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Helminth parasites transmission between species of ruminants in urban and peri-urban areas of Ada'a district of Central Ethiopia

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A study on gastrointestinal helminth parasites (GIHPs) in cattle and sheep was conducted from January 2021 to December 2021 in the urban and peri-urban areas of the Ada'a District of Central Ethiopia. The aim was to estimate the prevalence of GIHPs and associated risk factors, and to assess community awareness of anthelmintic treatment practices for the control of parasitic diseases. The methodology comprised of random cross-sectional studies on animals using conventional parasitological techniques, flotation and sedimentation methods, and questionnaire surveys. In total, 351 animals (192 cattle and 159 sheep) were examined. The overall prevalence of gastrointestinal helminth parasites (GIHPs) was 61.25%. The highest prevalence of parasite infection was found to be 68.55% in sheep and 55.21% in cattle, with a statistically significant difference (0.001<P-value) between the two animal species. Helminth parasite eggs with strongyle eggs (55.34%) were predominantly recorded, suggesting a high rate of animals infection with nematodes, followed by F*asciola* eggs (13.48%) among trematode infections, and comparatively lower infection was observed with *Toxocara vitolorum* eggs (2.79%), *Moniezia* eggs (10.69%) and with mixed infections (10.69%) of the study animals. Body condition scores and production systems were significantly associated with the incidence of GIT helminths along with animal species variation. The questionnaire survey revealed that ivermectin was the most widely used anthelmintic compared to albendazole, tetramisole, and levamisole. The results implied that transmission requires a shared habitat, where host animals have access to the same resources, such as pasture or watering holes. In certain situations, additional requirements might be necessary, including the requirement for a suitable intermediate host. Further studies are recommended to design a rationale for the sustainable management of GI parasite infections in domestic animals in local regions, particularly in terms of both urban and peri-urban practices of the study areas.

Key words: Nematodes, prevalence, cattle, sheep, trematode, moniezia, Ethiopia.

INTRODUCTION

Ethiopia has one of the largest ruminant populations, including more than 57 million heads of cattle and 58 million small ruminants (Sori et al., 2013). The infection with parasite is of great importance in many agro

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ecological zones and remains a serious threat to inflict harm on livestock economies worldwide (Molla et al., 2015; Wadhawa et al., 2011). Gastrointestinal (GI) nematode and trematode (fluke) infections in ruminants cause major problems for both small- and large-scale farmers in the developing world (Huang et al., 2014; Sheferaw et al., 2013). The infection with parasitism causes lower productivity, mortality, and high economic losses, affecting the income of smallholder dairy farming communities (Huang et al., 2014; Income et al., 2021). Ruminants, cattle, goats, and sheep represent an important source of animal protein in many countries worldwide, supplying a high percentage of daily meat and dairy products in cities and villages, including Ethiopia. In addition to being a source of animal proteins, waste is also of great significance in agriculture (Huang et al., 2014). The infection with gastrointestinal helminths is wide spread, it has been reported to range from 0.72 to 84.1% in domestic animals from different corners of the world (Singh et al., 2012; Haymanot and Kaba, 2022; Dorny et al., 2015; Sori et al., 2013). Gastrointestinal helminths are among the most important disease-causing agents in veterinary medicine, especially in livestock, and lead to economic losses because of a decrease in meat, milk, and wool production (Income et al., 2021). The animals mostly get infection with gastrointestinal helminths via ingestion of infective stage larvae or eggs. Eggs and larvae are excreted in the feces of the host into the environment and become a source of transmission. Strongyle nematodes of the order Strongylidae are an important group of gastrointestinal helminths that significantly affect ruminant health, particularly in tropical areas (Haymanot and Kaba, 2022; Welay et al., 2018; Sori et al., 2013). In the Torrid Zone, the most important nematode species affecting small ruminants are *Haemonchus contortus*, *Trichostrongylus* spp., *Nematodirus* spp., *Cooperia* spp., *Bunostomum* spp., and *Oesophagostomum* spp (Sheferaw et al., 2013; Birhanu et al., 2022).

Most GIT nematodes have the same course of developmental changes. The majorities are oviparous, the eggs are similar and characteristic, and the immediate transfer of infection from one host to another does not occur. The life cycle of nematodes may be direct or include an intermediate host (Regassa et al., 2006; Thrusfield, 2005). The adult trematodes are commonly called ‘flukes’ and the families which include parasites of major veterinary importance are Fasciolidae, Dicrocoelidae, Paramphistomatidae, and Schistosomatidae (Dorny et al., 2015). *Fasciola* (liver fluke), paramphistomes (rumen/stomach fluke), and *Schistosoma* (blood fluke) are the most important flukes recorded worldwide (Frandson et al., 1992). Fasciolosis is an economically important disease that affects domestic livestock, particularly cattle, sheep, and occasionally humans (Hansen and Perry, 1994). *Fasciola hepatica* and *F. gigantica* are the two species most implicated as the etiological agents of fasciolosis (Hansen and Perry, 1994).

The larvae (cercariae) of flat worms develop in snail tissues, escape, and find suitable secondary intermediate hosts or definitive hosts (humans and animals) using passive transmission (metacercaria) and active penetration (Lamrioui et al., 2013; Huang et al., 2014; Aragaw and Tilahun, 2019), respectively. Gastrointestinal helminth infection is one of the most prevalent diseases that affect ruminants in Ethiopia.

A study conducted (Hailu, 2019) in and around Holleta indicated that 82.8% of the overall prevalence of gastrointestinal helminth infections was recorded in cattle. According to a study conducted in and around the Ada’a district in the East Showa Zone of Central Ethiopia (Hayider et al., 2018), the overall prevalence of gastrointestinal (GI) helminths was 61%, and among the prevalent helminth eggs identified were Strongyle-type eggs (41%), *Fasciola* (36.5%), *Paraphostomum* (18.4%), *Toxocara* (7.7%), *Trichuris* (5.2%), and *Moniezia* (2.8%), whereas Strongyle-type nematode eggs were found to be significant (P=0.00) among animals of different body conditions. Another study conducted on gastrointestinal (GI) parasites of small ruminants in and around Ambo town in central Ethiopia also showed that the overall prevalence of GIT parasites was 49.2%, with a predominant prevalence of Strongyle eggs of nematodes and Eimeria parasites (Yonas et al., 2018). To identify appropriate schemes for helminth control in animals for farmers, it is crucial to investigate the load of helminthiasis in sheep and cattle and describe specific risk factors unique to this area and farming system. Therefore, this study was aimed at the following specific objectives: to investigate the various types of GI helminths affecting cattle and sheep; to investigate the prevalence and worm load of helminths in cattle; and to assess some risk factors associated with the prevalence of GI helminths in cattle and sheep in and around Ada’a district of central Ethiopia.

MATERIALS AND METHODS

Study area

This study was conducted in the Ada’a district of central Ethiopia, including the town of Bishoftu. Bishoftu city, with smallholder dairy farms, along with different peri-urban areas of Ada’a district, namely, Anbelta, Ganda, gorba, Koftu, Kaliti, and Godinokebeles, were selected to collect samples from animals. Bishoftu is situated at 9°N latitude and 40°E longitude, at an altitude of 1,850 m above sea level in the central highlands of Ethiopia. Bishoftu has an annual rainfall of 866 mm, of which 84% falls during the long rainy season, extending from June to September. The rainfall was bimodal. The mean annual maximum and minimum temperature ranges are 26 and 14°C, respectively (Bedasa et al., 2016) (Figure 1).

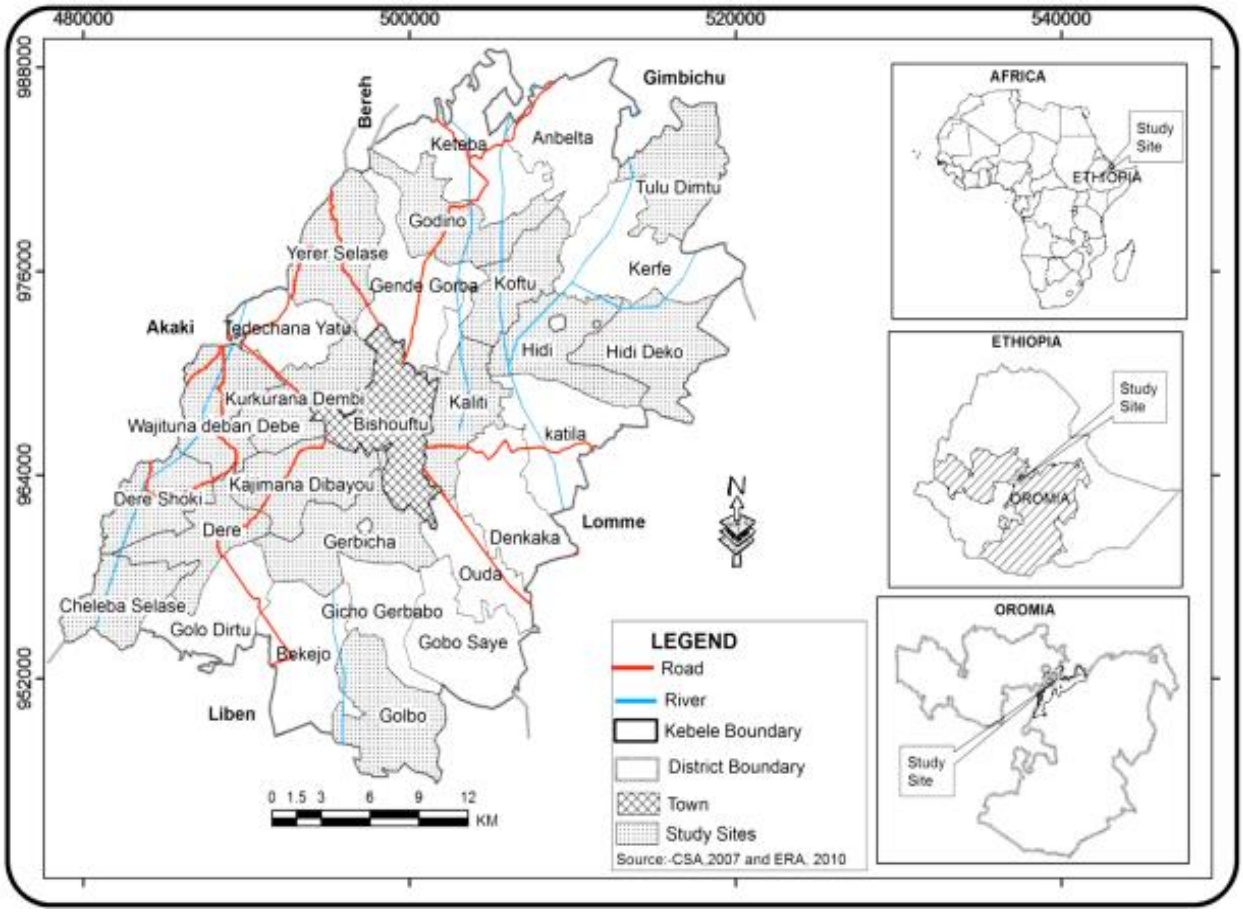

Figure 1. Ada'a district of central Ethiopia including Bishoftu town.

Study animals

The cattle and sheep reared in both peri-urban and small dairy farms in Bishoftu Town, Central Ethiopia, were selected. The animals were randomly selected for examination for the presence of major gastrointestinal helminth parasites (GIHPs), such as nematodes, trematodes, and cestodes.

Study design and sample size determination

A cross-sectional study was conducted from January 2022 to November 2022 to collect data on gastrointestinal helminth parasites in cattle and sheep. Animals maintained under a traditional management system in selected districts were included in this study. During the sampling, to access their anthelminthic utilization, a semi structured interview was conducted with all farmers and farm owners whose animals were sampled to collect basic data on the treatment practices in the study area. A simple random sampling technique was used to select the study animals. The minimum sample size was determined using a formula described bypreviously (Terefe, 2018) at a 99% confidence level and 5% precision. Considering the reported prevalence of 42.33% (Yonas et al., 2018 and Telila et al., 2020) in the same study area, a minimum number of 375 animals needed to be sampled. However, owing to a lack of logistics, only 321 animals were sampled. Age and body condition scores were estimated according to guidelines (Heinon, 1989; Frandson et al., 1992), respectively.

Fecal sample collection and examination

Fecal samples were collected from each animal directly from the rectum using disposable gloves and coded with the animal identification number using a permanent marker. After collection, fecal samples were transported to the Veterinary Laboratory of Parasitology of the College of Veterinary Medicine and Agriculture, Addis Ababa University, Bishoftu campus, and were processed on the day of collection or stored in a refrigerator at +4^{o}C for processing the next day. Fecal samples were processed and examined for the presence of gastrointestinal helminth parasite infection using qualitative techniques (flotation and sedimentation), as described by Hansen and Perry (1994) and Wyk and Mayhew (2013; Carlos et al., 2019). Sodium chloride and zinc sulfate solutions were used as the flotation fluids for parasite egg recovery.

Questionnaire survey

During the study, a semi structured questionnaire survey was designed for selected farmers whose animals were sampled to gather the required data on anthelmintic treatment practices, the

Table 1. Overall prevalence of gastrointestinal helminth parasite infection (GIHPs) in the study animals.

Gastrointestinal Helminth parasite eggs (GIHPs)	Number examined (351)	Number of positive	Prevalence (%)	Chi-square (χ^2)	P-value
Toxocara vitolorum eggs		06	2.79		
Monezia		23	10.69		
Strongyle		119	55.34		
Trichuris		06	2.79		
Fasciola		29	13.48		
Paraphistomum		09	4.19		
Mixed infections		23	10.69		
Total	351	215	61.25	**31.86**	**0.02**

Whereas helminth infection showing statistically significant with higher prevalence of strongyle eggs.

class of anthelmintic drugs mostly used, and the number of yearly treatments using face-to-face interviews. One hundred participants were used according to the Arsham (2020) formula based on the scenario with the answer item scored 0/1 for no/yes, and the standard deviation (SD) was defined as SD = [p(1-p)/N] 1/2, where p is the proportion with a score of 1 and N is the sample size.

Data analysis

IBM SPSS Statistics 27 software was used for data analysis, and statistical significance was set at $P<0.05$. The proportion of animals with a particular parasite that was investigated at the time was divided by the total number of animals to determine the prevalence of the parasite infection, and significant correlative associations were recorded using χ^2 (chi-square test) within different risk factors. Data from the questionnaire survey, aimed at assessing the anthelmintic utilization of the respondents, were analyzed for their basic knowledge and awareness of anti-parasitic drug resistance and parasite infection.

RESULTS

Overall prevalence of gastrointestinal helminth parasite infection (GIHPs) in the animals

In this study, 351 fecal samples were collected from animals at their grazing pastures in and around the Ada'a district and smallholder dairy farms in Bishoftu Town, central Ethiopia. Therefore, 192 and 159 fecal samples were collected from the bovine and ovine samples, respectively. A coprological examination was performed to detect gastrointestinal helminth parasite (GIHP) infection. Based on this finding, from a total of 351 examined animals, 215 were found to be positive, with a total prevalence of 61.25%, as indicated in Table 1. Overall, it was observed that small ruminants were substantially infected in the Ada'a district at a total percentage of 68.55 %, as indicated in Table 2. Infecting parasites were recorded as parasitic eggs with *Ascaris, Moniezia*, Stronglye, and Trichuroid, eggs detected as mixed infections from the nematode and cestode genera and *Fasciola* and *Paraphistomum* eggs from the trematode genera (Figure 2). Similarly, among the different gastrointestinal helminth parasite eggs detected in both groups of animals, Stronglye eggs representing gastrointestinal nematodes showed the highest prevalence (55.34%), followed by Fasciola eggs with a prevalence of (13.48%) and cestode helminth parasites with *Moniezia* eggs, with a prevalence of 10.69%. However, in animals with cestode helminth parasites, *Monezia* eggs, and mixed infections were recorded with an equal prevalence of 10.69% (Table 1). Whereas the infections with *Parasphistomum* eggs of flat worms and trichuroid eggs of nematode worm was, respectively, described as indicated in Table 1.

Prevalence of Gastrointestinal Helminth Parasite Infection among the different associated risk factors

The prevalence of gastrointestinal helminth parasitism (GIHP) among different risk factors was also analyzed. A total of 351 fecal samples were collected from cattle (192) and sheep (159), of which 106 cattle and 109 sheep were positive, with a total prevalence of (55.21%) in cattle and (68.55%) in sheep. The prevalence and abundance values are widely different among the animal species owing to substantial differences in widespread and abundance values of gastrointestinal helminth parasites (GIHPs) in sheep. Other risk factors were identified based on the body condition and production systems of the animals. The prevalence of infection was found to be significantly higher in animals with poor body condition (67.42%) (Figure 4) and in animals grazed or reared in an extensive production system (64.88%), which again showed strong differences in both the prevalence and abundance of these parasites (Figure 5). The prevalence of infection was highest in sheep (68.55%) in the test protocol, purposively performed by flotation and sedimentation techniques to detect the eggs of both gastrointestinal nematodes, cestodes,

Table 2. Prevalence of GIHPamong different associated risk factors.

Different risk factors		Number of examined	Number of positive	Prevalence (%)	Chi-square	P-value
Species	Bovine	192	106	55.21	31.86	0.134
	Ovine	159	109	68.55		
Breed	Local	190	124	65.26		
	Exotic	159	90	56.60	21.631	0.003
	Cross	2	1	50.00		
Sex	Male	247	139	56.28	5.002	0.064
	Female	104	76	73.01		
Age	Adult	133	72	54.14	6.230	0.238
	Young	218	143	65.60		
Body condition	Good	74	46	62.16		
	Medium	145	80	55.17	39.118	0.000
	Poor	132	89	67.42		
Production system	Extensive	168	109	64.88		
	Intensive	175	99	56.57	50.055	0.000
	Semi intensive	8	7	87.5		
Total		351	215	61.25		

Figure 2. Gastrointestinal helminth parasite eggs (GIHPs) in sheep and cattle. Triangular red arrow indicate that Trichuris eggs, green color arrow indicated Fasciola eggs and triangular blue color arrow indicate that strongyle eggs.

trematodes, and their mixed infections (Figure 3).

Questionnaire survey

According to the findings from the questioner survey, the analyzeddata for respondents' awareness and basic knowledge about treatment practices indicated that animal owners (95%) responded that they use anthelmintics only when animals show symptoms, such as poor body condition, diarrhea, or coughing. Based on

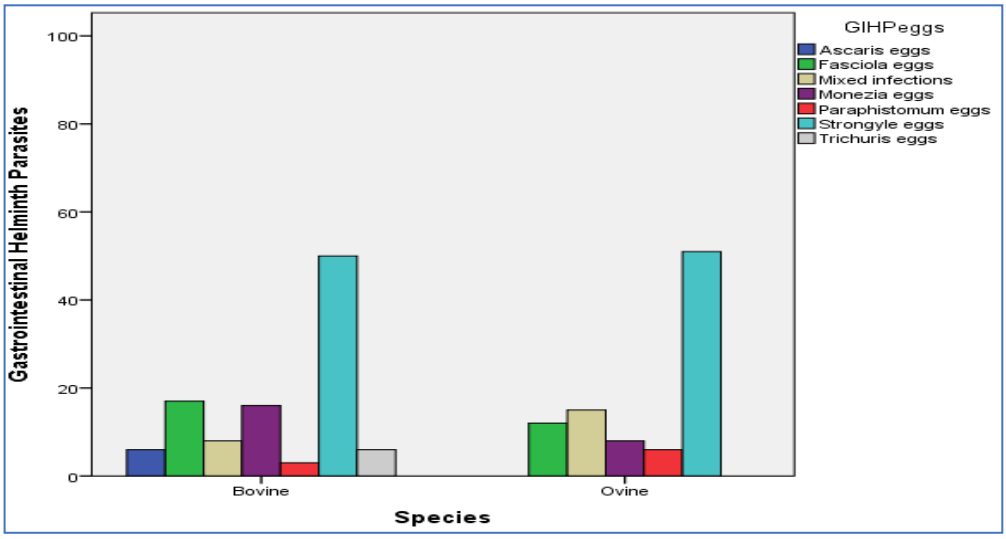

Figure 3. The burden of parasite infection among animal species categories.

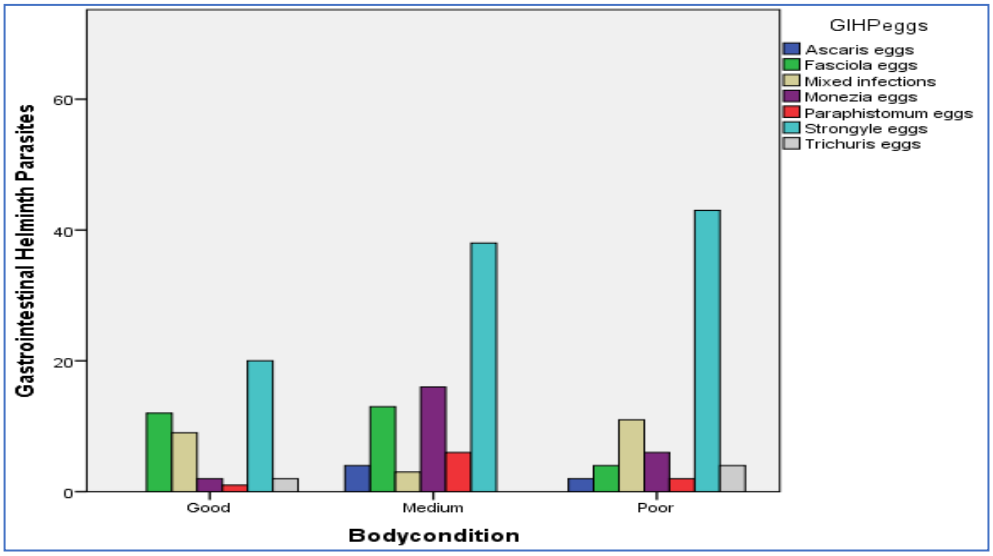

Figure 4. The burden of parasite infection among animals' body condition categories.

these findings, ivermectin (80%) was the most used anthelmintic drug, followed by albendazole (9%), levamisole (6%), tetramisole (4%), and albendazole and ivermectin (1%). They mostly used anthelmintics following prescription guidance from animal health professionals or owner's decisions. A significantly higher number of respondents had their animals administered anthelmintics by animal health personnel (including all ivermectin injections) than those who did so on their own (0.021<P-Value). On average, the animals were frequently administered anthelmintics at least twice per year (Table 3). The sources of anthelmintics indicated that private clinic users were more abundant (48) than others, as indicated in Table 3.

DISCUSSION

Overall prevalence of gastrointestinal helminth parasite infection (GIHPs) in animals

Parasitic helminths are responsible for large problems in

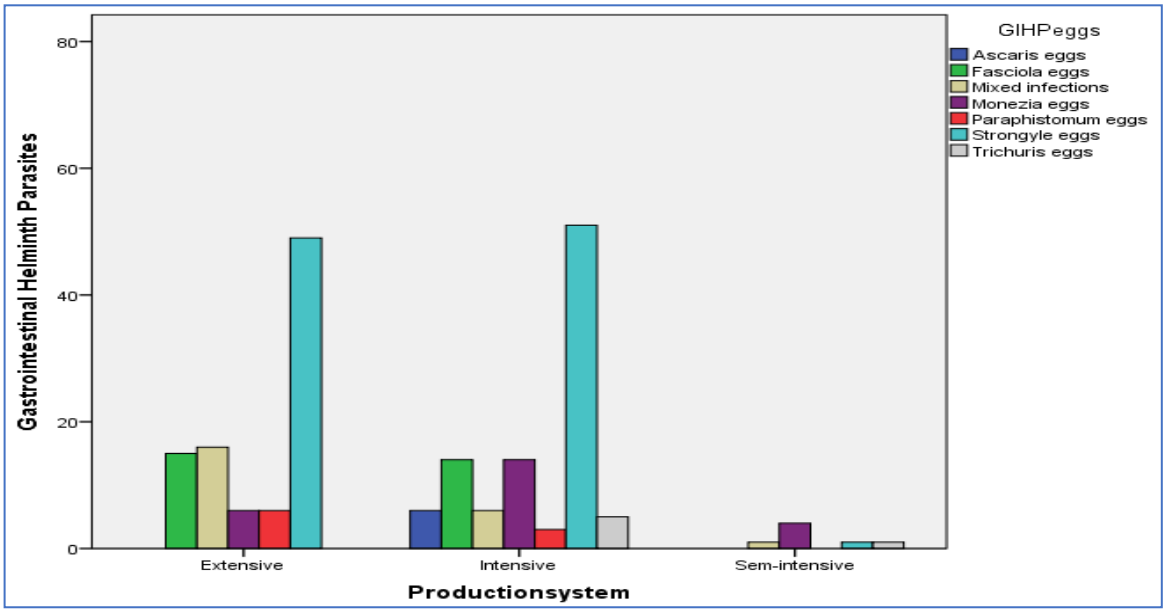

Figure 5. The burden of parasite infection among different animals' production system categories.

Table 3. Responses of farmers to a questionnaire survey on anthelmintic utilization practice.

Associated risk groups	List of items	Percent
Antihelminthic use	No	5.0
	Yes	95.0
Type of commonly used	Albendazole	9.0
	Ivermectin	81.0
	Levamisole	6.0
	Tetramisole	4.0
Who administers AH	Both	3.0
	Farmers by their own	21.0
	Professional	76.0
Frequency per year	Four times	1.0
	One time	28.0
	Three times	33.0
	Two times	38.0
Source of AH	Both private and government	5.0
	Government clinic	37.0
	Open market	10.0
	Private clinic	48.0
Total		100.00

health parameters, reproducibility, and productivity of sheep, goats, and cattle in Ethiopia (Hernandez and Sanchez, 2014; Huang et al., 2014; Hurisa et al., 2021). Helminths usually cause body weight loss, digestive

disturbance, and emaciation (Income et al., 2021; Johansson, 2017; Heinon, 1989; Lamrioui et al., 2013). According to the findings of this study, of the 351 animals tested for the presence of GIHPs, (61.25%) were positive for helminth infection. Among the risk factors for species category, 55.21% of cattle were positive, and (68.55%) of sheep were positive for gastrointestinal helminth parasites (GIHPs), suggesting that helminths are still a major problem for animals in the Ada' a district within the different management systems. This observation is higher than the 50.2% reported in Western Oromia (Johansson, 2017), 49% reported in the West Arsi zone (Income et al., 2021), and 39.6% reported in Southern Ethiopia (Karshima et al., 2018). This finding is also lower than 68.2 and 77.6% reported by Kebede (2019) and Kemal and Terefe (2013) in Holleta dairy farms at the Agricultural Research Center and Kucha in Southern Ethiopia, respectively.

Whereas the flotation test results indicated that Strongyle infections (55.34%) representing several gastrointestinal nematodes were more prevalent than all other helminth parasites and, for example, trematodes genera; *Fasciola* eggs (13.48%) and (4.19%) *Paraphistomum* eggs were respectively recorded. In cestodes and mixed infections (10.69%), the results of the present study were higher than a previous report in and around Gechi district, Western Oromia by Lamrioui et al., (2013), which agree with a previous report carried out on the prevalence of gastrointestinal parasites studies in cattle and sheep in Colombian Northeastern Mountain Juan by Hansen and Perry (1994); the studies on major gastrointestinal helminth parasites of cattle in Tulo District, West Hararghe Zone, by Kumsa et al. (2010), but were lower than reported studies ofhelminth incidence in goats by Kumsa et al. (2011)) in Morocco and not inconsistent with a previous report carried out by Dorny et al. (2015) on trematode infections and associated host risk factors in cattle in and around Bahir Dar, northwest Ethiopia in which paraphistomum were highly prevalent trematodes and in reported studies carried out in eastern Nigeria by (Lamrioui et al. (2013). The observation of (55.34%) Strongyle-type eggs in both animals in the present study is also in agreement with a previous report with an overall prevalence of gastrointestinal helminths of 42.33% in and around Bishoftu (Molla et al., 2015) and 36.2% in the West Hararghe Zone Lamrioui et al. (2013), and a reported study of Degefu et al. (2011) in small-scale dairy cattle farms in Jimma town, Ethiopia.

Prevalence of gastrointestinal helminth parasite infection among the associated risk factors

In this study, Strongyle eggs (55.34%) were predominantly higher than mixed helminth species (10.69%) in positive animals, in line with a previous report by Karshima et al. (2018), which was performed on helminth parasites of cattle in the GedebanoGutazerWolene district in Southern Ethiopia. The higher percentages of Fasciola eggs representing the trematode helminth category in Ada'a district, second to gastrointestinal nematode helminths in this study, was most probably attributed to the availability of intermediate hosts to complete their life cycles in the peri-urban areas of Ada'a district, especially those under semi-intensive and extensive production favoring suitable environmental conditions; other reported findings are associated with (Income et al., 2021; Kumsa et al., 2010; Kebede, 2019), and elsewhere in Ethiopia. In this study, the intensity of helminth infection was not assessed; however, it could be accepted as a determinant factor for the prevalence of large Stronglyes. However, when viewed from the perspective of the presence of GIHPs, the percentage of parasite infection in the study was higher than that in a previous investigation (22.9%) in the GedebanoGutazerWolene district in Southern Ethiopia (Karshima et al., 2018). These variations could be attributed to differences in the study seasons, age, and management status of the animals, as well as the climate and agroecology of the study areas among different studies (Karshima et al., 2018; Hayider et al., 2018).

The causes of the comparatively higher degree of infection in sheep than in cattle in the same district but within different animal or host species, production, and management systems are discussed from three assumptions: The first reason is that, in intensive farm management, the prevalence of gastrointestinal parasites in cattle is significantly reduced because of the use of regular deworming anthelmintics and the application of regular management at the farm and breed resistance, particularly local breeds of cattle, to some extent, which are not prone to helminth infections. Second, cattle intensified under intensive farming systems are not accessible to open pastures and grazing. Third, if sheep are exposed to the external environment and grazing on communal grazing pastures, it increases the probability of being infected by parasites that survive relative temperature and humidity, which play a specific role in parasite infections (Kemal and Terefe, 2013; Molla et al., 2015; Hayider et al., 2018 and Tulu et al., 2016). Furthermore, gastrointestinal helminth parasites cause increased loss of body condition, which could be a potential cause of loss due to reduced production in both cattle and sheep.

Anthelmintic utilization practices

Farmers residing in and around Ada'a district, including Bishoftu town, with smallholder dairy farms, treated their animals under intensive, extensive, and semi intensive farming systems that utilize anthelmintic drugs. The anthelmintics, albendazole, ivermectin, levamisole, and

tetramisole for example, are used by farmers to treat parasitic infections, based on prescriptions by animal health professionals or their own decisions. However, the frequent use of the same group of anthelmintics, the use of anthelmintics at suboptimal doses, prophylactic mass treatment of domestic animals, and frequent and continuous use of a single drug in each area contribute to the widespread development of anthelmintic resistance, causing a pragmatic problem. The results of the questionnaire indicated that ivermectin was the most widely used anthelmintic, followed by albendazole, levamisole, and tetramisole. This is contrary to many other reports that have demonstrated that easily administrable anthelmintics in the form of bolli are preferable to injectable ivermectin (Owhoeli et al., 2014), and is consistent with the unpublished msc thesis (Alkadir, 2023 and Coles et al., 1992)) on in vitro studies of commercially available anthelmintics against isolates of *Haemonchus. contortus* and *Trichostrongylus. columbriformis*inthe Ada'a district of central Ethiopia. According to this survey, in parallel with obtaining anthelmintics from formal veterinary service providers or drug store purchases, 10.0% of the respondents indicated the purchase of anthelmintics from open markets, suggesting that irrational and abusive use of commonly used anthelmintics is possible. This observation also agrees with those of previous studies (Sheferaw et al., 2013; Terefe, 2018). Thirty-eight percent (38%) of the respondents stated that they had dewormed their sheep twice a year, while 33.0% of owners treated them thrice a year. This is in line with previous findings (Seyoum et al., 2017; Sheferaw et al., 2013 and Haftu et al.,2014) but does not agree with previous reports evaluating the efficacy of common anthelmintics (Sissay et al., 2007; Tibebu et al.,2018) in the control of gastrointestinal nematodes in sheep in the Dabat district, Northwest Ethiopia. Thirty-seven percent (37%) of the respondents were under extensive production systems, with farmers lacking good knowledge and skills about anthelmintic use, preferring to use only their interests over the long term and based on parasite load. However, dosing and continued use of one class of anthelmintics, irrespective of their efficacy status, could be the main risk factor and may accelerate selection dynamics. To preserve the efficacy of anthelmintics, targeted selective treatments traditionally practiced by farmers should be encouraged and supported by laboratory tests to identify animals that require treatment.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, gastrointestinal helminth parasites (GIHPs) were identified as the most prevalent and abundant gastrointestinal parasites in the study area, as has been previously reported in other areas of Ethiopia. In particular, Strongyle-type and *Fasciola* eggs represented nematodes, and trematode helminth groups were more prevalent than other parasite eggs. *Moniezia* eggs, a mixed infection form, and *Paraphistomum, Trichuris,* and *Ascaris* eggs were sporadically present. In this study, it was possible to identify animals with poor body conditions, extensive production systems, and animal species as important risk factors for most parasitic taxa. Therefore, farmers and practitioners should keep in mind that animals showing poor body weight and clinical signs of parasite infection are at a higher risk of being heavily infected. Furthermore, the prevalence of gastrointestinal helminth parasite (GIHP) infection was significantly associated with BCS, suggesting that this parameter can be considered when deciding on the pharmacological treatment of animals.

Selective treatment of cattle with poor body condition may be effective for targeting animals with higher burden without compromising period of unfavorable conditions. This represents a cost-effective strategy to increase animal productivity and prevent anthelminthic resistance. It is important to monitor anthelmintic efficacy at regular intervals to detect subtle changes as early as possible to avoid the establishment of anthelmintic resistance. This study was conducted to investigate the prevalence of gastrointestinal helminth parasitism and assess the anthelmintic utilization practices of farmers in the urban and peri-urban areas of Ada'a district with different animal farming systems. Some practices potentially predispose available anthelmintics to drug resistance. Farmers with extensive, semi-intensive, and intensive farming practices should be educated on parasitic infections related to production and economic value. Anthelmintic utilization and management practices should be improved for livestock beneficiaries.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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