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ORIGINAL ARTICLE

A study on prevalence and factors associated with ectoparasitism in goats of two agro-climatic regions in India

Y. Ajith[1] · U. Dimri[1] · A. Gopalakrishnan[1] · Gopinath Devi[1]

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Abstract The present study was aimed to evaluate the factors associated with prevalence of various ectoparasites among goats during winter season in two different agro-climatic regions of India. A total of 320 goats (Uttarakhand-208; Uttar Pradesh-112) were screened and evaluated for ectoparasitism and associated factors. The occurrence of ectoparasitism in goats was studied in relation with age, sex, breed, housing, agro-climatic region and system of rearing. Prevalence of ectoparasitism among goats of lower Shivalik region (Dehradun and Tehri Garhwal districts) of Uttarakhand and Bareilly district of Uttar Pradesh was 90.38 and 39.29%, respectively. The common ectoparasites observed were chewing lice (*Bovicola caprae*), sucking lice (*Linognathus africanus*), fleas (*Ctenocephalides felis*) and ticks (*Haemaphysalis* spp.). Among all the ectoparasitic infestation, pediculosis was the most common affection during the study period in both agro-climatic region; chewing lice in Uttarakhand and sucking lice in Uttar Pradesh. Agro-climatic region, breed, immune status, system of rearing and hygiene were highly affecting the prevalence and distribution of ectoparasites among goats. High prevalence of ectoparasitism in the study area warrants the need for formulating appropriate intervention strategies to improve control of ectoparasites and awareness among goat farmers.

Keywords Bareilly · Critical factors · Dehradun · Ectoparasite · Epidemiology · Goat · Shivalik region · Tehri Garhwal

✉ Y. Ajith
ajithy123456789@gmail.com

[1] Division of Medicine, Indian Veterinary Research Institute, Bareilly, UP, India

Introduction

Goat, also known as "Poor man's cow", is the small ruminant reared mainly by the poor and marginalized farmers of Asian and African countries (World Food and Agriculture Organization of the United Nations 2012). Low space requirements, wide climatic adaptations, ease in management, low maintenance cost, high prolificacy and huge demand for goat products made goat rearing an important part in economy of the developing countries. India stands second in world goat population (135.17 million) behind China and it is the second most reared livestock in India (Indian Livestock census 2012). Ectoparasitism plays significant role in the economics of goat rearing by deteriorating animal health, growth rate and production performance (Ghosh et al. 2007). The common ectoparasites of livestock come under the phylum arthropoda, which includes class insecta and class arachnida. The class insecta (six legged invertebrates with three specific body parts; head, thorax and abdomen) includes flea, lice, sheep ked and other flies. The class arachnida (eight legged arthropods with only two specific body parts; prosoma or cephalo-thorax and opisthosoma or abdomen) include ticks and mites (Soulsby 1982). The damaging effects of the ectoparasites are mostly attributed in the form of inflammatory skin diseases causing alopecia, scaling, itching, irritation and secondary pyoderma. Severe ectoparasitic infestations may lead to anaemia, hypoproteinemia, reduced weight gain and poor production performances (Taylor et al. 2007). The role of ectoparasites, mainly ticks, in transmission of various hemoprotozoan and rickettsial diseases in goats is well established (Friedhoff 1997).

High prevalence of ectoparasitism was observed among goats in the studies conducted at various parts of south Asia (Kumar et al. 1994; Sarkar et al. 2010; Iqbal et al. 2014).

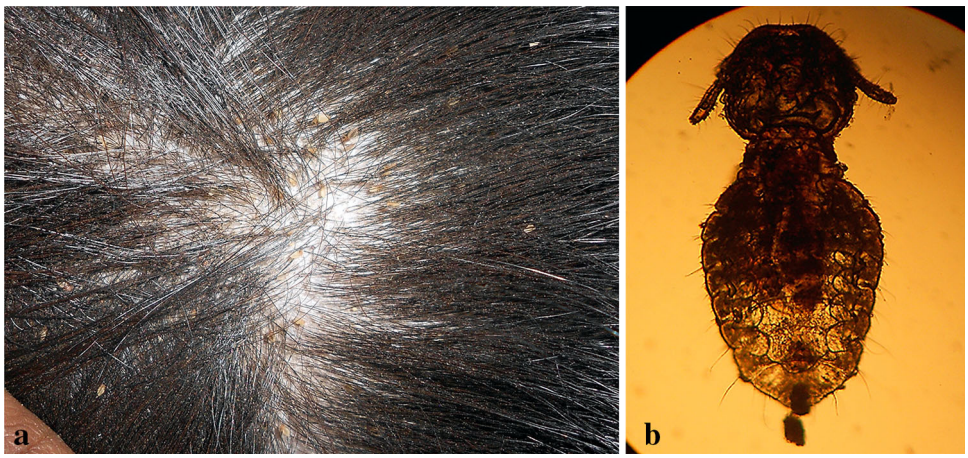

Fig. 1 **a** Chewing or biting lice (*Bovicola caprae*) infestation in a goat. **b** Microphotograph of a chewing louse (*B. caprae*) having broad head with blunt mouth parts adapted for chewing

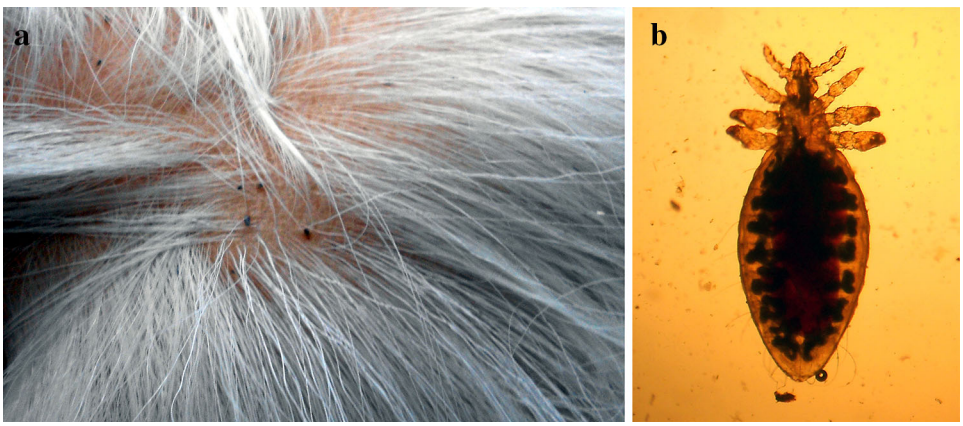

Fig. 2 **a** Sucking lice (*Linognathus africanus*) infestation in a goat. **b** Microphotograph of a sucking louse (*L. africanus*), having conical head with bulging of posterio-lateral aspect, which is a differentiating character from *L. stenopsis*

There exists considerable relation between climate as well as management practices and incidence of ectoparasitism in animals (Sertse and Wossene 2007). It is essential to give prime importance to the epidemiological factors while formulating strategies to curb ectoparasitism. As per authors' knowledge, a recent epidemiological study on ectoparasitism among goats of India is lacking. Hence, the present study was designed to evaluate various factors associated with the prevalence of ectoparasitism among goats during winter season in two different agro-climatic regions of India.

Materials and methods

Study area

The study was conducted among selected animals from two agro-climatic zones of India; Lower Shivalik region (Dehradun (30.32°N, 78.03°E) and Tehri Garhwal (30.30°N, 78.57°E) districts of Uttarakhand) and Indo-gangetic plain (Bareilly (28.37°N, 79.43°E) district of Uttar Pradesh). Dehradun and Tehri Garhwal districts are located in Doon valley, the foot hills of Shivalik ranges of Himalayas at an altitude ranging from 600 to 1550 m and come under humid subtropical and temperate climate with heavy rain fall during monsoon season. Bareilly is located at an altitude of 268 m in the fertile Indo-Gangetic plain with arid subtropical climate.

Prevalence survey

The prevalence survey was conducted during the winter months of November, 2015 to January, 2016. Animals were selected by stratified random sampling from the villages of lower Shivalik region and from the animals presented at Referral Veterinary Polyclinic, ICAR-IVRI, Bareilly. Animals from well organized farms and those

Table 1 Prevalence of ectoparasites among goats of lower Shivalik region (Dehradun and Tehri Garhwal districts), Uttarakhand during November, 2015 to January, 2016

Type of ectoparasite		Number of goats infested	Prevalence (%)
Linognathus africanus (sucking lice)		24	11.54
Ctenocephalides felis (flea)		24	11.54
Bovicola caprae (chewing lice)		132	63.46
Mild[a]	64 (30.80%)		
Moderate[a]	40 (19.23%)		
Severe[a]	28 (13.46%)		
Concurrent infestation: *C. felis* and *B. caprae*		8	3.85
No ectoparasite (healthy)		20	9.62
Total		208	100

n = 208

[a] Based on the total count over all the six sites (neck, shoulder, withers, inguinal, flank and rump), the severity of infestation is classified as mild (<10), moderate (10–100) and severe (more than 100)

Table 2 Prevalence of ectoparasites among goats of Bareilly, Uttar Pradesh during November, 2015 to January, 2016

Type of ectoparasite	Number of goats infested	Prevalence (%)
Linognathus africanus (sucking lice)	33	29.46
Ctenocephalides felis (flea)	7	6.25
Bovicola caprae (chewing lice)	2[a]	1.79
Haemaphysalis sps. (tick)	2	1.79
No ectoparasite (healthy)	68	60.71
Total	112	100

n = 112

[a] Mild infestation

underwent recent ectoparasiticidal therapy were not included in the study. A total of 320 goats (119 male and 201 female) were screened for ectoparasitic infestation from lower Shivalik region, Uttarakhand (208 animals—91 male and 117 female) and Bareilly district, Uttar Pradesh (112 animals—28 male and 84 female).

Clinical evaluation of animals

The animals were thoroughly examined for the presence of ectoparasite and associated clinical signs. The parasites were collected in 70% ethanol and identified microscopically based on the morphological characteristics (Soulsby 1982). The severity of chewing lice infestation was assessed by summation of lice counted using the standard counting technique in 10 × 10 cm areas of the six sites on the neck, shoulder, withers, inguinal, flank and rump (Holdsworth et al. 2006). Based on the total count, the severity of infestation was graded as mild (<10), moderate (10–100) and severe (more than 100). Ectoparasitic infestation was studied in relation with age, breed, sex, hair length, herd strength, system of rearing, flooring system of animal sheds, feeding and treatment history.

Statistical analysis

The data obtained was analyzed using Microsoft Excel spreadsheet 2007 and SPSS 16.0. Descriptive statistics such as percentage were used to summarize prevalence of ectoparasitism and the association of risk factors on prevalence and distribution of ectoparasites was analyzed using χ^2 test. The differences were considered as significant when $P < 0.05$ at 95% confidence intervals (Snedecor and Cochran 1994).

Results

The ectoparasitism was found to be a serious issue faced by the goat farmers of the study area and severe infestations of lice, fleas (*Ctenocephalides felis*) and ticks (*Haemaphysalis* sps.) were observed among goats (Tables 1, 2). The major ectoparasitism observed in the study area was pediculosis (Figs. 1a, 2a); chewing lice (*Bovicola caprae*) and sucking lice (*Linognathus africanus*) infestations (Figs. 1b, Fig. 2b). In lice infested animals, the lice eggs or "nits" were found to be attached mostly on the long hairs of wither and neck region (Fig. 3). More number of ectoparasites was observed in the least accessible areas (for self grooming) of the body like neck and shoulder, followed by withers, inguinal, flank and rump regions. Animals with ectoparasitism showed clinical signs like pale mucous membrane, alopecia, itching and varying degrees of

Fig. 3 Lice eggs or "nits" attached on hair shaft of goats

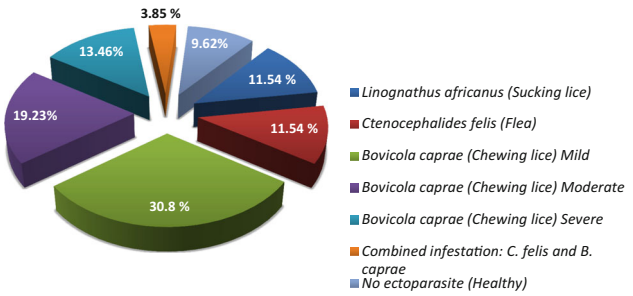

Fig. 4 Prevalence of ectoparasites among goats of lower Shivalik region (Dehradun and Tehri Garhwal districts), Uttarakhand during November, 2015 to January, 2016 (%)

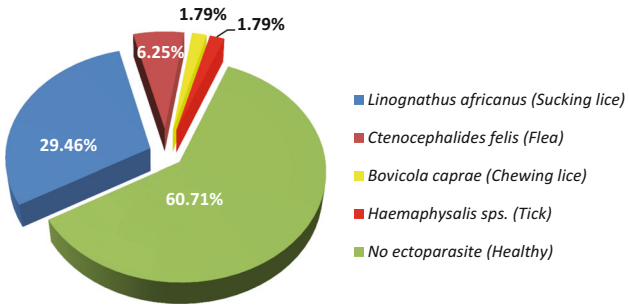

Fig. 5 Prevalence of ectoparasites among goats of Bareilly, Uttar Pradesh during November, 2015 to January, 2016 (%)

dermatitis, which was in association with the severity of infestation.

In lower Shivalik region, severe ectoparasitism was observed during the study period and the most prevalent one was pediculosis caused by chewing lice (*B. caprae*) (Fig. 4). Out of 208 animals screened, only 20 (9.62%) animals in Uttarakhand and out of 112 animals screened, 68 (60.71%) animals in Bareilly district were found to be free from any ectoparasitic infestation. The most prevalent ectoparasite in Bareilly district among goats during study period was the sucking lice, *L. africanus* (Fig. 5). Eventhough, age and sex were not found to be highly correlated with occurrence or severity of ectoparasitism, we observed significantly higher prevalence of chewing lice among female goats of above 24 months age group (Table 3; Figs. 6, 7), which may be attributed to the immune suppression due to lactation stress and pregnancy. All animals screened from pashmina breed were having at least one ectoparasitic infestation, which may be related to the increased hair length (>3 inches), and the most prevalent ectoparasite was flea (Fig. 8). The prevalence of chewing lice infestation was very high and severe in shorthaired goats, whereas, relatively low prevalence was observed in pashmina breed (Table 4). All animals reared under extensive grazing system were infected by at least one type of ectoparasite and the prevalence of chewing lice infection was very high among them, this enlights the possible transmission via essential direct contact during grazing in common grazing land (Fig. 9). The animals kept under semi intensive system of rearing in concrete floored sheds were least affected by ectoparasitism (Table 5), indicated the role of hygiene and cleanliness in reducing the occurrence of ectoparasitic infestation.

Table 3 Age and Sex wise distribution of lice infestation in goats

Sex	Age	Animals screened	*Bovicola caprae*	*Linognathus africanus*	No lice infestation
Male	Up to 6 months	11	5 (45.46%)	2 (18.18%)	4 (36.36%)
	7–24 months	94	40 (42.55%)	18 (19.15%)	36 (38.30%)
	Above 24 months	14	6 (42.86%)	2 (14.29%)	6 (42.86%)
	Subtotal	119	51 (42.86%)	22 (18.49%)	46 (38.66%)
Female	Up to 6 months	21	9 (42.86%)	3 (14.29%)	9 (42.86%)
	7–24 months	83	37 (44.58%)	14 (16.87%)	32 (38.55%)
	Above 24 months	97	45 (46.39%)	18 (18.56%)	34 (35.05%)
	Subtotal	201	91 (45.27%)	35 (17.41%)	75 (37.31%)
Total		320	142 (44.38%)	57 (17.81%)	121 (37.81%)

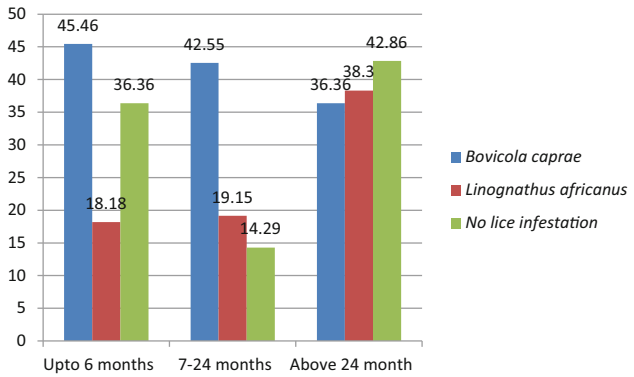

Fig. 6 Age wise distribution of lice infestation in male goats (%)

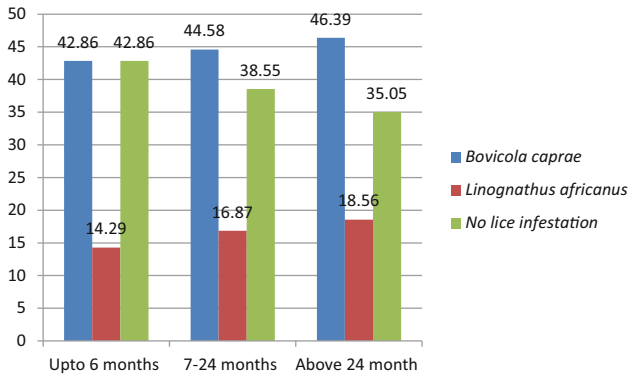

Fig. 7 Age wise distribution of lice infestation in female goats (%)

Discussion and conclusions

Ectoparasitism is a common, but often underestimated, problem in goat farming (Cornall and Wall 2015). Ectoparasites cause considerable deterioration in growth and production performance of animals, resulting in reduced profits from livestock rearing (Milne et al. 2008). Apart from the direct damage caused, ectoparasites were involved in the transmission of several bacterial, viral, protozoan and rickettsial diseases in animals. The critical role of fleas, ticks and sucking lice in transmission of mycoplasmal polyarthritis, hemoprotozoal diseases and ovine eperythrozoonosis, respectively, in small ruminants was well documented (Nayak and Bhowmik 1990; Taylor et al. 2007; Hornok et al. 2010).

Previous studies observed variable levels of ectoparasite infestations among goats from various parts of the world; Prevalence of 72.8% in Bangladesh (Sarkar et al. 2010), 56.4% in Ethiopia (Sertse and Wossene 2007) and 9.9% from Iran (Yakhchali and Hosseine 2006) were reported. Previous epidemiological studies from India on goat ectoparasites are meager. In the present study, the prevalence of ectoparasites among goats of lower Shivalik region was very high and of Bareilly was relatively low. The previous reports on prevalence clearly show the influence of agro-climatic zone on the occurrence of ectoparasitic infestations. In Dehradun (humid subtropical climate and high altitude), prevalence of chewing lice and sucking lice was reported as 79.2and 38%, respectively (Kumar et al. 1994). But, in Rajasthan (hot arid subtropical climate and low altitude), sucking louse (49.98%) was highly prevalent among goats (Giri et al. 2013) and in Kerala (warm-humid tropical climate and low altitude) ticks (38.89%) were the most common ectoparasite, followed by lice (27.78%), mites (25.93%) and fleas (7.40%) in goats (Anumol et al. 2011). Current study revealed increased prevalence of chewing lice and sucking lice among goats reared in lower Shivalik region (high humid subtropical climate) and Bareilly (dry subtropical climate), respectively, which is in agreement with previous studies (Kumar et al. 1994; Giri et al. 2013).

The prevalence of ectoparasites depends on several environmental, host and parasite related factors like herd density, hygiene, climate, system of rearing, age, sex, host immune status, parasite biology etc. (Taylor et al. 2007). Even though, age and sex wise susceptibility was not much pronounced in present study, increased prevalence of lice was observed among adult female goats, which is in agreement with the findings of Sarkar et al. (2010), which

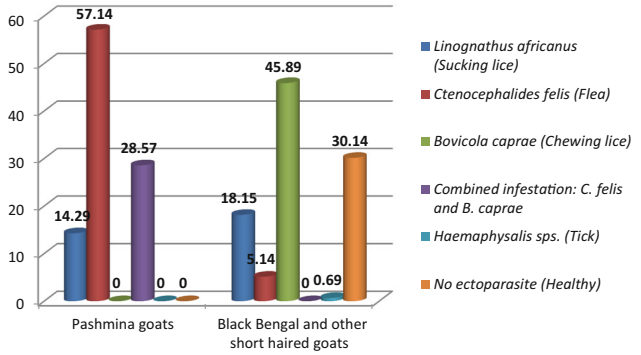

Fig. 8 Breed wise distribution of ectoparasites in goats (%)

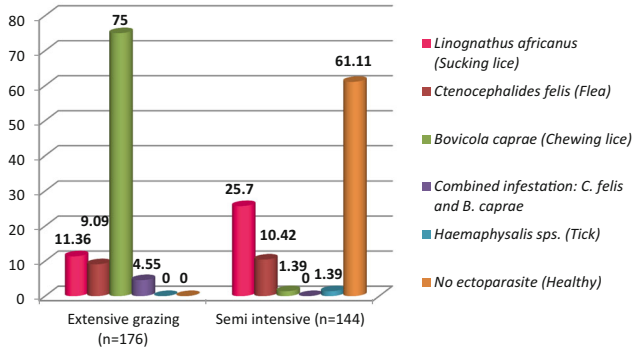

Fig. 9 Prevalence of ectoparasites among goats in relation to the system of rearing (%)

can be attributed to the immune suppression due to lactation stress and pregnancy (Patterson et al. 2015). Current study showed increased prevalence of sucking lice and fleas, whereas, relatively low prevalence of chewing lice among pashmina breed of goats. The relative resistance of these breeds to chewing lice is to be further explored. The severity and prevalence of chewing lice in Black Bengal goats and other short haired goats were very high and was in agreement with the observations made by Maunder (1983). The system of rearing plays important role in the transmission and maintenance of ectoparasitic infestation in a herd. Extensive grazing of animals allows direct contact of animals which is essential for the transmission of most of the ectoparasites like lice, which cannot survive away from host body surface for long time (Soulsby 1982; Taylor et al. 2007). The higher ectoparasitic prevalence in extensively reared animals was in agreement with previous studies (Kusiluka et al. 1995). In Bareilly, the animals were mostly kept under semi intensive system and the scope for transmission of ectoparasite from grazing land was rare, this may be the reason for the relatively low prevalence. No animals reared in concrete sheds were having lice infestation and ectoparasitism was found to be very low (8.33%)

Table 4 Breed wise distribution of ectoparasites in goats

Breed	Type of ectoparasite		Number of goats	Prevalence (%)
Pashmina goats (n = 28)	*Linognathus africanus* (sucking lice)		4	14.29
	Ctenocephalides felis (flea)		16	57.14
	Bovicola caprae (chewing lice)			
	Mild[a]	0		
	Moderate[a]	0		
	Severe[a]	0	0	0
	Combined infestation: *C. felis* and *B. caprae*		8	28.57
	No ectoparasite (healthy)		0	0
Total			28	100
Black Bengal and other short haired goats (n = 292)	*Linognathus africanus* (sucking lice)		53	18.15
	Ctenocephalides felis (flea)		15	5.14
	Bovicola caprae (chewing lice)			
	Mild[a]	66 (22.60%)		
	Moderate[a]	40 (13.70%)		
	Severe[a]	28 (9.59%)	134	45.89
	Haemaphysalis sps. (tick)		2	0.69
	No ectoparasite (healthy)		88	30.14
Total			292	100

[a] Based on the total count over all the six sites (neck, shoulder, withers, inguinal, flank and rump), the severity of infestation is classified as mild (<10), moderate (10–100) and severe (more than 100)

Table 5 Prevalence of ectoparasites among goats in relation with the system of rearing and flooring

System of rearing and flooring		Type of ectoparasite	Number of goats	Prevalence (%)
Extensive grazing (n = 176)	Soil/hay bed	*Ctenocephalides felis* (flea)	16	9.09
		Linognathus africanus (sucking lice)	20	11.36
		Bovicola caprae (chewing lice)	132	75.00
		Both *C. felis* and *B. caprae*	8	4.55
Total			176	100
Semi intensive (n = 144)	Soil/hay bed	*Ctenocephalides felis* (flea)	9	6.25
		Linognathus africanus (sucking lice)	37	25.70
		Bovicola caprae (chewing lice)	2	1.39
	Concrete	*Ctenocephalides felis* (flea)	6	4.17
		Haemaphysalis sps. (tick)	2	1.39
		No ectoparasite (healthy)	88	61.11
Total			144	100

Table 6 Factors associated with prevalence and distribution of ectoparasites among goats

Sl. no.	Factors	Inferences
1.	Agro-climatic region	Severe ectoparasitism among goats in Shivalik region of Uttarakhand
		Pediculosis was the most prevalent problem in both regions during study period; chewing lice in Shivalik region and sucking lice in Bareilly
2.	Age and sex	Lactation and pregnancy stress makes goat susceptible to pediculosis
3.	Breed	Increased hair length favours ectoparasitism (mostly fleas) among pashmina goats.
		Short haired goats are highly susceptible for chewing lice infestation
4.	System of rearing	Extensive system of grazing favours occurrence of ectoparasitism
		Hygiene and cleanliness important in reducing ectoparasitism

among them. Hence, proper hygiene and semi-intensive system of rearing can reduce incidence of ectoparasitism in goats and this observation was similar to the findings of Hassan et al. (2011).

Severe ectoparasitism was considerably affecting health, growth and production performance of goats in the study area. The agro-climatic location and climatic factors significantly affects the occurrence and severity of ectoparasitic infestation in goats. Extensive grazing system favored transmission and maintenance of ectoparasites in goat herds. From present findings (Table 6), it can be concluded that the proper housing and management of grazing practices is the key towards the control of ectoparasitic diseases in goats. High prevalence of ectoparasitism in the study area warrants the need for formulating appropriate intervention strategies to improve control of ectoparasites and awareness among goat farmers.

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Author contributions All the authors were involved and well contributed during all stages of this research work.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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