American Journal of Biomedical Research, 2019, Vol. 7, No. 2, 44-50
Available online at http://pubs.sciepub.com/ajbr/7/2/4
Published by Science and Education Publishing
DOI:10.12691/ajbr-7-2-4

Haematological Parameters by Age and Sex of Asymptomatic Indigenous Cattle and Sheep Infected with Gastrointestinal Parasites in Kerio Valley, Kenya

E. C. Ngetich[1,2,*], M. Ngeiywa[2], G. M. Ng'wena[3], Chemwolo L.[4]

[1]Department of Biological and Biomedical Science, Laikipia University, P.O Box 1100, Nyahururu, Kenya
[2]Department of Biological Science, University of Eldoret, Box 1125, Eldoret, Kenya
[3]Department of Medical Physiology, Maseno University, Box 333, Maseno-Kenya
[4]University of Kabianga, Box 2030, Kericho- Kenya
*Corresponding author: engetich@laikipia.ac.ke

Received October 05, 2019; Revised November 11, 2019; Accepted December 24, 2019

Abstract Gastro-intestinal parasites are prevalent and directly impede livestock production causing impaired productivity. Haematological parameters, which are likely to be influenced by parasites, are generally indicators of healthy status in an animal. The effect of gastrointestinal infections on the health of indigenous cattle and sheep in semi-arid areas is still not clear. The objective of the present study was to determine the prevalence of gastrointestinal parasites in apparently healthy cattle and sheep kept under free-range management in upper Kerio Valley Kenya and determine any associations between intestinal parasite infections and haematological parameters. Blood and stool samples of 214 indigenous cattle and 82 sheep were evaluated. Haematological parameters from the parasite-infected and non-parasite livestock were compared. Analyses of lymphocytes, polymorphonuclear white blood cells, packed cell volume, red blood cell count and distribution width, white blood cell count (WBC) and platelet count were performed. *Strongyloides* and *Fasciola hepatica* species were the most frequently isolated. Overall, 37 (17.3%), 31 (14.5%) of cattle and 32 (39%), 8 (9.3%) of sheep faecal samples were positive for *Strongyloides* and *Fasciola hepatica* infections respectively. Haematological variations significantly ($p < 0.05$) existed for blood values (WBC, lymphocytes, monocytes, granulocytes, RBC, MCH, MCHC, RDW, PLT, and MPV) in sheep between those infected and those uninfected with intestinal parasites. In cattle, the white blood cell (WBC) (mean 15.10) and MPV (mean 8.9) were significantly higher compared with standard reference values (4-12 and 3.5-6.5, respectively). The blood parameters significantly lower ($p < .05$) in nematode infected sheep were monocytes, granulocytes, HGB and HCT while WBC, Lymphocytes, platelets and MPV were significantly ($p < .05$) elevated in infected compared with uninfected sheep. The finding of *Trichostrongyloides* species and trematode parasites among livestock in Kerio Valley is essential in understanding the epidemiology of gastrointestinal parasitic infection for better comprehensive treatment and control strategies. The changes in haematological values as observed in infected and non-infected livestock, can applied as an alternative means of diagnosis and understanding disease prognosis of animal disease and status. The haematological values reported in this study, can also serve as baseline information for selection of livestock that are genetically resistant to certain diseases and prevailing environmental conditions as found in Kerio Valley, Kenya.

Keywords: *indigenous livestock, haematological parameters, gastrointestinal parasites, Strongyloides, Fasciola, Kerio Valley, Kenya*

Cite This Article: E. C. Ngetich, M. Ngeiywa, G. M. Ng'wena, and Chemwolo L., "Haematological Parameters by Age and Sex of Asymptomatic Indigenous Cattle and Sheep Infected with Gastrointestinal Parasites in Kerio Valley, Kenya." *American Journal of Biomedical Research*, vol. 7, no. 2 (2019): 44-50. doi: 10.12691/ajbr-7-2-4.

1. Introduction

Livestock play an important role in many communities in terms of socio-economic development and contribute towards household food and nutritional security, especially among the rural communities [1]. Indigenous breeds are preferred by farmers living in semi-arid and arid areas due to their adaptability to water and food scarcity. The animals are heat tolerant and resistant to most common livestock diseases [2]. Gastrointestinal parasites present major threats to livestock production, especially in sub-Saharan African countries causing considerable economic impact due to high morbidity, high cost of treatment and loss of productivity [1,3]. The parasites have impacted negatively on livestock production particularly in East Africa where conditions for

intestinal parasites are favourable and risks posed by free-range type of management [1,4]. In addition, intestinal parasites infections affect nutrient absorption and water balance, thus leading into lower body composition, poor carcass quality and reduced animal performance [5,6,7,8].

Haematological parameters are components of blood; a connective tissue that act as a pathological reflector of the status of the health of an animal [9]. It has been reported that any changes in blood values are likely to be influenced by infection, nutrition or environment [10,11]. The most affected cell types in cases of parasite infections include red blood cells, white blood cells and thrombocytes, however, haematological changes may vary with levels of immunity, endemicity of diseases, nutritional status and demographic factors of the animal [9]. Therefore, the blood indices can be used as markers of the level of gastrointestinal parasite effects in asymptomatic indigenous cattle and sheep in semi-arid areas of Kenya. *Fasciola* species for instance feed on blood thus affecting haematological profiles of affected animals, which may result in anaemia [12]. Isaac showed that animals with good and normal blood composition are likely to exhibit good production performance [13]. Haematological profiles are also linked to the environment, and thus they can be used in the selection of animals that are genetically resistant to certain diseases under prevailing environmental conditions [9,11,13].

Although understanding haematological parameters is very critical in the management of livestock health and production [9,11,12,14] limited data is available on indigenous livestock reared in semi-arid areas such as Kerio valley, Kenya. The main aim of the present study was to establish the blood parameter status for indigenous livestock and alterations that may arise as a result of gastrointestinal parasite infection. Haematological parameters including differential white blood cell counts, red blood cell counts, haemoglobin concentration, haematocrit, red cell distribution width, haemoglobin cell volume, haemoglobin corpuscular volume and platelet numbers were compared in gastrointestinal infected and non-infected cattle and sheep from a semiarid areas of the Kerio valley.

2. Material and Methods

2.1. Study Site

The study was carried out in upper Kerio Valley in Elgeiyo-Marakwet County, Kenya between 2016 and 2017. The valley lies between 1000m and 1200m above sea level and it is covered by dry thorn bushes. Annual mean temperatures of 24^{o}C is experienced and rainfall between 1000mm and 1400mm. Most people living in Kerio Valley of Keiyo North and South Sub Counties are peasant farmers practicing small-scale farming and livestock raring while most farmers in Marakwet East and West Sub Counties are purely pastoralists. Livestock are grazed extensively in communal land except in some sections in Keiyo South Sub-County where animals are grazed on paddocked individual farms. Management of livestock in upper Kerio valley involves free range grazing and livestock are only kept in temporary stables at night. The livestock samples were collected from six areas namely Chesongoch, Tot, Kabulwo, Chesetan, Chemoibon and Kaptomonger. These study sites are located in the upper Kerio Valley of Elgeiyo-Marakwet County, Kenya.

2.2. Study Design

Cross-sectional study design was used which involved multistage stratified sampling method to select the study clusters. In each study area, households were randomly selected.

2.3. Collection of Samples

The investigations were performed on blood and stool whereby the samples were collected from every second animal from the order in which they aligned in a crush. In total, 214 cattle and 82 sheep were used for the study. At the time of sample collection, all the included animals apparently appeared asymptomatic. The cattle were restrained in a crush pen and sheep in a barn during sample collection.

Five millilitres (5ml) of jugular venous blood samples were collected using disposable hypodermic syringes and needles into well-labelled Ethylene Diamine Tetra-acetic Acid (EDTA) coated tubes for haematological analysis. After collection, the blood were kept in cooler box containing ice bottles and then transported to the laboratory for analyses.

2.3.1. Faecal Sample Collection and Analysis

Faecal samples were collected from the animals' rectum using sterile disposable gloves per animal into clean polypots to prevent cross contamination. The containers were sealed and then labelled with proper identification. In the laboratory, formol-ether concentration method was used to prepare and identify helminths and protozoan eggs/oocysts/cysts, which were confirmed by identification keys as per established protocols [15].

2.3.2. Evaluation of Haematological Parameters

Haematological parameters were analyzed using automated haematology analyser (BCC-3600-Duruy-South Korea) in which leukocyte counts, erythrocyte counts, haemoglobin concentration (Hb), haematocrit (HCT/PCV), mean corpuscular volume haemoglobin (MCH), Mean cell volume (MCV) Mean cell haemoglobin Hb concentration (MCHC), Platelet count (PLT), Red cell distribution width (RDW) and leukocyte differential counts were measured.

2.4. Data Analysis

Data was entered into Microsoft excel and later analysed using Stata version 12 software. Haematological profiles were expressed as means ± standard deviation. The student T-test was used to determine the differences between the haematological profiles of intestinal parasite-infected and uninfected livestock. Multiple correspondence analysis (MCA) was conducted to determine the relationship between gastrointestinal parasites in the livestock in relation to sex, age and their location. The values of $P \leq 0.05$ were considered significant.

2.5. Research Approval

This study was approved by the National Commission of Science Technology and Innovation (NACOSTI). The project was reviewed and approved by the University of Eastern Africa, Baraton ethical review committee. Permission to carry out research in upper Kerio valley was also received from Elgeyo-Marakwet County Animal health &Veterinary Department and the livestock owners.

3. Results

3.1. Intestinal Parasite Prevalence

Parasites found in faecal samples of cattle comprised of protozoa and helminths including nematodes, trematodes and cestodes (Figure 1). During the study period, overall prevalence with helminthoses was 54.7%, nematodes 35%, trematodes 32.2%, cestodes 16.4% and coccidian 7.9%. In sheep, 59.8% were infected different gastrointestinal helminths, 56% (nematodes) and coccidia were 8.5% Figure 2.

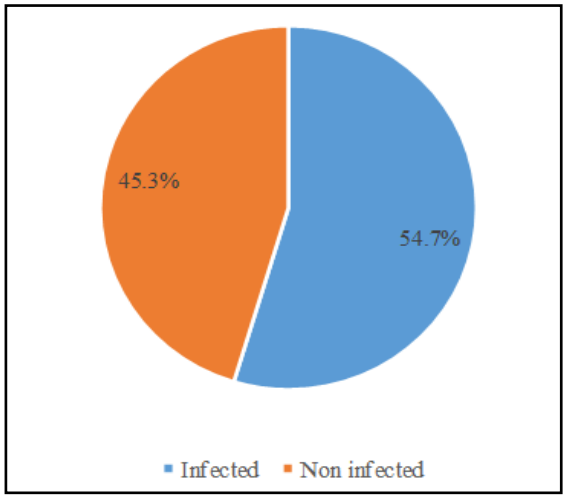

Figure 1. Percentage prevalence of gastrointestinal parasites in asymptomatic indigenous cattle

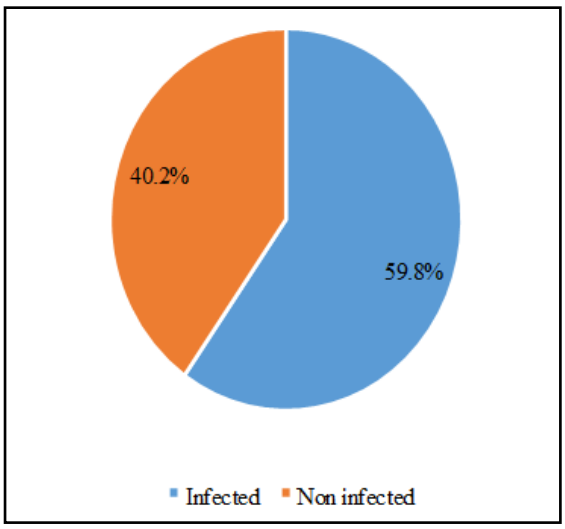

Figure 2. Percentage prevalence of gastrointestinal parasites in asymptomatic indigenous sheep

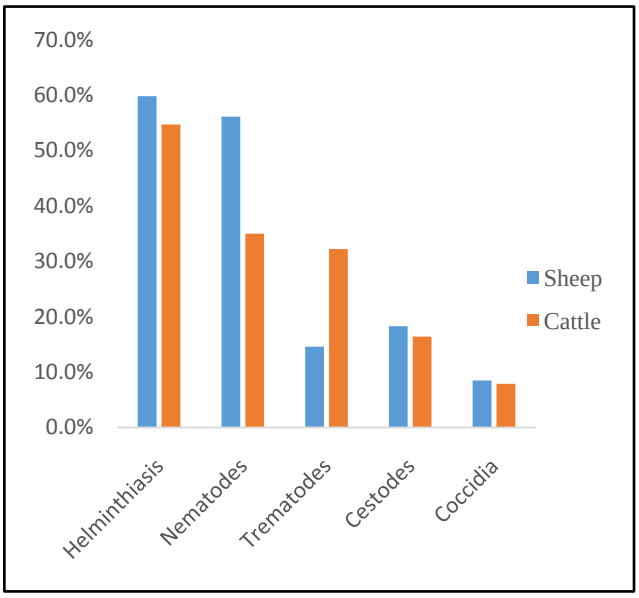

Figure 3. Prevalence of gastrointestinal parasites in cattle and sheep

Table 1. Nematode parasites prevalence in cattle

Nematodes (genera)	No. of Infected Cattle (N= 214)	Percentage prevalence	No. of Infected sheep (N= 82)	Percentage prevalence
Trichostrongylous	7	3.3%	7	8.5%
Strongyloides	37	17.3%	32	39%
Ascaris	25	11.7%	11	13.4%
Bunostomum	24	11.2%	-	-
Heamonchus contortus	3	1.4%	-	-
Ancylostoma caninum	-	-	23	28.1%
Trichuris	-	-	2	2.4%

Table 2. Prevalence of intestinal trematode and cestode parasites in cattle and sheep

	Cattle (N=214)	Prevalence	Sheep (N=82)	Prevalence
Fasciola hepatica	31	14.5%	8	9.3%
Schistosoma indicum	29	13.6%	4	1.3%
D canninum	4	4.2%	-	-
S. bovis	15	7%	1	0.2%
Dricoccelium dendriticum	2	0.9%	-	-
Ornithobilhazia turkestanicum	1	0.5%	-	-
Monieza hexpansa	1	0.5%	-	-
Avetellina centripunctata	29	13.6%	-	-
Hymenolepis sp	13	6%	14	17%

A multiple correspondence analysis (MCA) conducted to determine gastrointestinal parasites in cattle in relation to sex, age and location showed that helminth and protozoan infections occurred more in Kabulwo, Chemoibon and Kaptomonger sites affecting mostly adult livestock. The sex of cattle did not significantly appear to influence parasite prevalence. The eggs of nematode species detected were Trichostrongyles, which comprised of several genera including *Bunostomum (11.2%), Haemonchus (1.4%), Strongyloides (17.3%)* and *Trichostrongylus* (3.3%) species. *Trichuris ovina, Cooperia pectinita, Chabertia ovina, Oesophagustumum columbianum, Ostertagia circumcincta, Toxoscaris Leonina, neoascaris vitulorum Skijahinema ovis, Gongylomena pulchrom,* and *Physaloptera canis (<1%)* were among intestinal nematodes that were also observed as shown in Table 1.

Fasciola hepatica was predominant trematode infection in both cattle and sheep. *Avetellina centripunctata* and *Hymenolepis nana* was among the tapeworms identified in livestock (Table 2).

3.2. Haematological Parameters

Haematological changes in livestock were investigated according to whether the animal was infected or uninfected by internal parasites and also in comparison with normal standard Reference values (Merck's' Veterinary Manual, 2012).

3.2.1. Parasites Infection and Haematological Parameters in Cattle

White blood cells, and lymphocytes were higher in the infected (15.15±0.97) than the uninfected (14.9±1.39) cattle while the monocytes (8.2±1.5; 11.58±2.42), RBC (6.06±0.11; 6.12±0.14), HGB (9.66±0.14; 9.79±0.19), MCH (16.32±0.3; 17.07±0.83) and platelet counts (238.55±21.73; 254.69±24.89) were lower in infected than uninfected animals respectively but they were not significant ($p<0.05$). However, these blood values did not differ significantly between the infected and uninfected cattle. In addition, only two parameters, WBC (mean 15.10) and MPV (mean 8.9) were significantly higher in cattle in the study compared with standard reference values (4-12 and 3.5-6.5, respectively) as shown in Table 3.

Tapeworms did not significantly affect haematological parameters in cattle neither did intestinal protozoa have significant ($p > 0.05$) effect on blood values.

3.2.2. Effects of Parasite Infection on Haematological Parameters in Sheep

Evaluation of blood parameters and parasite infections using independent sample *T*-tests showed that ten parameters were significantly different in infected and uninfected sheep (at $p \leq 0.05$). Six blood indices; WBC, $t(80) = -3.32$, $p=.001$; lymphocytes, $t(80) = -3.09$, $p=.003$; MCH, $t(80) = -2.23$, $p = .029$; MCHC, $t(80) = -2.42$, $p = .018$; PLT, $t(66.89) = -3.35$, $p=.001$; and MPV, $t(80) = -2.12$, $p = .038$ were significantly higher ($p < 0.05$) in infected sheep relative to the uninfected animals. On the other hand, monocyte, $t(80) = 2.39$, $p = .021$; granulocyte, $t\ (80) = 3.04$, $p = .004$; RBC, $t\ (47.55) = 2.41$, $p = .018$; and RDW, $t(80) = 2.92$, $p = 0.005$ were significantly greater in uninfected sheep compared with infected ones (Table 4).

Table 3. Haematological parameters in comparison with helminth infection in cattle and normal Reference ranges

Parameter (n=214)	Overall			Infected	Uninfected	Reference range
	Mean±SEM	95% CI		Mean ± SEM	Mean ± SEM	
WBC (10e3/ul)	15.10±0.80	12.04	14.56	15.15±.97[a]	14.9± 1.39[a]	4-12[b]
Lymphocytes (%)	55.31±1.5	52.29	58.33	56.59±1.88[a]	53.37±2.55[a]	45-75[a]
Monocytes (%)	9.56±1.3	6.95	12.17	8.20±1.50[a]	11.58±2.42[a]	0-8[a]
Granulocytes (%)	13.67±2.4	8.94	18.40			
RBC (10e3/ul)	6.09±0.08	5.96	6.30	6.06±0.11[a]	6.12±0.14[a]	5-10[a]
HGB (g/dL)	9.72±0.11	9.54	9.99	9.66±0.14[a]	9.79±0.19[a]	8-15[a]
HCT (%)	27.50±0.57	26.66	29.12	27.68±0.83[a]	27.08±0.63[a]	24-46[a]
MCV (fl)	44.37±0.34	43.90	45.25	44.31±0.42[a]	44.44±0.49[a]	40-60[a]
MCH (pg)	16.61±0.40	15.76	17.32	16.32±0.30[a]	17.07±0.83[a]	11-17[a]
PLT (10e3/uL)	245.73±17.2	210.7	278.60	238.55±21.73[a]	254.69±24.89[a]	100-800[a]
MPV (fL)	8.9±0.40	8.17	9.76	9.31±0.54[a]	8.42±0.26[a]	3.5-6.5[b]

Different superscripted letters a, b and c denote a significant difference ($p<0.05$)
Key: WBC- white blood cells; RBC – red blood cells; HGB; HCT – haematocrit; MCV – mean corpuscular volume, MCH- mean corpuscular volume haemoglobin, PLT- platelets, MPV- mean platelet volume.

Table 4. Haematological parameters in sheep

Parameter (n=84)	**Overall**			**Infected**	**Uninfected**	**Reference range**
	Mean±SEM	95% CI		Mean ± SEM	Mean ± SEM	
WBC (10e3/ul)	69.56±5.71	58.19	80.94	83.15±6.62[a]	46.01±9.24[b]	4-8[c]
Lymp (%)	72.07±3.83	64.35	79.78	80.76±4.20[a]	58.34±6.24[b]	40-55[b]
Monocytes (%)	14.65±2.10	10.41	18.88	10.81±2.47[a]	20.70±3.40[b]	0-6[a]
Gran (%)	7.56±0.89	5.75	9.37	5.54±0.93[a]	10.73±1.55[b]	
RBC (10e3/ul)	7.57±0.35	6.85	8.29	6.93±0.38[a]	8.68±0.68[b]	9-15[b]
HGB (g/dL)	10.45±0.23	9.99	10.91	10.19±0.24[a]	10.91±0.47[a]	9-15[a]
HCT (%)	26.91±1.49	23.94	29.88	25.08±1.90[a]	30.07±2.33[a]	
MCV (fl)	34.34±0.21	33.94	34.75	34.09±0.21[a]	34.77±0.43[a]	28-40[a]
MCH (pg)	15.053±0.42	14.19	15.90	15.75±0.52[a]	13.82±0.71[b]	8-12[c]
MCHC	44.08±1.33	41.41	46.74	46.47±1.63[a]	39.93±2.15[b]	31-34[c]
RDW	11.80±0.33	11.20	12.41	11.16±0.26[a]	12.92±0.65[b]	
PLT (10e3/uL)	1600.1±209.	1181.7	2018.6	2101.8±302.9[a]	873.6±207.2[b]	800-1100[b]
MPV (fL)	12.74±1.05	10.65	14.83	14.55±1.64[a]	10.13±0.74[b]	

Different superscripted letters a, b and c denote a significant difference ($p<0.05$).

Comparison of blood values between infected or uninfected sheep with standard reference values using one-sample t-tests showed that WBC, MCH and MCHC were significantly higher ($p<0.05$) in sheep of the present study compared to the normal standard values. Lymphocytes, PLT, and MPV were significantly higher in infected sheep relative to reference values but these parameters were not significantly different between uninfected sheep and the reference values. Monocytes were significantly higher in uninfected sheep compared with either infected or standard values.

3.2.3. Effect of Nematode, Trematode, Cestode and Coccidia Parasites on Haematological Parameters

Infection with nematodes in sheep elevated WBC, lymphocytes, MCH, MCHC, PLT and MPV while monocytes, granulocytes, RBC, HGB, HCT were lowered ($p<0.005$) as shown in Table 5. However, in cattle only monocytes ($p= 0.008$) were significantly lower in infected animals.

Trematode infection on the other hand only lowered monocytes ($p = 0.02$) in sheep but in cattle, WBC and lymphocytes were significantly higher ($p<0.05$) while monocytes, granulocytes, HCT were lowered in infected cattle than those uninfected ($p < 0.05$) (Table 6).

Cestodes did not significantly affect haematological values in sheep but WBC and PLT ($p < 0.005$) were elevated. However, intestinal protozoan infection did not make any difference in infected or uninfected cattle but had significant effects on some of the blood values in sheep as shown in Table 7.

Table 5. Effect of nematode parasites on haematological parameters in sheep

Parameter (n=82)	Not infected (n=34)			Infected (n=48)			p value
	Mean±SEM	95% CI		Mean ± SEM	95% CI		
WBC (10e3/ul)	51.73±8.83	33.77	69.69	82.19±7.02	68.07	96.31	**0.008**
Lymp (%)	60.14±6.18	47.20	73.09	80.29±4.33	71.41	89.17	**0.008**
Monocytes (%)	19.93±3.34	12.93	26.93	11,01±2.54	5.80	16.21	**0.036**
Gran (%)	9.88±1.49	6.76	13.00	5.96±1.04	3.83	8.09	**0.031**
RBC (10e3/ul)	8.46±0.61	7.22	9.71	6.94±0.41	7.22	7.77	0.17
HGB (g/dL)	10.83±0.42	9.97	11.68	10.18±0.25	9.68	10.69	**0.04**
HCT (%)	29.42±2.10	25.15	33.68	25.13±2.05	21.00	29.26	**0.000**
MCV (fl)	34.85±0.39	34.05	35.64	34.00±0.20	33.58	34.39	0.16
MCH (pg)	14.04±0.72	12.58	15.50	15.76±0.51	14.73	16.78	**0.04**
MCHC	40.54±2.18	36.10	44.98	46.598±1.61	43.34	49.82	**0.03**
PLT (10e3/uL)	912.1±196.6	511.1	2814.9	2164.8±321.17	1514.6	2814.9	**0.001**
MPV (fL)	10.41±0.72	8.94	11.88	14.66±1.77	11.08	18.23	**0.04**

Values in bold show significant difference ($p < 0.05$).

Table 6. Effect of trematode infections on haematological parameters of cattle

Parameter (n=216)	Not infected (n=147)			Infected (n=69)			p value
	Mean±SEM	95% CI		Mean ± SEM	95% CI		
WBC (10e3/ul)	13.75±0.91	11.95	15.56	18.05±1.57	14.91	21.19	**0.01**
Lymp (%)	53.10±1.94	49.26	56.94	59.95±2.37	55.22	64.68	**0.04**
Monocytes (%)	11.89±1.87	8.18	15.60	4.59±0.76	3.08	6.11	**0.000**
Gran (%)	16.62±3.42	9.85	23.39	7.43±1.46	4.50	10.36	**0.02**
RBC (10e3/ul)	6.16±0.11	5.93	6.38	5.97±0.11	5.75	6.19	0.25
HGB (g/dL)	9.785±0.15	9.55	10.14	9.48±0.16	9.15	9.81	0.13
HCT (%)	28.35±0.80	26.76	29.94	25.80±0.50	24.79	26.81	**0.04**
MCV (fl)	44.79±0.40	43.99	45.58	43.54±0.56	42.43	44.65	0.08
MCH (pg)	16.90±0.53	15.85	17.95	15.99±0.17	15.65	16.32	0.24
MCHC	37.16±0.87	35.44	38.87	37.07±0.39	36.29	37.86	0.95
PLT (10e3/uL)	255.3±19.3	217.2	293.5	227.3±32.23	162.95	291.6	0.43
MPV (fL)	8.58±0.20	8.18	8.98	9.82±1.04	7.75	11.89	0.24

Values in bold show significant difference ($p < 0.05$).

Table 7. Haematological values in sheep infected or not infected with Coccidia

Parameter (n=82)	Not infected (n=56)			Infected (n=26)			p value
	Mean±SEM	95% CI		Mean ± SEM	95% CI		
WBC (10e3/ul)	59.05±7.03	44.96	73.15	92.20±8.34	75.02	109.4	**0.004**
Lymp (%)	66.16±4.63	56.78	75.55	90.27±2.50	84.77	95.76	**0.000**
Monocytes (%)	17.48±2.58	12.24	22.72	5.91±1.60	2.40	9.41	**0.000**
Granu (%)	8.95±1.09	6.74	11.17	3.26±0.44	2.29	4.23	**0.005**
RBC (10e3/ul)	8.29±0.48	7.32	9.26	6.02±0.26	5.48	6.56	**0.000**
HGB (g/dL)	10.92±0.30	10.33	11.51	9.44±0.26	8.91	9.97	**0.002**
HCT (%)	29.92±2.02	25.87	33.96	20.43±0.98	18.40	22.46	**0.000**
MCV (fl)	34.60±0.28	34.04	35.15	33.80±0.21	33.36	3423	0.07
MCH (pg)	14.49±051	13.47	15.52	16.23±0.74	14.71	17.75	0.06
MCHC	42.10±1.59	38.93	45.28	48.33±2.32	43.56	53.10	**0.03**
PLT (10e3/uL)	1229.1±238	751.4	11706.9	2615.6±350	1880.5	3350	**0.003**
MPV (fL)	11.84±1.41	9.02	14.66	15.23±0.42	14.35	16.11	**0.024**

Values in bold show significant difference ($p < 0.05$).

4. Discussion

Indigenous and local breeds of livestock kept under communal or free range in Kerio Valley, Kenya, are infected with various internal parasites. The nematodes that affect the cattle and sheep are mostly *Trichostrongylous, Strongyloides, Ascaris, Bunostomum, Enterobius* and *Avitellina species*. Among the less common nematode infections included *Haemonchus, Toxocaris, Ostergia, Acutellina, Coopera, and Oesophagystumum* species among others. *Trichostrongyles* are the most common nematodes diagnosed on faecal flotation of ruminants. Kenya agricultural institute (KARI, 1999 and *Odoi et al.*, (2007), reported similar findings in studies that were conducted on livestock in parts of Kenya [16, 17]. *Strongyloides* were shown to be the most abundant parasites occurring in cattle and sheep with 17.3% and 39% prevalence respectively. The prevalence of *Heamonchus contortus* in the study area was apparently very low contrary to what was suggested that it a common nematode infection of livestock under nomadic management of arid areas of Kenya [18, 19], this could probably be due to high level of resistance in these livestock. The presence of dog helminth parasites such as *D. canninum* and *Toxocaris* in ruminants revealed a problem of cross contamination of pastures by dog faeces or possibly due to close association between communities living in Kerio valley, their animals and dogs that predispose livestock to canine parasites.

Trematode species observed were *Fasciola, Schistosoma* and *Dicrocoelum* species. Of the three genera, *Fasciola hepatica* was most prevalent in cattle than in sheep probably reflecting on greater exposure while grazing in wider and distant grazing fields than the sheep. The presence of trematode parasites has previously been associated with high rainfall and poor drained soils, which favour survival of snail intermediate hosts [20]. In the current study, although not tested, trematode infections within the semi-arid conditions could be associated with the presence and proximity of Kerio River and its tributaries that provide constant wetlands and flooding during the rainy seasons, providing important habitats which favour survival for *Lymnea* snails. This in effect may potentially cause economic losses, depressed growth rates and liver condemnation at slaughter houses [12].

The overall prevalence of gastrointestinal helminths with 54.7% and 59.8% in cattle and sheep respectively, corroborates with other findings from previous work [18,21]. The presence of cestode eggs (*D. canninum, Taenia* species and *Hymenolepis diminuta*) in faecal samples of goats and cattle was surprising. Since the *Hymenolepis diminuta's* eggs were detected in the study population, having its natural host to be rats [15], it extrapolated the impact of forage and animal feed contamination with infected rodent faeces. The presence of *Taenid* eggs on the other hand could be due to poor sanitary conditions and high temperatures, which favour zoonotic infection [22]. The high prevalence and wide variety of gastrointestinal helminths may have a negative health impact on livestock that occur through subclinical effect on production of the animals and a good predictor of pasture contamination.

The study has confirmed alterations of haematological parameters by internal parasites, which is in agreement with previous work [1]. Although the results showed the haematological profiles from apparently healthy livestock varied from the standard references blood values [25, they did not differ significantly except for platelet counts (PLT) and white blood cell (WBC) counts. As reported by Conradie and others [1], significant high WBC counts observed, than standard reference values evidently shows that the livestock kept in Kerio valley are capable of generating antibodies in the process of phagocytosis and also have a high degree of resistance to diseases. This feature makes these livestock adaptable to prevailing harsh environmental conditions and provide rapid and effective defence to infectious pathogens as earlier reported in previous studies [11].

There was significant ($p < 0.05$) reduction in RBC, RDW and higher values of WBC, lymphocytes and PLT in infected sheep. This can be attributed to disruption of erythrocytes by feeding habits of the parasites [9] and as expected, elevation of defence cells such as WBC and lymphocytes was in attempt of the immune system to defend the host against infections. However, mean blood values compared favourably between infected and uninfected cattle, only WBC (15.1±0.8) were significantly higher ($p < 0.05$) than the normal standard values (4-12). This peculiar observation could be attributed to compensatory responses induced by cattle kept in Kerio valley that restore haematological levels probably due to endemicity of parasites where animals are equally and continuously exposed to them [9,24].

The present study, reports infection with helminths or protozoa generally lowered monocytes, granulocytes, RBC, haemoglobin (HGB) and packed cell volume (HCT). Reduction in RBC, HGB and HCT were expected in parasitic infection due to lysis of red blood cells [25]. This is exacerbated by blood-sucking adult worms, destruction by protozoan parasites and bleeding from epithelial layers through replication and development of parasitic protozoa [15]. Similar findings were documented by Esmaeilnejad and others [26] on the contribution of parasitic infections to anaemia. In determination on the effect of individual classes of gastrointestinal parasite on haematological parameters, those of nematode-infected sheep appeared to be most affected than that of cattle (Table 5). This correlated with high prevalence with *Strongyloides sp* and *Ancylostoma sp* which are known to be blood feeders [15]. Previous studies reported sheep to be more susceptible to nematodes compared to goats and tend to shed high level of egg output, which relates to nematode intensity [27]. Trematodes on the other hand significantly lowered monocytes levels in sheep, but WBC, HCT, lymphocytes, monocytes and granulocytes were altered. The results were similar to those found by Egbu and others [12], which could be attributed to chronic liver inflammation and blood loss as a result of fluke infestation of liver tissues. The changes in these blood indices thus, can be utilized as diagnostic predictors of gastrointestinal parasites in addition to other diagnostic techniques. The presence of outlier blood values in healthy animals may simply be as a result of management practices, nutritional provisions, genetics or environment in which the animals are kept and not been majorly due to parasitic infections.

5. Conclusion

Despite the presence of gastrointestinal parasites, there were no obvious observable clinical symptoms in cattle and sheep, suggesting that most parasitic infections in indigenous breeds of livestock in Kerio valley are generally subclinical and not life threatening. Since livestock were generally asymptomatic, it implies that these animals might continue to be source of infections and continuously contaminate the environment. Furthermore, helminthoses can affect the productive indexes of livestock and some animal parasites have potential zoonotic effects on humans in the long run. Infections with intestinal parasites produce significant changes of haematological parameters in cattle and sheep in this study and most affected blood values are white blood cell counts, red blood cell counts, HCT, HGB, monocytes and platelets. Haematological parameters therefore can serve to provide important data useful in critical decision making on livestock management and breeding programs. There is need to evaluate season, nutrition, management-related haematological changes for indigenous livestock in semi-arid areas to determine their effects on blood values. Further work is also required to investigate intensity of gastrointestinal parasites so as to determine the levels of infections in order to allow comparison with other studies, inform control strategies and selection of resistant traits in livestock.

Acknowledgements

NACOSTI- KENYA granted funds for research and University of Eastern African, Baraton granted us the ethical clearance to do research. We appreciate Regional Veterinary laboratory Eldoret led by Job, Nakuru and University of Eldoret biological Sciences laboratory led by J. Koech and C. Meshack. Mr G Wanyonyi and Mr B. Chesoo who gave technical assistance. Special gratitude for the veterinary assistance provided by Dr Kangogo, Dr. Kolitiang, Dr. Biwott among others during data collection.

References

[1] Conradie van Wyk, C. I., Gordard, A., Bronsvoort, B. d., & et al., e. (2013). Haematological profile of East African Short-Horn Zebu Calves from birth to 51 weeks of Age. *Comparative Clinical Pathology*, 2012, (22), 1029-1036.

[2] Mwacharo, J., & Drucker, A. (2005) Production objectives and management strategies of livestock keepers in South-East Kenya: implications for a breeding programme. *Tropical Animal Health and Production*, (37), 635-652.

[3] Kebede, B., Sori, T. and Kumssa, B., (2016). Review on Current Status of Vaccines against Parasitic Diseases of Animals, *Journal of Veterinary Science and Technology*, (7), 327-330.

[4] Shah, S.S.A., Khan, M.L., Rahman, H.U., (2017). Epidemiological and hematological investigations of tick-borne diseases in small ruminants in Peshawar and Khyber Agency, Pakistan. *Journal of Advanced Parasitololgy, 4* (1), 15-22.

[5] Fox, M., (1993). Pathophysiology of *Ostertagia ostertagi* in cattle. *Veterinary Parasitology*, 46-143.

[6] Gasbarre, L., (1997). Effects of gastrointestinal nematode infection on ruminant immune system. *Veterinary Parasitology*, (72), 327-343.

[7] Government of Kenya, (2010). *National Climate Change Response Strategy.*

[8] Bradan, I., Abuamsha, R., Aref, R., Alqisi, W., Alumor, J., (2012). Prevalence and diversity of gastrointestinal parasites in small ruminants under two different rearing systems in Jenin district of Palestine. *An-Najah University Journal. Research*, (26), 1-18.

[9] Etim, N. N., Williams, M. E., Akpabio, & and Offiong, E., (2014). Haematological parameters and factors affecting their values. *Agricultural Science*, (1), 37-47.

[10] Khan, T. A., and Zafar, F. (2005). Haematological study in response to varying doses of estrogen in broiler chicken. *International Journal of Poultry Science*, 4(10): 7-11.

[11] Kubkomawa, I. H., Tizhe, M. A., Emenalom, O. O., & Okoli, I. C. (2015). Handling, reference value and usefulness of blood biochemical of indigenous pastoral cattle in tropical Africa : A review. *Dynamic Journal of Animal Science and Technology*, *1*(2), 18-27.

[12] Egbu, F. M. (20`3). Haematological changes due to bovine fascioliasis. *African Biotechnology*, 1829-1833.

[13] Isaac, L. J., Abah, G., Akpan, B., & Ekaette, I. U. (2013). *Haematological properties of different breeds and sexes of rabbits* (pp. 24-27). Proceedings of the 18th annual conference of Animal Science Association of Nigeria.

[14] Onasanya, G. O., Oke, F. O., Sanni, T. M., & Muhammad, A. I. (2015). Parameters Influencing Haematological, Serum and Bio-Chemical References in Livestock Animals under Different Management Systems. *Open Journal of Veterinary Medicine*, *5*(August), 181-189.

[15] Gunn, A., & Pitt, J., *Parasitology; An Integrated Approach.* West Sussex: Wiley-Blackwell, 2012

[16] Department for International Develoment-KARI (1999). Integrated Helminth Control. *KARI technical note,* (2), p. 54

[17] Odoi, A., Gathuma, J. M., Gachuiri, C. K., & Omore, A. (2007). Risk factors of gastrointestinal nematode parasite infections in small ruminants kept in smallholder mixed farms in Kenya. *BMC Veterinary Research*, *3*(1).

[18] Waruiru, R., Kyvsgaard, N., & Thamsborg, S. (2000). Prevalence and Intensity of Helminths infections in Dairy Cattle in Central Kenya. *Veterinary Research Communications*, (24*)*, 39-53.

[19] Nganga, C. J., Maingi, N., Kanyari, P. W. N., & Munyua, W. K. (2004). Development, Survival and Availability of Gastrointestinal Nematodes of Sheep on Pastures in a Semi-arid Area of Kajiado District of Kenya. *Veterinary Research Communications*, (28), 491-501.

[20] Jacobs, D. F., Gibbons, L., & Hermosilla, C. (2016). *Principles of Veterinary Parasitology.* Oxford, UK: WILEY Blackwell.

[21] Tulu, D., & Lelisa, K. (2016). A study on Major gastrointestinal helminth parasites of cattle in Tulo District, West Hararghe Zone, South-Eastern Ethiopia. *Austin Journal of Veterinary Science and Animal Husbandry*, 3(2), 3-6.

[22] Hendrix, C. M., & Robinson, E. (2006). *Diagnostic Parasitology for Veterinary Technician.* Mosby Elsevier Inc.

[23] Merck Manual; *Haematologic Reference Ranges.* (2012). Retrieved Dec 2015 from Merck Veterinary Manual: HYPERLINK "http://www.merckmanuals.com/" http://www.merckmanuals.com/.

[24] Ng'wena, M. G., Mwaniki, D. M., Chemwolo, L. K. and Ndiema. M. (2011). Effects of *T. Congolense* Infection on Hematological Indices, Liver , Spleen and Lymph nodes of Male Goats from Kerio Valley District ... *Journal of Agriculture, Pure and Applied Science and Technology*, *9*(March), 1-15.

[25] Jatau, I. D., Abdulganiyu, A., Lawal, A. I., Okubanjo, O. O., Yusuf, K. H. (2011). Gastrointestinal and haemoparasitism of sheep and goats at slaughter in Kano, Northern-Nigeria. *Sokoto Journal of Veterinary Sciences*, 9(1): 7-11.

[26] Esmaeilnejad, B., Tavassoli, M., & Asrirezaei, S. (2009). Investigation of hematological and biochemical parameters in small ruminants naturally infected with *Babesia ovis*. *Veterinary Research Forum*, *3*(September), 31-36.

[27] Chartier, C., Paraud, C. (2012). Coccidiosis due to *Eimeria* in Sheep and Goats, a review. *Small Ruminant Research* (103), 84-92.

© The Author(s) 2019. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).