

Original Research Article

Prevalence and Intensity of Gastrointestinal Parasites of Goats in Belo Sub Division, Boyo Division, North West Region of Cameroon

Comment [M1]: Gastrointestinal parasitic infestation is more accurate

ABSTRACT

Background: Goats are one of the oldest domesticated animals by man, about 10000 years ago, increases economic wellbeing of the rural populations Worldwide. Goats provide milk, meat, fiber and are also companion pets. They are easy to rear though production is affected by environmental conditions and parasitism.

Objectives. : A study was conducted in Belo Sub Division from July 2016 to October 2016 with the main objective to investigate the prevalence and intensity of gastrointestinal (GI) parasitic infections in goats. The specific objectives., to identify gastrointestinal parasites of goats and evaluate their intensity., to determine if prevalence and intensity is influenced by either age or sex., to evaluate the effects of the type of management systems on the prevalence and intensity of gastrointestinal parasites and to determine if prevalence and intensity is influenced by locality.

Comment [M2]: Not specific. Please specify

Materials and Methods : A total of 499 fecal samples were randomly collected directly from the recta of 499 goats in six villages and analyzed for the detection of any parasitic ova or oocysts using standard saturated sodium chloride flotation technique, while fecal egg/oocyst count were estimated using the modified McMaster technique.

Comment [M3]: Shortly described about EPG

Results : The study found that all 499 goats with a mean EPG value of $494,3 \pm 374,8$ were found to harbor at least two gastrointestinal parasites. The prevalence and intensity of various parasites encountered respectively were: *Eimeria spp* (86%), ($455,2 \pm 400,8$), *Haemonchus spp* (74,5%), ($1282,9 \pm 1244,4$), *Toxocara spp* (72,5%) ($953,3 \pm 814,3$), *Charbertia spp* (55,9%), ($448,2 \pm 416,0$), *Fasciola spp* (45,4%), ($475,0 \pm 338,1$), *Moniezia spp* (42,2%), ($828,6 \pm 793,9$), *Oesophagostomum spp* (33,1%), ($638,3 \pm 463,5$), *Strongyloides spp* (32,5%), ($200,0 \pm 00$), *Trichostrongylus spp* (28,3%) ($200,0 \pm 00$), *Trichuris spp* (23,7%) ($200,0 \pm 00$), *Teladorsagia spp* (14,6), ($200,0 \pm 00$) and *Nematodorus spp* (8,1%), ($50,0 \pm 0,0$). There was no significant difference in prevalence (100%) in the different age groups, type of husbandry management system and locality ($P > 0,05$) except for gender where there was significant difference. Female goats had mean EPG value of $526,5 \pm 388,3$ compared to males $462,0 \pm 283,6$. Tethered goats had mean EPG value of $513,5 \pm 412,4$ compared to free range goats $446,2 \pm 333,1$. Belo had mean EPG value of $1233,6 \pm 1145,3$ compared to Njinikejem $562,0 \pm 172,7$, Anjin $466,9 \pm 197,8$, Kitchu $373,3 \pm 199,6$, Baingo $220,8 \pm 139,3$, Mbessa

36 197,2 ±308,6. Young goats had mean EPG value of 558,1± 331,2) compared to the adult
37 goats 529,3 ± 349,5 and the old goats 463,0 ± 330,7. There was no significant difference in
38 all cases (P>0.05).

Comment [M4]: So long result. Need to be concise

39 **Conclusion:** It can be concluded that gastrointestinal parasitic infections in goats from Belo
40 Sub Division are common, with a very high prevalence. This high prevalence of
41 gastrointestinal parasitism among the goats possibly reflected grazing, low immunity due to
42 malnutrition and lack of anthelmintic treatment programs.

43 **Key Words:** Prevalence, Intensity, Gastrointestinal Parasites, Goats, Belo Sub Division.

45 INTRODUCTION

46 Livestock increases economic status of the rural population and plays a crucial role in the
47 economic well-being of populations Worldwide. Goats are the oldest domesticated animals by
48 man¹. Evolutionary biology indicates that goats were domesticated about 10,000 years ago at
49 the dawn of the Neolithic age². The West African dwarf goats are popular as hobby goats due
50 to their easy maintenance resilience and small stature. In rearing them, they do not require as
51 much space as the larger dairy goat counterparts. Their gentle and friendly natures make them
52 good companion pets³. Goats are important to man in different spheres and aspects of life.
53 They provide milk which is more easily digestible than cow milk⁴. Their milk is also used
54 in industries in the production of cheese. The rearing of goats provides employment
55 and income to rural populations. In order to rear goats, a minimum investment of money is
56 required, even without specific arrangement for housing and homemade supplied feed.
57 Grazing is mostly done on road-side grass lands and fields⁵

58 According to Gadahi *et al.*⁶, improper care, unhygienic environment, extreme climate
59 and close contact with infected animals, goats get infected with a variety of parasites
60 Parasitism in goat is a substantial problem plaguing farmers across the nation and it has a
61 highly detrimental effect on the goat industry⁷. Production potential of livestock development
62 programs is plagued in tropical and subtropical areas by prevalence of helminthiasis which
63 causes high mortality and great economic losses⁸.

64 Goat production and rearing in Belo is challenged with gastrointestinal parasitism
65 being one of the main obstacles. The prevalence of gastrointestinal parasites is related to agro-
66 climatic conditions like quantity and quality of pasture, temperature, humidity and grazing
67 behavior of the host⁹. Infection with gastrointestinal parasites of goats depends on the quantity
68 and species of goats present, general health, age, nutritional and immunological status of the
69 animal. These infections occur mostly as mixed infections of different GIT parasites.
70 Emaciation, persistent diarrhea and weight loss are usually the main symptoms¹⁰. Villous

71 atrophy causes impaired digestion and malabsorption of nutrients, leading to decrease in live-
72 weight gain, fiber and milk production as well as reproductive performance of goats and
73 therefore has a serious impact on animal health and productivity. Hence, GIT parasitism of
74 goats represents the greatest economic constraint and the most important limiting factor of
75 small ruminant production^{11,12,13}.

76 The prevalence of GI parasitic infections may vary and clinical disease may or may
77 not occur due to various environmental factors in different areas. The rich potential from the
78 small ruminant sector is not efficiently exploited due to several constraints already
79 highlighted¹⁴. Amongst the gastrointestinal parasitic diseases of greatest importance in goats
80 are: Nematodes (roundworms), Cestodes (tapeworms), Trematodes (liverflukes) and
81 Coccidia¹⁵. Compared to sheep which develop a strong natural immunity around 12
82 months of age, goats have a lower level of immunity to gastrointestinal parasites. This
83 results in goats having greater populations of adult parasites with high egg output. Studies on
84 the epidemiology and other aspects of parasitic infection in goats have been carried out
85 extensively in different parts of the world. On the contrary not much attention has been
86 given to this important area of husbandry in Cameroon in general and in Belo Sub Division
87 in particular. Therefore this study was designed to determine the prevalence and intensity of
88 gastrointestinal parasites of goats in Belo Sub division, specifically to identify gastrointestinal
89 parasites and evaluate their intensity, determine if prevalence and intensity is influenced by
90 either age or sex, management systems and locality.

Comment [M5]: In this part, please describe about lackings, novelty and why you are interested to do this work?

92 MATERIALS AND METHOD

93 Study area Description

94 This study was carried out in Belo Sub Division, Boyo Division, North West Region,
95 Cameroon from July 2016 to October 2016. Belo Sub Division is located about 50 km from
96 Bamenda. It is found between latitude $6^{\circ}4'$ and $6^{\circ}20'$ North, between longitude $10^{\circ}11'$ and
97 $10^{\circ}30'$ East. The entire Sub Division covers a surface area of about 46.068 square kilometers
98 and situated within part of the most mountainous sections of the Western highlands of
99 Cameroon. In terms of relief, its morphology is characterized by two broad valleys separated
100 from each other by mountain ridges which all join in the east to form part of the Ijim-Kilum
101 Mountain of more than 3000m above sea level. Four types of vegetation can be distinguished:
102 the montane forest, domesticated sub montane landscape, shrub savanna and semi deciduous
103 forest. The main food crops cultivated in Belo Sub Division include: maize, beans and Irish
104 potatoes for consumption, though some small quantities are sold within and without the Sub

105 Division. The main cash crop is coffee.

106 Two seasons distinguish themselves here. The rainy season is longer starting from
107 March to late October with often torrential rains (about 2900mm on average) accompanied by
108 thunderstorms. The dry season is shorter and starts from November to March, during which
109 temperatures exceed 23⁰C during the Day and drop to about 18⁰C during the night.

110 The total population of Belo Sub Division is about 80775.4735. Only Belo town can
111 be classified as being a semi urban town. The rest of the villages are rural.

112 Belo Sub Division is bounded to the East by Oku Sub Division, to the North by
113 Njinnikom Sub Division, to the South by Tubah Sub Division and to the West by Bafut Sub
114 Division.

Comment [M6]: Its very big description. You may use map or short geographical description

115 **Characteristics of sampled animals**

116 The goats are grazed in open spaces, along the road, yard, and garbage sites and
117 around houses in the municipalities. The age of the goats considered for the study ranged
118 between 0–5 years, characterized as young goats (Less than 6 months old), adult goats (6 to
119 24 months old inclusive), and old goats (more than 24 months, but Less than 5 years old).
120 Goats of both sexes were involved in the study.

121 **2.3. Parasitological Techniques**

122 **2.3.1. Collection of samples**

123 During sample collection, information relating to their, age, sex, village and type of
124 husbandry management system were recorded and labels placed on plastic containers. A total
125 of four hundred and ninety nine (499) fecal samples from goats in six villages of Belo sub
126 division were collected and submitted to the Laboratory of Biology and Applied Ecology
127 (LABEA) at the University of Dschang, between July and October 2016 to be analyzed for
128 the confirmation of gastrointestinal parasitic infections. About 15 warm, moist, soft fecal
129 pellets were taken directly from the rectum with the finger and placed in sealable plastic
130 containers. Few minutes after collection, the samples were stored in a refrigerator at 10⁰C in
131 Belo, from where they were transported within 5 days to the refrigerator in the laboratory in
132 Dschang for analysis. All along, samples were kept cool until analysis, in order to prevent
133 trichostrongylid larvae from hatching.

134 **Examination of Sample**

135 **Fecal egg count**

136 The McMaster's fecal egg count is an easy, rapid, and accurate method to determine
137 the quantity of parasite eggs passed in the feces, which helps to determine the effectiveness of
138 various dewormers for a given worm population¹⁶

139 The number of eggs per gram was determined as follows: The egg counts (X_1 , X_2)
140 from both chambers of the McMaster's slide were summed (for each type of egg counted) and
141 the total (N) multiplied by a factor of 200.

142 **Egg counts in the first Chamber = X_1**

143 **Egg counts in the second Chamber = X_2**

144 **Total egg counts (N) = $X_1 + X_2$**

145 **Total number of eggs in 2g of fecal sample = $60/0.15X N$**

146 **Therefore number of eggs per gram of feces = $60/0.15 X N/2$**

147 **= $200 X N$**

148 **Parameters studied**

149 ❖ **Prevalence (P)**

150 The prevalence of infection is defined as the percentage of infected individuals on the
151 total number of individuals' examined¹⁸ and was calculated generally and for each parasite
152 using the formula:

153 **Prevalence of infection (P) = $\frac{\text{Number of infected Goats}}{\text{Total number of Goats examined}} \times 100$**

156 ❖ **Intensity (I)**

157 The intensity of infection is the mean number of eggs / oocysts of each parasite
158 species per gram of feces of each goat expressed as follows.

159 **Intensity of infection (I) = $\frac{\text{Number of eggs/oocysts per gram of feces (EPG/OPG)}}{\text{obtained by multiplying 200 by N (200XN)}}$**

Comment [M7]: Unify

165 **Classification of GI parasitic infections by virtue of mean EPG.**

166 The animals were categorized as lightly, moderately and severely (heavily) infected
167 according to their egg per gram of feces (EPG) counts. Egg counts from 50-799, 800-1200
168 and over 1200 eggs per gram of feces were considered as light, moderate and heavy infection,
169 respectively¹⁹.

170 **Statistical Analysis**

171 Data was stored in a Microsoft Excel spread, cleaned by checking for errors or missing
172 variables and then exported to SPSS (Statistical Package for Social Science, Version 20)
173 Software for analysis. Summary statistics were generated using the same software. For the
174 purpose of modeling these data, explanatory variables were first explored for associations
175 between parasites using χ^2 test. The prevalence of helminth parasites was compared between
176 demographic parameters using the chi square test. Non parametric test of Krustal Wallis was
177 used to compare mean intensity between age group and locality while Mann Whitney was
178 used to compare intensity with animal gender, breeding system and state of health. Before
179 comparison of intensity of infection (EPG), non infected host were discarded. EPG of each
180 parasite was used as variable and breeding system, gender, state of health of animal, age
181 group and locality as factor. They were all tested at 5% significance level.

Comment [M8]: Need to be short with reference

182
183 **RESULTS.**

184 **Overall Prevalence and Intensity of gastrointestinal parasites.**

185 The analysis of fecal samples (Table1) revealed that all 499 samples examined, were
186 positive with mixed gastrointestinal parasite infections. There was an overall prevalence of
187 100 percent and a mean EPG value of (494,3 ± 374,8).

188 **Table1: Prevalence and Intensity of gastrointestinal parasites**

Parasites	Number examined	Number of infested animals	Prevalence % of infestation	Intensity (mEPG/OPD ±SD)*	
Nematodes	<i>Nematodirus spp</i>	40	8.1	50.0 ± 0.0	
	<i>Haemonchus spp</i>	372	74.5	1282.9 ± 1244.4	
	<i>Oesophagostomum spp</i>	163	33.1	638.3 ± 463.5	
	<i>Chabertia spp</i>	279	55.9	448 ± 416.0	
	<i>Trichuris spp</i>	499	117	23.7	200.0 ± 00
	<i>Strongyloides spp</i>	162	32.5	200.0 ± 00	
	<i>Teladorsagia spp</i>	73	14.6	200.0 ± 00	
	<i>Toxocara spp</i>	362	72.5	953.3 ± 814.3	
	<i>Trichostrongylus spp</i>	141	28.3	200.0 ± 00	
Trematodes	<i>Fasciola spp</i>	499	224	45.4	475.0 ± 338.1
Cestodes	<i>Moniezia spp</i>	499	208	42.2	828.6 ± 793.9
Protozoa	<i>Eimeria spp</i>	499	429	86	455.2 ± 400.8

189
190 **Influence of gender on Prevalence and Intensity infections**

191 Globally, out of the 499 goats examined, 236 were males, while 263 were females
192 Both sexes each had 100% prevalence of GI parasitic infections with statistical significance
193 difference (P<0.05). Multiple infections were more prevalent in female goats than male goats.

194 (Table 2). Female goats had the highest mean EPG value of $526,5 \pm 388,3$ compared to $462,0$
 195 $\pm 283,6$ in male goats with no significant difference ($P>0.05$) (Table 3)..

196 **Table 2: Prevalence of infections by gender**

Parasite	Gender						Total N(%)	P-value
	Males			Females				
	N0. examined	N0. infected	Prevalence (%)	N0. examined	N0. infected	Prevalence (%)		
<i>Nematodirus spp</i>		12	2.4		28	7.7	40 (8.1)	0.028
<i>Haemonchus spp</i>		206	41.3		166	33.3	372 (74.6)	0.001
<i>Oesophagostomum spp</i>		31	6.3		132	26.8	163 (33.1)	0.000
<i>Chabertia spp</i>		86	17.2		193	38.7	279 (55.9)	0.000
<i>Trichuris spp</i>		38	7.7		79	16.0	117 (23.7)	0.000
<i>Eimeria spp</i>		194	38.9		235	47.1	429 (86.0)	0.022
<i>Fasciola spp</i>	236	60	12.2	263	164	33.3	224 (45.4)	0.000
<i>Moniezia spp</i>		68	13.8		140	28.4	208 (42.2)	0.000
<i>Strongyloides spp</i>		49	9.8		113	22.6	162 (32.5)	0.000
<i>Teladorsagia spp</i>		19	3.8		54	10.8	73 (14.6)	0.000
<i>Toxocara spp</i>		170	34.1		192	38.5	362(72,5)	0.80
<i>Trichostrongylus</i>		43	8.6		98	19.6	141 (28.3)	0.000

197

198 **Table 3: Gender related intensity (mEPG/OPG)**

199

Parasite	Gender				Total (mEPG/OPG±SD)	P- value
	Males		Females			
	N0 examined	Intensity (mEPG/OPG±SD)*	N0 examined	Intensity (mEPG/OPG±SD)		
<i>Nematodirus spp</i>		50.0 ± 0.0		50.0 ± 0.0	50.0 ± 0.0	1
<i>Haemonchus spp</i>		798.4 ± 680.1		1767.3 ± 1808.4	1282.9 ± 1244.4	0.00
<i>Oesophagostomum spp</i>		600.0 ± 0.0		676.6 ± 463.5	638.3 ± 463.5	0.47
<i>Chabertia spp</i>		400.0 ± 0.0		496.3 ± 416.0	448 ± 416.0	0.00
<i>Trichuris spp</i>		200.0 ± 0.0		200.0 ± 0.0	200.0 ± 0.0	1
<i>Eimeria spp</i>	236	463.9 ± 374.8	263	446.4 ± 426.7	455.2 ± 400.8	0.08
<i>Fasciola spp</i>		460.0 ± 393.7		489.9 ± 282.4	475.0 ± 338.1	0.04
<i>Moniezia spp</i>		823.5 ± 810.0		833.6 ± 777.8	828.6 ± 793.9	0.57
<i>Strongyloides spp</i>		200.0 ± 0.0		200.0 ± 0.0	200.0 ± 0.0	1
<i>Teladorsagia spp</i>		200.0 ± 0.0		200.0 ± 0.0	200.0 ± 0.0	1
<i>Toxocara spp</i>		1148.2 ± 1144.4		758.3 ± 484.2	953.3 ± 814.3	0.02
<i>Trichostrongylus</i>		200.0 ± 0.0		200.0 ± 0.0	200.0 ± 0.0	1

200

202 **Influence of age on Prevalence and Intensity of infection**

203 Table 4 shows the prevalence of infection by age group of the goats examined. 70 were
 204 young goats, 303 were adult goats, while 126 were old goats. A prevalence of 100% was
 205 recorded in each of the 3 age groups with no significant difference ($P>0.05$). Multiple
 206 infections were more prevalent in adult goats than young and old goats Table 5 shows the
 207 intensity of GI parasites by age group of the study. The highest mean EPG was recorded by
 208 the young goats ($558,1 \pm 331,2$), followed by the adult goats ($529,3 \pm 349,5$) and old goats
 209 ($463,0 \pm 330,7$) with no significant difference ($P>0.05$).

210 **Table 4: Age related Prevalence of infections.**

Parasite	Age						Total (N) Prevalence (%)	P-value
	Young		Adults		Old			
	N0 infected	Prevalence (%)	N0 infected	Prevalence (%)	N0. infected	Prevalence (%)		
<i>Nematodirus spp</i>	13	2.6	7	1.4	20	4.1	40 (8.1)	0.00
<i>Haemonchus spp</i>	40	8.0	240	48.1	92	18.4	372 (74.5)	0.001
<i>Oesophagostomum spp</i>	33	6.7	86	17.4	44	8.9	163 (33.1)	0.001
<i>Chabertia spp</i>	34	6.8	168	33.7	77	15.4	279 (55.9)	0.23
<i>Trichuris spp</i>	13	2.6	85	17.2	19	3.9	117 (23.7)	0.01
<i>Eimeria spp</i>	44	8.8	291	58.3	94	18.8	429 (86.0)	0.00
<i>Fasciola spp</i>	27	5.5	121	24.5	76	15.4	224 (45.4)	0.00
<i>Moniezia spp</i>	20	4.1	130	26.4	58	11.8	208 (42.2)	0.14
<i>Strongyloides spp</i>	21	4.2	98	19.6	43	8.6	162 (32.5)	0.84
<i>Teladorsagia spp</i>	0	0	47	9.4	26	5.2	73 (14.6)	0.00
<i>Toxocara spp</i>	58	11.6	210	4.1	94	18.8	362 (72.5)	0.06
<i>Trichostrongylus</i>	12	2.4	85	17.0	44	8.8	141 (28.3)	0.03

211

212

213 **Table 5: Age related intensity of infection**

Parasite	Age						P value
	Young		Adult		Old		
	N0 examined	Intensity (mEPG/OPG)	N0 examined	Intensity (mEPG/OPG)	N0 examined	Intensity (mEPG/OPG)	
<i>Nematodirus spp</i>		50.0 ± 0.0		50.0±0.0		50.0 ± 0.0	0.06
<i>Haemonchus spp</i>		1300.7 ±1220.1		1473.9±1434.2		1072.9 ±1079.6	0.001
<i>Oesophagostomum spp</i>		566.7 ± 196.6		1052.2±614.7		296.0 ± 102.0	0.001
<i>Chabertia spp</i>		450.0 ± 227.7		750.0±385.9		509.4 ± 437.8	0.23
<i>Trichuris spp</i>		200 ± 00		200.0±0.0		200.0 ± 0.0	0.07
<i>Eimeria spp</i>	70	404.5 ± 281.2	303	563.2±422.2	126	397.9 ± 499.0	0.00
<i>Fasciola spp</i>		850.2 ± 498.8		418.2±272.0		475.1± 243.5	0.00
<i>Moniezia spp</i>		840.0 ±409.3		578.0±594.0		1067.8 ± 972.0	0.14
<i>Strongyloides spp</i>		200.0 ±0.0		200.0±0.0		200.0 ± 0.0	0.84
<i>Teladorsagia spp</i>		200.0 ± 0.0		200.0±0.0		200.0 ± 0.0	0.70
<i>Toxocara spp</i>		1435.6 ± 1140.7		710.6±470.8		714.3 ± 531.4	0.06
<i>Trichostrongylus</i>		200.0 ± 0.0		200.0±0.0		200.0 ± 0.0	0.07

215

216

217 **Influence of husbandry systems on infection**

218 The prevalence of GI parasites by type of husbandry management system of the goats
 219 is shown in (Table 6). 210 goats were on free range, while 289 goats were tethered. Both
 220 types of husbandry management systems recorded each 100% prevalence of GI parasitic
 221 infections with no significant difference (P>0.05). Multiple infections were more prevalent in
 222 tethered goats than free range goats. The highest mean EPG value (513,5± 412,4) was
 223 recorded by tethered goats compared to (446,2 ± 333,1) on free range system with no
 224 significant difference (P>0.05).(Table 7)

225 **Table 6: Influence of husbandry systems on infection**

Parasite	Husbandry system				Total N(%)	P-value
	Tethered		Free range			
	N0. infected	Prevalence (%)	N0. infected	Prevalence (%)		
<i>Nematodirus spp</i>	20	4.1	20	4.1	40 (8.1)	0.323
<i>Haemonchus spp</i>	209	41.9	163	32.7	372 (74.5)	0.180
<i>Oesophagostomum spp</i>	104	21.1	59	12.0	163 (33.1)	0.101
<i>Charbertia spp</i>	32	6.4	41	8.2	73 (14.6)	0.008
<i>Trichuris spp</i>	78	15.8	39	7.9	117 (23.7)	0.043
<i>Eimeria spp</i>	239	47.9	190	38.1	429 (86.0)	0.014
<i>Fasciola spp</i>	133	27.0	91	18.5	224 (45.4)	0.756
<i>Moniezia spp</i>	109	22.1	99	20.1	208 (42.2)	0.170
<i>Strongyloides spp</i>	71	14.2	91	18.2	162 (32.5)	0.000
<i>Teladorsagia spp</i>	32	6.4	41	8.2	73 (14.6)	0.008
<i>Toxocara spp</i>	196	39.3	166	33.3	362 (72.5)	0.006
<i>Trichostrongylus</i>	95	19.0	46	9.2	141 (28.2)	0.007

226

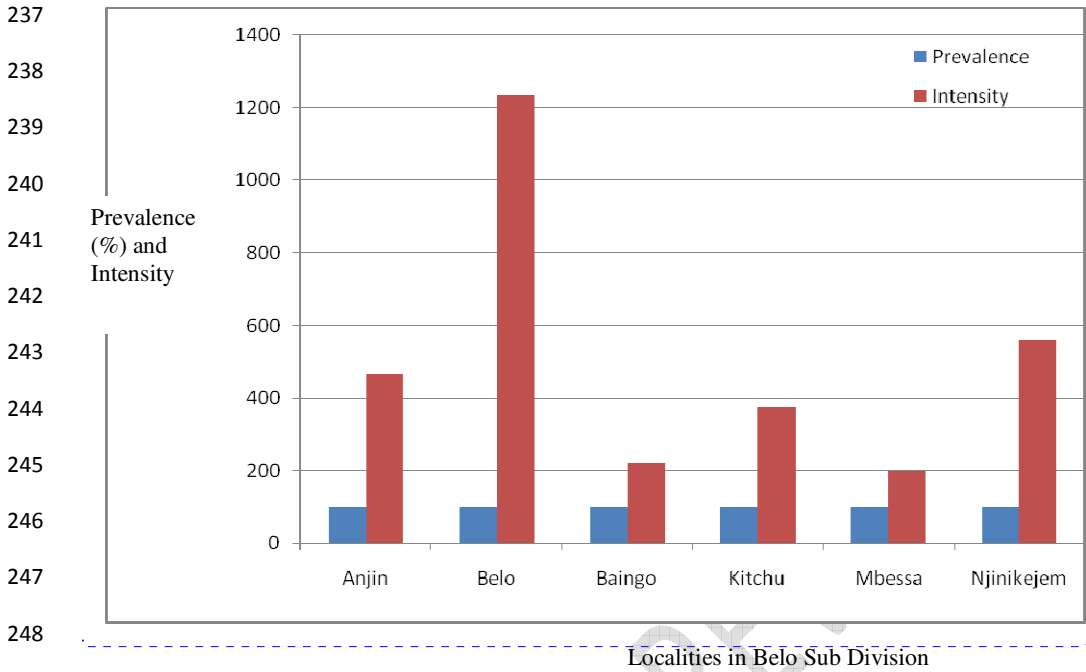
227 **Table 7: Influence of husbandry system on intensity of infections**

Parasite	Husbandry system				Total Intensity (mEPG/OPG) ±SD	P-value
	Tethered		Free range			
	N0 examined	Intensity (mEPG/OPG)±SD	N0 examined	Intensity (mEPG/OPG)±SD		
<i>Nematodirus spp</i>		50.00±0.0		50.0±0.00	50.0 ± 0.0	1
<i>Haemonchus spp</i>		1283.9±1253.3		1331.9±1237.5	1282.9 ± 1244.4	0.774
<i>Oesophagostomum spp</i>		642.5±485.1		674.1±441.9	638.3 ± 463.5	0.512
<i>Charbertia spp</i>		505.7±445.5		390.7±386.5	448 ± 416.0	0.001
<i>Trichuris spp</i>		200.0±0.0		200.0±0.0	200.0 ± 0.0	1
<i>Eimeria spp</i>	236	591.6±525.1	263	318.8±278.7	455.2 ± 400.8	0.022
<i>Fasciola spp</i>		515.1±345.2		435.1±331.5	475.0 ± 338.1	0.001
<i>Moniezia spp</i>		614.7±848.2		1042.5±739.6	828.6 ± 793.9	0.000
<i>Strongyloides spp</i>		200.0±0.0		200.0±0.0	200.0 ± 0.0	1
<i>Teladorsagia spp</i>		200.0±0.0		200.0±0.0	200.0 ± 0.0	1
<i>Toxocara spp</i>		1158.5±1046.5		748.1±582.1	953.3 ± 814.3	1
<i>Trichostrongylus</i>		200.0±0.0		200.0±0.0	200.0 ± 0.0	0.908

228

229 **Influence of locality on Prevalence and Intensity of GI parasite infections**

230 The spectrum of gastrointestinal parasites presented in figure 1 shows the prevalence
231 of GI parasites by locality of sampled goats. 62 goats were examined from Anjin, 219 from
232 Belo, 60 from Baingo, 47 from Kitchu, 90 from Mbessa, and 21 from Njinikejem. All 6
233 Villages recorded 100% prevalence each with no significant difference ($P>0.05$) of GI-
234 parasitic infections. Multiple infections were also more prevalent in Belo goats than goats in
235 the other village. The highest mean EPG value was recorded in Belo with no significance
236 difference ($p>0.05$).



Comment [M9]: This figure may be not so important.

Figure 1: Prevalence and intensity of GI parasitic infection in some Localities

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249 **DISCUSSION**

250 **Prevalence and Intensity of GI parasite infections**

251 Goats harbor a variety of gastrointestinal (GI) parasites. Data from this study indicated
252 that gastrointestinal parasitic infections in goats from Belo Sub Division were common, with
253 an overall prevalence of 100%. All the 499 goats examined were infected with at least two
254 gastrointestinal parasites amongst which were *Haemonchus spp*, *Nematodirus spp*,
255 *Oesophagostomum spp*, *Chabertia spp*, *Strongyloides spp*, *Teladorsagia spp*, *Toxocara spp*,
256 *Trichostrongylus spp*, *Trichuris spp*, *Moniezia spp*, *Fasciola spp*. and coccidian (*Eimeria spp*)
257 giving a total of twelve parasites (9 Nematodes, 1 cestode, 1 trematode and 1 protozoan).
258 Sathaporn et al.²⁰, Nuraddis et al.¹⁹ and Dogo et al.²¹ also reported slightly similar types of GI
259 parasites. The gastrointestinal parasitic infection rate of 100% recorded in goats during this
260 study agrees with the 100% prevalence reported by Dogo et al.²¹ in Vom and 90.4 reported by
261 Ntonifor et al.²² in Jakiri. This is higher than the (87.2%) prevalence reported by Nuraddis et
262 al.¹⁹ and (72%) reported by Paul et al.²³ in Maiduguri. This is quite high and shows that the
263 agro-ecological and geo-climatic conditions of the study area favor the growth and
264 multiplication of these parasites. Climatic conditions, particularly rainfall, are frequently
265 associated with differences in the prevalence of GI parasitic infections, because free-living
266 infective stages (eggs, larvae, cysts, and oocysts) survive longer in moist conditions¹⁹. Belo
267 Sub Division experiences about eight months of rainy season from mid March to mid
268 November and about four months of dry season from mid November to mid March. Since the
269 study was conducted from July to October towards the end of the rainy season, higher
270 parasitic infections might be related to the availability of browse and a longer browsing time
271 in the warm-rainy season by the host, sufficient moisture and optimum temperature. These
272 create favorable conditions allowing for the larval development, oocyst sporulation and
273 survival of the infective larvae stage²⁴. The high prevalence in this study could also be
274 attributed to illiteracy on the side of the goat keepers and their ignorance or avoidance
275 tendency of preventive measures²⁵. For example, effective pasture management, applied
276 knowledge about host-parasite interactions and interrelations building the base for low
277 pasture infection rates for grazing animals, stocking rate reduction and regular intensive
278 monitoring of animal condition that can help optimize animal health status and anthelmintic
279 treatments²⁶. The overall higher prevalence of GI parasitic infections in this study area could
280 also be attributed to lower immunity of hosts as a result of malnutrition^{25, 23}. Among other
281 factors that may have further contributed to these discrepancies observed are host breeds

282 and different husbandry practices. The physiological status of the animals like parturition,
283 lactation stage and pasture contamination can also influence the prevalence of GI parasites
284 in different areas²⁴.

285 Most important to the findings of Nuraddis et al.¹⁹ compared to the present study,
286 *Monezia spp.* and *Eimeria spp.* were the only cestode and protozoa types found
287 respectively, a finding similar to Kanyari et al.²⁷ Encountered in this study were
288 *Nematodorus spp* and *Toxocara spp*, that Nuraddis et al.¹⁹ did not encounter in Jimma,
289 Ethiopia. This difference may be due to variation in climate, parasite evolution or mixed
290 rearing that affect parasitic infection. The most prevalent and commonly observed parasite
291 was *Eimeria spp.*, with a significant infection rate of (86%), which is higher compared to the
292 low prevalence (48%) reported by Kanyari et al.²⁷ in Kenya and (20.6%) reported by
293 Nuraddis et al.¹⁹ in Jimma, Ethiopia. Similarly, low prevalence of (18.6) was reported by
294 Dogo et al.²¹, (2017) and Gebeyehu et al.²⁴ for *Eimeria spp* in Daegu, Korea. This high
295 prevalence of *Eimeria spp* in Belo Sub Division may be associated to the fact that *Eimeria*
296 oocysts are much resistant to disinfectants, and can remain in the environment (particularly
297 moist, shady areas) for long periods of time and maintain their infectivity. Stress factors such
298 as tethering, post weaning, dietary changes and other problems can precipitate an outbreak of
299 coccidiosis. In this study, the severity of GI parasitic infection depended on the number of
300 eggs per gram of feces. The intensity of infection measured by fecal egg or oocyst count
301 varied from light to heavy infection. In a high percentage of animals, light parasitic
302 infections were found, while heavy infections were less common. Among these
303 gastrointestinal parasites observed, *Haemonchus spp* had the highest overall mean EPG value
304 of 1445,2± 1594,4 which is higher than that reported by Ntonifor et al.²²

305 Female goats had higher multiple infections and mean EPG value than male goats
306 from our study and this agrees with the findings of Paul et al.²³ In a study by Sathaporn et
307 al.²⁰, male goats actually had a higher prevalence than female goats which disagrees with our
308 findings. This could be because most of the goats that are tethered in Belo Sub Division are
309 females.

310 In age related infections, multiple infections and mean EPG value was higher in
311 adults goats than the old and the young goats similar to the report of Gebeyehu et al.²⁴
312 However, this result did not agree with the reports of Kanyari et al.²⁷, Gwaze et al.²⁸ and
313 Sathaporn et al.²⁰ who showed that young goats had higher prevalence of GI parasites than

314 adult goats. This middle age group had a significant higher prevalence of *Eimeria spp*
315 infections (58,3%) and higher oocyst numbers compared to other age groups in the present
316 study. This did not also agree with Sathaporn et al.²⁰ in Satun, Thailand who reported that
317 young goats had a higher prevalence (94.9%) of coccidial infections and higher oocyst
318 numbers in young goats (< 1 year) than older goats (> 2 years). This higher prevalence of GI
319 parasites and of coccidial infections in this age group might be due to the fact that a higher
320 incidence occurs during post weaning stress (since, coccidia is most frequently observed in
321 kids 2 to 4 weeks post weaning), tethering stress and stress related to dietary changes^{29,30} in
322 addition to the fact that immunity is low. The low prevalence of coccidial infections in the
323 young goats is probably due to the absence of this stress factors and in old goats probably
324 because of acquired immunity. Although natural immunity develops with repeated exposure³¹
325 younger goats remain highly susceptible. The Institute for International Cooperation in Animal
326 Biologics³² reported that most ruminants stop shedding *Toxocara spp* eggs by the time they
327 are 2 to 4 months old and that *T.vitulorum* infections can be controlled by eliminating
328 patent infections, which occur only in 3 to 10 week old ruminants. Young goats (<6 months
329 old) had the highest mean EPG value of (630,8± 268,3) than other age groups, with the
330 highest parasitic intensity (2137,9 ± 4493,0) shown by *Toxocara spp* in this age group. This
331 high *Toxocara spp* intensity might probably be due to Transcolostral transmission in the life
332 cycle and sanitation standards related to *Toxocara spp*.³² This finding even though was not
333 consistent with the reports of Nuraddis et al.¹⁹, was not surprising because naive young and
334 old carriers frequently graze the same areas, coupled with the fact that young goats have low
335 immunity. The intensity of infection is also reportedly related to hygiene level³³

336 Goats examined in this study were either on free range or tethered systems all under
337 extensive management (grazing). Tethered goats actually had a higher multiple infections and
338 mean EPG than the free range goats. The highest infection rate of (47,9%) was recorded by
339 *Eimeria spp.* in tethered goats. This high infection rate and intensity in tethered goats could be
340 explained by the fact that tethering is a stress factor^{29,30} Again most people in Belo Sub
341 Division tether goats in the same area throughout the tethering period with little rotation.
342 Consequently, the grazing environment becomes contaminated with various GI parasites eggs
343 and oocysts which infect the goats²⁵

344 All Villages recorded 100% prevalence each of GI parasitic infection with no
345 statistical significance. These results differed from those of Sathaporn et al.²⁰ who reported in
346 Satun, that the prevalence of GI parasites of goats in seven Districts statistically varied from

347 60% to 86.4% (P< 0.05). Belo had a higher multiple infections and mean EPG of 1233,6±
348 1145,3 compared to other five villages. Geographical consistence of prevalence in Belo Sub
349 Division might be due to the climatic conditions that are consistent in this area. *Eimeria spp*
350 recorded the highest prevalence of 38,2% and *Haemonchus spp* had the highest mean EPG of
351 4467.3±4396.2 in Belo. Only Belo town can be classified as being a semi urban town. The
352 rest of the villages are rural. These geographical differences in the prevalence of coccidial
353 infections and other infections and high mean EPG value in Belo might be due to the high
354 population density and unhygienic conditions of the area compared to other Villages, which
355 leads to the high infection rates. Inadequate nutrition, however, which is common in this area,
356 may exacerbate the course of GI parasitic infections. The animals are generally malnourished
357 and suffer from other diseases, and are thus not resistant to nematode infection³⁴

358

359 CONCLUSION

360 Goats in Belo Sub Division are infested by gastrointestinal parasites. The adult goats
361 recorded higher multiple gastrointestinal parasites and mean EPG value than the young goats
362 and the old goats. Female goats recorded higher multiple gastrointestinal parasites and mean
363 EPG value than male goats. Tethered goats recorded higher multiple gastrointestinal parasites
364 and mean EPG value than free range. Belo recorded higher multiple gastrointestinal parasites
365 and mean EPG value than Njinikejem, Anjin, Kitchu, Baingo, Mbessa. Prevailing agro-
366 ecological and geo-climatic conditions, illiteracy on the side of goat keepers, avoidance
367 tendency of preventive measures and lack of anthelmintic treatments provide an ideal
368 condition for the transmission of the GI parasitic infections.

369 Ackowlagments

370 Conflict of interest

371 Funding

372

Comment [M10]: You must add this section

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