabeth Kizito E, Omodo M. Prevalence and risk factors of gastrointestinal parasite infection in goats in Sironko district, Eastern Uganda. *International Journal of Veterinary Sciences and Animal Husbandry*. 2020;5(3):27-35.
 28. Makun HJ, Ajanusi JO, Lakpini CAM, Ehoche OW, Rekwt PI. Response of Red Sokoto and Sahelian goats to trickle *Haemonchus contortus* infection. *Journal of Biological Sciences*. 2008;8(4):753-759.
 29. Nsereko G, Emudong P, Mulindwa H, Okwee-Acai J. Prevalence of common gastro-intestinal nematode infections in commercial goat farms in Central Uganda. *Uganda Journal of Agricultural Sciences*. 2015;6(1):99-106.
 30. Rasha TM, Alam Eman AA, Hassanen Shefaa AM, El-Mandrawy. *Haemonchus contortus* infection in Sheep and Goats: alterations in haematological, biochemical, immunological, trace element and oxidative stress markers. *Journal of Applied Animal Research*. 2020;48(1):357-364. DOI: 10.1080/09712119.2020.1802281.
 31. Baker RL, Nagda S, Rodriguez-Zas SL, Southey BR, Audho JO, Aduda EO, *et al.* Resistance and resilience to gastrointestinal nematode parasites and relationships with productivity of Red Maasai, Dorper and Red Maasai' Dorper crossbred lambs in the sub-humid tropics. *British Society of Animal Science*. 2003 Feb;76(1):119-36.
 32. Kusiluka L, Kambarage D. Diseases of small ruminants: A handbook of common diseases of sheep and goats in Sub-Saharan Africa; c2006.
 33. Okwee-Acai J, Ssajjakambwe P, Okech SG, Agwai B, Ekakoro E, Acon J. Haemonchosis associated mortalities and treatment of severe anaemia by syringe infusion of blood in Boer goats in a model breeding farm in Lyantonde District. Uganda. *African Journal of Animal and Biomedical Sciences*. 2010;5(1):80-84.