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

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

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.
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 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 (55).

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 calves | 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 | 72.652359° 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 rates were 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, 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...
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% (33) 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%

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**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 | 31.1704°N| Cattle, buffalo, sheep, and goat | 18,000    | 22.8%; 14.7%; 18.8%; 12.3% | (40)       |
| Peshawar              | 2003–2004  | 71.5249°E | 34.0151°N| Cattle, buffalo, sheep, donkey, and goat | 1,279   | 20.4%; 11.3%; 12.8%; 6.4%; 12.1% | (21)       |
| Guetta                | 2008       | 66.9750°E | 30.1798°N| Cattle and buffalo            | 790         | 10.14%; 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   | 75.1%; 51.6%; 40.08%; 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       | 72%; 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         | 43.37%; 41.53% | (43)       |
| KPK                   | 2009       | 72.3311°E | 34.9526°N| Buffalo, cattle, camel, donkey, goat, and sheep | 992   | 24.13%; 35.87%; 23.13%; 4.2%; 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       | 33.36%; 22.58% | (48)       |
| Punjab                | 2007       | 72.7097°E | 31.1704°N| Cattle and buffalo            | 1,030       | 70%; 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       | 84.33%; 86.50% | (51)       |
| Hajira, Rawalakot, Azad Kashmir | 2011 | 73.7810°E | 33.7670°N| Cattle, buffalo, sheep, and goat | 669  | 55.45%; 51.03%; 54.66%; 48.0% | (52)       |
| Peshawar              | 2011       | 71.5249°E | 34.0151°N| Goat and sheep               | 170         | 66.66%; 73.68% | (2)        |
| Central Punjab        | 2008       | 74.2682°E | 31.4469°N| Sheep                        | 1,200       | 64.25%     | (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 Manshehra to Gilgit recorded tick infestation in 81.47% of the sheep and 72.05% of the goats (53), 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 organophosphorous 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 acetate + 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.

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REFERENCES

1. Mather TN and Abdullah GA. Building molecular biology capacity for preventing tick-transmitted diseases in Pakistan. Pak-USA Sci Technol Coop Program, (2015) 11:123–15.

2. Shah A, Shah SR, Rauf MA, Noorurrahim, Shah M, Mitra A. Identification of the prevalent ticks (Ixodida) in goats and sheeps in Peshawar, Pakistan. J Entomol Zool Stud. (2015) 3:11–4.

3. 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: 10.1080/01676257.2019.171803.

4. Siddique RM, Sajid MS, Iqbal Z, Saqib M. Association of different risk factors with the prevalence of babesiosis in cattle and buffaloes. Pak J Agric. (2020) 57:517–24. doi: 10.21162/PJAKAS/19.8626.

5. 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/bjapb.2020.90247.

6. Rehman A, Nihjof 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.

7. Bilal MQ, Suleman M, Raziq A. Buffalo: black gold of Pakistan. J Anim. (2008) 41:344–50. doi: 10.1080/01647954.2020.1711803.

8. Shah A, Shah SR, Rafi MA, Noorrahim, Shah M, Mitra A. Identification of ticks infesting selected domestic livestock population of Azad Jammu and Kashmir. Parasit Vectors. (2015) 3:416–8.

9. 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.

10. Aftab J, 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. (2004) 14:819–24.

11. Khatoon N, Nooreen S, Khan DZ, Gul SU, Rehman HU, Ullah N, et al. Domestic animals ectoparasite fauna of District Karachi, KP, Pakistan. Int J Biosci. (2018) 13:384–8. doi: 10.21692/ijb.13.384-388.

12. Khan MN, Sajid MS, Iqbal Q, Siddique F. Ecological aspects of mite (Acari: Sarcoptiformes) infestation in domestic sheep (Ovis aries) of District Toba Tek Singh, Punjab, Pakistan. J Agri Biol Sci. (2018) 4(2):21–2.

13. Anwar K. Epidemiology of tick-borne infection in ruminants in Peshawar. Adv Parasitol. (2018) 1:5–7.

14. Rehman A, Nihjof 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.

15. Jehan Zeb, Szekeers S, Takacs N, Kontschjan J, Shams S, Ayaz et al. Genetic diversity, pirolasms and trypanosomes in Rhhipicephalus microplus and Hyalomma anatolicum collected from cattle in northern Pakistan. Exp Appl Acarol. (2019) 79:233–43. doi: 10.1007/s10493-019-00418-9.

16. 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.

17. Shams M, 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 Zool Stud. (2015) 3:416–8.

18. 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.

19. 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.

20. Perveen F, Yaseen, Bibi N, Iqsid ticks infestation in livestock and their traditional control in NWFP, Pakistan. Pakistan J Entomol. (2010) 25:43–54.
51. Mustafa I, Shabbir RMK, Subhani M, Ahmad I, Jamil S, et al. Hematology of tick borne hemoparasitic diseases in equines in and around Lahore. Pak J Zoology. (2017) 49:2113–21. doi: 10.17582/journal.pjz/2017.49.6.2113.2121

54. Ahmad Z, Anwar Z, Adnan M, Imtiaz N, Rashid HU, Gohar F. Prevalence and distribution of tick infestation in goats and buffaloes of Punjab province (District Sargodha, Pakistan). Pak J Vet Fak Derg. (2014) 20:266–70.

55. Sajid MS, Iqbal Z, Shamim A, Siddique RM, Hassan MJ, Rizwan HM.硬蜱（Acari: Ixodidae）侵害巴基斯坦索汉省山羊（Capra hircus）的分布和密度。J Vete Animal Sci. (2013) 3:31–5.

50. Khawaja MM, Khurshid MA, Ali M, Khurshid S, Arshad S, et al. Blood smear examination for tick borne hemoparasites in slaughtered cattle. J Basic Appl Zool. (2019) 18:1–6. doi: 10.1186/s41936-018-0071-1

56. Javed K, Ijaz M, Ali MM, Khan I, Mehmoon K, Ali S. Prevalence and hematology of tick borne hemoparasitic diseases in equines in and around Lahore. Pak J Zoology. (2014) 46:401–8. doi: 10.12681/ajvms.15556

52. Sultana N, Shamim A, Awan MS, Ali U, Hassan MU.硬蜱（Acari: Ixodidae）侵害巴基斯坦索汉省山羊（Capra hircus）的分布和密度。J Basic Appl Zool. (2015) 3:31–5.

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.

56. Javed K, Ijaz M, Ali MM, Khan I, Mehmoon K, Ali S. Prevalence and hematology of tick borne hemoparasitic diseases in equines in and around Lahore. Pak J Zoology. (2014) 46:401–8.

57. Rafique N, Kakar A, Ghani A, Iqbal A, Achakazi WM, Sadozai S, et al. Ixodid ticks (Acarina: Ixodidae) infesting domestic goats (Capra hircus) of lower Punjab, Pakistan. Parasitol Res. (2011) 108:601–9.

58. Sajid MS, Iqbal Z, Khan MN, Muhammad G, Needham G, Khan MK.硬蜱（Acari: Ixodidae）侵害巴基斯坦索汉省山羊（Capra hircus）的分布和密度。J Animal Plant Sci. (2013) 23:20–6.

59. Sajid MS, Iqbal Z, 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

60. Jabbar A, Abbas T, Saddiqi HA, Qamar MF, Gasser RB.硬蜱（Acari: Ixodidae）侵害巴基斯坦索汉省山羊（Capra hircus）的分布和密度。Parasit Vectors. (2013) 6:1–3.

61. Iqbal A, Usman M, Abubakar M.硬蜱（Acari: Ixodidae）侵害巴基斯坦索汉省山羊（Capra hircus）的分布和密度。J Vete Animal Sci. (2011) 10:861–9.

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