Research Article

Association of Various Risk Factors with the Distribution of Gastro-intestinal, Haemo and Ectoparasites in Small Ruminants

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Abstract | This study was conducted to determine the prevalence and association of various factors with endo and ectoparasites in the small ruminant population of district Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. Faecal and blood samples were collected along with ectoparasites directly from the animal rectum, jugular vein and skin, respectively. The examination of gastrointestinal (GI) parasites and haemoparasites was carried out through qualitative and quantitative methods, and Giemsa-stained thin smear, respectively. Morphological identification of ectoparasites was carried out under the stereomicroscope. The overall prevalence of GI parasites, haemoparasites and ectoparasites in the small ruminant population was 74%, 16% and 53%, respectively. Sheep were found more prone to endoparasites conversely ectoparasites were more prevalent in the goat population. A higher prevalence of GI, haemo and ectoparasites was observed in young animals, females and Damani breed of sheep and goat. Among the extrinsic factors, a significantly ($P < 0.05$) higher prevalence of endoparasites was determined in grazing animals (goat = 91.30%; sheep = 89.60%), animals with a poor hygienic measure (goat = 83.16%; sheep = 98.44%), open housing system (goat = 94.12%; sheep = 96.36%), and un-cemented floor patterns (goat = 91.47%; sheep = 94.31%). In the study area, nematodes (sheep = 48.43%, goat = 34.38%), babesia (sheep = 17.71%, goat = 3.91%) and ticks (goat = 48.70%; sheep = 39.58%) were prevalent significantly ($P < 0.05$). However, the association of extrinsic factors like tehsils with the prevalence of ectoparasites was non-significant ($P > 0.05$) in the sheep and goat population. The present study provides useful data on the prevalence and association of various intrinsic and extrinsic factors on endo and ectoparasites to manage the clinical, subclinical parasitic infection and vector transmitted diseases in a better way.

Keywords | Prevalence, Ecto-parasites, Endo-parasites, Risk factors, Small ruminants

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INTRODUCTION

Parasitism is one of the major health concerns of animals and humans in all agroecological zones of the world and causes huge economic impacts. Both ecto and endoparasites can cause morbidity and mortality in domestic animals around the world (Diallo et al., 2018) especially in developing countries like Pakistan (Khan et al., 2017; Ahmad et al., 2017; Rizwan et al., 2019; 2021; Sajid et al., 2020). The prevalence of parasitic diseases has been reported about 30–60% from various localities of Pakistan (Rizwan et al., 2017; 2019a; Qudoos et al., 2017; Ahmad et al., 2020, Sajid et al., 2020).

Ectoparasites like ticks, lice, flies, and bugs are the primary parasites of small ruminants which cause huge economic losses and affect the economy of nations (Sumbria et al., 2016). The increased prevalence of these parasites in the animal population reduces milk production, meat quality, and leather quality. However, ticks are prevalent worldwide and are responsible for blood loss, skin damage, and transmission of several pathogens like spirochaetes, protozoa, rickettsiae, bacteria, and viruses (Salih et al., 2015; Karim et al., 2017; Sajid et al., 2020). Temperature and relative humidity are the primary climatic factors favoring the multiplication and development of ectoparasite (Latif and Walker, 2004; Sajid et al., 2017). Gastrointestinal (GI) parasites have been reported, globally and considered one of the major constraints in the development of the economy (Ahmad et al., 2017; Rizwan et al., 2017; 2019). The presence of GI parasites in animals may lead to gastritis, limited development, low weight gain, reduced reproductive efficiency, milk, and meat production (Maqbool et al., 2017).

The various regions of Pakistan are notorious for the presence of the vector: tick (Acari: Ixodidae) and tick-borne diseases of domesticated animals (Khan et al., 2004). Three main tick-borne diseases, theileriosis, anaplasmosis, and babesiosis has been reported to affect small ruminants and cause huge economic losses in Pakistan (Jabbar et al., 2015). Theileriosis is a tick-borne haemoparasitic infection that leads to heavy economic losses in the livestock industry due to its association with high morbidity and mortality (Schnittger et al., 2000). Babesia species infect a wide variety of animals and some of them are of zoonotic importance as they cause diseases in humans (Kim et al., 2007).

In Khyber Pakhtunkhwa (KPK), Pakistan, parasitic diseases have been considered to cause financial losses of up to 40%. It has also been reported that ticks are the major vectors in the transmission of different pathogens to domesticated animals (Shah et al., 2015). A higher prevalence of endo and ectoparasites has been examined in the ovine population of the Bannu district and is considered as a major hindrance in the efficiency of these animals (Khan et al., 2015).

In KPK, a limited number of districts (Mardan, Bannu, and Peshawar) have been explored to determine the prevalence of ecto and endoparasites (Shah et al., 2015; Khan et al., 2015; Haleem et al., 2016). A comprehensive study regarding the prevalence and association of various risk factors with ecto and endoparasites is still missing in KPK. Keeping in view the available data and appropriate climatic conditions for the accessibility of vectors, and endoparasites, the present study was focused on screening the small ruminant population of district Dera Ismail (D.I.) Khan, Khyber Pakhtunkhwa, Pakistan for parasitism. Consequently, the present study will help to determine the epizootiology of parasitic infection in the small ruminant population of D.I. Khan, KPK, Pakistan.

MATERIALS AND METHODS

Study Area

This survey was performed in the small ruminant population of district D.I. Khan has six administrative divisions (tehsils) like (a) Yarik, (b) Paharpur, (c) Diyal, (d) D.I. Khan city (e) Draban and (f) Paroa. The D.I. Khan district is located in the subtropical desert of KPK, Pakistan, between longitude 70˚55' east, 31˚49' north, with 165 meters above the ocean level. The total population of goats and sheep in this region is about 4,672 and 3,695, respectively. The normal temperature and relative humidity of the study district are 24.2ºC and 56%, respectively. The animal population (n=384 sheep and 384 goats) was selected by using stratified random sampling for one year.

Collection and Processing of Samples

The ectoparasites were collected from the study population with the help of plane forceps. Different parts of the animal body including neck, head, dewlap, ear, belly, back, hindleg, foreleg, tail, and genital regions were examined for the collection of ectoparasites. Collected samples were preserved in 70% ethanol and transported to the Molecular Parasitology Lab (MPL), Department of Parasitology, the University of Agriculture, Faisalabad (UAF). The identification of ectoparasites was performed under a stereomicroscope using the standard keys given by Soulsby (1982). The blood samples were collected in EDTA containing vacutainers on the kind consent of the flock owners and stored at 4ºC until further processing. These blood samples were subjected to Giemsa staining. For this, a thin blood smear was made on a glass slide and left for air-dry. Slides with thin blood films were dipped in pure methanol (2-3 times) for fixation and left for air-dry. Then 5% Giemsa stain was flooded on the slide for 20-30 minutes. After that, slides were washed with tap water and left for air-dry (Hasan, 2012).

Faecal sample (5 g) was collected directly from the rectum and preserved in 10% formalin. Properly labeled and preserved samples were transported to MPL, UAF for further processing. Qualitative fecal examination techniques (sedimentation and flotation techniques) and quantitative techniques (McMaster Egg counting method) were used

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Table 1: Frequency distribution of gastrointestinal parasites in sheep and goat population of district Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

Variables	Factors	Animals Screened	Positive	Prev-alence (%)	Chi-Square	P-value	Animals Screened	Positive	Preva-lence (%)	Chi-Square	P-value
		Sheep					Goat				
Breed	Damani	184	179	97.28	55.979	0.000	186	166	89.25	106.932	0.000
	Beetal						166	85	51.20		
	Teddy						32	3	9.38		
	Thali	112	80	71.43							
	Kajli	88	57	64.77							
Age	Young	246	233	94.72	72.504	0.000	224	192	85.71	91.93	0.000
	Adults	138	83	60.14			160	62	38.75		
Sex	Female	266	250	93.98	81.22	0.000	212	196	92.45	146.274	0.000
	Male	118	66	55.93			172	58	33.72		
Tehsils	Daman	64	60	93.75	68.98	0.000	64	52	81.25	58.844	0.000
	D.I.Khan City	64	30	46.88			64	18	28.13		
	Yaraik	64	58	90.63			64	46	71.88		
	Paroa	64	54	84.38			64	38	59.38		
	Paharpur	64	59	92.19			64	48	75.00		
	Daraban	64	55	85.94			64	52	81.25		
Feeding system	Grazing	174	156	89.66	11.83	0.001	207	189	91.30	126.936	0.000
	Stall feeding	210	160	76.19			177	65	36.72		
Hygienic measure	Poor	192	189	98.44	158.58	0.000	196	163	83.16	70.287	0.000
	Fair	131	110	83.97			110	67	60.91		
	Good	61	17	27.87			78	24	30.77		
Housing system	Open	138	133	96.38	121.33	0.000	102	96	94.12	53.375	0.000
	Semi-closed	170	153	90.00			200	120	60.00		
	Closed	76	30	39.47			82	38	46.34		
Floor patterns	Un-cemented	177	167	94.35	87.08	0.000	211	193	91.47	141.606	0.000
	Partially-cemented	142	121	85.21			107	46	42.99		
	Cemented	65	28	43.08			66	15	22.73		
Watering system	Canal	118	85	72.03	23.82	0.000	137	82	59.85	17.251	0.000
	Tap	104	80	76.92			133	79	59.40		
	Pond	162	151	93.21			114	93	81.58		
Animal keeping system	Open	182	166	91.21	18.87	0.000	207	176	85.02	71.471	0.000
	Tethered	202	150	74.26			177	78	44.07		

for the identification of parasitic eggs from faecal samples. Each sample was examined under a light microscope at 10X and parasites were identified using the key given by Soulsby (1982).

Statistical Analyses

Variations among different variables (age, sex, breed, location, feeding system, hygienic measure, housing system, floor patterns, watering system and animal keeping system) with the prevalence of GI parasites were examined using the Chi-square test. Data were analyzed using Mi

Table 2: Frequency distribution of blood parasites in sheep and goat population of district Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

Variables	Factors	Animals Screened	Positive	Prevalence (%)	Chi-Square	P-value	Animals Screened	Positive	Prevalence (%)	Chi-Square	P-value
		Sheep					Goat				
Breed	Damani	184	53	28.80	1.693	0.429	186	14	7.53	0.643	0.725
	Beetal						166	9	5.42		
	Teddy						32	2	6.25		
	Thali	112	26	23.21							
	Kajli	88	20	22.73							
Age	Young	246	82	33.33	20.403	0.000	224	20	8.93	5.165	0.023
	Adults	138	17	12.32			160	5	3.13		
Sex	Female	266	85	31.95	17.242	0.000	212	18	8.49	3.049	0.081
	Male	118	14	11.86			172	7	4.07		
Tehsils	Daman	64	20	31.25	2.899	0.716	64	3	4.69	1.754	0.882
	D.I.Khan City	64	15	23.44			64	4	6.25		
	Yaraik	64	17	26.56			64	3	4.69		
	Paroa	64	19	29.69			64	5	7.81		
	Paharpur	64	15	23.44			64	6	9.38		
	Daraban	64	13	20.31			64	4	6.25		
Feeding system	Grazing	174	21	12.07	31.265	0.000	207	8	3.86	5.165	0.023
	Stall feeding	210	78	37.14			177	17	9.60		
Hygienic measure	Poor	192	66	34.38	15.616	0.000	196	19	9.69	6.752	0.034
	Fair	131	20	15.27			110	4	3.64		
	Good	61	13	21.31			78	2	2.56		
Housing system	Open	138	30	21.74	26.314	0.000	102	4	3.92	23.875	0.000
	Semi-closed	170	32	18.82			200	6	3.00		
	Closed	76	37	48.68			82	15	18.29		
Floor patterns	Un-cemented	177	74	41.81	44.161	0.000	211	20	9.48	6.783	0.034
	Partially-cemented	142	18	12.68			107	3	2.80		
	Cemented	65	7	10.77			66	2	3.03		
Watering system	canal	118	34	28.81	10.066	0.007	137	8	5.84	1.075	0.586
	Tap	104	36	34.62			133	11	8.27		
	Pond	162	29	17.90			114	6	5.26		
Animal keeping system	Open	182	31	17.03	13.838	0.000	207	5	2.42	12.372	0.000
	Tethered	202	68	33.66			177	20	11.30		

nitab 17.0 software and prevalence was calculated by dividing the number of positive samples by the total number of samples and multiplying with 100. Variables having $P < 0.05$ were considered significantly different.

RESULTS

The overall prevalence of ecto and endo parasites in the small ruminant population was 74.22%, however, sheep showed a significantly higher prevalence (82.29%) than

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Table 3: Frequency distribution of ectoparasites in sheep and goat population of Dera Ismail Khan District, Khyber Pakhtunkhwa, Pakistan

Varia-bles	Factors	Animals screened	Positive animals	Prev-alence (%)	Chi-square	P-value	Animals screened	Positive animals	Prevalence (%)	Chi-square	P-value
		Sheep					Goat				
Breed	Damani	184	112	60.87	30.922	0.000	186	121	65.05	7.825	0.020
	Thali	112	52	46.43							
	Kajli	88	22	25.00							
	Beetal						166	84	50.60		
	Teddy						32	17	53.13		
Age	Young	246	124	50.41	1.063	0.303	224	187	83.48	145.242	0.000
	Adults	138	62	44.93			160	35	21.88		
Sex	Female	266	145	54.51	12.786	0.000	212	156	73.58	48.276	0.000
	Male	118	41	34.75			172	66	38.37		
Tehsils	Daman	64	32	50.00	4.004	0.549	64	36	56.25	2.563	0.767
	D.I.Khan City	64	24	37.50			64	32	50.00		
	Yaraik	64	31	48.44			64	39	60.94		
	Paroa	64	32	50.00			64	37	57.81		
	Paharpur	64	33	51.56			64	38	59.38		
	Daraban	64	34	53.13			64	40	62.50		
Feeding system	Grazing	174	58	33.33	29.063	0.000	207	105	50.72	9.25	0.002
	Stall feeding	210	128	60.95			177	117	66.10		
Hygienic measure	Poor	192	134	69.79	70.333	0.000	196	145	73.98	60.378	0.000
	Fair	131	37	28.24			110	59	53.64		
	Good	61	15	24.59			78	18	23.08		
Housing system	Open	138	40	28.99	76.056	0.000	102	54	52.94	4.955	0.084
	Semi-closed	170	90	52.94			200	112	56.00		
	closed	76	56	73.68			82	56	68.29		
Floor patterns	Un-ce-mented	177	114	64.41	32.298	0.000	211	155	73.46	54.376	0.000
	Partial-ly-ce-mented	142	52	36.62			107	50	46.73		
	Cement-ed	65	20	30.77			66	17	25.76		
Watering system	Canal	118	58	49.15	4.035	0.133	137	77	56.20	4.419	0.110
	Tap	104	58	55.77			133	86	64.66		
	Pond	162	70	43.21			114	59	51.75		
Animal keeping	Open	182	64	35.16	24.403	0.000	207	89	43.00	40.426	0.000
	Tethered	202	122	60.40			177	133	75.14		

goats (66.15%).

Both sheep and goat showed a significantly higher ($P < 0.05$) prevalence of nematodes (sheep = 48.43%, goat = 34.38%) followed in order by trematodes (sheep = 16.14%, goat = 22.40%), cestodes (sheep = 14.58%, goat = 7.30%) and mixed infection (sheep = 3.12%, goat = 2.83%). Among nematodes, the highest prevalent ($P < 0.05$) species was *Haemonchus (H.) contortus* (62%) followed by *Strongyloides* spp. (48.75%) and *Trichostrongylus* spp. (25.36%). Two

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trematodes i.e., *Fasciola* spp. (7.35%) and *Paramphistomum* spp. (20.52%) were recorded in the present study. Among cestodes, only *Moniezia* spp. was detected with prevalence of 22%. A significant variation (P < 0.05) in the prevalence of GI parasites was determined in all intrinsic (age, sex, and breed) and extrinsic factors (tehsils, feeding system, hygienic measure, housing system, floor patterns, watering system, and animal rearing system) of sheep and goat. The frequency distribution of GI parasites of sheep and goat population of D.I. Khan is given in Table 1.

The overall prevalence of haemoparasites in the small ruminant population was 16.15%, however, sheep showed a significantly higher (P < 0.05) prevalence (25.78%) than goats (6.51%). Two species of blood parasites were found in the sheep and goat population of the D.I Khan district. In the sheep population, the prevalence of *Babesia* (17.71%) was significantly higher (P < 0.05) than *Theileria* (8.07%) however, the goat population showed an insignificant variation of *Babesia* (3.91%) and *Theileria* (2.60%) infection. Intrinsic factors like age (young) and sex (female) showed a significant (P < 0.05) association with haemoparasites while factor breed showed insignificant (P > 0.05) association in small ruminants. Tehsils showed an insignificant (P > 0.05) association with haemoparasites while feeding system (grazing), hygienic measure (poor), housing system (closed), floor patterns (un-cemented), and animal keeping system (tethered) presented a significant (P < 0.05) association. Prevalence of blood parasites of sheep and goat population of D.I. Khan is given in Table 2.

The overall prevalence of ectoparasites in the small ruminant population was 53.13%. The prevalence of ectoparasites in the sheep (48.44%) and goat (57.18%) population differed insignificantly (P > 0.05). However, distribution of ticks (48.70%; 39.58%), lice (25.00%; 14.58%), and flea (3.65%; 5.73%) significantly varied (P < 0.05) in goat and sheep population, respectively. The ticks present in the study district were *Rhipicephalus* spp. (64.9%) and *Haemaphysalis* spp. (35.43%). The lice *Linognathus* spp. (23.75%) and *Damalinia* spp. (17.42%) were reported in the study district. *Ctenocephalides* spp. (9.38%) were the only flea prevalent in the study area. In the case of goat, all intrinsic factors like age, sex, and breed showed significant variation (P < 0.05) of ectoparasites. However, in the case of sheep, age was found to be an insignificant (P > 0.05) variable while breed and sex showed significant (P < 0.05) variation. Location, housing, and the watering system provided the insignificant (P > 0.05) association with the ectoparasites of goats while feeding system, hygienic condition, floor pattern, and animal keeping system showed significantly (P < 0.05) higher prevalence. The frequency distribution of ectoparasites of sheep and goat population is given in Table 3.

DISCUSSION

Parasitic diseases are a significant threat to the livestock population in tropical and subtropical regions of the world. Small ruminants are still under the burden of subclinical and clinical infections due to parasites, which decrease their productive potential (Zeryehun, 2012; Ayaz et al., 2013) due to insufficient utilization of digested food (Hassan et al., 2011). Parasitic infections reduce animal resistance thereby increasing the risk of other pathogenic contaminations and it may cause overwhelming financial losses (Mabbott, 2018).

Ruminants suffer from a broad range of GI parasites and among these, nematodes are more important because of their direct lifecycle. Various types of helminths reported in the current investigation were in line with those reported by Nabi et al. (2014), Raza et al. (2014), Rizwan et al. (2017), Rizwan et al. (2019) and Ahmad et al. (2020) from various regions of Pakistan while Mohanta et al. (2007), Khajuria et al. (2013), Elshahawy et al. (2014), Hurisa et al. (2021), reported these helminths in different parts the world. *Nematodirus spathiger* (28.66%), *H. contortus* (14.66%), *Trichostrongylus colubriformis* (4%), *Strongyloides papillosus* (6%), and *Trichuris ovis* (11.33%) were reported by Nabi et al. (2014). The species of parasites identified from the collected faecal samples by Rizwan et al. (2019) were *H. contortus* (32.81%) followed in order by *Strongyloides* spp. (18.75%), *Trichostrongylus* spp. (15.36%) and *Fasciola* spp. (7.55%). Parasitic species identified from the microscopically scanned faecal samples were: *Fasciola* spp., *H. contortus*, *Oesophagostomum* spp., *Trichuris ovis*, *Strongyloides* spp., and *Trichostrongylus* sp. (Ahmad et al., 2020). Some of the scientists found different types of GI parasites and the presence of various types of GI parasites in the animal population might be due to the climatic condition of the area, management of animals, grazing pattern, sex, and use of anthelmintics (Ouattara and Dorchies, 2001). The lower rate of trematodes and cestodes in the study area might be due to less availability of intermediate hosts.

The higher rate (78.1%) of GI parasites in small ruminant population was reported by Raza et al., (2014) however, a lower rate was reported by Mehmood et al. (2013), Nabi et al. (2014), Rizwan et al. (2017) and Ahmad et al. (2020). The difference in results might be due to climatic changes in various zones and the handling of animals. Lashari and Tasawar (2011) declared that the Kacchi breed is more susceptible to GI helminths as compared to other breeds and this might be due to variation in the resistance of animals against GI parasites. Raza et al. (2007) and Nabi et al. (2014) reported that young animals were more prone to GI parasitic infection as compared to adults which were in line with the present study. The young animals were found

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to be more infected with GI helminths which is due to the high immunosuppression and low resistance against parasitic infection. The low level of parasitism in adult animals is due to the increased immunity and resistance against parasites due to early infections (Vlassoff et al., 2001).

Rupa and Portugaliza (2016) acknowledged that the open housing system, poor hygienic conditions, and uncemented floor are the significant factors for the increase in the GI parasitic infection which are in line with the present study. Eggs of parasites and survival of larvae due to suitable microenvironments in the uncemented floor, inefficient cleaning and poor hygienic measures may lead to the development of new parasitic infection or reinfection (Wang et al., 2014). Similar to the present study, Dabasa et al. (2017) declared an insignificant association of parasitic infection in various locations. The difference in climatic conditions, veterinary services in the study area, management system, and association of peasants might attribute to the differences in parasitic prevalence. The present study showed that grazing animals and animals in open animal rearing systems rather than tethered were more prone to infection due to more exposure to animals with parasitic eggs and larvae.

The overall prevalence of haemoparasites in the small ruminant population was in line with the results of Rjeibi et al. (2014) however, Razmi et al. (2003) and Akhter et al. (2011) showed a lower prevalence. The variation in the prevalence of blood parasites might be due to the difference in genetic resistance of animals and climatic conditions. Similar to our study, Rjeibi et al. (2014), and Riaz and Tasawar (2017) declared a higher prevalence of haemoparasites in sheep as compared to goats. This might be due to the difference in the haircoat of goats which is thin as compared to sheep. Due to more resistance for attachment of ticks on the skin of goats, there could be less chance of tick infestation. The ticks could trap in the skin of sheep easily and cause tick-borne piroplasmosis. In contrast to the present study, Zangana and Naqid (2011) found a higher rate of *Theileria* infection than *Babesia*. This might be due to the presence of more *Ixodes* species of tick in the study area which is a possible vector of *Babesia*.

Breed-wise prevalence determined by Riaz and Tasawar (2017) was significant in sheep and insignificant in goat breed. Rjeibi et al. (2014) found a significant variation of haemoparasites in sheep and goat breeds. This variation might be due to the difference in host management, genetic resistance against blood-borne parasites, and agroecological variation which is directly proportional to the distribution of ticks and tick-borne parasites. In contrast to the present study, Razmi et al. (2003), Riaz and Tasawar (2017) found a higher prevalence of blood parasites in adult animals as compared to young. The results of Iqbal et al. (2013) declared a higher prevalence in young animals which is in line with the present study, however, Rjeibi et al. (2014) found an insignificant variation of blood parasites in the different age groups. This variation may be due to the difference in breeds investigated in different studies. The higher prevalence of blood parasites in young animals might be due to naïve immune systems while in older animals due to decreased resistance against parasitic infection. Similar to the present study, Zangana and Naqid (2011) and Rjeibi et al. (2014) found a higher prevalence in females as compared to males however, Iqbal et al. (2011) declared a higher prevalence in males than in female animals. This might be the result of immunosuppression in female animals due to continuous stress and hormonal variation during lactation and pregnancy.

The prevalence of *Theileria* and *Babesia* in sheep and goat populations in different areas of Iraq (Zangana and Naqid, 2011) and Tunisia (Rjeibi et al., 2014) was insignificant as reported in the present study. This might be due to the close association between the distribution area of the ticks, activity time, the incidence of piroplasmosis, and climatic conditions. To our knowledge, most of the extrinsic factors observed in the present investigation have been considered the very first time to determine the prevalence of *Theleiria* and *Babesia*. However, it has been reported that the stall-feeding system, close housing system, uncemented floor pattern, and tethered animal rearing system increase the risk of tick infestation which are the vector of *Theileria* and *Babesia* (Rehman et al., 2017; Sajid et al., 2017; 2020).

The overall prevalence of ectoparasites reported in the present study was higher reported by Iqbal et al. (2014), and Seyoum et al. (2015), while lower than reported by Sajid et al. (2017). The variety of ectoparasites reported in the present study like ticks, lice, and fleas have also been reported by various scientists around the world (Iqbal et al., 2014; Seyoum et al., 2015). This higher infestation might be associated with various factors like poor diet especially during the dry season which may lead to malnutrition, poor husbandry practices, poor animal health, favorable geographical, and climatic conditions (Sarkar et al., 2011). The insignificant variation in the overall prevalence of ectoparasites in the sheep and goat population was also reported by Seyoum et al. (2015) however, Tesfaye et al. (2012) reported a significant variation in the small ruminant population. The breeds of goat showed an insignificant variation in ectoparasites which is in line with the results of Iqbal et al. (2014) while the breeds of sheep presented a significant variation ($P < 0.05$). This might be due to variation in the resistance of different breeds for ectoparasites. The exotic breeds of animals are more prone to infection than local breeds (Muchenje et al., 2008). Increased grooming, skin hypersensitivity, and avoidance behavior of animals

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may also contribute to the resistance of the local breed to ectoparasites. The higher infestation of ectoparasites in young and female animals has been reported by Iqbal et al. (2014), Seyoum et al. (2015), and Sajid et al. (2017). This might be due to the incapability of young and emaciated animals to groom and the presence of weak immunity to protect themselves against ectoparasites (Urquhart et al., 1996). The higher infestation in female animals might be related to the purpose of rearing (dairy purpose) which is associated with continuous hormonal changes and stress during reproduction and lactation.

The results of different husbandry practices were in line with the results of Sajid et al. (2008) and Iqbal et al. (2014). A significantly higher prevalence of ectoparasites was reported in stall feeding animals, animals with poor hygienic conditions, close housing system, lived in the uncemented floor, and in tethered animals, however different watering systems (canal, tap, and pond) showed an insignificant association with ectoparasites. The higher prevalence in stall feeding and tethered animals might be due to the presence of ectoparasites in the microclimate that is under cracks and crevices and dump of faeces (Radon et al., 2001). In Kacha or uncemented floors, the higher rate of ectoparasites might be due to the depth of the soil which provides suitable temperature, humidity, and more niches for the development of parasites. Factors like low exposure to sunlight, increased humidity, and the presence of cracks and crevices in the closed housing system, provide a suitable environment for the propagation of ectoparasites (Muhammad et al., 2008).

CONCLUSIONS

The results of the present study can be used to target small and large livestock farms for suitable control measures for ecto and endoparasites of small ruminants of Pakistan and countries with comparable climatic conditions. The present study provided suitable indicators related to ecto and endoparasitic infection in the study area which will be a reference of direction for poor farmers to obtain maximum production and economic advantage. Through the implementation of proper husbandry management and particular care for the female and younger animals, we can minimize the parasitic threat in livestock.

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CONFLICT OF INTEREST

There is no conflict of interest.

NOVELTY STATEMENT

The present study was designed to determine the prevalence of ectoparasites, endo-parasites, and haemo-parasites of small ruminants and their association with various intrinsic (age, sex, and breed) and extrinsic factors (tehsils, feeding system, hygienic measure, housing system, floor patterns, watering system, and animal keeping system).

AUTHORS CONTRIBUTION

Study conception and design: MSS and HMR; sample collection and analyses: AB, FB, FA, WA; Data analysis and interpretation of results: AI, IJ; draft manuscript preparation: IR, HMR, AB; Final review of the draft: MSS and MNK.

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