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Gastrointestinal Helminths in Local (Black Bengal) and Jamunapari Goats of Barishal Sadar, Southern Bangladesh

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ABSTRACT

Gastrointestinal helminths are important causes of hindering global goat production. To find the prevalence of gastrointestinal helminths of Black Bengal and Jamunapari breeds of goats, the current investigation was carried out at Barishal Sadar Upazilla of Barishal district, Bangladesh. The gastrointestinal helminths were identified through coprological examination. A total of 112 fecal samples were collected from household goats across different seasons, breeds, sexes, and ages. During the study period, four types of gastrointestinal helminths were identified based on the presence of helminth eggs in fecal samples. The overall prevalence of gastrointestinal helminths in goats was found to be 82.1%, while the prevalence rates of *Fasciola gigantica* (*F. gigantica*), *Paramphistomum* spp., *Bunostomum* spp., and *Hemonchus* spp. were 34.8% (95% CI: 1.4-2.5), 22.3% (95% CI: 0.7-1.8), 14.3% (95% CI: 0.1-1.5), and 10.7% (95% CI: 0.2-1.0), respectively. A significantly different prevalence was observed among different gastrointestinal helminths in goats. A significantly lower prevalence of *F. gigantica* and *Paramphistomum* spp. was observed in male goats, compared to females. A higher prevalence of *F. gigantica* was significantly observed during the winter, compared to the summer. The current study elucidates that *F. gigantica* was more prevalent in female goats. The current study indicated that *F. gigantica* was more prevalent in female goats. These findings underscore the importance of further research and control measures to manage gastrointestinal helminth infections in goats across southern Bangladesh and other regions with similar environmental conditions.

Keywords: *Fasciola gigantica*, Gastrointestinal helminth, Goat, Prevalence, Summer

INTRODUCTION

Globally livestock production is considered a crucial sub-sector of agricultural production (Islam et al., 2018; Naide et al., 2018; Sumon et al., 2018) and goat production plays a significant role in promoting human health and economy. Kamaruddin (2003) reported that by exporting skin, meats, and other by-products of goats, there was a substantial amount of foreign currency earnings by the government of developing countries. Since goats are essential production animal species for the supply of milk, they are considered as the cow for poor people. The annual production of milk, meat, and skin from goats makes a significant contribution to the gross domestic product of developing nations (FAO, 2003). The goats have a high potential to reduce poverty in emerging countries like Bangladesh (Faruque et al., 2010) and are crucial in the maintenance of nutrition and boosting of up rural economy.

Among all diseases, parasitic infection is one of the critical constraints in the worldwide production of livestock (Islam et al., 2022). The gastroenteritis caused by helminth parasites is a major problem of the health maintenance of goats. Globally helminths reduce goat production by infecting them, resulting in reduced health (morbidity) or even death (mortality) of the animals. The goat industry experiences a decrease in earnings due to the expenses for treating gastrointestinal helminths or implementing control measures (Hashemnia et al., 2013; Rahman et al., 2017). Among the diseases caused by helminths, Fasciolosis, Paramphistomiasis, Bunostomiasis, Hemonchosis, Agriostomiasis, and Moneziasis are considered economically crucial infections of goats (Win et al., 2020). The gastrointestinal helminth infection among goats in emerging countries is widespread and the financial losses due to helminth infection are significantly high in those countries (Hossain et al., 2011). Among helminths, the most important and prevalent helminth infection is *F. gigantica* and in Bangladesh only prevalent helminth fluke is *F. gigantica* in livestock (DLS, 2010-2011).

It has been reported previously that gastrointestinal helminth infection is the most prevalent parasitic disease of ruminants in Asia and Africa (Hamond and Sewell, 1990; Spithill et al., 1999; Khatun et al., 2021). Globally, there were huge economic losses in ruminants due to reduced production of meat and milk, liver condemnation, and failure of reproductive functions due to different gastrointestinal helminth infections (Fabiyi, 1986; Diaw et al., 1998; Rahman et

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al., 2012). The 7.54% condemnation of 1000 goat livers cause an economic loss of about 28.86 $ (Selim et al., 1997). Furthermore, at present, it is recognized that among gastrointestinal helminths, Fasciolosis is an emerging disease of humans. It is estimated that 2.4 million people are infected with *Fasciola hepatica* and 180 million people are at risk of *Fasciola hepatica* infection (WHO, 2006). The immature *Paramphistomum* spp. causes severe gastroenteritis and adult *Paramphistomum* spp. causes blockage of the intestinal tract of goats (Godara et al., 2014). The *Bunostomum* spp., and *Hemonchus* spp. are important helminths that suck goats' blood and ultimately cause anemia which lead to production losses in the goats (Santos et al., 2012).

Despite the wide prevalence and huge economic losses incurred by gastrointestinal helminths, no epidemiological study of the gastrointestinal helminths of goats has been undertaken so far at the Barishal Sadar, southern part of Bangladesh (Rahman et al., 2012; Talukder et al., 2015). Therefore, in the present study, an attempt was undertaken to find out the prevalence of gastrointestinal helminth infections in goats and the effects of various animal factors, including goat's sex, age, breed, and environmental factors, such as seasonal influence on the prevalence of gastrointestinal helminth infections in goats at Barishal Sadar, Southern Bangladesh.

MATERIALS AND METHODS

Ethical approval

The present study was conducted according to the guidelines of Post-graduate Studies and Research, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.

The area and period of study

A cross-sectional study was undertaken to find out the prevalence of gastrointestinal helminth infections in meat type goats at Barishal Sadar, Bangladesh from July 2011 to June 2012. The study was conducted during all the seasons in a year. Barishal Sadar is an Upazilla of the Barishal district (southern part of Bangladesh). An Upazilla is the smallest administrative unit of Bangladesh. The location of the Barishal Sadar Upazilla is 90°22′E 22°42′N and has a total area of 263.56 km² (Figure 1) with a riverine area of 15.54 km^2 (5.9% riverine area). The highest average annual temperature is 35.1°C, the lowest 12.1°C, and 1955 mm mean annual rainfall. The region is known as the riverine area of Bangladesh with high rainfall. Five rivers flow through the Barishal Sadar Upazilla. Goats were typically raised by the locals in that area using a semi-scavenging method (BBS, 2011).

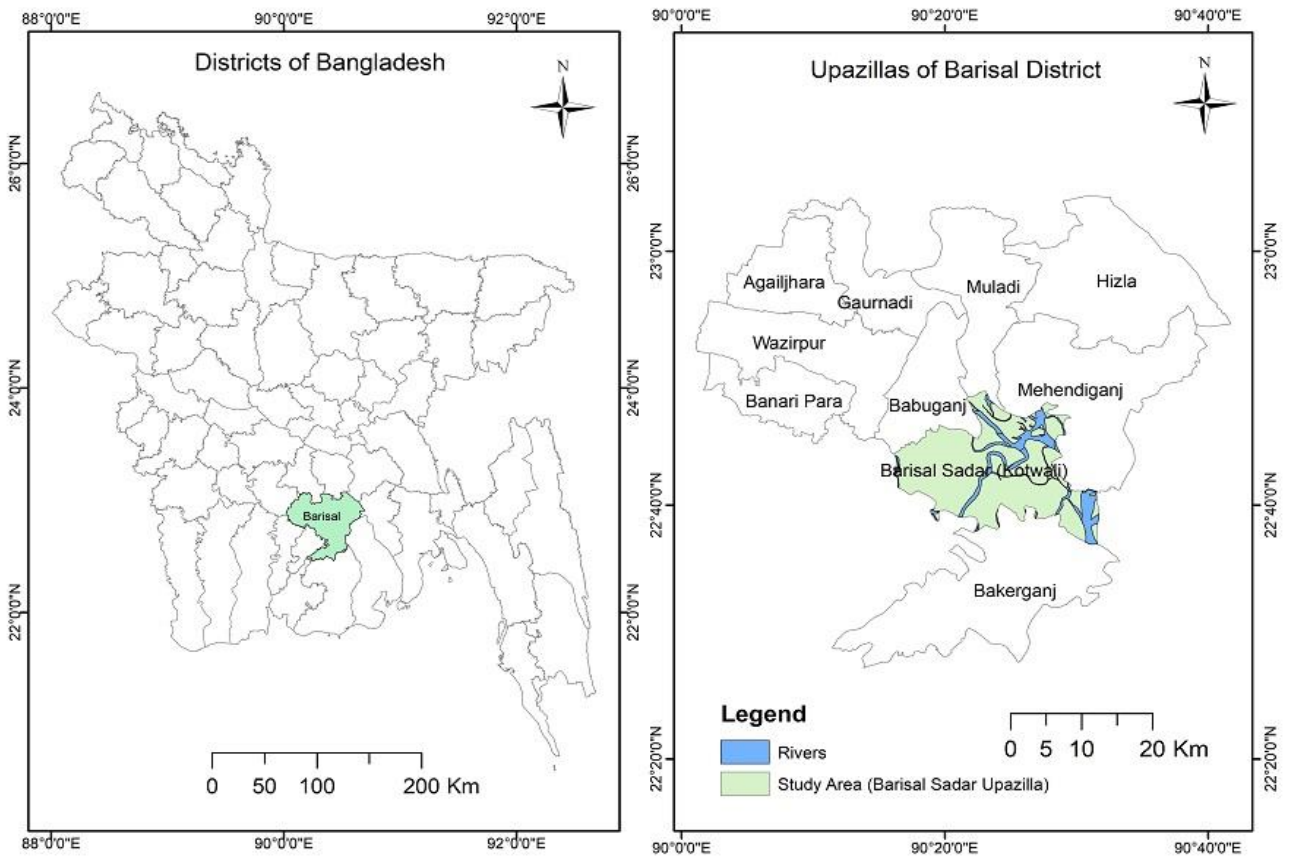

Figure 1. Study area located in Barishal Sadar Upazilla of Barishal district, Bangladesh

Study design and sample size determination

There are about 4037 households in the Barishal Sadar Upazilla. Among 4037 households, at least 200 households had goat farms commonly known as family farms (BBS, 2011). For the determination of the sample size, Epi-Info™ software Version 7 (2008) was used (CDC, Atlanta). In a one-stage cluster sampling using the StatCalc of the Epi-Info™, a total of 132 samples were required from Barishal Sadar for the study (at the level of 95% confidence interval) with at least one representative sample from each family farm. However, due to the limitations (e.g., too poor transport and communication systems), 112 fecal samples from 112 farms were collected using on-site sampling. A study questionnaire was developed to record the information of each goat, including age, sex, breed, season, and management practices, such as grazing habits and the information of the goat owner. The questionnaire was in English therefore, it was translated into the common language of the locality during the face-to-face interview with the owner of the goats. The collected information was saved in Microsoft Excel for data analysis.

Sample collection and examination

A total of 112 fecal samples were randomly collected from 112 apparently healthy goats with a history of no anthelmintic treatment in Barishal Sadar Upazilla. The samplings were performed early in the morning between 8:00-9:00 a.m. before moving the goats to the pasture areas. About 5-10g of faeces were directly collected by hand from the rectum of the goats and put into a plastic container with 10% formalin. The particulars of the goats, such as the name of the goat owner and the body weight of goats were also recorded. The label depicting the particulars of the goat, the address of the owner, and the date of the collection were taped to the plastic container's wall. The samples were immediately transferred to the Medicine laboratory of Patuakhali Science and Technology University, Babuganj, Barishal-8210 by using an ice box to examine subsequently.

The faecal samples were examined by direct smear, sedimentation, and flotation methods as described previously by Soulsby (1986). The economical binocular light microscope XSZ-107BN (2010) from Labtex Bangladesh was used for examining the fecal samples. From each faecal sample and each test, at least, two smears were prepared for the identification of eggs of different gastrointestinal helminths (Soulsby, 1986; Hendrix, 2006). The prevalence was confirmed based on the morphological characters of helminth eggs as described by Soulsby (1986) and Valero et al. (2009).

Statistical analyses

The data were entered into an Excel spreadsheet of MS Office. Determination of the prevalence was performed by employing the overall frequency of positive and negative sample test results using Equation 1 (Islam et al., 2020). For examining the statistical associations between the prevalence of gastrointestinal helminths infection and various risk factors of goats (e.g. sex, breed, and seasons), the one-way analysis of variance (ANOVA) followed by post tests and descriptive statistics were utilized. Test results were considered significant at ($p < 0.05$).

Prevalence (%) = $^{n}/_{N} \times 100$ (Equation 1).

Where n is the number of samples positive for different types of gastrointestinal helminths and N is the number of the total samples examined.

RESULTS

A total of 112 faecal samples from goats were examined in different sexes and ages during all the seasons. Four different types of gastrointestinal helminths were detected in the present study. The overall prevalence of gastrointestinal helminths in goats at Barishal Sadar is 82.1%. The prevalence of *F. gigantica*, *Paramphistomum* spp., *Bunostomum* spp., and *Hemonchus* spp. were 34.8%, 22.3%, 14.3%, and 10.7%, respectively. The prevalence of different gastrointestinal helminths was significantly different ($p < 0.05$) as shown in Table 1.

The results indicated *F. gigantica* prevalence was significantly higher in *Hemonchus* spp. prevalence ($p < 0.05$) as shown in Table 2. The highest prevalence of *F. gigantica* (36.9%) was observed in female goats, which was significantly different from the prevalence of male goats ($p < 0.05$; Table 3). As can be seen in Table 3 the highest prevalence of *F. gigantica* was observed during the winter season (52.6%) which was significantly different than the prevalence in rainy and summer seasons ($p < 0.05$). The prevalence of *F. gigantica* in winter was significantly higher than summer prevalence as shown in Table 4 ($p < 0.05$). Table 5 indicates the prevalence of *Paramphistomum* spp. was significantly higher in female goats than male goats ($p < 0.05$).

A significantly different prevalence of *Bunostomum* spp., and *Hemonchus* spp. did not observe between breed and sexes and among different seasons (Tables 6 and 7). A comparatively higher prevalence of *F. gigantica*, *Paramphistomum* spp., *Bunostomum* spp., and *Hemonchus* spp. were observed in younger goats compared to older goats

(Tables 3, 5, 6, and 7). A total of 17.85% mixed gastrointestinal helminthiasis (20 mixed infections out of 112 samples) were also observed. The mixed infections of *F. gigantica* and *Paramphistomum* spp. (8.03%), *F. gigantica* and *Hemonchus* spp. (2.68%), *F. gigantica* and *Bunostomum* spp. (2.68%), *Paramphistomum* spp. and *Hemonchus* spp. (0.90%), and *Hemonchus* spp. and *Bunostomum* spp. (3.57%) were recorded.

Table 1. Prevalence of different gastrointestinal helminths in goats of Barishal Sadar, Bangladesh

Name of helminth	Examined Samples (Mean ± SD)	Positive samples (Mean ± SD)	Prevalence percentage (95 % CI)	p-value
Fasciola gigantica (*F. gigantica*)	112 (5.6 ± 1.76)	39 (1.95 ± 1.23)	34.8 (1.4–2.5)	< 0.05*
Paramphistomum spp.	112 (5.6 ± 1.76)	25 (1.25 ± 1.25)	22.3 (0.7–1.8)	
Bunostomum spp.	112 (5.6 ± 1.76)	16 (0.8 ± 1.58)	14.3 (0.1–1.5)	
Hemonchus spp.	112 (5.6 ± 1.76)	12 (0.6 ± 0.94)	10.7 (0.2–1.0)	

CI: Confidence interval, *Significant difference ($p < 0.05$)

Table 2. The prevalence of different helminths in goats of Barishal Sadar, Bangladesh

Sl. no	Variables	Name of helminths	p-value
01	*F. gigantica*	*Paramphistomum* spp.	> 0.05
02	*F. gigantica*	*Bunostomum* spp.	> 0.05
03	*F. gigantica*	*Hemonchus* spp.	< 0.05*
04	*Paramphistomum* spp.	*Bunostomum* spp.	> 0.05
05	*Paramphistomum* spp.	*Hemonchus* spp.	> 0.05
06	*Bunostomum* spp.	*Hemonchus* spp.	> 0.05

*Significant difference ($p < 0.05$).

Table 3. Prevalence of *F. gigantica* in goats of Barishal Sadar, Bangladesh

Variables		Examined samples (Mean ± SD)	Positive samples (Mean ± SD)	Prevalence percentage (95 % CI)	p-value
Breed	Black Bengal	74 (3.70 ± 1.59)	25 (1.25 ± 1.02)	33.8 (0.8-1.7)	> 0.05
	Jamunapari	38 (1.90 ± 0.79)	14 (0.70 ± 0.66)	36.8 (0.4-1.0)	
Sex	Male	28 (1.40 ± 1.05)	8 (0.4 ± 0.68)	28.6 (0.1-0.7)	< 0.05*
	Female	84 (4.2 ± 1.58)	31 (1.55 ± 0.83)	36.9 (1.2-1.9)	
Age	0–6 months	11 (0.55 ± 1.05)	3 (0.15 ± 0.37)	27.3 (-0.02-0.3)	> 0.05
	6 months-1 year	35 (1.75 ± 1.94)	12 (0.60 ± 0.82)	34.3 (0.2-1.0)	
	1 year-1.5 years	14 (0.70 ± 1.13)	7 (0.75 ± 0.99)	50 (-0.1-0.8)	
	1.5 years-2 years	17 (0.85 ± 1.31)	7 (0.35 ± 0.75)	41.2 (0.001-0.7)	
	2 years-2.5 years	12 (0.60 ± 1.19)	4 (0.20 ± 0.52)	33.3 (-0.04-0.4)	
	2.5 years-3 years	13 (0.65 ± 1.53)	4 (0.20 ± 0.70)	30.8 (-0.1-0.5)	
	> 3 years	10 (0.50 ± 1.10)	2 (0.10 ± 0.31)	20 (-0.04-0.2)	
Seasons	Rainy	35 (5.83 ± 1.47)	11 (1.83 ± 0.75)	31.4 (1.0-2.6)	< 0.05*
	Winter	38 (5.50 ± 2.74)	20 (2.83 ± 1.47)	52.6 (1.6-4.1)	
	Summer	39 (5.50 ± 1.38)	8 (1.00 ± 0.89)	20.5 (0.3-2.0)	

Season: Rainy; July-October, Winter; November-February, Summer; March-June, CI: Confidence Interval, *Significant difference ($p < 0.05$)

Table 4. Prevalence of *F. gigantica* during different seasons in goats of Barishal Sadar, Bangladesh

Sl. no	Variables	Season	p-value
01	Rainy	Winter	> 0.05
02	Rainy	Summer	> 0.05
03	Winter	Summer	< 0.05*

*Significant difference ($p < 0.05$)

Table 5. Prevalence of *Paramphistomum* spp. in goats of Barishal Sadar, Bangladesh

Variables		Examined samples (Mean ± SD)	Positive samples (Mean ± SD)	Prevalence percentage (95 % CI)	p-value
Breed	Black Bengal	74 (3.70 ± 1.59)	16 (0.80 ± 0.77)	21.6 (0.4-1.6)	> 0.05
	Jamunapari	38 (1.90 ± 0.79)	9 (0.45 ± 0.83)	23.7 (0.06-0.8)	
Sex	Male	28 (1.40 ± 1.05)	6 (0.30 ± 0.66)	21.4 (-0.007-0.6)	< 0.05*
	Female	84 (4.20 ± 1.58)	19 (0.95 ± 1.15)	22.6 (0.4-1.5)	
Age	0-6 months	11 (0.55 ± 1.05)	1 (0.05 ± 0.22)	9.1 (-0.05-0.15)	> 0.05
	6 months-1 year	35 (1.75 ± 1.94)	9 (0.45 ± 0.89)	25.7 (0.03-0.9)	
	1 year-1.5 years	14 (0.70 ± 1.13)	2 (0.10 ± 0.45)	14.3 (-0.1-0.3)	
	1.5 years-2 years	17 (0.85 ± 1.31)	5 (0.25 ± 0.55)	29.4 (-0.008-0.5)	
	2 years-2.5 years	12 (0.60 ± 1.19)	2 (0.10. ± 0.31)	16.7 (-0.04-0.2)	
	2.5 years-3 years	13 (0.65 ± 1.53)	4 (0.20 ± 0.70)	30.7 (-0.1-0.5)	
	> 3 years	10 (0.50 ± 1.10)	2 (0.10 ± 0.31)	20 (-0.04-0.2)	
Seasons	Rainy	35 (5.83 ± 1.47)	7 (1.17 ± 1.17)	20 (-0.06-2.4)	> 0.05
	Winter	38 (5.50 ± 2.74)	6 (0.50 ± 0.84)	15.8 (-0.3-2.0)	
	Summer	39 (5.50 ± 1.38)	12 (1.83 ± 1.47)	30.8 (0.4-3.0)	

CI: Confidence interval, *Significant difference ($p < 0.05$), Rainy: July-October, Winter: November-February, Summer: March-June

Table 6. Prevalence of *Bunostomum* spp. in goats of Barishal Sadar, Bangladesh

Variables		Examined samples (Mean ± SD)	Positive samples (Mean ± SD)	Prevalence percentage (95 % CI)	p-value
Breed	Black Bengal	74 (3.70 ± 1.59)	9 (0.45 ± 1.10)	12.1 (-0.06-1.0)	> 0.05
	Jamunapari	38 (1.90 ± 0.79)	7 (0.35 ± 0.67)	18.4 (0.04-0.7)	
Sex	Male	28 (1.40 ± 1.05)	4 (0.20 ± 0.52)	14.3 (-0.04-0.4)	> 0.05
	Female	84 (4.20 ± 1.58)	12 (0.60 ± 1.39)	14.3 (-0.05-1.3)	
Age	0-6 months	11 (0.55 ± 1.05)	1 (0.05 ± 0.22)	9.1 (-0.05-0.2)	> 0.05
	6 months-1 year	35 (1.75 ± 1.94)	6 (0.30 ± 0.80)	20 (-0.08-0.7)	
	1 year-1.5 years	14 (0.70 ± 1.13)	4 (0.20 ± 0.70)	28.6 (-0.1-0.5)	
	1.5 years-2 years	17 (0.85 ± 1.31)	2 (0.10 ± 0.31)	11.8 (-0.04-0.2)	
	2 years-2.5 years	12 (0.60 ± 1.19)	1 (0.05 ± 0.22)	8.3 (-0.05-0.2)	
	2.5 years-3 years	13 (0.65 ± 1.53)	1 (0.05 ± 0.22)	7.7 (-0.05-0.2)	
	> 3 years	10 (0.50 ± 1.10)	1 (0.05 ± 0.22)	10 (-0.05-0.2)	
Seasons	Rainy	35 (5.83 ± 1.47)	5 (0.83 ± 1.60)	14.3 (-0.8-2.5)	> 0.05
	Winter	38 (5.50 ± 2.74)	7 (1.17 ± 2.40)	18.4 (-1.1-3.1)	
	Summer	39 (5.50 ± 1.38)	4 (0.67 ± 0.82)	10.3 (-0.2-1.3)	

CI: Confidence interval, Rainy: July-October, Winter: November-February, Summer: March-June

Table 7. Prevalence of *Hemonchus* spp. in goats of Barishal Sadar, Bangladesh

Variables		Examined samples (Mean ± SD)	Positive samples (Mean ± SD)	Prevalence percentage (95 % CI)	p-value
Breed	Black Bengal	74 (3.70 ± 1.59)	7 (0.35 ± 0.67)	9.5 (0.04-0.7)	> 0.05
	Jamunapari	38 (1.90 ± 0.79)	5 (0.25 ± 0.55)	13.2 (-0.008-0.5)	
Sex	Male	28 (1.40 ± 1.05)	3 (0.15 ± 0.37)	10.7 (-0.02-0.3)	> 0.05
	Female	84 (4.20 ± 1.58)	9 (0.45 ± 0.83)	10.7 (0.06-0.8)	
Age	0-6 months	11 (0.55 ± 1.05)	0 (0.00 ± 0.00)	0 (0-0)	> 0.05
	6 months-1 year	35 (1.75 ± 1.94)	4 (0.02 ± 0.62)	11.4 (-0.09-0.5)	
	1 year-1.5 years	14 (0.70 ± 1.13)	3 (0.15 ± 0.49)	21.4 (-0.08-0.4)	
	1.5 years-2 years	17 (0.85 ± 1.31)	1 (0.05 ± 0.22)	5.9 (-0.05-0.2)	
	2 years-2.5 years	12 (0.60 ± 1.19)	3 (0.15 ± 0.49)	25 (-0.08-0.4)	
	2.5 years-3 years	13 (0.65 ± 1.53)	0 (0.00 ± 0.00)	0 (0-0)	
	> 3 years	10 (0.50 ± 1.10)	1 (0.05 ± 0.22)	10 (-0.05-0.2)	
Seasons	Rainy	35 (5.83 ± 1.47)	2 (0.33 ± 0.52)	5.7 (-0.2-0.9)	> 0.05
	Winter	38 (5.50 ± 2.74)	5 (0.83 ± 1.33)	13.1 (-0.4-1.9)	
	Summer	39 (5.50 ± 1.38)	5 (0.50 ± 0.84)	12.8 (-0.2-1.6)	

CI: Confidence interval, Rainy: July-October, Winter: November-February, Summer: March-June

DISCUSSION

It is essential to maintain the optimum health of livestock to get the maximum production of farming livestock (Hendawy et al., 2022; Haque et al., 2020; 2021). Among infectious diseases, gastrointestinal helminth infections are crucial agents affecting the production of livestock as gastrointestinal helminth infections and sometimes get unnoticed during subclinical infections (Rahman et al., 2012; Rahman et al., 2017). Therefore, accurate surveillance of infections caused by gastrointestinal helminth in livestock is essential to undertake control measures against gastrointestinal helminthiasis.

The overall prevalence of gastrointestinal helminth infection in goats in Barishal Sadar was 82.1% in the present study which could be considered as high. In prior studies, a higher prevalence of gastrointestinal helminth infection in goats was reported (Islam et al., 2017; Chikweto et al., 2018; Squire et al., 2019; Win et al., 2020). The most likely reason for this high prevalence of gastrointestinal helminth infections in goats in Barishal Sadar, Bangladesh might be due to contaminated pasture where both young and adult goats were grazed together. This high prevalence of gastrointestinal helminths will cause severe losses of production in goats (Rahman et al., 2012). Therefore, immediate actions need to be undertaken to control the higher prevalence of gastrointestinal helminths in goats in southern Bangladesh.

In the present study, the overall prevalence of *F. gigantica* infection was 34.82%. Spithill et al. (1999) reported a similar rate of *F. gigantica* infection. Selim et al. (1997), Islam and Taimur (2008), and Hossain et al. (2011) reported a relatively lower infection rate of *F. gigantica* in goats which were 8.70%, 14.28%, and 20.75%, respectively. The present findings denote that *F. gigantica* infection rate increased with the progression of time. It is possible that the current samples were collected from goats that have not received any anthelmintic treatment in the past, or they could have been obtained from low-lying areas with high levels of rainfall.

The prevalence of *Paramphistomum* spp. infection in goats was 22.3%, which could also be considered as high. Previously it was reported by Godara et al. (2014) that 13.6% goats were infected with *Paramphistmum* spp. in Jammu, India. The high prevalence of *F. gigantica* and *Paramphistomum* spp. in goats in Barishal Sadar was due to low-lying areas associated with the presence of intermediate snail hosts.

A comparatively low prevalence of *Bunostomum* spp., and *Hemonchus* spp. were observed in the present study which was 14.3% and 10.7%, respectively. In the current study the most probable reason for the low prevalence of *Bunostomum* spp., and *Hemonchus* spp. infection in goats might be due to the irregular passage of eggs in faeces or low ingestion of infective stage larvae (L3) of *Bunostomum* spp., and *Hemonchus* spp. (Waruiru et al., 2001) by goats. The irregular passage of eggs through feces causes variations of gastrointestinal helminth eggs during coprological examination (Robert, 2011).

A similar rate of infection of all gastrointestinal helminths was detected both in the Jamunapari breed (a local breed of the neighboring country India) and the Black Bengal breed (local breed) in Barishal Sadar, Bangladesh. It might be due to the adjustment of the Jamunapari breed to the climate of Bangladesh. The exotic Jamunapari breed had a long habitat in Bangladesh, although the Jamunapari breed was not considered as a local breed of goat in Bangladesh. It is concluded from the present study, that gastrointestinal helminth can infect both the Black Bengal and Jamunapari breeds at a similar rate and a similar trend of endoparasitic diseases in the Black Bengal breed and Jamunapari breed has been reported previously (Parvez et al., 2014). The present findings indicated that adaptation of an exotic breed of goats in a certain climate causes a similar rate of helminth infection to the exotic breed of goats.

A significantly high prevalence of *F. gigantica* and *Paramphistomum* spp. in female goats compared to male goats was similar to the findings of other studies by Hossain et al. (2011) and Parvez et al. (2014). Change of physiological conditions during milking and/or undernutrition during production in female goats was a reason for a higher rate of infection. The other factors that might affect the rate of infection were long-time exposure of the female goats to the *F. gigantica* and *Paramphistomum* spp. as their heavy grazing habit in the submerged areas, which were characteristics of the Barisal region. A significant difference in prevalence of *Bunostomum* spp., and *Hemonchus* spp. between males and females were not observed. The most probable reason was due to the lower infection of *Bunostomum* spp., and *Hemonchus* spp. in goats in Barishal Sadar, Bangladesh.

Infection of goats at their early stages of life could have serious consequences with stunting growth and will make goats susceptible to other parasitic, bacterial, and viral infectious diseases and ultimately will cause great economic losses. Besides causing serious loss by the parasite itself, immature *F. gigantica* caused liver damage, and immature *Paramphistomum* spp. caused damage to the intestinal wall and ultimately predisposed goats to *Clostridium novyi* infection (black disease) and there may be the ultimate death of the infected goat kids (Smith, 2014).

The highest prevalence of *F. gigantica* in the younger age group (50% in 1 year-1.5-year age groups) was not in agreement with studies of Tasawar et al. (2007) and Hossain et al. (2011) and in agreement with a study of Parvez et al.

(2014). Tasawar et al. (2007) and Hossain et al. (2011) found a 35.71% and 14% prevalence, respectively in 1 year-1.5-year age groups. The probable reason for the different findings might be different geographic locations and individual immunity of goats. The lowest gastrointestinal helminth infection in the older age group was in agreement with studies of Hossain et al. (2011) and Tasawar et al. (2007). The most probable reason for the low rate of infection in adult goats than young goats could be due to the impacts of the self-cure phenomenon (Fryod, 1975; Assanji, 1988) and/or higher immunity that was acquired by goats due to aging (Singh et al., 2015). Previously it was reported that the host recovers from the infection of helminths with aging and ultimately becomes resistant to helminth diseases (Soulsby, 1986). In order to improve our understanding of the age immunity of gastrointestinal helminths in goats, it is essential to conduct studies that involve goats aged up to 10 or 12 years (as the present study includes goats up to 4 years).

The higher prevalence of Fasciolosis in winter and rainy seasons in goats was in line with the findings of Keyyu et al. (2005). The probable reason for higher findings (52%) of Fasciolosis during the winter season in the present study was due to the infection of goats in summer with *F. gigantica* and passing of *F. gigantica* ova/eggs with feces starting from the mid-rainy season and continued to whole winter season (as the prepatent period of *F. gigantica* ~120 days). Keyyu et al. (2005) reported that the passing of fluke eggs through feces gradually increased when the dry season started and egg passing reached its peak at the end of the dry season (winter) and again egg passing with feces decreased when the summer season starts which supports the present findings.

Specifically rainy weather, played a significant role in the varying prevalence of *F. gigantica* and *Paramphistomum* spp. This is due to the fact that rainy weather is essential for the reproduction of the intermediate snail hosts. Furthermore, the snail can survive a longer period under conditions that are moist and rainy (Ahmed et al., 2007). Moreover, summer in Bangladesh is rainy up to October (end of the rainy season), which facilitates the survival of *F. gigantica* and *Paramphistomum* spp. in such an environment and causes massive infection in susceptible goats during the rainy and winter season. A relatively lower prevalence of *Bunostomum* spp., and *Hemonchus* spp. were found throughout the year. The most probable reason for this lower prevalence of these two helminths were due to lower ingestion of *Bunostomum* spp., and *Hemonchus* spp. larvae by goats as evidenced by previous studies (Nyingi et al., 2001; Waruiru et al., 2001).

The mixed infections of different types of gastrointestinal helminth infections in goats were considered high (17.85%). The mixed parasitic infection in goats was also reported in other published studies by Chikweto et al. (2018) and Win et al. (2020). Single helminth infection predisposes goats to get infections with other parasites (mixed infections) and these mixed infections might severely reduce goat production compared with a single helminthic infection (Campos et al., 2008; Win et al., 2020). The high percentage of mixed infections of *F. gigantica* and *Paramphistomum* spp. (8.03%) in goats might be due to both helminths requiring snail intermediate hosts for the completion of their life cycle. A relatively lower rate of mixed infections of *Bunostomum* spp., and *Hemonchus* spp. might be due to the adverse effects of the environment on the infective stage of larvae as evidenced by previous studies (van Dijk et al., 2009; Santos et al., 2012).

A limitation of the present study was the few numbers of samples comprising only one Upazilla. Future studies should be directed at finding the prevalence of gastrointestinal helminth infections in goats using more samples including entire southern Bangladesh. Only qualitative methods (direct smear, sedimentation, and floatation) for the determination of gastrointestinal helminth infection in animals were problematic and might cause a lower detection rate. To facilitate a more precise and captivating discussion, it is imperative to consider employing serological and molecular identification techniques for the detection of gastrointestinal helminths in the future.

CONCLUSION

Gastrointestinal helminth infections in goats were 82.1% in Barishal Sadar which could be considered as endemic in Barisal Sadar, Bangladesh. Female goats were infected more with *F. gigantica* and *Paramphistomum* spp. compared to male goats. Therefore, specific and accurate diagnosis of *F. gigantica* and *Paramphistomum* spp. need to be undertaken to prevent gastrointestinal helminth infections in the female goat population. A higher prevalence (52.6%) of *F. gigantica* was observed in goats during the winter. Thus, the administration of a specific anthelmintic against *F. gigantica* during the winter will be crucial to preventing *F. gigantica* infection in goats. Control of the snail population (intermediate host), avoiding low-lying areas of grazing, and avoiding mixed grazing of adults and young in the grazing area would be other alternate options. The findings of the present study reveal the determination of other parasitic infections in goats of Barishal Sadar, Bangladesh. In the present study, due to the limitation, the species of the *Paramphistomum* spp., *Bunostomum* spp., and *Hemonchus* spp. were not determined. Future studies should be conducted to determine the species of gastrointestinal helminths in goats in Southern Bangladesh.

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Competing interests

The authors have not declared any conflict of interest.

Authors' contributions

Md. Aminul Islam conceptualized the study idea, managed funding, developed the methodology, analyzed the data, and wrote the original draft manuscript. Anup Kumar Talukder, Sheikh Arafatur Rahman, and Mohammad Shah Alam reviewed and edited the original draft of the manuscript. Md. Sodrul Islam, Mohammad Anisur Rahman, and Shib Shankar Saha viewed and edited the manuscript. All authors checked the analyzed data and the last edition of the manuscript before submission and confirmed the previous revisions of the article before publication.

Availability of data and materials

All data related to this manuscript is included in the prepared manuscript. For any additional information, please contact to corresponding author.

Ethical considerations

The authors declared that the submitted manuscript was written originally and the data of this study is not submitted or published in any other journals.

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