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EPIDEMIOLOGICAL STUDIES OF GASTROINTESTINAL HELMINTHS IN GOATS (*Capra aegagrus hircus*) OF ALIGARH, UTTAR PRADESH, NORTH INDIA

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ABSTRACT

The present epidemiological study was aimed to assess the seasonal prevalence, mean intensity and abundance of gastrointestinal (GI) helminths in goats between January 2017 and December 2019 in Aligarh district of Uttar Pradesh (India). Entire GI tracts from slaughtered goats were brought to the laboratory, dissected and worms from different parts of GI tract were collected, counted and recorded on monthly basis. Eggs per gram of faeces in positive samples were estimated by McMaster technique. The collected data were analysed with respect to rainfall, relative humidity and temperature of months/seasons. Out of 499 goats, 350 were found infected with one or more helminth parasites. *Haemonchus contortus* was predominant (68.74%), followed by *Trichuris ovis* (57.72%), *Moniezia expansa* (23.84%), *Oesophagostomum columbianum* (15.43%) and amphistomes (9.81%). Considerable variations were noticed in prevalence, mean intensity, abundance and total egg counts during different months/seasons, and the highest values were recorded in monsoon and lowest in winter. Female goats were more infected by all helminth parasites than males. The study provides important information about the seasonal dynamics of helminth parasites, which can be utilized to develop integrated control measures for these parasites in North India.

Keywords: Epidemiology, faecal egg count, gastrointestinal helminths, small ruminants

INTRODUCTION

About 70% population in India primarily depends on agriculture for their livelihood (FAO, 2022). Rearing of livestock is a common practice in rural India, which has been pivotal in improving the socio-economic status of landless, marginal and small farmers and is considered as the backbone of Indian economy (Kumar and Roy, 2013; Singh *et al.,* 2020). In rural areas, livestock is still reared on a grazing-based system where natural breeding is common; however, artificial insemination is used in government institutes to improve animal productivity. Sheep and goats are common meat producers in India, and their flesh (chevon/mutton) is in high demand. They contribute significantly to the country's economy and are considered "poor man's cow" (Kumar and Roy, 2013). Although sheep and goat farming has a vast socio-economic value for underprivileged farmers, they are neglected compared to other livestock (Singh *et al.,* 2021). According to the 20th livestock census, the share of sheep and goats in the total Indian livestock population is about 14.13 and 28.3%, respectively (Anon, 2019). In spite of the large population of sheep and goats, the economic benefits to their owners are minimal because of the poor health of animals due to parasitic infection (FAO, 2002).

Among the parasites that inflict heavy morbidity and mortalities to sheep and goats and cause productivity losses worldwide, GI helminths rank highest on global index (Perry *et al.,* 2002; Mpofu

et al., 2022). To prevent the losses incurred by such parasites, there is dire need to protect farm animals from parasitic attacks by using integrated control measures, which vary in different farming systems due to differences in management practices and ecological factors (Sharma *et al.*, 2020). The hot and humid climate of India favours the development and survival of infective stages of parasites; therefore, parasitic infections are more prevalent in the country. Since the prevalence and intensity of GI helminths in livestock depend upon various environmental and host's contributory factors (Singh *et al.*, 2017; Mpofu *et al.*, 2022), it is essential to identify the main epidemiological factors that determine the frequency and transmission of infections. Many workers have investigated the influence of climatic factors on the prevalence of GI helminths from different parts of India (Bansal *et al*., 2013; Brahma *et al*., 2015; Das *et al.*, 2017; Chaurasiya *et al*., 2021) as well as from Uttar Pradesh (Singh *et al*., 2013; Anugrah *et al.*, 2018; Jaiswal *et al.*, 2020) and reported variable prevalence rate during different seasons. But no comprehensive work has been done so far in Aligarh district of Uttar Pradesh (India). Therefore, the present study was aimed to assess the impact of various environmental factors on the prevalence and intensity of GI helminths in goats in Aligarh district of Uttar Pradesh (India).

MATERIALS AND METHODS

Study area

The present study was carried out from January 2017 to December 2019 in Aligarh district, Uttar Pradesh (India). The district is situated between the latitude of 27°53′N, 78°05′E, and longitude of 27°88′N, 78°08′E, with an area of 3747 km^2 and human population of over 3.7 million. Aligarh district has 172196 goats, 11841 sheep, 25711 pigs, 841392 buffaloes, and 153453 cattle (Anon, 2013). Aligarh has a monsoon-influenced humid subtropical climate with three different seasons: winter (November to February), summer (March to June) and monsoon (July to October) (Anon, 2022). The temperature, relative humidity and rainfall data in different months/seasons of 3 years (2017-2019) were collected from Meteorological Centre, Department of Physics, AMU, Aligarh, UP (India).

Sample collection and examination

A total of 499 GI tracts were collected from the slaughtered goats at Aligarh abattoir and brought to the laboratory in separate containers. The GI tracts were opened longitudinally and the contents from rumen, abomasum and small and large intestines were collected in separate beakers. The mucosae of different parts were washed with Hanks balanced salt solution (HBSS, pH 7.4) (Rashid and Irshadullah, 2018) and washing was collected in the same beaker and then scraped carefully to remove any adhering worms. The contents from different parts of GI tract were diluted with HBSS and examined microscopically at 20X for the presence of helminth parasites. The worms from each part of GI tract were separated, identified, counted and recorded monthly. The identification of parasites was done on the basis of morphological characters (Soulsby, 1982) using a light microscope (Magnus, HM-100). The data was used to calculate the prevalence, mean intensity, and abundance by using the formulae of Rashid and Irshadullah (2018). Further, to assess the influence of meteorological factors, the data were analysed based on temperature, rainfall, and relative humidity of different months/seasons.

Faecal egg count (FEC)

The faecal samples were collected directly from rectum in separate plastic bottles, labelled, stored and used for counting of eggs. Faecal egg count was carried out according to the method of Zajac and Conboy (2013). For this, 2 g faeces sample was thoroughly mixed with 28 mL saturated sodium chloride solution, filtered and the filtrate used for counting the eggs using 3-chambered McMaster slide (Chalex, LLC, USA). The eggs per g faeces were calculated by using the dilution factor 50.

Statistical analysis

Chi-square (λ^2) test was performed using GraphPad Prism software (version 8.0.1.244) to assess the association between meteorological factors and infection indices and significant differences between

prevalence, mean intensity and abundance values during different seasons. One-way ANOVA followed by Duncan's post-hoc test was performed to analyse the significant differences between FEC during different months. To evaluate the impact of host sex on the prevalence of GI helminths, the odds ratio (OR) was calculated through binary logistic regression by using SPSS software version 23 (SPSS Inc., USA). The confidence level was 95%, and a p-value ≤ 0.05 was considered significant.

RESULTS AND DISCUSSION

The mean values of meteorological data with respect to temperature, humidity, precipitation, for three years are given in Table 1. Aligarh's summer was very severe, with maximum temperature recorded in June. The rainy season began in late June and continued till September. Annual rainfall was 730 mm, of which 84.3% was received during monsoon period. The coldest months were December and January, with minimum temperature of 1.8 and 3.6˚C, respectively. The relative humidity was comparatively low during summer and high during winter and rainy seasons.

Table 1: The mean temperature, relative humidity and rainfall in Aligarh district of Uttar Pradesh, India during 2017-2019

Seasons	Months	Temperature (˚C)	Relative humidity (%)	Rainfall (mm)
Rainy	July	30.9 (22.4-40.8)	75.1 (39-100)	241.3 (0.2-112.4)
	August	30.1 (23.2-37.4)	78.1 (55-98)	144.9 (0.2-246.8)
	September	29.3 (21.2-37.4)	74.6 (40-97)	129.0 (0.2-162)
	October	26.7 (15.2-36.8)	58.4 (29-91)	1.13 (0-3.4)
Winter	November	20.8 (9.0-31.6)	66.0 (39-98)	1.73 (0-4.6)
	December	14.8 (1.8-26.8)	76.5 (31-97)	8.0 (0.8-21.4)
	January	14.2 (3.6-25.8)	77.5 (41-100)	18.0 (0.4-29.8)
	February	17.9 (7.0-31.6)	69.0 (23-98)	10.0 (4-26)
Summer	March	23.2 (8.4-39.8)	53.6 (23-98)	19.2 (0.8-40.6)
	April	30.1 (16.6-43.6)	38.5 (15-83)	24.2 (1.2-39)
	May	32.4 (20.2-45.8)	41.3 (16-90)	33.1 (0.2-64.6)
	June	33.2 (19.2-46.4)	52.4 (22-98)	99.8 (0.2-256.2)

Source: Meteorological Centre, Department of Physics, AMU, Aligarh, UP, India
The values are mean of 3 year's data (2017-2019).
The values in parenthesis represent the minimum and maximum range.

Out of the 499 goats, 350 (70.14%) were found infected with different GI helminth species. The highest prevalence was recorded for *Haemonchus contortus,* followed by *Trichuris ovis*, *Moniezia expansa*, *Oesophagostomum columbianum* and amphistomes, while mean intensity and abundance varied according to parasites (Fig. 1). χ^2-test showed significant difference between the prevalence rate of all months for *H. contortus* ($\chi = 44.9$, $p < 0.01$), *O. columbianum* ($\chi^2 = 41.17$, $p < 0.001$) and amphistomes ($\chi^2 = 40.31$, $p < 0.001$), while insignificant differences for *T. ovis* ($\chi^2 = 29.93$, $p \leq 0.12$) and *M. expansa* ($\chi^2 = 21.38$, $p \leq 0.26$). Contrarily, many workers have reported either low or higher prevalence rates of GI helminths from different parts of India that may be due to the variations in sample size, prevailing geographical and climatic conditions, availability of intermediate hosts and infective stages of parasites on pasture in the study areas (Bansal *et al.,* 2013; Singh *et al.,* 2015; Singh *et al.,* 2017; Malathi *et al.,* 2021; Ashraf *et al.,* 2022). Besides climatic factors, breed, sex, age, nutritional and physiological status of host reportedly may influence the severity of helminth infections (Kuchai *et al.,* 2011; Mpofu *et al.,* 2022). *H. contortus* was most common and predominant parasite in goats, as also reported by Singh *et al.* (2013); Anugrah *et al.* (2018) and Jaiswal *et al.* (2020),

Table 2: Seasonal prevalence, mean intensity and abundance of gastrointestinal helminths in goats in Aligarh India

Parasites	Prevalence (%)			Mean intensity			Mean abundance		
	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer
H. contortus	84.5 ± 6.5	53.6 ± 10.1	65.0 ± 6.8	224 ± 40.5	167 ± 54.5	157 ± 4.6	187 ± 17	89 ± 14.9	101 ± 11.4
T. ovis	74.1 ± 1.4	45.8 ± 5.2	54.6 ± 4.8	54 ± 6.7	17 ± 4.6	27 ± 6.0	41 ± 6.6	7 ± 1.15	14 ± 2.0
O. columbianum	21.2 ± 8.6	3.5 ± 2.4	17.9 ± 10.6	34 ± 15.6	4 ± 1.7	12 ± 4.7	6 ± 1.0	0	2 ± 0.5
M. expansa	33.9 ± 15.2	4.8 ± 2.9	28.6 ± 11.6	7 ± 2.6	4 ± 0.6	6 ± 2.3	2 ± 0.0	0	1 ± 0
Amphistomes	14.2 ± 3.7	1.1 ± 1.9	12.5 ± 5.2	81 ± 18.8	38 ± 66.4	90 ± 34	12 ± 6.0	3 ± 4.61	10 ± 5.5

The values are the mean of 3-years data (2017-2019)

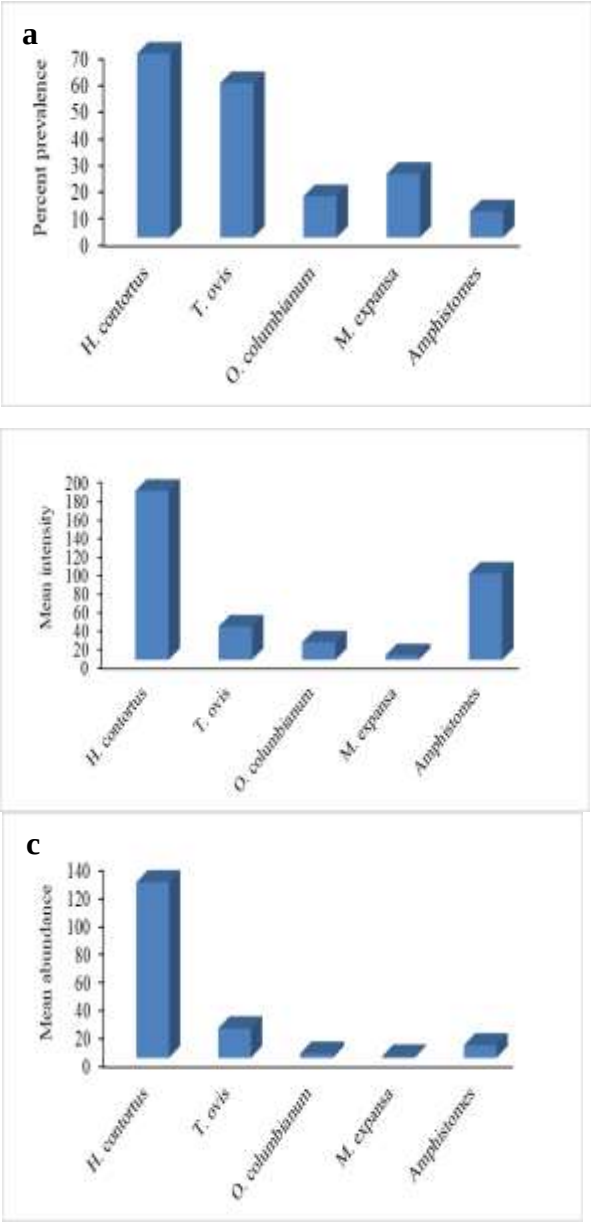

Fig. 1: Percent prevalence (a), mean intensity (b) and mean abundance (c) of different gastrointestinal helminths in goats in Aligarh, UP, India

which could be due to its high biotic potential, relatively short generation interval, and ability to take rapid advantage of favourable environmental conditions (Malathi *et al.*, 2021).

The prevalence, mean intensity and abundance of all helminths were high during monsoon followed by summer and winter (Table 2), which was significantly ($p \leq 0.05$) associated with the rainfall. The high prevalence of *H. contortus* and *O. columbianum* in rainy season may be due to the more availability of L3 larvae on pasture/ herbage as well as maximum growth of vegetation during monsoon, which may favour the survival and migration of larvae (O'Connor *et al.*, 2006; Silva *et al.*, 2008; Amaradasa *et al.*, 2010). Increased rainfall during monsoon generates a suitable molarity of salts in soil, which enhances ecdysis and facilitates the easy transformation of L1 to L3 (Khajuria *et al.*, 2013). Besides, heavy rainfall may also be responsible for dispersion of larvae on pasture, thereby increasing the chances of contact between host and infective larvae (Rashid and Irshadullah, 2018). It has been reported that in the absence of rainfall and at low temperatures, L3 takes more time to complete migration on herbage (Silva *et al.*, 2008). However, in sufficient rainfall, larvae migrated vertically up to 22.5 cm as compared to 5 to 15 cm during non-rainy season (Amaradasa *et al.*, 2010). The high incidence of *M. expansa* during rainy season could be correlated with more availability of oribatid mites on grass due to the erosion of upper surface of soil (Panitz *et al.*, 2006). The highest prevalence of amphistomes was recorded during monsoon and lowest in winter, which is in agreement with Maitra *et*

al. (2014) and Singh *et al.* (2015). The higher prevalence of amphistomes during monsoon may be due to the increased population of snails (intermediate host) and more availability of infective stages of fluke (metacercarial cysts) on pasture in this season, as it was suggested that rainy season is more favourable for the development of snails and dispersal of infective stages (Maitra *et al.,* 2014), and with the onset of rainy season a new crop of snails are produced which contribute to the availability of infective stages of fluke on pasture resulting in gradual build-up of fluke population in monsoon and post monsoon months (Godara *et al.,* 2014).

The low prevalence of gastrointestinal helminths during summer and winter could be explained by the fact that these seasons were not suitable for the development of infectivestages, therefore, pasture contamination was low. O'Connor *et al.* (2006) reported lowest pasture contamination during dry season and highest during monsoon with free-living infective larvae (L3). Furthermore, the grass covering on field is reduced during summer and eggs/larvae are exposed to desiccation; therefore, the larvae either die or migrate deep into soil (Ng'ang'a *et al.,* 2004). In addition, a short photoperiod during winter reduces the grazing hours and thus decreases the chances of contact between host and parasites and pre-parasitic stages also undergo hypobiosis (Singh *et al.,* 2017). Urquhart *et al*. (1996) reported that the development of eggs becomes slow at low temperatures and below 10°C the development of L3 stopped. In winter, the growth of parasite's larval stages is inhibited, snails undergo hibernation, and many die in extreme winter (Khajuria *et al.,* 2013).

Female goats (80.2%) were found more infected than males (52%), but significant differences were found only for *H. contortus*, *T. ovis* and *O. columbianum* (Table 3). The higher prevalence in female goats may be correlated with their physiological status, stress and decreased immunity during lactation and peri-parturient periods (Urquhart *et al.,* 1996; Kuchai *et al.,* 2011; Singh *et al.,* 2017). Many workers have reported similar findings (Bansal *et al.,* 2013; Singh *et al.,* 2017; Jena *et al.,* 2018) where the same suggestions have been made. García *et al.* (2007) reported high incidence of parasites in lactating and pregnant sheep as compared to non-pregnant animal by

Table 3: Prevalence of gastrointestinal helminths in the male and female goats

Parasites	Overall prevalence {%} (n = 499)	Gender-wise prevalence (%)		Values of odds ratio	Odds ratio	
		Male goats (n = 181)	Female goats (n = 318)		Lower limit	Upper limit
H. contortus	68.73 (343)	49.72 (90)	79.55 (253)	1.005***	1.002	1.007
T. ovis	57.71 (288)	44.75 (81)	65.40 (208)	1.034***	1.020	1.054
O. columbianum	15.43 (77)	11.60 (21)	17.61 (56)	0.903**	0.882	0.983
M. expansa	23.84 (119)	19.33 (35)	26.41 (84)	1.252#	0.955	1.510
Amphistomes	9.81 (49)	8.28 (15)	10.69 (34)	1.011#	0.996	1.029

Values in parentheses represent the number of infected individuals.
p-value ≤ 0.05 is considered as significant, **, p≤0.01; ***, p≤0.0001; #, insignificant.

Table 4: Faecal egg counts (FEC) of goats during different months/seasons in Aligarh

Seasons	Months	Animals examined (No.)	Animals infected (No.)	Mean FEC
Rainy	July	43	34	1995.57 ± 148.0^{cde}
	August	51	51	2746.67 ± 515.1^{b}
	September	43	39	3735.82 ± 455.3^{a}
	October	34	28	2220.15 ± 339.9^{e}
Winter	November	39	29	2173.22 ± 177.7^{c}
	December	39	26	1664.05 ± 84.4^{de}
	January	39	14	1628.33 ± 10.4^{de}
	February	39	17	1572.85 ± 11.2^{e}
Summer	March	30	18	2077.78 ± 55.5^{cd}
	April	51	34	2182.18 ± 194.2^{c}
	May	52	31	1976.18 ± 170.9^{cde}
	June	39	29	1852.78 ± 137.5^{cde}

Means bearing different superscript are significantly different at p ≤ 0.05;
All the values are mean ± S.D. of three years data (2017-2019).

feacal egg counts and correlated it with temporary loss of immunity during pregnancy and lactation. The differences in the prevalence could also be correlated with the sex hormones, as it was suggested that high levels of prolactin and progesterone during pregnancy and the peri-parturient period might increase the susceptibility of females to parasites (Urquhart *et al.,* 1996).

Although eggs were recorded throughout the year in faeces, significant variations were noticed in faecal egg counts (FECs) during different months/seasons (Table 4). The highest FEC was recorded in monsoon (2674.55 ± 176.03), followed by summer (2022.30 ± 139.52) and winter (1759.61 ± 70.93), which agrees with previous reports (Al-Shaibani *et al.,* 2008; Khajuria *et al.,* 2013; Barua *et al.,* 2015). The highest egg counts and worm burden during rainy season may be attributed to the more availability and ingestion of infective stages, as this season is more conducive to the development and survival of the pre-parasitic stages (Khajuria *et al.,* 2013; Barua *et al.,* 2015). The lowest FEC during winter could be due to the fact that the development of parasites in the host may be arrested in this season, and therefore, infection and productions of eggs are affected (Khajuria *et al.,* 2013). Our findings on faecal egg counts during rainy season carry great importance as it indicates a high risk of pasture contamination during monsoon, which increases the chance of infection to the hosts; as a result, the prevalence rate and worm burden increase. Thus, it is suggested that small ruminants should be treated with broad-spectrum anthelmintics during the monsoon period to reduce helminth infection and its propagation, which may increase the productivity of animals. According to Jithendran and Bhat (1999), monitoring and surveillance of GI helminth infection are the keys for integrated parasite control and sustainable livestock production success.

Conclusion: The GI helminth infection in goats showed a well-defined seasonal pattern and rainfall seems to be the major limiting factor for the incidence of parasites compared to other climatic factors. The present findings may be helpful for designing an epidemiologically based control strategy and for selecting treatment times of animals to stop the indiscriminate use of anthelmintics.

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Author contributions: All the authors contributed to the conception and design of the study. Sabiha Bi collected and analysed the data. She and Humera Aslam prepared the manuscript and did data interpretation, and preparation of tables. Sabiha Bi wrote the first draft of the manuscript. Malik Irshadullah performed the supervision. All authors commented on previous versions and read and approved the final manuscript.

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