



# Epidemiology of Ectoparasites (Ticks, Lice, and Mites) in the Livestock of Pakistan: A Review

Ali Muhammad<sup>1</sup>, Rida Bashir<sup>1</sup>, Majid Mahmood<sup>1</sup>, Muhammad Sohail Afzal<sup>2</sup>, Sami Simsek<sup>3</sup>, Usman Ayub Awan<sup>4</sup>, Mobushir Riaz Khan<sup>5</sup>, Haroon Ahmed<sup>6\*</sup> and Jianping Cao<sup>7,8,9,10\*</sup>

<sup>1</sup> Department of Zoology, University of Poonch Rawalakot, Azad Jammu and Kashmir, Pakistan, <sup>2</sup> Department of Life Sciences, Faculty of Science, University of Management and Technology (UMT), Lahore, Pakistan, <sup>3</sup> Department of Parasitology, Firat University, Elâzığ, Turkey, <sup>4</sup> Department of Medical Laboratory Technology, The University of Haripur, Haripur, Pakistan, <sup>5</sup> School of Environmental Science, Charles Sturt University, Albury, NSW, Australia, <sup>6</sup> Department of Biosciences, COMSATS University Islamabad (CUI), Islamabad, Pakistan, <sup>7</sup> Chinese Center for Disease Control and Prevention (Chinese Center for Tropical Diseases Research), National Institute of Parasitic Diseases, Shanghai, China, <sup>8</sup> Key Laboratory of Parasite and Vector Biology, National Health Commission of the People's Republic of China, Shanghai, China, <sup>9</sup> WHO Collaborating Center for Tropical Diseases, Shanghai, China, <sup>10</sup> Chinese Center for Tropical Diseases Research, The School of Global Health, Shanghai Jiao Tong University School of Medicine, Shanghai, China

## OPEN ACCESS

### Edited by:

Mariangela Caroprese,  
University of Foggia, Italy

### Reviewed by:

Faham Khamesipour,  
Shahid Beheshti University of Medical  
Sciences, Iran

Sara Savic,  
Scientific Veterinary Institute Novi  
Sad, Serbia

### \*Correspondence:

Haroon Ahmed  
haroonahmad12@yahoo.com  
Jianping Cao  
caojp@yahoo.com

### Specialty section:

This article was submitted to  
Veterinary Infectious Diseases,  
a section of the journal  
Frontiers in Veterinary Science

**Received:** 21 September 2021

**Accepted:** 29 October 2021

**Published:** 16 December 2021

### Citation:

Muhammad A, Bashir R, Mahmood M, Afzal MS, Simsek S, Awan UA, Khan MR, Ahmed H and Cao J (2021) Epidemiology of Ectoparasites (Ticks, Lice, and Mites) in the Livestock of Pakistan: A Review. *Front. Vet. Sci.* 8:780738. doi: 10.3389/fvets.2021.780738

Ectoparasites, including lice, ticks, and mites, inhabit the host skin and depend on their host for sustenance, maturation, and multiplication. Among these, ticks are more prevalent in various regions of Pakistan because of favorable climatic conditions, lack of awareness of livestock keepers' regarding ectoparasite infestation rate, insufficient veterinary services, and inadequate control measures. Ectoparasitic infestation is a primary threat to cost-effective livestock production by damaging skin and transmitting multiple diseases between animals. This review aimed to determine the infestation rates of various ectoparasites in cattle, buffaloes, sheep, goats, camels, equids and to ascertain the prevalence and epidemiology of ectoparasites in different regions of Pakistan. This review could be useful in devising prevention and control strategies and identifying the risk factors associated with ectoparasites to enhance animal productivity. It provides directions for veterinary schools, researchers, and organizations aiming to collaborate with neighboring countries to eradicate these parasites. Future studies could support working veterinarians and administrators and contribute to human well-being.

**Keywords:** epidemiology, ectoparasites, ticks, mites, lice, livestock, Pakistan

## INTRODUCTION

Pakistan is an agricultural country with 75% of its population involved directly or indirectly in agriculture. It is the second-largest sector, providing 21.2% of the gross domestic product (GDP) and employment to 45% of the labor force (1). Livestock, the "spine of the Pakistan agricultural economy," are in danger due to the huge numbers of ecto- and endoparasites (2, 3), and the costs of the control measures could have a serious economic impact on the livestock and dairy industries (4). The livestock sector is an integral part and the basis of the rural economy (5) as more than 70% of the population resides in rural regions (6). Domestic mammals contribute 53.2% of the agricultural worth and 11.4% of the overall GDP. Buffaloes produce about 68% of the milk in Pakistan, while 27% is produced by cattle, and 5% by sheep, goats, and camels (7).

Livestock is the main source of energy, food, raw materials, and compost for crops. Consequently, it is not surprising that livestock, particularly the dairy industry, have risen as an important economic source and a trademark for the agri-business in dairy, meat, and numerous other products (8). Cows and buffaloes are a key source of animal proteins, and their products, such as bones, skins, and products made from their components, are of great importance for humans (9). Cattles are used as a source of meat, milk, and other dairy products; however, ticks harm their skin and hinder meat and milk production (10). Goats invest an impressive quantity of vital proteins in their struggle against a diversity of ectoparasites, and frequently transfer a range of pathogens (11). Sheep have great social and economic importance as they are used for cultural merriments and religious sacrifices to counter crop failure (12). Parasite infection places a major restriction on profitable dairy production (13).

Ectoparasites, including lice, ticks, mites, fleas, are organisms that inhabit the skin or skin surface of another organism (the host) for several days and could be detrimental as they depend on their host for sustenance, maturation, and multiplication. As “a principal blockage to the growth of animals,” ectoparasites play a vital role in the spread of specific pathogens (14). For example, ticks and mites are the vectors of many bacterial, viral, rickettsial, and protozoal diseases, some of which are zoonotic (15).

Ectoparasitic infestation poses the greatest threat to cost-effective livestock production (16). Ectoparasites are involved in mechanical damage, anemia, loss of condition, irritation, allergic reaction, toxicosis, morbidity, and mortality. Indirect effects of ectoparasites consist of transmission of pathogens that cause babesiosis, theileriosis, anaplasmosis, and more (17). Some parasites even cause diseases in humans when the protection measures are ignored (11).

Among the ectoparasites, ticks have been recognized as a disreputable threat due to the severe irritation, allergy, and toxicosis they cause, and diseases like babesiosis, theileriosis, and anaplasmosis they transmit (18). Ticks are potential disease vectors and act as reservoirs of certain infectious agents (2). They are vectors of several pathogenic microorganisms, including viruses, bacteria, spirochetes, rickettsia, and protozoans (19), acting as a cause of morbidity in livestock (20). Livestock are also affected by other tick damages, including tick-bite abscesses, irritation, dermatophilosis, and blood loss with its detrimental stressful effect on the animals (21). Ticks are obligate blood-sucking parasites (3), with the hard ticks having an outstanding medical and veterinary importance (22).

Mange mites were blamed for great economic losses due to the damages they cause to the skin and wool, anemia, poor body condition, and decreased milk and meat production and growth rate (23). Louse infestation is the base of reduced hide and skin features which influence tanning industry and ruins country's economy, about 1.9 to 94% of louse infestation in cattle and buffaloes raised under different management system (24, 25). Mites cause severe losses due to rejection skin, loss of production, anemia, and death when found in large numbers (25).

**Abbreviations:** WHO, World Health Organization; TBD, Tick born diseases; NZDs, Neglected Zoonotic Diseases; DALYs, Disability Adjusted Life Years.

Livestock sector is backbone of the country like Pakistan and till date no up to date information on ectoparasites were available. That why the current review was designed on the epidemiology of ectoparasites (Ticks, lice and mites) in livestock of Pakistan.

## THE REVIEW PROTOCOL

This review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). All available published research articles on ectoparasites in livestock were considered. The various review steps included literature search, inclusion and exclusion criteria for relevance to the topic, and extraction of relevant data to achieve the study objective.

## LITERATURE SEARCH

The literature search included all studies published during 2002–2020 on livestock ectoparasites in Pakistan. The search used Google Scholar, PubMed, NCBI, ResearchGate, and Web of Science. Keywords used for the search were ectoparasites, ticks, lice, mange mites, flies, fleas, small ruminants, livestock, sheep, goat, cattle, buffalo, horse, camel, donkey, prevalence, domestic animals, risk factors, livestock diseases caused by ectoparasites, tick and lice infestations, the incidence of ectoparasites, threats to the dairy sector, theileriosis, anaplasmosis, cattle tick, and Pakistan. Various keyword combinations were used, and the full text of selected articles and their reference lists were screened to relevant articles.

We identified 100 articles related to animal ectoparasites in Pakistan for this review. However, 17 articles were excluded due to duplication. We included 56 articles in this review while 44 articles were excluded. The literature assessment and selection process is illustrated in **Figure 1**.

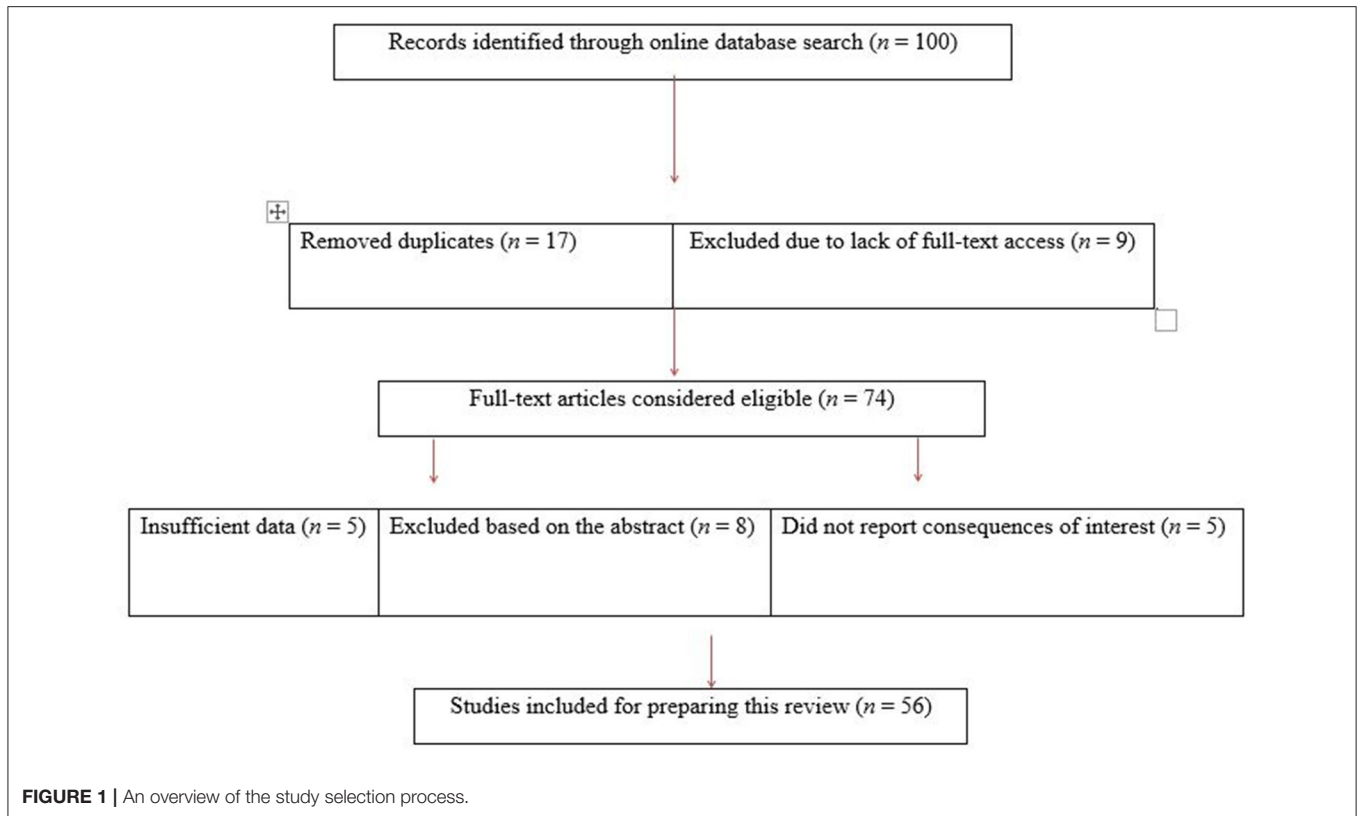
## RESULTS AND DISCUSSION

An attempt was made to compile all available published research articles on livestock ectoparasites in Pakistan. Prevalence was estimated as the number of host specie infected by at least one parasite divided by the total number of host specie examined for parasites. The distribution of ectoparasites among different host is shown in **Figure 2**. Data on the prevalence of livestock ectoparasites was collected from the included studies.

### Prevalence of Lice in Pakistan

Lice are small wingless parasitic insects on animals that suck their blood. Louse infestation reduces hide and skin features, influencing the tanning industry and having a harmful economic impact. Louse infestation was found in 1.9–94% of the cattle and buffaloes raised under various management systems (24).

The prevalence of louse infestations varies between the regions of Pakistan and depends on the region studied. Fourteen studies investigated louse infestation in cattle, sheep, horses, buffaloes and cattle calves in Pakistan, and four studies focused on lice in cattle or buffaloes. Details of source, host, area, lice, and estimated prevalence are presented in **Table 1**. Data of reported prevalence estimates for lice infestation varied between species,



as the prevalence in goats differed from that in sheep, cattle, and buffaloes.

### Prevalence of Lice in Buffaloes

The prevalence of lice in buffaloes ranged between 0 and 92%. Lice infestation in the buffaloes of Multan (31) was 92%, considerably higher than the 0% prevalence reported in the cattle and buffaloes of Azad Jammu and Kashmir (24). In 2002, 118 buffalo calves were investigated in the Dir District, and 34.75% were found to harbor lice (26). A study in Faisalabad reported in 2006 that about 18% of the buffaloes were infested with lice, higher than the 9.84% reported in Quetta (28, 29). The overall highest prevalence of lice, ticks, and mites recorded during the month of July, 2008 in the sheep, goats, buffaloes, and cows of the Muzaffarabad District, Azad Jammu and Kashmir was 41% (25), while a study from 2016 (16), recorded an overall louse and tick prevalence of 7.5% in the goats, buffaloes, and sheep of Kotli, Azad Jammu and Kashmir (Table 1).

### Prevalence of Lice in Goats

The range of louse infestation was from 9.58% in the goats of the Toba Tek Singh District (11) to 13.3% in the goats of Karak in Khyber Pakhtunkhwa (33).

### Prevalence of Lice in Sheep

A louse prevalence of 20% in the sheep of Karak, Khyber Pakhtunkhwa was reported in 2008 (33). An overall louse and tick

prevalence of 26% was reported in 2016 in the goats, buffaloes, and sheep of Kotli, Azad Jammu and Kashmir (16) and an overall prevalence of 41% in sheep, goats, buffaloes, and cows was reported in the Muzaffarabad District, Azad Jammu and Kashmir (25).

### Prevalence of Lice in Cattle

The louse prevalence in cattle was in the range of 0–38.3%. A 0% prevalence was reported in Rawalakot, Azad Kashmir in 2015 (24), 5% in DG Khan (32), 23.3% in Punjab (17) and 38.3% and 7.17% was reported in Quetta (9, 29), 24% in Faisalabad (28).

### Prevalence of Lice in Horses

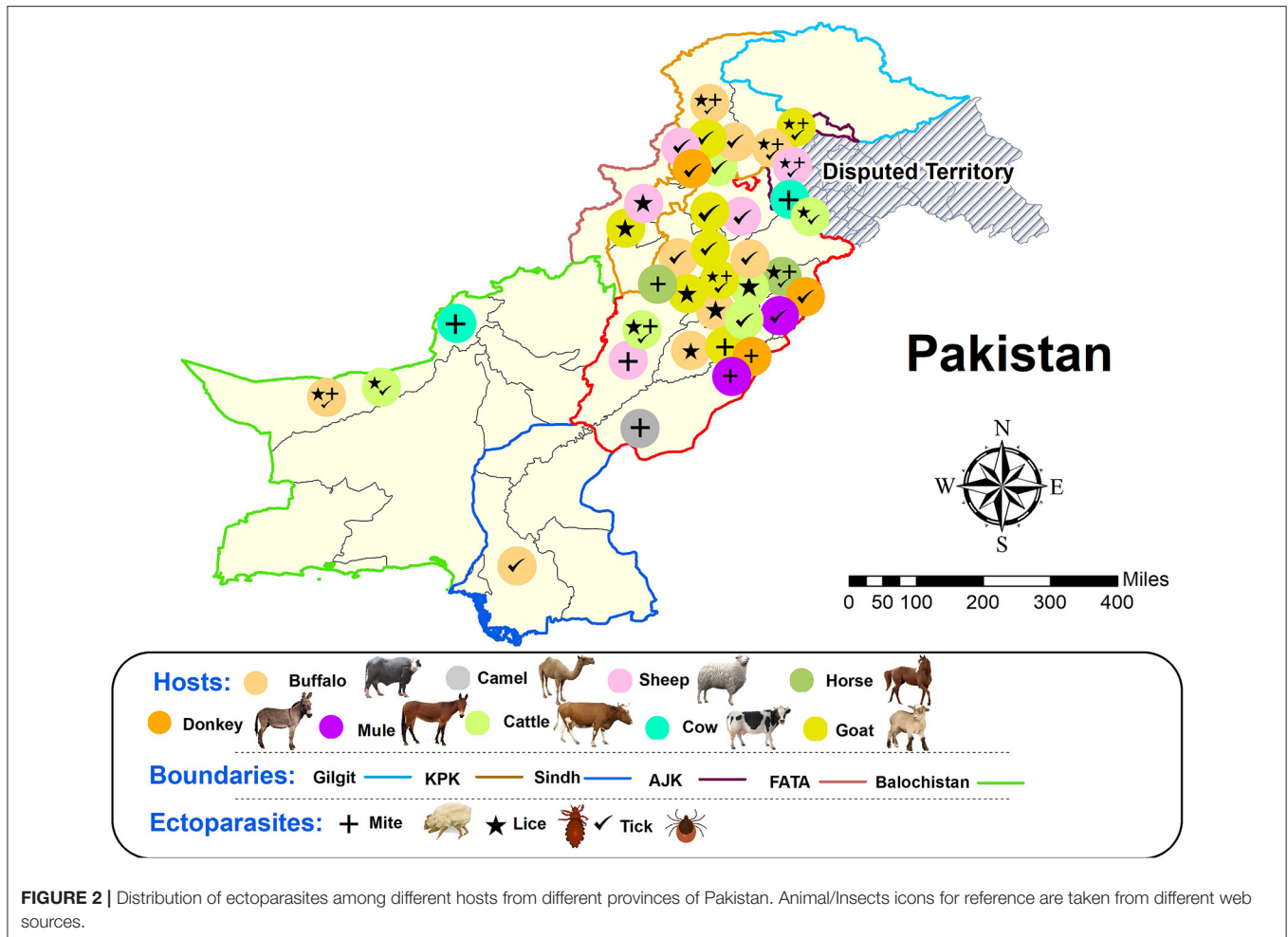
Of the 14 studies on lice, only one reported about horses. A study from 2005 (27) examined 84 horses but found no lice infestation, i.e., a prevalence of 0% (Table 1).

### Prevalence of Mites in Pakistan

Any of the numerous small acarid arachnids that often infest animals could cause inflammation and loss of hair. Mange mites are an important ectoparasite of sheep (34), resulting a severe economic impact among livestock (34). The prevalence of mites varied between parts of Pakistan, as shown in Table 1.

### Prevalence of Mites in Sheep

The prevalence of mite infestation in sheep ranged from 6 to 17% in several studies. In Punjab, prevalence was 11.37% (34), 17% (12), and 6% (23). In 2016, overall prevalence (louse and



**FIGURE 2** | Distribution of ectoparasites among different hosts from different provinces of Pakistan. Animal/Insects icons for reference are taken from different web sources.

tick) was 26% among sheep, goats and buffaloes from AJK (16). Details are shown in **Table 2**.

**Prevalence of Mites in Buffaloes**

The highest mite prevalence of 11.86% was recorded in buffalo calves in 2002 in the Dir District (26), and the lowest (4.92%) was reported in the buffaloes of Quetta (29).

**Prevalence of Mites in Camels**

Of the 16 studies on mites as ectoparasites, only two reported about camels. In 2015, 1,489 camels were examined for a mite infestation, recording an infestation rate of 11.28% from three (North, south and western) parts of Punjab (37). In a study in the Cholistan area, 55.56% of the camels were infested by these ectoparasites (including ticks and lice) (39).

**Prevalence of Mites in Equids (Horse, Mule, and Donkey)**

Of the 16 studies on mites, three reported mite prevalence in horses, mules, and donkeys.

Two studies reported a prevalence of 53.33% (35) and 29.76% (27) in the horses of Lahore. A study from 2013 (36)

recorded an overall prevalence of 1.5% in the horses, donkeys, and mules of Punjab.

**Prevalence of Mites in Goats**

Only two studies reported the prevalence of mite infestations in goats. A study in Toba Tek Singh recorded a prevalence of 3.23% (11), while in a study in Multan, 35.5% of the goats were found to be infested with mites (12).

**Prevalence of Mites in Cattle**

Of the 16 studies published on mites as ectoparasites of domestic animals in Pakistan, four investigated the prevalence in cattle alone, and one recorded an overall prevalence in several animal species, including cows. The range of mite infestation in these studies was 4–8%. A study from 2008 in Quetta (29) observed that 5.19% of the cows were infested with mites. Three studies on cattle in Punjab reported prevalence rates of 5% (32), 4% (30), and 4.34% (17).

**Prevalence of Ticks in Pakistan**

The prevalence of ticks infestation in different livestock species as shown in **Table 3**.

**TABLE 1** | Characteristics of key studies conducted on lice infestations of livestock in Pakistan.

Area/city	Study year	Longitude	Latitude	Host	Sample size	Prevalence	References
Dir district	2002	72.0468° E	35.3356° N	Buffalo calves	118	34.75%	(26)
Lahore	2005	74.3587° E	31.5204° N	Horse	84	0%	(27)
Faisalabad	2004–2005	73.1350° E	31.4504° N	Cattle and buffalo	1,200	Cattle, 24%; buffalo, 18%	(28)
Quetta	2008	66.9750° E	30.1798° N	Cattle and buffalo	790	Cattle, 7.17%; buffalo, 9.84%	(29)
Punjab	2006–2007	72.7097° E	31.1704° N	Cattle	300	36.3%	(30)
Multan	2008	71.5249° E	30.1575° N	Buffalo	100	92%	(31)
Dera Ghazi Khan	2008	70.6455° E	30.0489° N	Cattle	300	5%	(32)
Quetta	2006	66.9750° E	30.1798° N	Cattle and buffalo	1,580	Cattle, 38.3%; buffalo, 41.2%	(9)
Punjab	2011–2012	72.7097° E	31.1704° N	Cattle	3,864	23.23%	(17)
Toba Tek Singh	2011–2012	72.652359° E	30.894875° N	Goat	4,020	9.58%	(11)
Rawalakot (AJK)*	2014–2015	73.7654° E	33.8584° N	Cattle and buffalo	200	0% in both	(24)
Muzaffarabad (AJK)*	2015	73.4769° E	34.3551° N	Sheep, goats, cattle, and buffalo	100	41% overall (Lice, ticks, and mites)	(25)
Kotli, (AJK)*	2015	73.9007° E	33.5008° N	Buffaloes, sheep, and goats	200	26% overall (Lice and ticks)	(16)
Karak	2018	71.0914° E	33.1105° N	Sheep and goats	75	Sheep, 20%; goats, 13.3%	(33)

\*Azad Jammu and Kashmir.

**TABLE 2** | List of key studies conducted on mite infestations of livestock in Pakistan.

Area	Study year	Longitude	Latitude	Host	Sample size	Prevalence	References
District of Dir	2002	72.0468° E	35.3356° N	Buffalo calve	118	11.86%	(26)
Lahore	2005	74.3587° E	31.5204° N	Horse	84	29.76%	(27)
Lahore	2005	74.3587° E	31.5204° N	Horse	48	53.33%	(35)
Dera Ghazi Khan	2007	70.6455° E	30.0489° N	Sheep	400	6%	(23)
Quetta	2008	66.9750° E	30.1798° N	Cow and buffalo	790	5.19 and 4.92%	(29)
Punjab	2008	72.7097° E	31.1704° N	Cattle	300	4%	(30)
Dera Ghazi Khan	2008	70.6455° E	30.0489° N	Cattle	300	8%	(32)
Punjab	2013	72.7097° E	31.1704° N	Horse, donkey, and mule	450	Overall prevalence (1.5%)	(36)
Punjab	2011–2012	72.7097° E	31.1704° N	Cattle	3,864	4.34%	(17)
Toba Tek Singh	2011–2012	72.652359° E	30.894875° N	Goat	4,020	3.23%	(11)
Punjab	2013–2014	72.7097° E	31.1704° N	Camel	1,489	11.28%	(37)
Toba Tek Singh	2010–2011	72.652359° E	30.894875° N	Sheep	800	11.37%	(34)
Dera Ghazi Khan	2013–2014	70.6455° E	30.0489° N	Sheep	500	17%	(12)
Multan	2016	71.5249° E	30.1575° N	Goats	200	35.5%	(38)
Muzaffarabad (AJK)	2015	73.4769° E	34.3551° N	Buffalo, cow, sheep, and goat	100	Overall prevalence (Mites, ticks and lice) of 41%	(25)
Cholistan	2010–2011	71.5724° E	28.5062° N	Camel	450	Overall prevalence (Tick and mite/fly) of 55.56%	(39)

### Prevalence of Ticks in Cows

The prevalence of tick infestation in cows ranged between 10.14 and 89.9%. Ten studies in Punjab reported that 28.2% (40), 31.5% (42), 39.1% (17), 38.33% (45), 66.7% (30), 70% (49), 72% (41), 75.1% (18), and 65.6% (46) of the cows were infested with ticks. These prevalence rates were higher than the 20.4% reported in Peshawar (21). A prevalence of 10.14% was reported in the cows of Quetta (29). The details as shown in **Table 3**.

Tick infestation prevalence of 35.87% (44) were recorded in the cows of Khyber Pakhtunkhwa, 38.33% in Sahiwal (45), and 65.6% in Lahore from Punjab province (46). The cattle in Hajira,

Rawalakot, Azad Kashmir were more infested than other animals, with 55.45% being the highest prevalence recorded (52). 11.73% in a study from 2019 in Islamabad (54), 75% in the District of Karak (10), 63.33% in Multan (3), and 24% in Hyderabad (8).

In 2017, tick prevalence was recorded in various animal species from Mansehra to Gilgit. Of all the examined cattle, 77.91% were found to be infested with ticks (55). In Baluchistan province (Quetta city) prevalence was 65.96% in the cattle (56). Of the total observed farmed cattle in a study from 2017, 89.9% were infested with ticks in the semiarid and arid agro-ecological zones from Punjab (6). A recent study

**TABLE 3** | List of key studies conducted on tick infestations of livestock in Pakistan.

Area	Study year	Longitude	Latitude	Host	Sample size	Prevalence	References
District of Dir	2002	72.0468° E	35.3356° N	Buffalo calve	118	5.08%	(26)
Lahore	2005	74.3587° E	31.5204° N	Horse	84	0%	(27)
Punjab and KPK	2007	72.7097° E 72.3311° E	31.1704° N 34.9526° N	Cattle, buffalo, sheep, and goat	18,000	Cattle, 28.2%; buffalo, 14.7%; sheep, 18.8%; goat 12.3%	(40)
Peshawar	2003–2004	71.5249° E	34.0151° N	Cattle, buffalo, sheep, donkey, and goat	1,279	Cattle, 20.4%; buffalo, 11.3%; sheep, 12.8%; donkey, 6.4%; goat, 12.1%	(21)
Quetta	2008	66.9750° E	30.1798° N	Cattle and buffalo	790	Cattle, 10.14%; buffalo, 6.99%	(29)
Punjab	2008	72.7097° E	31.1704° N	Cattle	300	66.7%	(30)
Punjab	2008	72.7097° E	31.1704° N	Cattle, buffalo, camel, sheep, and goat	3,400	Cattle, 75.1%; goat, 51.6%; buffalo, 40.08%; camel and sheep, 0%	(18)
Dera Ghazi Khan	2008	70.6455° E	30.0489° N	Cattle	300	36%	(32)
Punjab	2009	72.7097° E	31.1704° N	Cattle and buffalo	3,500	Cattle, 72%; buffalo, 47.3%	(41)
Punjab	2006–2007	72.7097° E	31.1704° N	Cattle	1,000	31.5%	(42)
Attock	2009	72.3609° E	33.7660° N	Sheep and goat	662	Sheep, 43.37%; goat, 41.53%	(43)
KPK	2009	72.3311° E	34.9526° N	Buffalo, cattle, camel, donkey, goat, and sheep	992	Buffalo, 24.13%; cattle, 35.87%; goat, 23.13%; camel, 28.9%; donkey, 4.2%; sheep, 27.3%	(44)
Sahiwal	2010	73.1114° E	30.6682° N	Cattle	300	38.33%	(45)
Lahore	2012	74.3587° E	31.5204° N	Cattle	2,160	65.6%	(46)
Toba Tek Singh	2012	72.652359° E	30.894875° N	Buffalo	1,128	31.21%	(47)
Punjab,	2013	72.7097° E	31.1704° N	Horse, donkey, and mule	450	4%	(36)
KPK	2013	72.3311° E	34.9526° N	Cattle and buffalo	2,529	Cattle, 33.36%; buffalo, 22.58%	(48)
Punjab	2007	72.7097° E	31.1704° N	Cattle and buffalo	1,030	Cattle, 70%; buffalo, 34%	(49)
Sindh	2008–2009	68.5247° E	25.8943° N	Buffalo	1,600	23%	(50)
Punjab	2011–2012	72.7097° E	31.1704° N	Cattle	3,864	39.1%	(17)
Toba Tek Singh	2011–2012	72.652359° E	30.894875° N	Goat	4,020	33.58%	(11)
Sargodha	2012–2013	72.6861° E	32.0740° N	Buffalo and goat	2,400	Buffalo, 84.33%; goat, 86.50%	(51)
Hajira, Rawalakot, Azad Kashmir	2011	73.7810° E	33.7670° N	Cattle, buffalo, sheep, and goat	669	Cattle, 55.45%; buffalo, 51.03%; sheep, 54.66%; goat 48.0%	(52)
Peshawar	2011	71.5249 E	34.0151 N	Goat and sheep	170	Sheep, 66.66%; goat, 73.68%	(2)
Central Punjab	2008	74.2682° E	31.4469° N	Sheep	1,200	64.25%	(53)

from 2020 (5) studied tick infestation in various livestock species, finding that 65% of the cows were infested with ticks from Baluchistan. These ticks are responsible of causing different diseases like babesiosis, theileriosis, and anaplasmosis in cattle (57).

### Prevalence of Ticks in Camels

Of the 44 studies published on ticks as livestock ectoparasites, three examined the prevalence of ticks in camels. A study from 2010 (44) reported that 28.9% of the camels examined were infested with ticks in Khyber Pakhtunkhwa, while 55.56% were found infested in Cholistan (39). More recently, a study from 2020 noted that 47.5% of the examined camels in Balochistan were infested (5).

### Prevalence of Ticks in Equids

The prevalence of tick infestation in equids was in the range of 0–26.9%. No horse was found to be tick-infested in Lahore (27). The overall reported tick infestation prevalence in donkeys and other animals in Peshawar was 13.37% (21). In 2010, researchers recorded a prevalence of 4.2% in donkeys in Khyber

Pakhtunkhwa (44), while the overall tick infestation prevalence in equids in Punjab was 4% (36).

### Prevalence of Ticks in Buffaloes

The prevalence of ticks in buffaloes varied between regions of Pakistan, as shown in **Table 3**. The highest prevalence (87.55%) was recorded in Multan (3), and the lowest (3.0%) in Islamabad (54).

The following tick infestation prevalence rates were reported in buffaloes: 5.08% in calves in the Dir District (26); 14.7% (40) and 24.13% (44) in Khyber Pakhtunkhwa; 40.08% (18) and 47.3% (41) in Punjab. The overall prevalence of ticks in different animals in Peshawar, including buffaloes, was 11.30% (21). The detailed prevalence of ticks in other areas is shown in **Table 3**.

### Prevalence of Ticks in Sheep and Goats

The prevalence of ticks in goats and sheep varied between regions of Pakistan, as shown in **Table 3**. In Punjab, it was found that about 18.8% (40) and 64.25% (53) of the sheep and 12.3% (40) of the goats were infested with ticks. A study in Punjab from 2008 recorded a prevalence of 51.6% in goats and 0% in sheep (18). The recorded prevalence in Attock was 43.37% in sheep and 41.53%

in goats (43). In 2010, a prevalence of 23.13% was recorded in the goats of Khyber Pakhtunkhwa (44), 33.58% of the goats of the district of Toba Tek Singh (11), and 86.50% of the goats in Sargodha (51). In Hajira, Rawalakot, Azad Kashmir, 54.66% of the sheep and 48.0% of the goats were infested (52), while the respective rates in Peshawar were 66.66% and 73.68% (2).

A 2017 assessment of various animals from Mansehra to Gilgit recorded tick infestation in 81.47% of the sheep and 72.05% of the goats (55), while another study found infestation in 60.0% of the goats and 11.1% of the sheep (6). More recently, studies from 2020 reported tick infestation rates of 30% in sheep and 27.5% in goats in Balochistan (5), and 50% in sheep and 40.30% in goats in Multan (3).

Babesiosis infection holds a massive economic influence due to loss of beef and meat production in infested animals also causes mortality and morbidity in cattle's all over the world (58).

There is a paucity of available data on tick control in small ruminants in Pakistan, partially because farmers prefer cattle over sheep and goats due to their higher economic significance (59). Considering the significant health and environmental risks connected with acaricides such as organophosphorus compounds, formamidines, pyrethroids, macrocyclic lactones, and phenylpyrazoles, their routine administration is the primary technique of ectoparasites management utilized in Pakistan's ruminants (60–62). In addition, grooming, which is the manual plucking of ticks by agricultural workers, is a popular practice in Pakistan for tick management (63). However, only two studies have evaluated the efficiency of acaricidal medicines *in vivo*, and the authors reported that cypermethrin was the most efficient tick control drug in livestock (59, 64). Numerous studies have been conducted to determine the efficiency of different medicines (alone or in combination with antibiotics) in treating ectoparasites, including buparvaquone, diminazene aceturate + imidocarb dipropionate, and oxytetracycline (65).

Ectoparasites are found throughout Pakistan's diverse ecological and topographical zones. Pakistan's diverse landscapes include plains, deserts, forests, and plateaus, extending from the Arabian Sea coast in the south to the mountains in the north. Due to Pakistan's geography inside South Asia's subtropical region (30° N, 70° E), the majority of the country provides favorable climate patterns for parasites especially ticks and other ectoparasites, which may invade a myriad of hosts and transfer illness to human, livestock, and pet animals (60).

Vector-borne microorganisms and many illnesses are present in the ecology of a range of arthropods, and their prevalence may be rising due to climate change and human-induced arthropod promotion (66). These activities include agricultural methods, communal sports and recreation, tourist and commerce globalization, and forestry incursion, all of which enhance communities' exposure to microorganisms created in these changing environments (67–69). As for the limitation, the review protocol is not registered, which is the primary limitation of the current study.

## CONCLUSION

Ectoparasites have a detrimental impact on the production and performance of livestock. The data presented in this

study revealed a high prevalence of ectoparasite infestations in livestock, including goats, sheep, buffaloes, cattle, camels, and horses. The various ectoparasites transmit a broad spectrum of pathogens to all these animals. Lack of awareness about the magnitude of the problem among owners, unavailability of control systems, and pitiable efficacy of chemical control have contributed to the prevalence of a range of ectoparasites in Pakistan, even after enacting movement control. This review could guide veterinary schools, researchers, and organizations in designing future studies and might support the work of veterinarians, administrators, human well-being care providers, and help nearby countries that might want to help eradicate the ectoparasites from the region.

## RECOMMENDATIONS

- Wakefulness of the local farmers is important for successful control of the ectoparasites.
- Alertness and control programs for livestock farmers concerning the serious and detrimental outcomes of ectoparasite infestations must be launched by various associations.
- Intended treatment of livestock with pesticides must be adapted to each region to lessen the influence of the ectoparasites on the animals fitness.
- Newly acquired animals should be checked and treated before they are introduced into the herd or farmhouse.
- Improved control practices should be applied to lessen the transmission of diseases and increase the livestock yield.
- Proper veterinary facilities and training should be offered as part of the control efforts that should include regular spraying against the ectoparasites.

## AUTHOR CONTRIBUTIONS

AM, HA, and JC designed the study and provided overall supervision of the current work. MM and RB performed the data collection. MK and UA prepared the maps. MA performed the data analysis. HA and RB drafted the manuscript. SS and JC made critical revisions. All authors read and approved the final manuscript.

## FUNDING

This study was supported by the National Natural Science Foundation of China (Grant Nos. 81772225 and 81971969 to JC), Key Laboratory of Parasite and Vector Biology, National Health Commission of the People's Republic of China (No. WSBKFKT2017-01), and the Fifth Round of Three-Year Public Health Action Plan of Shanghai (No. GWV-10.1-XK13 to JC). The funders had no role in the study design, the data collection and analysis, the decision to publish, or the preparation of the manuscript.

## ACKNOWLEDGMENTS

The authors are thankful to Dr. Shahzad Ali for their input which aided the completion of current review.

## REFERENCES

- Mather TN and Abdullah GA. Building molecular biology capacity for preventing tick-transmitted diseases in Pakistan. *Pak-USA Sci Technol Coop Program*. (2015) 11:23–15.
- Shah A, Shah SR, Rafi MA, Noorrahim, Shah M, Mitra A. Identification of the prevalent ticks (Ixodid) in goats and sheep in Peshawar, Pakistan. *J Entomol Zool Stud*. (2015) 3:11–4.
- Ramzan M, Naem-Ullah U, Saba S, Iqbal N, Saeed S. Prevalence and identification of tick species (Ixodidae) on domestic animals in district Multan, Punjab Pakistan. *Int J Acarol*. (2020) 46:344–50. doi: 10.1080/01647954.2020.1711803
- Siddique RM, Sajid MS, Iqbal Z, Saqib M. Association of different risk factors with the prevalence of babesiosis in cattle and buffaloes. *Pak J Agri Sci*. (2020) 57:517–24. doi: 10.21162/PAKJAS/19.8626
- Bibi S, Rafique N, Kareem A, Taj MK, Iqbal K, Bibi A, et al. Prevalence and taxonomic identification of hard ticks (Ixodidae) found in livestock of Harnai District, Balochistan, Pakistan. *J Pure Appl Biol*. (2020) 9:2330–8. doi: 10.19045/bspab.2020.90247
- Rehman A, Nijhof AM, Sauter-Louis C, Schauer B, Staubach C, Conraths FJ. Distribution of ticks infesting ruminants and risk factors associated with high tick prevalence in livestock farms in the semi-arid and arid agro-ecological zones of Pakistan. *Parasit Vectors*. (2017) 10:190. doi: 10.1186/s13071-017-2138-0
- Bilal MQ, Suleman M, Raziq A. Buffalo: black gold of Pakistan. *Livest Res Rural Dev*. (2006) 18:140–51
- Khan MS, Bhutto MB, Khan SA, Awan K, Shah SRA, Shah SKA. Epidemiological study on tick infestation in indigenous and cross breed cattle in Hyderabad, Pakistan. *Pak J Sci*. (2019) 71:63.
- Kakar MN, Kakarsulemankhel JK. Prevalence of lice species on cows and buffaloes of Quetta, Pakistan. *Pak Vet J*. (2009) 29:49–50.
- Akhtar K, Anees R, Karim T, Gul SU, Rehman RU, Ali A, et al. Prevalence of tick infestation in cows of various Regions of district Karak, Pakistan. *J Entomol Zool Studies*. (2019) 7:791–5.
- Iqbal A, Siddique F, Mahmood MS, Shamim A, Zafar T, Rasheed I, et al. Prevalence and impacts of ectoparasitic fauna infesting Goats (*Capra hircus*) of District Toba Tek Singh, Punjab, Pakistan. *Global Vet J*. (2014) 12:158–64.
- Lashari MH, Akhtar MS, Ayaz M, Tasawar Z, Aziz F, Farooq AS, et al. A preliminary report on prevalence of mange infestation in dumbi sheep in and around fort Munru, Dera Ghazi Khan, Punjab, Pakistan. *Wayamba J Animal Sci*. (2016) 1402–5.
- Anwar K. Epidemiology of tick-borne infection in ruminants in Peshawar. *Adv Parasitol*. (2018) 5:1–7.
- Sahito HA, Kousar T, Mughal MA, Mangrio WM, Shah ZH, Ghumro BD et al. Prevalence of cattle lice; *Haematopinus tuberculastus* and Ticks; *Haemaphysalis bispinosa* on cattle at region Sukkur, Sindh - Pakistan. *Int J Res Studies Biosci*. (2017) 5:1–5. doi: 10.20431/2349-0365.0512001
- Apanaskevich DA, Mumcuoglu KY, Steinman A. Species distribution and seasonal dynamics of equine tick infestation in two Mediterranean climate niches in Israel. *Parasit Vectors*. (2018) 11:1–10. doi: 10.1186/s13071-018-3093-0
- Ashraf A, Mughal SH, Iqbal MN, Ashraf A, Yunus FN, Muhammad A. Prevalence of ectoparasites of ruminants in Tehsil Nikayal, District Kotli, Azad Jammu and Kashmir. *PSM Vet Res*. (2016) 1:50–53.
- Iqbal A, Sajid MS, Khan MN, Muhammad G. Epizootiology of ectoparasitic fauna infesting selected domestic cattle population of Punjab, Pakistan. *Int J Agri Biol*. (2014) 16:443–6.
- Sajid MS, Iqbal Z, Khan MN, Muhammad G. Point prevalence of hard ticks (Ixodids) infesting domestic ruminants of Lower Punjab, Pakistan. *Int J Agri Biol*. (2008) 10:349–51.
- Jongejan F, Uilenberg G. The global importance of ticks. *Parasitology*. (2004) 129:S3–14. doi: 10.1017/s0031182004005967
- Sultana N, Awan MS, Shamim A, Iqbal A, Ali U, Minhas RA, et al. Prevalence of ticks infesting selected domestic livestock population of Azad Jammu and Kashmir. *Scholar's Advan Anim Vet Res*. (2015) 2:98–106.
- Manan A, Khan Z, Ahmad Z, Abdullah B. Prevalence and identification of Ixodid tick genera in Frontier region Peshawar. *J Agri Biol Sci*. (2007) 2:21–2.
- Jehan Zeb, Szekeres S, Takacs N, Kontschan J, Shams S, Ayaz et al. Genetic diversity, piroplasms and trypanosomes in *Rhipicephalus microplus* and *Hyalomma anatolicum* collected from cattle in northern Pakistan. *Exp Appl Acarol*. (2019) 79:233–43. doi: 10.1007/s10493-019-00418-9
- Aatish HU, Sindhu Z, Iqbal Z, Jabbar A, Tasawar Z. Prevalence of sheep mange in District Dera Ghazi Khan (Pakistan) and associated hematological/biochemical disturbances. *Int J Agri Biol*. (2007) 9:917–20.
- Shamim A, Mushtaq A, Hassan MU. No record of lice (Pthiraptera) distribution and abundance in traditionally managed buffalo and cattle in Rawalakot Azad Kashmir Pakistan. *J Entomol Zoo Studies*. (2015) 3:416–8.
- Sayyad B, Mughal SH, Iqbal MN, Ashraf A, Muhammad A. Prevalence of ectoparasites of ruminants in Muzaffarabad District, Azad Jammu and Kashmir. *PSM Vet Res*. (2016) 1:22–5.
- Azam M, Siddique MM, Habib G. Prevalence of parasitic infections in buffaloes and calves in Khadagzai, District Dir. *Pak Vet J*. (2002) 22:87–90.
- Hassan R, Khan MA, Akhtar T, Khan I, Abbas T, Younus M. Epidemiology of parasitic load and therapeutic control against ecto and endoparasites with ivermectin in horses. *Punjab Univ J Zool*. (2005) 20:143–50.
- Hussain MA, Khan MN, Iqbal Z, Sajid MS, Arshad M. Bovine pediculosis: prevalence and chemotherapeutic control in Pakistan. *Livestock Res Rural Dev*. (2006) 18:45.
- Kakar MN, Kakarsulemankhel JK. Prevalence of endo (trematodes) and ecto-parasites in cows and buffaloes of Quetta, Pakistan. *Pak Vet J*. (2008) 28:34–6.
- Durrani AZ, Shakoori AR, Kamal N. Bionomics of hyalomma ticks in three districts of Punjab, Pakistan. *J Anim Plant Sci*. (2008) 18:17–23.
- Tasawar Z, Bano I, Hayat CS, Lashari MH. Prevalence of lice on buffaloes at private cattle farm. *Pak Vet J*. (2008) 28:147–9.
- Ramzan M, Khan MS, Avais M, Khan JA, Pervez K, Shahzad W. Prevalence of ectoparasites and comparative efficacy of different drugs against tick infestation in cattle. *J Anim Plant Sci*. (2008) 18:17–9.
- Khatoon N, Noureen S, Khan DZ, Gul SU, Rehman HU, Ullah N, et al. Domestic animals ectoparasite fauna of District Karak, KP, Pakistan. *Int J Biosci*. (2018) 13:384–8. doi: 10.12692/ijb/13.5.384-388
- Khan MN, Sajid MS, Iqbal A, Siddique F. Epidemiological aspects of mite (Acari: Sarcoptiformes) infestation in domestic sheep (*Ovis aries*) of District Toba Tek Singh, Punjab, Pakistan. *Scholar's Advan in Animal Vet Res*. (2015) 2:55–63.
- Aftab J, Khan MS, Pervez K, Avais M, Khan JA. Prevalence and chemotherapy of ecto- and endoparasites in rangers horses at Lahore-Pakistan. *Int J of Agricult Biol*. (2005) 7:853–4.
- Goraya K, Iqbal Z, Sajid MS, Muhammad G. Frequency distribution of equine diseases in three metropolises of the Upper Punjab, Pakistan. *Int J Agricult Biol*. (2013) 15:1067–74.
- Zahid MI, Maqbool A, Anjum S, Ashraf K, Khan MS, Ahmad N. Prevalence of sarcoptic mange in camels in Punjab, Pakistan. *J Animal Plant Sci*. (2015) 25:1259–63.
- Lashari M, Shumaila H, Tasawar Z. Prevalence of *Sarcoptes scabiei* var. *caprae* infestation in goats of Multan, Pakistan. *J Applied Animal Sci*. (2016) 9:49–56.
- Qamar MF, Ayaz MM, Nazir MM. Isolation and identification of ectoparasites in single humped camels (*Camelus dromedarius*) of Cholistan area, Pakistan. *Iraqi J Vet Sci*. (2018) 32:291–7. doi: 10.33899/ijvs.2019.153866
- Khan MQ, Irhad H. Status of tick distribution in Bangladesh, India and Pakistan. *Parasitol Res*. (2007) 101:207–16. doi: 10.1007/s00436-007-0684-7
- Sajid MS, Iqbal Z, Khan MN, Muhammad G, Khan MK. Prevalence and associated risk factors for bovine tick infestation in two districts of lower Punjab, Pakistan. *Prevent Vet Med*. (2009) 92:386–91. doi: 10.1016/j.prevetmed.2009.09.001
- Durrani AZ, Mehmood N, Shakoori AR. Comparison of three diagnostic methods for *Theileria annulata* in Sahiwal and Friesian cattle in Pakistan. *Pak J Zool*. (2010) 42:467–72.
- Irshad N, Qayyum M, Hussain M, Khan MQ. Prevalence of tick infestation and theileriosis in sheep and goats. *Pak Vet J*. (2010) 30:178–80.
- Perveen F, Yasmeen N, Bibi N. Ixodid ticks infestation in livestock and their traditional control in NWFP, Pakistan. *Pakistan J Entomol*. (2010) 25:43–54.



45. Qayyum A, Farooq U, Samad HA, Chaudhry HR. Prevalence, clinicotherapeutic and prophylactic studies on the theileriosis in District Sahiwal (Pakistan). *J Animal Plant Sci.* (2010) 20:266–70.
46. Ahmed S, Numan M, Manzoor AW, Ali FA. Investigations into Ixodidae ticks in cattle in Lahore, Pakistan. *Vet Italiana.* (2012) 48:185–91.
47. Iqbal A, Sajid MS, Khan MN, Khan MK. Frequency distribution of hard ticks (Acari: Ixodidae) infesting bubaline population of district Toba Tek Singh, Punjab, Pakistan. *Parasitol Res.* (2012) 112:535–41. doi: 10.1007/s00436-012-3164-7
48. Khan A, Mushtaq MH, Ahmad M, Tipu Y, Khan A, Munibullah. Tick infestation rate in cattle and buffalo in different areas of khyber pakhtunkhwa, Pakistan. *J Vete Animal Sci.* (2013) 3:31–5.
49. Ali Z, Maqbool A, Muhammad K, Khan MS, Younis M. Prevalence of *Theileria annulata* infected hard ticks of cattle and buffalo in Punjab, Pakistan. *J Animal Plant Sci.* (2013) 23:20–6.
50. Soomro MH, Soomro SP, Bhutto MB, Akbar Z, Yaqoob M, Arijio AG. Prevalence of ticks in buffaloes in upper Sindh, Pakistan. *Buffalo Bull.* (2014) 33:323–7.
51. Mustafa I, Shabbir RMK, Subhani M, Ahmad I, Raza A, Jamil S, et al. Seasonal activity of tick infestation in goats and buffalo of Punjab Province (District Sargodha), Pakistan. *Kafkas Univ Vet Fak Derg.* (2014) 20:655–62.
52. Sultana N, Shamim A, Awan MS, Ali U, Hassan MU, Siddique RM. First pilot study on the prevalence of tick infestation in livestock of Tehsil Hajira, Rawalakot, Azad Kashmir. *Advan Animal Vet Sci.* (2015) 3:430–4. doi: 10.14737/journal.aavs/2015/3.8.430.434
53. Iqbal A, Siddique F, Fatima N, Saleem I. Tick infestation in sheep: prevalence, associated determinants and *in vivo* chemotherapeutic control in Central Punjab, Pakistan. *Scholar's Advan in Anim Vet Res.* (2015) 2:41–54.
54. Ahmad Z, Anwar Z, Adnan M, Imtiaz N, Rashid HU, Gohar F. Collection and prevalence of ticks in cattles and buffaloes from free range management systems of Islamabad. *J Basic Appl Zool.* (2019) 18:1–4. doi: 10.1186/s41936-018-0071-1
55. Sajid MS, Iqbal Z, Shamim A, Siddique RM, Hassan MJ, Rizwan HM. Distribution and abundance of ticks infesting livestock population along Karakorum highway from Mansehra to Gilgit, Pakistan. *J Hellenic Vet Med Soc.* (2017) 68:51–8. doi: 10.12681/jhvms.15556
56. Rafiq N, Kakar A, Ghani A, Iqbal A, Achakzai WM, Sadozai S, et al. Ixodid ticks (Arachnida: Acari) prevalence associated with risk factors in the bovine host in District Quetta, Balochistan. *Pak J Zool.* (2017) 49:2113–21. doi: 10.17582/journal.pjz/2017.49.6.2113.2121
57. Javed K, Ijaz M, Ali MM, Khan I, Mehmood K, Ali S. Prevalence and hematology of tick borne hemoparasitic diseases in equines in and Around Lahore. *Pak J Zool.* (2014) 46:401–8.
58. Rafique N, Kakar A, Iqbal A, Kamran K, Razaq W, Masood Z. Pervasiveness of tick borne disease, babesiosis in Quetta City of Province Balochistan, Pakistan. *Biol Forum.* (2015) 7:792–4.
59. Sajid MS, Iqbal Z, Khan MN, Muhammad G, Needham G, Khan MK. Prevalence, associated determinants, and *in vivo* chemotherapeutic control of hard ticks (Acari: Ixodidae) infesting domestic goats (*Capra hircus*) of lower Punjab, Pakistan. *Parasitol Res.* (2011) 108:601–9.
60. Jabbar A, Abbas T, Saddiqi HA, Qamar MF, Gasser RB. Tick-borne diseases of bovines in Pakistan: major scope for future research and improved control. *Parasit Vectors.* (2015) 8:1–3.
61. Iqbal A, Usman M, Abubakar M. Mini review: current tick control strategies in Pakistan are possible environmental risks. *Iraqi J Vet Sci.* (2017) 31:81–6.
62. Ramzan M, Khan MS, Avais M, Khan JA, Pervez K, Shahzad W. Prevalence of ecto parasites and comparative efficacy of different drugs against tick infestation in cattle. *J Anim Plant Sci.* (2008) 18:17–19.
63. Rehman A, Nijhof AM, Sauter-Louis C, Schauer B, Staubach C, Conraths FJ. Distribution of ticks infesting ruminants and risk factors associated with high tick prevalence in livestock farms in the semi-arid and arid agro-ecological zones of Pakistan. *Parasit Vectors.* (2017) 10:1–5.
64. Ghafar A, Abbas T, Rehman A, Sandhu ZU, Cabezas-Cruz A, Jabbar A. Systematic review of ticks and tick-borne pathogens of small ruminants in Pakistan. *Pathogens.* (2020) 9:937.
65. Niazi N, Khan MS, Avais M, Khan JA, Pervez K, Ijaz M. A study on babesiosis in calves at livestock experimental station Qadirabad and adjacent areas, Sahiwal (Pakistan). *Pak J Agricul Sci.* (2008) 45:209–11.
66. Ogden NH, Lindsay LR. Effects of climate and climate change on vectors and vector-borne diseases: ticks are different. *Trends Parasitol.* (2016) 32:646–56.
67. Wu X, Lu Y, Zhou S, Chen L, Xu B. Impact of climate change on human infectious diseases: Empirical evidence and human adaptation. *Environ Int.* (2016) 86:14–23.
68. Atehmengo NL, Nnagbo CS. Emerging animal parasitic diseases: a global overview and appropriate strategies for their monitoring and surveillance in Nigeria. *Open Microbiol J.* (2014) 8:87.
69. Mushtaq A, Shoukat T, Mumtaz T, Qasim M, Ajmal K, Fatima N, et al. Tick-borne diseases in sheep and goats in Pakistan: a systematic review and meta-analysis. *Acta Parasitol.* (2021) 66:1316–25. doi: 10.1007/s11686-021-00396-2

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Publisher's Note:** All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2021 Muhammad, Bashir, Mahmood, Afzal, Simsek, Awan, Khan, Ahmed and Cao. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.