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ORIGINAL ARTICLE

Distribution and prevalence of gastrointestinal tract nematodes of sheep at highland and midland areas, Ethiopia

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Abstract Gastrointestinal nematodes infections are the most important causes of wastage and decreased productivity. This study was conducted with the objectives of estimating the prevalence of gastrointestinal nematodes infection, and the associated risk factors. The overall prevalence of gastrointestinal nematodes infection was 83% (n = 568). The prevalence of gastrointestinal nematodes infection at Debre-Zeit and Debre-Birhan were 84% and 82.3%, respectively. It was significantly higher in poor body condition and soft faecal consistency ($P < 0.05$) sheep. The overall mean eggs per gram of faeces was 635.2 (95% CI 590.6–679.9). The mean egg per gram was significantly influenced by site of the study, body condition score and faecal consistency ($P < 0.05$). The faecal egg count was higher in midland area, and in sheep with poor body condition, and soft faecal consistency and diarrhea. The light and moderate level of infections accounted for 73.8% and 17.3%, respectively. With the coproculture the main genera identified were include: *Haemonchus*, *Trichostrongylus*, *Teladorsagia*/*Ostertagia* and *Trichuris* in decreasing order of their abundance. To improve sheep health and productivity their control is crucial. Hence, appropriate animal health extension work and training of sheep farmers how they able to identify anemic and diarrheic sheep are helpful. Moreover, training on how to deworm with correct drug and dose for animal owners is important in the control of these parasites. Further epidemiological studies and survey on the development of anthelmintic resistance in the areas is required.

Keywords Debre-Birhan · Debre-Zeit · GIT nematodes · Prevalence · Sheep

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Introduction

In Ethiopia, sheep are kept by smallholder farmers for multiple objectives with source of income being the primary importance (Kenfo et al. 2018; Edea et al. 2012). About 31–38% of the Ethiopian smallholder farmers own sheep (Negassa and Jabbar 2008). The estimated sheep population of the country is 31.3 million, out of which about 71.8% are females, and about 28.2% are males (CSA 2018). In spite of the huge population and importance of small ruminants, the sheep farmers and the country has not benefited from this enormous resource. Nevertheless, many factors affect the maximum benefit to be obtained from sheep production; and gastrointestinal nematodes infection is the most in influencing productivity (Biffa et al. 2007). Gastrointestinal nematode parasites infections are the most important causes of wastage and decreased productivity in sheep worldwide, especially under grazing conditions (Roeber et al. 2013; Kusiluka and Kambarage 1996).

High burden of infections with nematodes may lead to death; and under field conditions, most infections are usually mixed consisting of different species of nematodes. Indeed, the impact of nematode infections on the animal not only depends on the burden of infection, but also the physiological and immunological status of the host (Bishop and Stear 1999). It is impossible to avoid production losses without applying nematode control, particularly under intensive grazing conditions (Waller 1997). Quantifying of the egg per gram of feces is the best way of estimating parasite loads (Pugh 2002).

Therefore, the aim of this study were to estimate the prevalence of gastrointestinal nematodes infection of sheep and moreover, the study compared the two agro-ecologies i.e. midland (Debre-Zeit) and highland (Debre-Birhan), to assess the major risk factors associated with gastrointestinal nematode infection and to assess the degree of infection. The findings of this study add up into the existing knowledge of gastrointestinal nematodes infection prevalence, degree of infection and genera distribution in relation to agro-ecology.

Material and method

Study area

The study was conducted from November 2014 to May 2015 around Debre-Birhan and Debre-Zeit. Debre-Birhan is located at a 09°31′N and 39°28′E with an altitude of 2780 masl, which is highland. Whereas, Debre-Zeit is located at 38°51′ to 39°04′ E and 8°46′ to 8°59′ N with an altitude of 1600 to 2000 masl that is midland. The range of annual rainfall of Debre-Birhan and Debre-Zeit were 960 mm and 860 mm, respectively. Both the study areas were characterized by bimodal pattern of rainfall, short and long rainy seasons. The long rainy season extend from June to September, while the short rainy season from March to May. The mean monthly minimum and maximum temperature of Debre-Birhan ranged from 2 to 8 °C and 18 to 23 °C, respectively. The mean relative humidity was 60%. The mean annual minimum and maximum temperature of Debre-Zeit was 8.5 and 30 °C, respectively. The mean annual humidity was 61.3% (Ayele et al. 2018; Alemayehu et al. 2012).

Study animals and sampling methods

The study animals were selected from all grazing sheep with various age groups, and both sexes. The study sheep were selected by systematic random sampling technique from the sheep that kept under traditional and extensive management system and owned by smallholder farmers. Conventionally, those animals with the age of less than one year were considered as young, while those greater than or equal to one year were adults according to the age groups classification by Gatenby et al. (1991). The body condition score of selected sheep were categorized into three: poor, medium and good as described by Russel (1991).

Sample size and study design

A cross-sectional study design was used to estimate the prevalence of GIT nematode in sheep, and to identify the nematode genera circulating in the study areas. The sample sizes were computed by taking into consideration 83.6% prevalence reported by Abunna et al. (2009) for Debre-Zeit and 50% expected prevalence for Debre-Birhan based on the formula described Thrusfield (2005). The study considered 5% absolute precision and 95% confidence interval. Accordingly, the overall calculated sample size was 684.

Sample collection and examination techniques

Faecal samples were collected directly from the rectum of sheep selected for the study. The collected samples were kept in screw capped universal bottle, labeled with all required information. Then the samples collected from in and around Debre-Zeit were transported to Veterinary Parasitology Laboratory of College of Veterinary, while the samples collected from in and around Debre-Birhan transported to Debre-Birhan Agriculture, Agricultural research center of animal health laboratory. The samples were kept under refrigerator working at 4 °C, and examined within twenty four hours of the collection. The faecal samples were examined qualitatively for the presence of strongly type of eggs using flotation technique; and quantitatively to assess the intensity of nematode infection using the modified McMaster technique (Hansen and Perry 1994).

Pooled faecal samples of those sheep positive for gastrointestinal nematodes eggs were cultured for 14 days at room temperature as described by Kaufmann (1996). Then, the third stage larvae (L_3) were recovered using modified Baerman technique (Zajac and Conboy 2012; Hansen and Perry 1994), and the genera were identified using the key morphological features described by Van Wyk et al. (2004) and Zajac, and Conboy (2012).

Data analysis

The collected data were entered to Microsoft Excel spread sheet, coded and then summarized by using descriptive statistics like mean and percentage. The prevalence was computed as the number of sheep infected divided by the total number of samples sheep, and then multiplied by 100. Risk factors assumed to affect the prevalence of gastrointestinal nematodes infection in sheep were analysed with univariable logistic regression analysis. Then, those risk factors with P-value < 0.25 in univariable logistic regression were subjected to multivariable logistic regression analysis. After the $\log_{10}$ transformation of faecal egg count the association between the assumed risk factors and mean FEC were analysed using ANOVA. For the entire statistical analyses STATA version 14.2 (Stata Corp 4905 Lakeway Drive, College station, TX 77,845, USA) was used.

Results

Coproscopic prevalence of GIT nematode infection

Of the total 684 sheep examined, 568 (83%) were found harboring gastrointestinal nematodes. The prevalence of gastrointestinal nematodes in the two separate study areas was 84% and 82.3%, at Debre-Zeit and Debre-Birhan, respectively. The result of the analysis of the risk factors (i.e. Study area, body condition, sex, age and faecal consistency) considered for this study shown below (Table 1). Those risk factors with $P < 0.25$ in univariable logistic regression were subjected to the multivariable logistic regression analysis. To test the association of faecal egg count vs. risk factors t-test was employed, and for the analysis those sheep positive (n = 568) for gastrointestinal nematode infection were considered (Table 2).

Degree of infection

The degree of parasitic infection was determined from the total faecal egg count. A total of 568 faecal samples were subjected to nematode eggs counting by using McMaster egg counting chamber, and found 419 (73.8%), 98 (17.3%) and 51 (8.9%) of the sheep were lightly, moderately and highly infected, respectively (Table 3).

Coproculture and nematode genera identified

Pooled faecal samples were taken from those sheep coproscopically positive for gastrointestinal nematodes and were cultured. A total of 584 third stage larvae were recovered in both study areas. From larvae the genera identified and their proportions were shown in Table 4.

Discussion

The overall prevalence of sheep gastrointestinal nematode infection was 83.0% (Table 1), of this 84% and 82.3% accounted to midland and highland study areas, respectively. This prevalence is very high, and in a general agreement with the report from various, highland and midland, areas of the country (Mohammed et al. 2016; Bikila et al. 2013; Emiru et al. 2013; Argaw et al. 2014; Kumsa et al. 2011 and Abunna et al. 2009). The epidemiological factors that influence the existence, distribution and contamination of grazing areas by nematode parasites include appropriate temperature and humidity (Urquhart et al., 1996). Moreover, the overstocking grazing practice of communal pasture land of the country is a responsible for the availability of infective larvae of nematodes on pasture (Hansen and Perry 1994). The environmental conditions of the study areas were favourable for the development and survival of the

Table 1 Univariable logistic regression analysis of sheep GIT nematodes prevalence versus risk factors

Risk factors	Level of factor	No examine	No positive (%)	95% CI	Univariable			Multivariable	
					OR	OR 95% CI	P-Value	OR	P-Value
Study area	Debre-Zeit (ML)	300	252 (84%)	79.4–87.7	1.13	0.75–1.69	0.555	–	–
	Debre-Birhan (HL)	384	316 (82.3%)	78.1–85.8		Ref	–	–	–
Sex	Male	254	207 (81.5%)	76.2–85.8		Ref			
	Female	430	361 (84.0%)	80.2–87.1	1.19	0.78–1.79	0.408	–	–
Age	Young	190	83 (82.6%)	82.5–87.4		Ref		–	–
	Adult	494	169 (83.2%)	79.6–86.3	1.04	0.67–1.62	0.860	–	–
BCS	Good	321	267 (83.2%)	78.7–86.9	1.66	1.09–2.51	0.017	0.57	0.057
	Medium	235	176 (74.9%)	68.9–80.0		Ref	–		
	Poor	128	125 (97.7%)	92.9–99.2	13.43	4.28–45.57	0.000	1.91	0.011
Faecal consistency	Normal	373	270 (72.4%)	67.6–76.7		Ref		Ref	
	Soft	242	229 (94.6%)	91.0–96.9	6.72	3.68–12.28	0.000	6.04	0.000
	Diarrhea	69	69 (100%)*	–	–	–	–	–	–
Overall		684	568 (83.0%)						

[*] = 100% infected and hence, omitted

Table 2 Result of the association between faecal egg counts versus potential risk factors analysis with ANOVA

Risk factors	No positive	EPG		$Log_{(x+1)}$ EPG		
		Mean	95% CI	Mean ± SD	F-value	P-value
Site						
Debre-Zeit (ML)	252	760.2	671.5–848.8	2.74 ± 0.34	13.42	0.0003
Debre-Birhan (HL)	316	535.6	500.6–570.6	2.65 ± 0.28	Ref	
Sex						
Male	207	594.0	522.9–665.1	2.66 ± 0.31	Ref	
Female	361	658.9	601.5–716.3	2.71 ± 0.31	2.90	0.0889
Age						
Young	157	633.6	552.5–714.8	2.69 ± 0.32	Ref	
Adult	411	635.8	582.2–689.4	2.69 ± 0.31	0.02	0.8909
BCS						
Good	267	459.2	427.7–490.7	2.61 ± 0.22	Ref	
Medium	176	483.2	427.8–541.6	2.58 ± 0.31	0.032	0.431
Poor	125	1225.3	1096.5–1354.0	3.02 ± 0.25	16.72	0.0000
Faecal consistency						
Normal	270	366.7	345.3–388.1	2.51 ± 0.23	Ref	
Soft	229	685.5	635.5–735.6	2.77 ± 0.25	0.261	0.0000
Diarrhea	69	1518.8	1312.0–1725.7	3.12 ± 0.23	0.608	0.0000
Overall	568	635.2	590.6–679.9			

Table 3 Table to show the level of GI nematode infections in sheep

Degree of infection	No examined (%)	Mean EPG	95% CI
Light	419 (73.8%)	401.9	375.9—427.8
Moderate	98 (17.3%)	978.4	934.9—1021.9
Heavy	51 (8.9%)	2155.1	1908.7—2401.5
Overall	568	635.2	590.6–679.9

gastrointestinal nematodes. The other factor for the higher prevalence of the gastrointestinal nematodes might be due to poor health management system by the owners, lack of strategic deworming practice and higher stocking rate that increasing the contamination of communal grazing land (Andrews 1999). The lower prevalence of GIT nematodes in the present study compared to other studies in the country could be due to unfavorable environmental factors that avoid the survival and development of infective larval stage of most helminths in the pasture.

Among the potential risk factors considered for this study body condition score and faecal consistency were significantly associated ($P < 0.05$) with gastrointestinal nematodes infection in sheep. Higher prevalence of

Table 4 Genera of nematodes recovered in coproculture in sheep and goats

Nematodes genera	Debre-Birhan		Debre-Zeit		Total Recovered larvae No (%)
	Recovered larvae No	Proportion (%)	Recovered larvae No	Proportion (%)	
Haemonchus	104	34.7	150	52.8	254 (43.5)
Trichostrongylus	40	13.3	74	26.1%	114 (19.5)
Teladorsagia/Ostertagia	29	9.7	40	14.1%	69 (11.8)
Trichuris	65	21.7	20	7.0%	85 (14.6)
Bunostomum	18	6.0	–	–	18 (3.1)
Strongyloides	8	2.7	–	–	8 (1.4)
Chabertia	13	4.3	–	–	13 2.2)
Oesophagostomum	23	7.7	–	–	23 (3.9)
Overall	300	100	284	100%	584

gastrointestinal nematodes infection was recorded in sheep with poor (OR 13.43, $P < 0.05$) and good (OR 1.66, $P < 0.05$) body conditions. This observation is in a general agreement with the reports of Nuraddis et al. (2012) and Bisset et al. (1996). Clinically, gastrointestinal nematodes infections are manifested by loss of appetite, diarrhea, and one of the consequences of these two conditions are the loss of body condition (Urquhart et al. 1996; Soulsby 1986). This finding is consistent with some reports from various areas (Kenea et al. 2015; Bashir et al. 2012; Salem et al. 2011; Abebe and Esayas 2001; Regassa et al. 2006). The higher prevalence of gastrointestinal nematodes infection in good body condition might be due to recent infection of sheep.

Sheep with soft (OR 6.72, $P < 0.05$) faeces had significantly higher prevalence of infections than those with normal faeces. All diarrheic sheep (100%) were found positive for gastrointestinal nematodes infection. Infections by *Trichostrongylus* and *Teladorsagia* species are clinically manifested by diarrhea that is due to damage to the intestinal mucosal cells and inflammatory response (Larsen and Anderson 2008). So, it is a common, widespread and frustrating reality in sheep production areas (Jacobson et al. 2020).

The faecal egg counts of this study were highly variable ranging from 50 to 3800. The overall mean EPG was 73.8%, 17.3% and 8.9% for light, moderate and heavy infections, respectively. Higher proportion of light gastrointestinal nematode infection was observed, which is consistent with the report of Mohammed et al. (2016), Sheferaw et al. (2015) and Asha and Wossene (2007). Various factors influencing the faecal egg counts, which include grazing system, season, age of sheep and deworming status (Odoi et al. 2007). The mean EPG was significantly higher ($P < 0.05$) in sheep with poor body condition, soft faeces and diarrhoea, and at midland area (Debre-Zeit). This study was conducted in dry season, and this period was characterized by scarcity of animal feed. So the poor body condition was most likely attributed to the nutritional status of sheep, and also to the impact of the parasites. In poorly fed sheep the body condition and resistance to nematode infection deteriorated, and this might increase the chance of nematodes establishment (Kumba et al. 2003; Greer 2008; Kyriazakis and Houdijk 2006). As stated by Jacobson et al. (2020) diarrhea is a common, widespread and frustrating sequel in sheep, especially where the infestation with *Trichostrongylus* and *Teladorsagia* species are common. In general, the resistance and resilience of sheep adversely affected by stress and nutritional deficiencies (Constable et al. 2017). On the other hand, FEC was significantly lower in those animals relatively with good body condition. This might be due to good immunity or animals' ablility to impair the egg laying potential of the nematodes. The significant FEC at the midland, Debre-Zeit, was related to the higher proportion of *Haemonchus* species (Table 4) in the area. It has a high faecal egg output (Taylor et al. 2016), and hence, contribute to the higher faecal egg count.

Overall eight genera of gastrointestinal nematode were identified from Debre-Birhan, while only four genera identified from Debre-Zeit areas. For both study areas, the common and highly prevalent nematodes parasites genera were *Haemonchus*, *Trichostrongylus*, *Teladorsagia* and *Trichuris*. The systematic review and meta-analysis reported by Asmare et al. (2016) revealed that these nematode parasites are the most common and widespread in the country.

Conclusions and recommendations

Gastrointestinal nematode parasites infection in sheep was the most important and serious problem in and around Debre-Birhan and Debre-Zeit. *Haemonchus*, *Trichostrongylus*, *Ostertagia/Teladorsagia* and *Trichuris* were the commonly encountered genera of gastrointestinal nematodes in the study areas. Light infection level accounted for the highest proportion of gastrointestinal nematode parasites infection both at the highland and midland areas. Therefore, strategic deworming and appropriate animal health extension work should be practiced. Training of sheep farmers how they able to know anaemia and diarrhea on their animal and deworm with appropriate and correct dose of anthelmintic. Further epidemiological studies and survey on the existence of anthelmintic resistance development in the areas is required.

Declarations

Conflict of interest The authors declare that they have no competing interests.

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