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Research Article

SPATIO-TEMPORAL PATTERNS AND RISK ASSESSMENT OF IXODID TICKS IN CATTLE OF MID HILL ZONE OF NORTH - WESTERN HIMALAYAS

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ABSTRACT: A cross-sectional survey was conducted to study the distribution of ixodid ticks along with associated risk factor assessment in cattle (n=749) in the mid-hill zone of Himachal Pradesh in the north-western Himalayas, India. The results revealed an overall tick prevalence rate of 68.6% with three tick-predominant species, *viz. Rhipicephalus (Boophilus) microplus* (64.6%), *R. (B.) annulatus* (32.9%) and *Hyalomma anatolicum* (2.5%). Among the various risk factors evaluated, significant (p<0.05) variation was recorded with age, sex, and season. Ticks were most prevalent in the rainy season (76.2%) [OR = 3.10 (1.71-5.61)] followed by summer (65.1%) and winter season (63.9%). High prevalence was recorded in animals > 1 year age (78.9%) followed by > 6 months - 1 year age (44.1%) [OR = 0.17 (0.09-0.33)] and young animals ≤ 6 months (25.6%) [OR = 0.16 (0.09-0.26)] (p<0.05). The tick infestation was significantly higher in female animals (76.5%) as compared to males (29%) and more in crossbred cattle (79.6%) [OR = 4.90 (3.19-7.52)] compared to the indigenous cattle (45.7%) (p<0.05). The study on management practices revealed that the prevalence of ticks was significantly (p<0.05) high when the animals were kept in kutcha sheds (85.2%). The regression analysis revealed that the odd tick infestation was higher if acaricide was sprayed only in sheds [OR = 2.93 (1.49-5.76)] rather than on both sheds and animals [OR = 1.60 (0.69-3.70)]. The present study assumes importance in the strategic control and management of ticks and tick-borne diseases (TTBDs) of the cattle population in the region.

Keywords: Cattle, Ixodid ticks, Prevalence, Risk factors, Himachal Pradesh.

INTRODUCTION

Ticks are obligatory blood suckers and require animal hosts for survival and propagation [1]. Among all the ectoparasites of mammals, birds, and reptiles, ticks are considered the most harmful blood-sucking external parasites. Ticks rank first as arthropod vectors of pathogens in domestic animals [2]. Ticks are distributed throughout the world particularly the tropical and sub-tropical regions including India. Nearly 80% of the world's cattle population is at risk of infection with ticks and tick-borne diseases (TTBDs) [3]. The cost of control of TTBDs in the dairy sector of India has been estimated at $ 498.7 million annually [4]. The mild temperate climate and environmental conditions of the mid-hill zone are favorable for the survival and propagation of ticks.

Various studies have been conducted to assess the prevalence of TTBDs worldwide in domestic animals [5, 6, 7] and in India [8,9,10]. However, no data on the prevalence of ixodid ticks from the mid-hill zone and none regarding the risk factors associated with ixodid ticks are available to date. Hence, the present study was envisaged to generate baseline data on the epidemiology of ixodid ticks in cattle and assessment of the risk factors associated with a tick infestation in the mid-hill zone of Himachal Pradesh in the north-western Himalayas.

MATERIALS AND METHODS

Sampling and study area description

The state of Himachal Pradesh is located in the northwestern Himalayan region extending from

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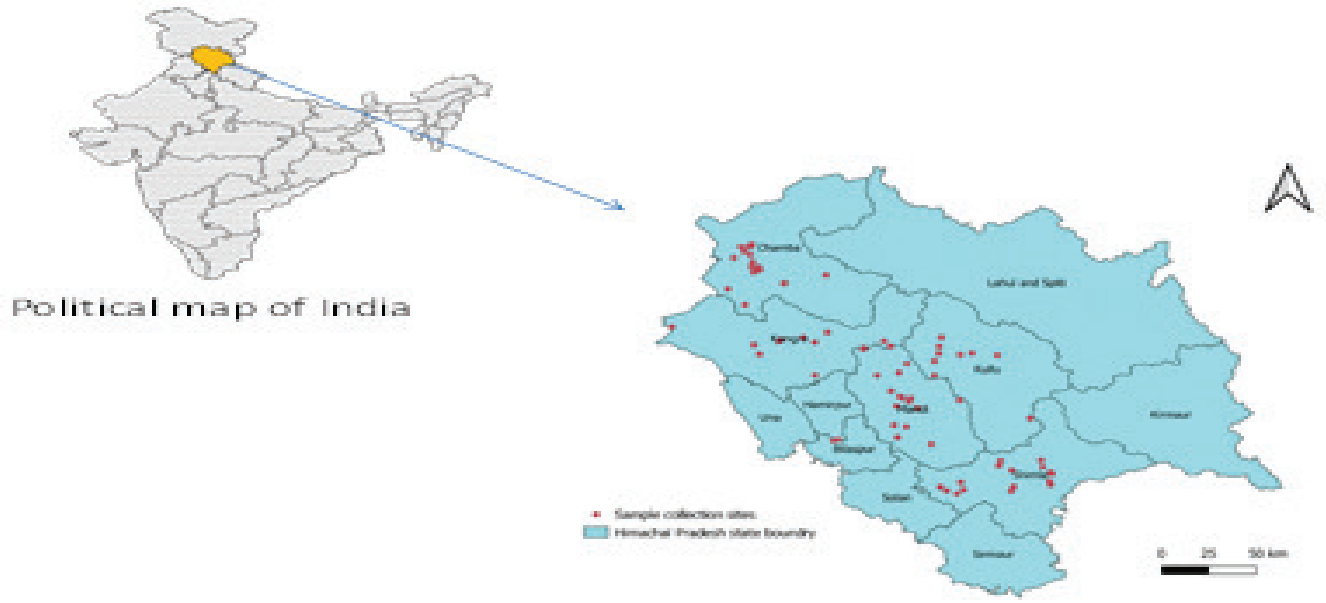


Fig. 1. Dot plot map of various sites of sample collection.

latitudes 30.22°N to 33.12°N and longitudes 75.45°E to 79.04°E covering a geographical area of 55,673 km^2 (Fig. 1). The districts of Kangra, Mandi, Chamba, Kullu, and Shimla included in the study lie between altitudes of 180 and 300 meters above sea level with an average annual rainfall of 152 cm. The climate of the study area falls under sub temperate type as per the Köppen-Geiger climate classification [11].

The sample size was calculated by using Software EpiTool (http://epitools.ausvet.com.au) with a cattle population of the region (n=779505, approximately), an expected prevalence of 50%, the margin of error as 3.1% (≤5%) and a 95% confidence interval. In addition to the calculated sample size (n=323), additional convenient sampling was done to include more animals, and a total of 749 animals were screened throughout the year covering all seasons, *viz.* summer (n=235), monsoon (n=265) and winter (n=249).

Collection of ticks

Ticks were collected from October 2020 to September 2021 from 749 cattle from different locations in mid hill zone of Himachal Pradesh, India (Fig.1). Animals of both sexes and all age groups were searched for ticks by passing hands through the coat of the animal and collected manually without damaging their mouthparts. After collection, male tick samples were brought to the laboratory separately in 70% ethanol and identified under a stereomicroscope, according to their morphological characteristics [12].

Data collection and demographic assessment

The data were collected through a questionnaire and information was collected regarding various risk factors, *viz.* season (winter/ summer/ rainy), age (<6 months/6 months - 1 year/ >1 year), housing system (kutcha or traditional housing system)/ pucca), sex (male/ female), breed (indigenous/ crossbred), frequency of application (every 3 months/ 3-6 months/ 1 year) and site of application (animal/ shed/ both), commonly used acaricides, etc.

Statistical analysis

The IBM SPSS Statistics for Windows, Version 22.0 of the statistical software (released 2013. © 2013, Armonk, NY: IBM Corp) was used for analysis. The bivariate association between tick prevalence and each hypothesized risk factor was evaluated using the Pearson chi-square test at a 95% confidence interval ($p<0.05$). The significantly associated factors for the risk of tick infestation were then subjected to regression analysis. A binary logistic regression analysis model was developed and the relationship between the prevalence of tick infestation and independent variables was analyzed using tick infestation (positive/negative) as the dependent variable. The effect of each risk factor on the likelihood of infestation was measured by the odds ratio (OR) along with their 95% confidence intervals (CI) which was computed as the exponent of the respective regression coefficient.

RESULTS AND DISCUSSION

Out of a total of 749 cattle screened, 514 were found infested with ixodid ticks indicating an overall tick prevalence rate of 68.6%. The prevalence rates of *R. (B.) microplus*, *R. (B.) annulatus* and *H. anatolicum* (Fig. 2) were 64.6%, 32.9%, and 2.5%, respectively. Districtwise, the highest tick infestation rate was recorded in district Chamba (72.8%), followed by Shimla (69.6%), Kullu (69.3%), Kangra (67.5%) and Mandi (63.8%). The odd tick infestation in cattle population from all districts was similar to Kullu (reference district) with odd ratios: Mandi [OR = 0.062 (0.032-1.20)], Shimla [OR = 0.13 (0.06-0.28)], Kangra [OR = 0.56 (0.27-1.17)] and Chamba [0.73 (0.38-1.40)], respectively (Table 1). Similar high prevalence of *R. (B.) microplus* has been recorded from other parts of India like Jammu [13], Madhya Pradesh [14], Kerala [15], Gujarat [16], Assam [17] and Chhattisgarh [18].

Table 1. Regression Analysis of the risk factors associated with tick prevalence in cattle population of Mid hill zone of Himachal Pradesh.

Risk Factor	Variables	Odds ratio [OR]	p-value	95% confidence level for OR [CI]	Risk Factor
District	Kullu		0.001		
	Mandi	0.62	0.16	0.32	1.20
	Shimla	0.13	0.001	0.06	0.28
	Kangra	0.56	0.12	0.27	1.17
	Chamba	0.73	0.34	0.38	1.40
Season	Winter		0.001		
	Summer	1.98	0.009	1.18	3.32
	Rainy	3.10	0.001	1.71	5.61
Age	> 1 year		0.001		
	> 6 months-1year	0.17	0.001	0.09	0.33
	≤ 6 months	0.16	0.001	0.09	0.26
Housing	Kuccha	1	0.001		
	Pucca	0.14	0.001	0.09	0.21
Type of application of Acaricide	Animal		0.007		
	Shed	2.93	0.002	1.49	5.76
	Both	1.60	0.267	0.69	3.70
Breed	Indigenous		0.001		
	Crossbred	4.90	0.001	3.19	7.52

Table 2. Risk factors associated with prevalence of ixodid ticks in mid hill zone of Himachal Pradesh.

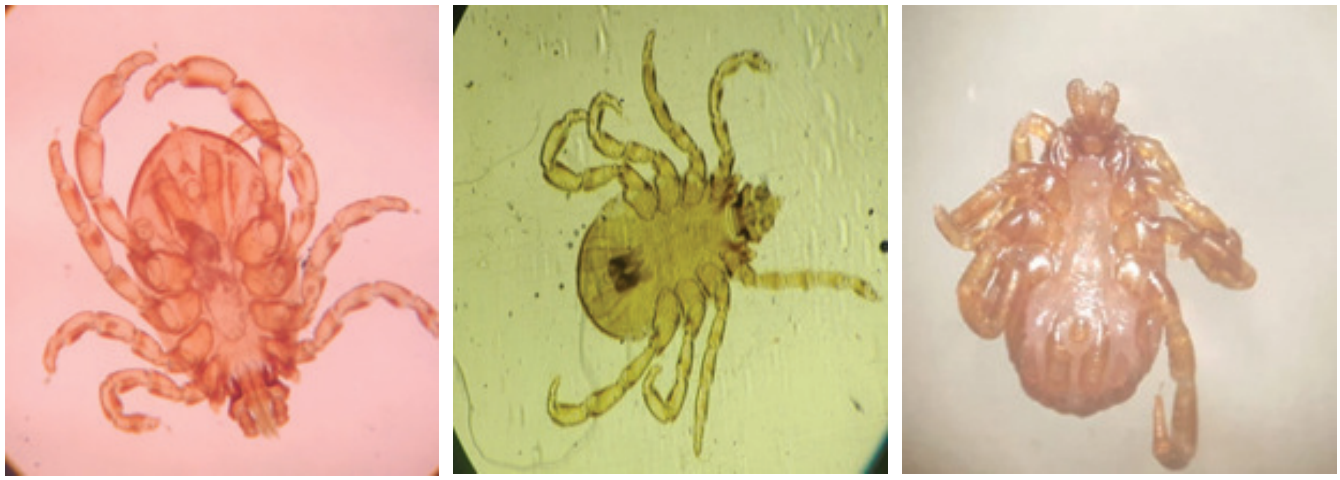
Risk Factors	Variables	Animals screened (n)	Positive	Prevalence	χ^2 (df)
Season	Summer	235	153	65.1	11.09(2)
	Monsoon	265	202	76.2	
	Winter	249	159	63.9	
Age	≤6 Months	78	20	25.6	1.23 (2)
	>6 Months-1 Year	102	45	44.1	
	>1 Year	569	449	78.9	
Sex	Female	625	478	76.5	1.08 (1)
	Male	124	36	29.0	
Breed	Indigenous	243	111	45.7	87.95 (1)
	Exotic/ Crossbred	506	403	79.6	

[p = level of significance; χ^2 = Chi square; df = degree of freedom].

Table 3. Management factors associated with prevalence of ixodid ticks in mid hill zone of Himachal Pradesh.

Risk Factors	Variables	Animals screened (n)	Positive	Prevalence (%)	χ^2 (df)
Application site	Body of animal	122	101	82.8	15.74 (2)
	Animal shed	24	24	100	
	Both	603	389	64.5	
Animal House	Pucca	338	164	48.5	1.15 (1)
	Kucha	411	350	85.2	
Frequency of application	Every 3 month	395	213	53.9	93.05 (2)
	3-6 months	246	197	80.1	
	Yearly	108	104	96.3	

[p = level of significance; χ^2 = Chi square; df = degree of freedom].



Ventral view of male *Boophilus microplus* (4X) | Ventral view of male *Boophilus annulatus* (4X) | Ventral view of male *Hyalomma anatolicum* (4X)

Fig. 2. The species of ixodid ticks from the North-western Himalayan region (mid hill zone of Himachal Pradesh).

A high prevalence rate was recorded from the region. This might be because of favorable environmental conditions with adequate precipitation along with poor management practices. The highest tick infestation rate was recorded in rainy (76.2%) followed by summer (65.1%) and winter season (63.9%) with statistically significant variation ($p<0.05$). Odds of tick infestation in cattle were increased during summer [OR=1.98 (1.18-3.32)] and rainy season [OR=3.10 (1.71-5.61)] as compared to winter season (reference season) (Table 2, Fig. 3). Similarly, other workers have also recorded highest tick prevalence rate during monsoon season from various parts of India [19, 20, 21]. Ambient temperature and atmospheric humidity in the monsoon season along with the favorable climatic conditions of grazing lands are beneficial for tick propagation and growth [22]. The highest prevalence rate of ticks was recorded in the > 1 year age group (78.9%) followed by 6 month - 1 year (44.1%) and <6 months age group (25.6%) with statistically significant variation ($p<0.05$). The odds of tick infestation were less in animals aged > 6 months - 1 year [OR=0.17 (0.09-0.33)] and ≤ 6 months old [OR=0.16 (0.09-0.26)] as compared to > 1-year group animals (reference age) (Table 1 and 2, Fig. 2). A statistically significant ($p<0.05\%$) difference was found in female (76.5%) and male animals (29.0%) (Table 1, Fig. 3). The prevalence rate in crossbred/ exotic (79.6%) [OR=4.90 (3.19-7.52)] was found to be significantly ($p<0.05$) higher as compared to indigenous cattle (45.7%, reference breed) (Table 1 and 2, Fig. 2). The present study reported the highest tick prevalence rate in > 1 year age group cattle. Similarly, other studies have also recorded a higher tick infestation in adult animals as compared to younger ones [23, 24]. This might be due to the fact that adult animals are exposed to various stages of ticks while grazing in pastures. Moreover, calves are frequently groomed by their dams, especially around the neck, ear, and regions,

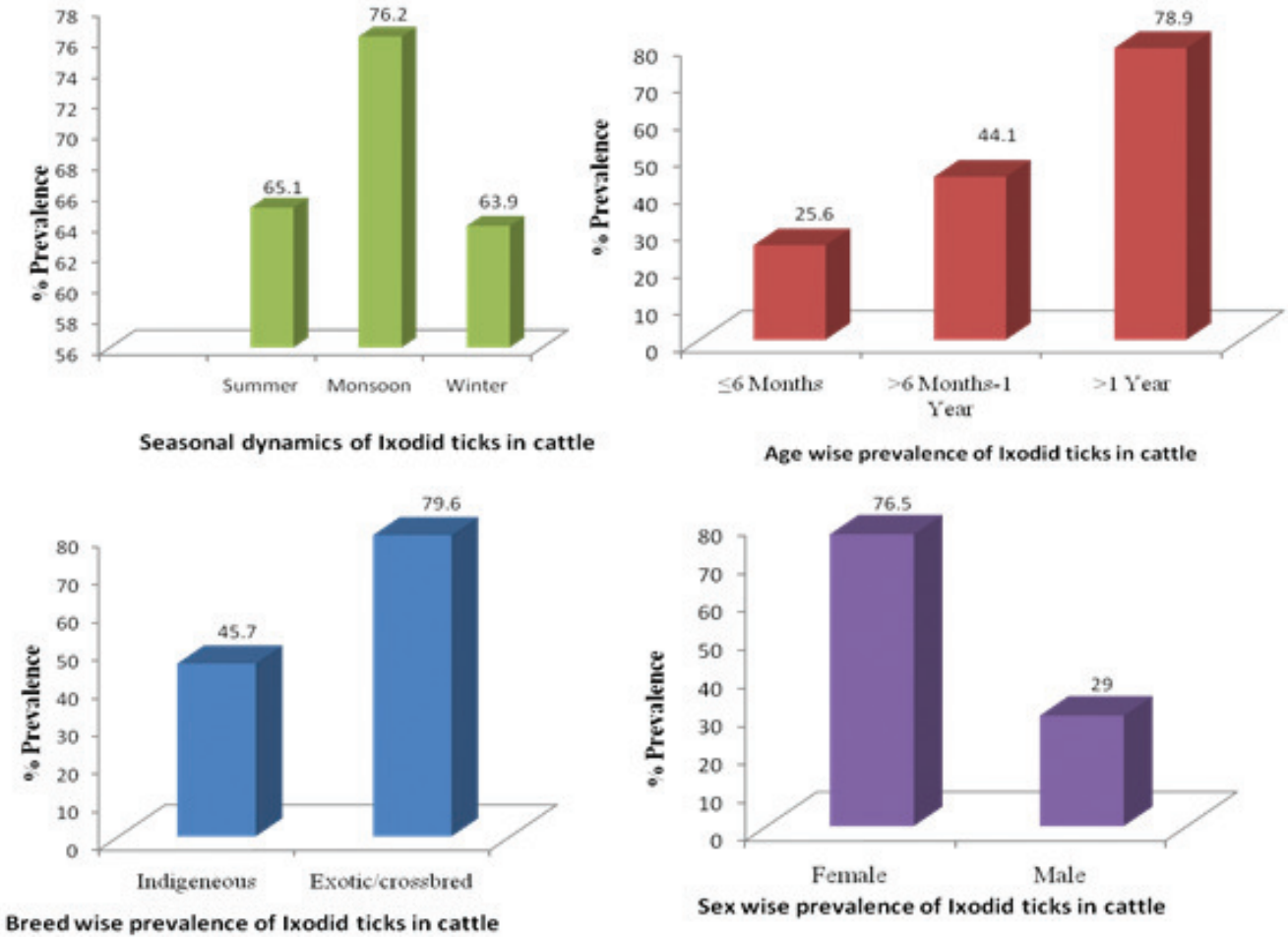


Fig. 3. Risk factors associated with prevalence of ixodid ticks in mid hill zone of Himachal Pradesh.

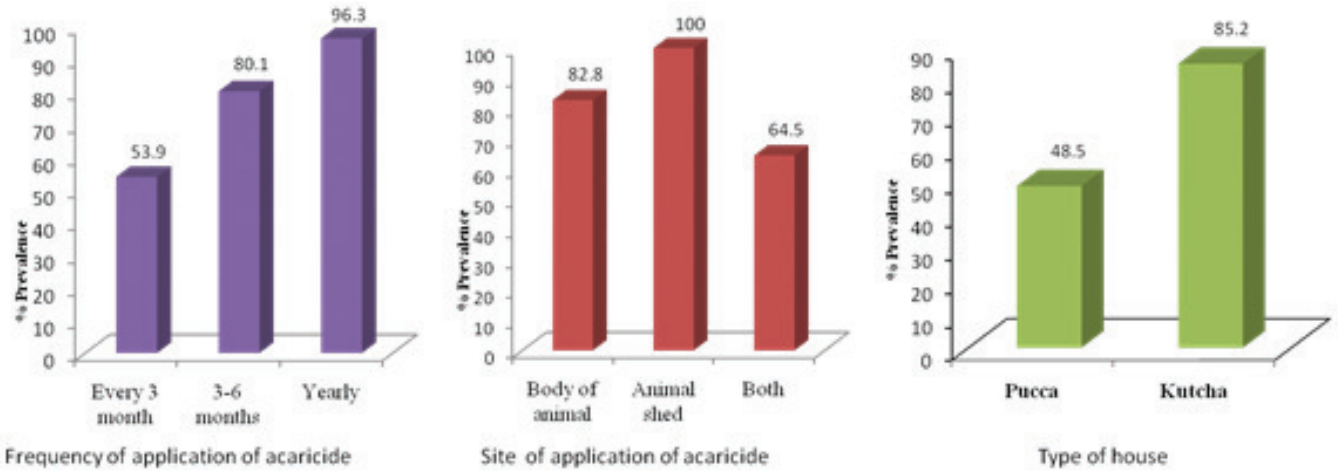


Fig. 4. Management factors associated with prevalence of ixodid ticks in mid hill zone of Himachal Pradesh.

resulting in less tick infestation. The cause of higher tick infestation in female animals as compared to males may be due to hormonal effects [25, 26] as female animals are vulnerable to infections when there is a high level of prolactin and progesterone in the blood [27]. Moreover, females undergo high lactation, pregnancy, and production stress which makes them more prone to infections [28]. In corroboration to our findings, a higher tick infestation in female animals has been reported by other workers also [29, 30, 31]. In the present study, crossbred cattle were found infested more with the ticks as compared to the indigenous cattle. Similar were the findings from Odisha and Assam states of India [32, 33]. The biological factors related to bovine susceptibility to tick infestation are not properly understood. Yet, host-related factors such as age, sex, skin composition, grooming behavior, lactation, and host surface area, coat length, and environmental factors play a significant role [34]. The gene expression studies of peripheral blood mononuclear cells have identified transcripts for IL-2, IL2Rα, TNFα, and CCR1 to be significantly up regulated in resistant cattle relative to susceptible cattle. A significantly higher expression of CXCL10, higher levels of CD14+ monocyte, and MHC II presenting cells have been reported in resistant cattle [35].

The rate of spread of various tick-borne diseases is directly related to the level of host tick infestation [36, 37]. It was recorded that the tick prevalence was significantly higher ($p<0.05$) on animals when application of chemical acaricides was done only in shed [OR=2.93 (1.49-5.76)] as compared when done only on the animal's body (Table 1 and 2, Fig. 4). The least infestation (64.5%) was recorded when acaricides were applied both in sheds as well as on animal's body [OR=1.60 (0.69-3.70)]. The odds of infestation were higher if the acaricide was sprayed only in sheds rather than on both sheds and animals (Table 1). Similar were the findings from an earlier study from the Shivalik hill zone of Himachal Pradesh [38]. The application of acaricides on both the animal's body and shed increases the level of exposure of ticks to the acaricide, hence, resulting in lower infestation rates. The tick infestation was significantly ($p>0.05$) lower in animals kept in pucca houses (48.5%) [OR=0.14 (0.09-0.21)] in comparison to kutcha houses/ traditional housing system (85.2%). (Table 1, Fig. 4). Similarly, a high prevalence of ticks in cattle has been reported in traditional housing systems by other workers [39]. The crevices and cracks in the kutcha houses provide suitable places for engorged female ticks to take shelter and lay eggs. On the other hand, pucca houses have proper ventilation, even walls, and good drainage facilities with low humidity. Therefore, kutcha houses have plenty of hiding places where the female ticks can hide easily and lay eggs resulting in re-infestation, high prevalence rate, and more vulnerability of animals to tick infestation. The frequency of application of chemical acaricides on the animals significantly ($p<0.05$) affected the prevalence rate. The animals when treated with acaricides every 3 months were found to have the lowest prevalence rate of tick infestation (53.9%). Frequent application every 3 months facilitated in reduction of ticks on the animal body as well as larval stages in the environment due to repeated exposure of larval as well as adult stages of ticks to chemical acaricides resulting in higher tick mortalities. Thus, based on the odds Ratio (OR) and statistical analysis, it was revealed that season and management factors such as type of housing system, frequency of acaricide application, and site of application of application affected the level of tick infestation in cattle population.

Hence, it could be concluded that favorable environmental conditions and poor management practices might have resulted in higher tick prevalence in this region. However, the change in management practices like frequency of application of acaricide along with pucca housing can fairly reduce prevalence rates and this could be incorporated into the methods for sustainable and effective control of the tick population in the region.

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