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Epidemiology and Risk Factor Analysis of Gastrointestinal Parasitism in Goats in Peri-Urban Smallholder Production Systems: A Preliminary Study

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Abstract

Gastrointestinal parasitic infections pose a significant threat to goat health and productivity, resulting in substantial economic losses. This study evaluated the prevalence and associated risk factors of gastrointestinal parasitism in goats in and around Lucknow, Uttar Pradesh, India, representing typical peri-urban smallholder production systems of North India.The study used a descriptive cross-sectional study design, with random sampling of goats across the semi-intensive and backyard production systems. A total of 427 fecal samples were collected and examined using the standard qualitative and quantitative parasitological techniques. The overall prevalence of gastrointestinal parasitic infections was recorded at 75.64% (95%CI = 71.57–79.71). *Strongyles* spp. (65.55%)were the most prominent gastrointestinal parasites infecting goats, followed by *Eimeria* spp. (33.02%), *Monezia* spp. (13.11%), *Fasciola* spp. (11.47%), *Amphistome* spp. (8.66%), *Strongyloides* spp. (7.72%), and *Trichuris* spp. (6.79%).The intensity of Strongylid-type egg (STE) infection varied significantly across seasons, with the highest mean egg per gram (EPG) counts observed during the monsoon (1118 ± 74.1), followed by summer (590 ± 42.0), and the lowest during winter (307 ± 35.7).Univariable logistic regression analysis identified age, sex, body condition score (BCS), and housing as significant predictors of parasitic infection in goats. However, after adjusting for other variables in the multivariable model, goats younger than one year continued to show significantly lower odds of infection (AOR = 0.42, $p < 0.001$).Overall, these findings highlight the importance of host physiological status along with management practices in determining gastrointestinal parasitic infection burden in goats.

Introduction

Goats, often referred to as the “poor man’s cow,” contribute significantly to household income, employment, and nutrition in rural India (Sone et al., 2015; Sharma et al., 2018; Khan and Parashari,2022). Goat farming is a sustainable, low-input livestock enterprise that offers several advantages, including lower land and water requirements, faster reproductive rates, and resilience to harsh climatic conditions (Kumar and Deoghare,2002; Kumar et al., 2010; Raj et al., 2023; Das *et al.*, 2025). However, gastrointestinal parasitic infections remain one of the leading causes of morbidity and mortality in small ruminants, particularly in tropical and subtropical regions (Choudhary and Palsaniya, 2024). Most studies on gastrointestinal infections in small ruminants have traditionally focused on sheep, despite goats being more prevalent livestock in many developing countries (Tesfaheywet and Murga, 2019).

India accounts for the world’s largest goat population, estimated at 148.88 million (BAHS, 2024), with goat farming forming a crucial livelihood source for the smallholders and marginalized, providing income security and resilience against agricultural risks (Ali, 2007; Birthal et al., 2014). Gastrointestinal parasitism remains a major challenge for goat production in India, with a pooled prevalence estimated at 74% (95% CI: 66–80%, PI: 14–98%), and the highest burden (82%) reported from the northern zone (Krishnamoorthy et al., 2023).Gastrointestinal parasitism in goats commonly causes anemia, diarrhea, weight loss, and weakness, with severe cases leading to emaciation, pallor, edema, and respiratory

distress (Babjak *et al*., 2017; Moudgil et al., 2017; Vasilatis *et al.*, 2023). These infections also disrupt metabolism, resulting in hypoproteinemia and malnutrition (Alam *et al.*,2020; Jasim *et al.*,2023). Aditionally, goats reared under resource-poor settings can act as reservoirs for human-infective pathogens like *Giardia duodenalis*, *Cryptosporidium parvum*, *Blastocystis* spp., and *Enterocytozoon bieneusi*, increasing the risk of zoonotic transmission (Utaaker et al., 2021; Yu et al., 2024).Moreover, veterinary services in rural India are largely curative, with preventive care and vaccination coverage remaining inadequate, further exacerbating fatalities and economic losses in small ruminants (Kumar et al., 2003; Balamurugan et al., 2024).

Although gastrointestinal parasitism in goats has been reported from various regions of India, integrated studies combining prevalence, infection intensity, and risk factor analysis in peri-urban smallholder systems remain limited.Therefore, this study aimed to investigate the epidemiology and risk factors of gastrointestinal parasitism in goats reared under peri-urban smallholder systems in and around Lucknow, Uttar Pradesh, India, a representative setting for evaluating infection dynamics relevant to similar production systems.

Materials and Methods

Study Area

The study was conducted in the Lucknow district of Uttar Pradesh, India. Lucknow lies in the fertile alluvial belt of the Central Gangetic Plain (26°30'–27°10' N, 80°30'–81°13' E), spanning approximately 2,528 km² with an elevation of 103–130 m above sea level (CGWB, 2024). Lucknow experiences an extreme continental climate. Most of the rainfall occurs during the monsoon season (June–September). Summers are very hot, while winters are cold with occasional fog. Lucknow district has a sizeable goat population, with 160,719 goats reported (Ministry of Agriculture & Farmers Welfare, 2020). The majority of farms in the region are small, family-operated holdings with minimal infrastructure, relying predominantly on resources available within the household (Fig. 1).

Study Design and Sample Collection

The year-long study was conducted between November 2024 and October 2025, divided into three seasons – Summer (March -June), Monsoon (July-October), Winter (November-February).

The required sample size was calculated using the formula for finite population (Thrusfield, 2018), assuming an expected gastrointestinal parasite prevalence of 67.6% (Jaiswal et al., 2020). Accordingly, the calculated sample size was 371. However, to enhance the accuracy and precision of prevalence estimates, a total of 427 fecal samples were collected from goats across both the urban and rural settlements of Lucknow, Uttar Pradesh, India.Farms and households were selected with the help of local veterinarians, social media platforms, and recommendations from nearby farmers. The animals within herds were randomly chosen across different age groups and sexes to ensure representativeness.

Exclusion criteria included newborns, visibly sick or debilitated animals, and goats receiving anthelmintic treatment. A proportional sampling strategy was applied based on herd size: up to 12 goats were randomly selected from herds with > 20 animals, up to 8 from herds with 11–20, and all goats from herds with ≤ 10.The farmers were briefed on the sampling process and its objectives before collection, and verbal /written informed consent was obtained from each participant.

For each selected goat, fresh fecal samples (30 g) were collected immediately after spontaneous defecation using disposable gloves to prevent cross-contamination. Eachsample was placed in a labeled, airtight zip-lock bag and transported to the Parasitology Laboratory, Department of Zoology, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India for subsequent analysis. Alongside fecal sampling, comprehensive data on individual animals were recorded, including age, sex, breed, body condition score (BCS), and health status. Animals were classified into three age groups—less than 1 year, 1–2 years, and over 2 years based on dentition and information provided by the farmers. Body condition score (BCS) was evaluated manually by palpating the musculature and fat over the lumbar vertebrae in the loin area, under the supervision of a trained observer. Animals were then categorized as emaciated (scores 1–2), healthy (scores 3–4), or obese (score 5) (Ghosh *et al.*, 2019). Management and husbandry-related information, such as housing type, was collected through structured interviews with farm owners or caregivers.

Laboratory Analysis

The fecal examination involved qualitative assessment using direct smear, flotation, and sedimentation techniques (Soulsby,1982) for the detection of gastrointestinal parasite eggs and larvae, and quantitative assessment using the modified McMaster technique (MAFF, 1986) to determine eggs per gram (EPG) of feces.

Statistical Analysis

The host-related attributes and management practices obtained through structured questionnaires were tabulated in Microsoft Excel 2016 and subsequently analyzed using R version 4.5.1 (https://www.R-project.org/). The prevalence of gastrointestinal infection was calculated as the proportion of fecal samples that tested positive out of the total number examined, and expressed as a percentage (%). Univariate associations between individual risk factors and infection status were assessed using Pearson's chi-square test ($p < 0.05$). To further quantify the independent effect of each predictor, multivariable logistic regression was performed using the *glm* function in R. Strongylid-type egg (STE) infection intensity was evaluated by determining the eggs per gram (EPG) of feces across seasons, with results reported as mean ± SE(range). The distribution of EPG data was assessed for normality using the Shapiro–Wilk test.Seasonal differences in infection intensity were then examined using the Kruskal–Wallis test, followed by Dunn's post-hoc test with Bonferroni correction to account for multiple comparisons.

Results

Out of the total 427 fecal samples examined, 323 were found positive for one or more gastrointestinal parasitic infections (Fig. 2). The overall prevalence of gastrointestinal parasitic infections was recorded at 75.64% (95% CI 71.57–79.71).Among the parasite species detected in the fecal sample, *Strongyles* spp. were the most common, affecting65.55%of goats, followed by *Eimeria* spp. **(**33.02%**)**, *Monezia* spp. **(**13.11%**)**, *Fasciola* spp. **(**11.47%**)**, *Amphistomes* spp. **(**8.66%), *Strongyloides* spp. **(**7.72%**)**, and *Trichuris* spp. (6.79%)(Table 1).

Table 1
Prevalence of different gastrointestinal parasites affecting goats in Lucknow, Uttar Pradesh, India.

Parasitic species (n = 427)	**Number of infected fecal samples**	**Prevalence (%)**
Strongyle spp.	280	65.55
Eimeria spp.	141	33.02
Trichuris spp.	29	6.79
Amphistome spp.	37	8.66
Moniezia spp.	56	13.11
Fasciola spp.	49	11.47
Strongyloides spp.	33	7.72
Overall Count	323[a]	75.64

[a] The total number of infected goats is lower than the sum of individual infections, as some goats harbored multiple types of GI parasites.

Regarding the parasitic load, the intensity of Strongylid-type eggs (STE) varied significantly across seasons. The highest mean EPG was recorded during the monsoon (1118 ± 74.1), followed by summer (590 ± 42.0), and the lowest during winter (307 ± 35.7) (Table 2). The Kruskal–Wallis test revealed a highly significant variation in infection intensity across the three seasons ($p < 0.001$). Post-hoc analysis using Dunn's test with Bonferroni correction showed that EPG values were significantly higher during the monsoon compared to summer ($p < 0.001$) and winter ($p < 0.001$). Moreover, the summer season also recorded significantly higher EPG values than winter ($p < 0.01$) (Table 3).

Table 2
Seasonal variation in the intensity and severity of Strongylid-type egg (STE) infection in goats in Lucknow, Uttar Pradesh, India.

Seasons	**Examined**	**STE, n (%)**	**Mean EPG ± SE (range)**	**(EPG < 500) (%)**	**(EPG 500–1500) (%)**	**(EPG > 1500) (%)**	**Kruskal-Wallis test (*p*)**
Summer	142	96 (67.60)	590 ± 42.0 (0-1500)	13 (9.15)	83 (58.45)	0 (0)	< 0.001*
Monsoon	157	125 (79.61)	1118 ± 74.1 (0-2800)	20 (12.73)	50 (31.84)	55 (35.03)	
Winter	102	58 (56.86)	307 ± 35.7 (0-1150)	23(22.54)	35(34.31)	0(0)	
*p values significant at < 0.05; EPG: egg per gram; STE: Strongylid –type egg							

Table 3
Pairwise comparisons of seasonal EPG counts in goats performed using Dunn's post-hoc test with Bonferroni adjustment.

Pairwise comparison	**Z-value**	**P.adj**
Monsoon – Summer	4.49	< 0.001*
Monsoon – Winter	7.61	< 0.001*
Summer – Winter	3.46	< 0.01*
P.adj:**Bonferroni-adjusted p-value;** *p values significant at < 0.05		

Univariate analysis revealed statistically significant associations between the prevalence of gastrointestinal parasitic infections in goats and several host- and management-related variables (Table 4).Univariable logistic regression analysis identified age, sex, body condition score (BCS), and housing as significant predictors of gastrointestinal parasitic infection in goats (Table 5). Goats younger than one year showed significantly lower odds of infection (OR = 0.35, $p < 0.001$). Similarly, male goats (OR = 0.54, $p = 0.007$), animals with a healthy body condition (OR = 0.38, $p < 0.001$), and goats housed in cemented structures (OR = 0.58, $p = 0.015$) exhibited significantly reduced odds of infection. However, breed was not significantly associated with infection status.

Table 4
Univariate analysis of potential risk factors for GI parasitic infections in goats in Lucknow, Uttar Pradesh, India.

Risk Factor	Category	Examined	Positive, n (%)	*p*-value
Breed	Desi/Non- descript	198	152(76.76)	0.476
	Barbari	105	82(78.09)	
	Jamunapari	124	89(71.77)	
Age	< 1 year	103	62(60.19)	< 0.001
	1–2 years	148	120(81.08)	
	> 2 years	176	141(80.11)	
Sex	Male	185	128(69.18)	0.009
	Female	242	195(80.57)	
BCS	Emaciated(1–2)	202	171(84.65)	< 0.001
	Healthy (3–4)	225	152(67.55)	
Housing	Kutcha sheds	257	205(79.76)	0.020
	Cemented	170	118(69.41)	
*p values significant at < 0.05				
BCS: body condition score				

Table 5
Multivariable logistic regression analysis to ascertain risk factors associated with gastrointestinal parasitic infection in goats in Lucknow, Uttar Pradesh, India.

Variable	Category	OR crude (95% CI)	p-value	OR Adjusted (95% CI)	p-value
Breed	Barbari	Ref	-	Ref	-
	Desi / Non-descript	0.93 (0.51–1.62)	0.793	0.95(0.55–1.65)	0.853
	Jamunapari	0.71(0.38–1.30)	0.274	0.88(0.49–1.58)	0.681
Age	1–2 years	Ref	-	Ref	-
	< 1 year	0.35(0.19–0.62)	< 0.001	0.42(0.25–0.71)	< 0.001
	> 2 years	0.94(0.53–1.63)	0.827	1.05(0.60–1.83)	0.839
Sex	Female	Ref	-	Ref	-
	Male	0.54(0.34–0.84)	0.007	0.82(0.56–1.21)	0.318
BCS	Emaciated	Ref	-	Ref	-
	Healthy	0.38(0.23–0.60)	< 0.001	0.79(0.47–1.32)	0.301
Housing	Kutcha	Ref	-	Ref	-
	Cemented	0.58(0.36–0.89)	0.015	0.83(0.55–1.26)	0.387
*p values significant at < 0.05; OR, odds ratio; CI: 95% Confidence Interval					
BCS: body condition score					

Multivariable logistic regression analysis identified age as the only factor independently associated with gastrointestinal parasitic infection in goats after adjustment for potential confounders. Goats younger than 1 year had a significantly lower risk of infection compared with those aged 1–2 years (adjusted OR = 0.42; $p < 0.001$).

Discussion

The present study provides a comprehensive epidemiological assessment of gastrointestinal parasitism in goats reared under peri-urban smallholder production systems in and around Lucknow, Uttar Pradesh, India. The overall prevalence of GI infection in goats recorded in the present study (75.64%;95% CI: 71.57–79.71) is comparable with reports from several regions of India, including Maharashtra (Kalwaghe et al., 2022), Rajasthan (Sodha et al., 2024), and Madhya Pradesh (Chaurasiya et al., 2021). Higher prevalence values have been reported by Singh et al. (2015) and Kaur et al. (2025), whereas earlier studies from Uttar Pradesh documented comparatively lower prevalence (Anugrah *et al.*, 2018; Ramakant *et al.*, 2024).The observed differences between the present findings and previous studies may be

attributed to several factors, including variations in sample size, study duration, diagnostic techniques employed, management practices, and the prevailing agro-climatic conditions of the respective regions. Additionally, the increasing use of anthelmintic drugs and the emergence of drug resistance over time may further contribute to the disparities in GI infection prevalence reported (Ndwandwe et al., 2025).

Strongyle spp. (65.55%) were the most prevalent gastrointestinal parasitesdetected in the present study, consistent with earlier reports (Ghimire and Bhattarai, 2019; Dey et al., 2020). The predominance of *strongyles* spp.is likely related to their short, direct life cycle and favorable survival of free-living larval stages under warm and humid conditions (Urquhart et al., 1996).*Strongyloides* spp. were detected at a prevalence of 7.72%, which falls within the range previously reported from different regions (Singh et al., 2014; Lata et al., 2017; Srinivasarao et al., 2024). *Trichuris* spp. were recorded at a prevalence of 6.79%, comparable with earlier reports from Madhya Pradesh and Meghalaya (Singh et al., 2015; Das et al., 2017). Among the GI protozoan parasites, only *Eimeria* spp. was detected in the present study, with a prevalence of 33.02%. Hot and humid weather conditions, which prevail throughout much of the year in Lucknow, Uttar Pradesh, India may provide an ideal environment for *Eimeria* oocyst sporulation and survival when combined with local management issues such as overcrowded goat sheds, infrequent cleaning routines, and moist bedding (Ruiz et al., 2006; Bauer et al., 2023). The year-round detection of *Eimeria* spp. in the study may also be linked to the limited use of coccidiostatic or coccidicidal drugs by farmers in the region. *Moniezia expansa* was the only cestode species identified, consistent with previous studies reporting *Moniezia* spp. as the sole cestode infecting goats (Hurisa et al., 2021). Molecular evidence indicates that *M. expansa* primarily infects sheep and goats, whereas *M. benedeni* is more commonly associated with cattle (Nguyen et al., 2012). The relatively lower prevalence of *Moniezia expansa* observed in this study may be linked to the availability and ecological distribution of oribatid mites, which serve as intermediate hosts for these tapeworms (Doloriert et al., 2025). In addition, two trematode species, *Amphistome* spp. and *Fasciola* spp. were detected at prevalence rates of 8.66% and 11.47%, respectively, consistent with the ranges reported from other regions with similar climatic and demographic conditions (Maitra et al., 2014; Godara *et al.*, 2013;Solanki *et al.*, 2016).Variations in trematode prevalence are likely influenced by differences in climatic conditions, seasonal water logging, and the availability of suitable snail intermediate hosts, particularly *Lymnaea* spp., which are favored by high rainfall, increased humidity, and moderate temperatures (Uddin et al., 2008).

Our study identified significant associations between gastrointestinal parasitism and various host- and management-related risk factors in goats. The prevalence of infection was markedly higher in adult animals, particularly those in the 1–2-year age group (81.08%) and goats over 2 years of age (80.11%), compared to kids under 1 year (60.19%). This increased susceptibility among adults may be attributed to their broader grazing range, prolonged exposure to contaminated pastures, and physiological stress associated with reproduction, all of which can compromise the immune efficiency. In contrast, the younger goats in the study area were largely confined near the household and primarily dependent on milk, which limited their access to infected pastures. These observations are consistent with previous reports by Sunandhadevi *et al.* (2016), Shakya et al. (2017), and Amran et al. (2018), which also documented a higher burden of gastrointestinal parasites in adult goats compared with younger ones.

Similarly, female goats (80.57%) exhibited higher prevalence of gastrointestinal parasitism compared to their male counterparts (69.18%). Similar findings of higher infection rates in females have been reported earlier (Singh et al., 2017; Sukupayo and Rayamajhee, 2018). This increased vulnerability in females is likely linked to the physiological demands of late pregnancy and early lactation, which involve major hormonal adjustments. These factors can lead to a transient suppression of immune function, commonly referred to as periparturient relaxation of immunity (PPRI) (González-Garduño *et al*.,2021). Inadequate nutritional supplementation during these periods may further compromise immune competence, contributing to greater infection levels (Houdijk, 2008).

The infection levels were recorded across the three commonly reared goat breeds in the study area. The highest prevalence was observed in the Barbari (78.09%), followed by Desi/Non-descript goats (76.76%), while Jamunapari (71.77%) showed the lowest prevalence. However, no significant breed-wise difference was observed, indicating that environmental and management factors likely outweigh genetic susceptibility (Kalwaghe et al., 2022). In the present study, emaciated goats (84.65%) showed a higher prevalence of infection compared to those in healthy condition (67.55%), which conforms to earlier reports.(Paul et al., 2016; Sorathiya et al., 2017; Moje et al., 2021; Koyan et al., 2025), which similarly documented a higher burden of infection in animals with poor health status. Management practices such as housing conditions were also found to be a potential risk factor in the transmission of gastrointestinal parasites in goats. Many pens had soil or mud floors, which became difficult to clean, especially during the rainy season, leading to the accumulation of feces and moisture. Poor ventilation and overcrowding further increased exposure to parasites (Chakrabortty et al., 2023; Sharma et al., 2025), and inconsistent use of bedding materials exacerbates these risks, creating a favorable environment for parasite transmission.

In the present study,infection with Strongylid-type egg (STE) showed a pronounced seasonal trend, with mean EPG highest during the monsoon (1118 ± 74.1), followed by summer (590 ± 42.0), and the lowest in winter(307 ± 35.7).Warm and humid conditions prevailing during the monsoon season promote larval development of nematodes and ecdysis on moist pastures, resulting in enhanced exposure risk*(*Soulsby, 1982*).* Conversely, cold and dry winter conditions limit egg hatching and larval development, with larvae entering hypobiosis, resulting in reduced infection pressure.

The main limitation of this study was the uneven distribution of animals across age and sex categories, which occurred due to practical field conditions during sample collection. This reflects the common management practices in the region, where milk production is the primary objective, leading farmers to retain more females, while most male kids are sold or removed at an early age. Only a few males are usually kept for breeding, which naturally limits their availability for sampling. These factors may have influenced the representation of certain categories and could affect the strength of comparisons across groups. Another important limitation is that the study followed a cross-sectional design, where it is not possible to determine whether conditions such as poor body condition existed before parasitic infection or developed as a result of infection. The associations observed in this study should therefore be interpreted as a preliminary reportwith caution, as the direction of these relationships cannot be

confirmed. These limitations will be followed up in subsequent studies and will improve understanding of transmission dynamics and support sustainable parasite control strategies.

Conclusion

The present study demonstrates a high burden of gastrointestinal parasitism among goats in peri-urban smallholder production systems in and around Lucknow, Uttar Pradesh, India with an overall prevalence of 75.6% (95% CI: 71.57–79.71). Infection patterns were significantly associated with multiple risk factors, including age, sex, body condition score, housing system, and season. Adult goats aged 1–2 years (81.08%) exhibited higher prevalence compared to kids under 1 year **(**60.19%**)**, while female goats (80.57%) were more frequently infected than males (69.18%). Goats with poor body condition (BCS 1–2; 84.65%) and those housed in kutcha sheds (79.76%) showed markedly higher infection rates than their healthier and better-housed counterparts. Seasonal variation in strongylid-type egg (STE) counts was pronounced, with mean EPG highest during the monsoon, emphasizing the role of favorable climatic conditions in parasite survival and transmission. *Strongyles* spp. were the predominant parasites (65.55%**)**, followed by *Eimeria* spp. **(**33.02%**)** in the region. These findings provide valuable baseline epidemiological data for the region and emphasize the need for season-specific, targeted parasite control strategies, including improved housing, strategic deworming, and nutritional management of gastrointestinal parasitic infection in the goats.

Declarations

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Author contributions Muskan Shambhi: Writing –original draft, Data collection, review & editing, Conceptualization, Methodology, Formal analysis, Data curation, Investigation. Kamal Jaiswal: Conceptualization and review. Suman Mishra: Conceptualization, Supervision, Writing – review & editing, Methodology, Formal analysis, Data curation.

Data availability The datasets created during the current study are available from the corresponding author on reasonable request.

Ethical approval During the present study, non-invasive methods based on fecal examination were employed.

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117. Statements & Declarations

Figures

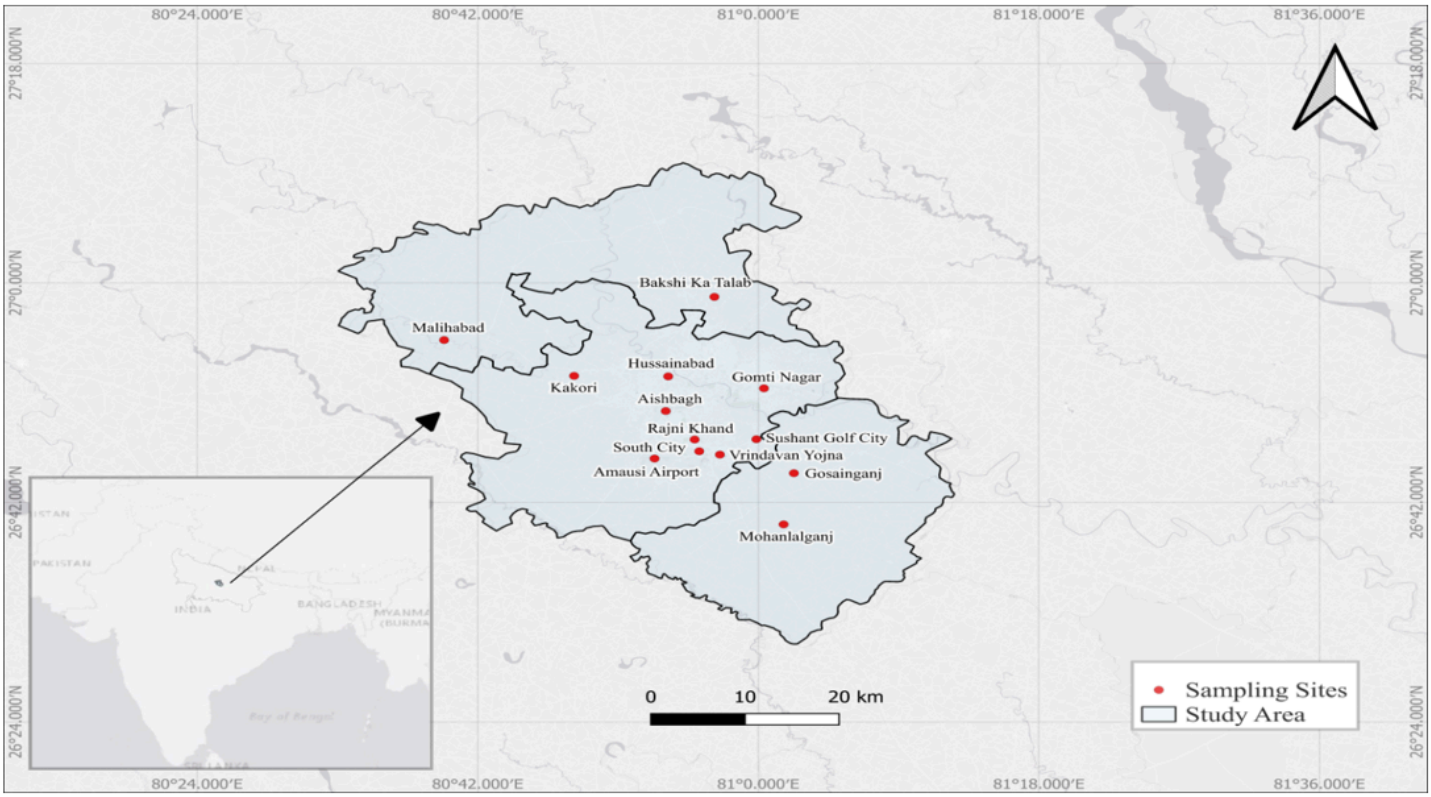


Figure 1

Location map of study area and sampling points across the urban and rural settlements of Lucknow, Uttar Pradesh,India.

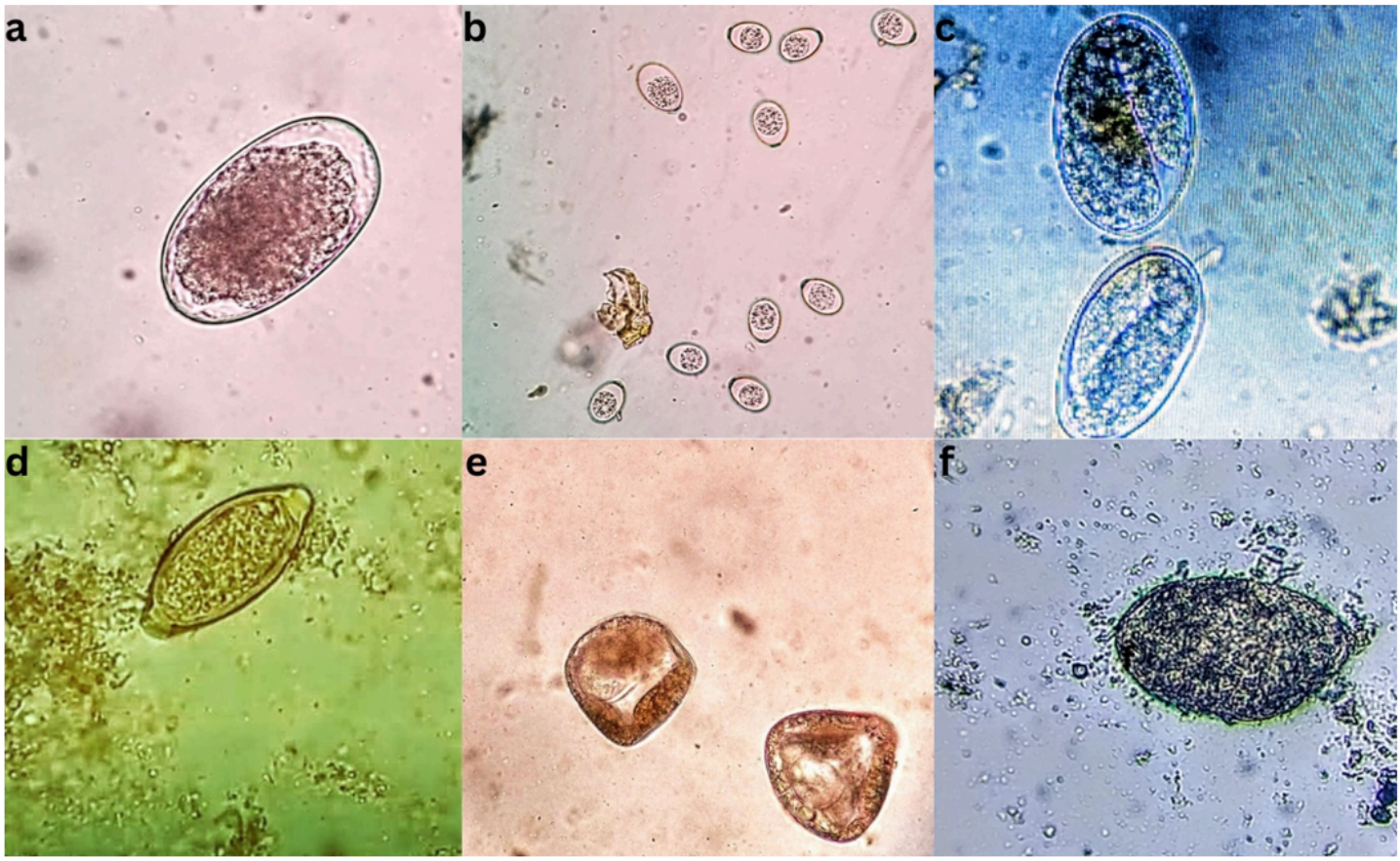


Figure 2

Gastrointestinal eggs found in fecal samples in goats in Lucknow, Uttar Pradesh, India. **a)** *Strongyle* spp.; **b)** *Eimeria*spp.; **c)** *Strongyloides* spp.; **d)** *Trichuris* spp.; **e)** *Moniezia* spp.; **f)** *Fasciola*spp. (microscopic image at 400x magnification)