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Association of herd management with the infestation of ticks in domestic goats

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ABSTRACT: Three-stage cluster random sampling was done for determination of the association of herd management with the prevalence of tick (Acari: Ixodidae) infestation in goats (*Capra hircus*) in southern Punjab, Pakistan. A total of 136 nomadic goat herds and settled farms were screened for ticks and related information like nature of herds, herd size, farming pattern, animal keeping, housing, floor pattern and hygienic measures and documented on a pre-structured questionnaire. In addition, participatory epidemiological tools were used to document trends of consultancy and therapy, choice of drugs and therapeutic approaches. A significant tick infestation (56.30%) was found in all the settled farms or nomadic herds irrespective of the herd size; however, herds having 40-60 goats showed highest infestation. Among 109 (80.1%) settled farms and 27 (19.8%) nomadic herds, highest infestation was found in nomadic herds. No significant association of tick infestation was found with the goat herds reared with large ruminants or separately. Association of tick infestation with goat herds reared in closed housing system was found to be significantly higher as compared to partially-closed or open. Tethered goats showed significantly higher rate of tick infestation than free living. Uncemented (Kacha) floor was a higher risk factor for tick infestation as compared to cemented and bricked. The goats of the settled farms were more prone to tick infestation whose owner neglected the tick infestation, consulted with quacks, used ethnoveterinary medicine and petroleum for control of ticks. The findings of present study will be helpful in devising appropriate extension services for the control of tick infestation in the selected region in specific and in resource-poor countries with similar livestock husbandry systems, in general.

Keywords: Herd management, *Capra hircus*, Determinants, Ticks, Pakistan

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INTRODUCTION

Tick (Acari: Ixodidae) infestation is one of the serious threats to the livestock population all around the world especially in resource-poor countries like Pakistan. Directly, tick infestation is responsible for damaging the quality of hides and skin which ultimately reduce their economic value in leather industry. Indirectly, tick infestation is related to reduced milk production (Sajid et al., 2007), increased mortality (Jongejan & Uilenberg, 2004), transmission of serious diseases (such as anaplasmosis, babesiosis and theileriosis), causation of allergy, severe irritation and toxicosis (Khan et al., 2013; Peckle et al., 2013; Palomar et al., 2014; Rojas et al., 2014, Sajid et al., 2018). Livestock sector is an integral part of the economy of Pakistan as a considerable number of people depend upon keeping livestock for their sustenance. In Pakistan, investigations regarding tick abundance and distribution, taxonomy, ecology of the pest complex, acaricidal efficacy (Kakar & Kakar-sulemankhel, 2008; Durrani & Shakoori, 2009; Perveen et al., 2010) as well as functional genomics of ticks have gained currency since last decade (Karim et al., 2017). Ticks have been well-documented from almost all regions of Pakistan including Sindh (Soomro et al., 2014), Khyber Pakhtunkwa (KPK) (Ali et al., 2019), Balochistan (Kakar et al., 2017), Punjab (Sajid et al., 2008; 2009; 2011) and northern areas of Pakistan including Gilgit-Baltistan (Sajid et al., 2017). Many risk factors are associated with tick infestation in farm animals which have a direct impact on the epidemiology of tick-borne diseases (Karim et al., 2017; Sajid et al., 2018; Hassan et al., 2018; Rashid et al., 2019; Rizwan et al., 2019) Small ruminant population particularly goats (called as the poor man's cow) contribute a major share in the livestock population of the country (Afzal and Naqvi, 2003). However, in spite of immense significance of goats in the livestock economy of Pakistan, along with other animal health issues, information regarding the ticks and tick-borne disease dynamics in nomadic and settled farming systems and trends of the small holder goat farming community/ nomads about tick management in the country is lacking. The present study determined the possible risk factors relating to the tick infestation in goat population of the selected districts; Layyah and Muzaffargarh, in Punjab, Pakistan and highlighted the possible statistical associations with prevailing management practices in this area. The information collected from the survey explores the relevant ground realities which will not only be helpful for the nomads

and small farm holders of the area but also for the decision makers for subjective planning of tick control program in the area.

MATERIALS AND METHODS

Study Area and Sampling of Animals

The study was conducted in two districts of lower Punjab i.e. Muzaffargarh and Layyah. These districts are situated in the north side of Chenab and Indus rivers. Three stage cluster random sampling was used for the selection of goats from study areas. Sample size of the union councils as primary units, farms/herds as secondary and animals as elementary units were randomly calculated using formulae given by Thrusfield et al. (2018). A total of 136 farms/herds (5644 goats) were entered into the current survey. Farms/herds were selected to at least be 10 km apart from each other and having at least 10 goats. All the animals from selected farms/herds were examined and sampling was done during July 2017 to December 2017.

Collection of Information Regarding Herd Management Factors

Before initiation of the study, a pilot survey for refinement of the questionnaire was conducted. Relevant information from the 136 enrolled goat herds (settled or free grazing herds/farms) regarding (i) herd size; (ii) herd nature (settled or nomadic farms); (iii) pattern of farming (separate or associated with large animals); (iv) housing (closed, partially closed or open); (v) animal keeping (free or tethered); (vi) floor pattern (cemented, partially cemented or uncemented) and hygienic measures (excellent, poor or acceptable) were collected on a pre-designed questionnaire (Thrusfield et al., 2018). Parameters like, (i) trend of therapy by farmers (attending or neglecting tick infestation); (ii) trend of consultancy (quacks, veterinarians or self-medication); (iii) therapeutic approach (allopathic acaricides or ethnoveterinary medicine) and (iv) choice of drugs (cypermethrin spray or pour-ons, ivermectin injectable, plant extracts, petroleum or oils) were also collected from settled farms and nomadic herds.

Collection and Identification of Ticks

All goats of 136 herds were screened for tick infestation. Ticks were carefully collected from infested goats with the help of forceps (Soulsby, 1982) and preserved in 70% ethyl alcohol. Ticks from each goat were stored in a separate plastic bottle and labeled with the area, age, sex and date of collection. Taxo-

nomic identification of collected ticks was done in the Department of Parasitology, University of Agriculture, Faisalabad (UAF), Pakistan by using keys given by Walker et al. (2007).

Statistical Analyses

The association of tick infestation with different risk factors was statistically analyzed using chi-square test. Pair-wise comparison was carried out at 95% confidence level keeping the 10-20 goats/herd, nomadic herds, separate farming, open housing system, non-tethered animal keeping, cemented floor pattern, trend of attending tick infestation, veterinarian consultancy, allopathic therapeutic approach and cypermethrin as drug of choice as reference groups in the analysis (Schork and Remington, 2010). All the analyses were done by using SAS (2010) software package.

RESULTS

Two species of ticks i.e. *Hyalomma (Euhyalomma) anatolicum* and *Rhipicephalus (R.) sanguineus* were identified from the study areas. Prevalence of *H. anatolicum* (76.72%) was significantly higher than *R. sanguineus* (23.28%). Overall prevalence of the tick infestation was 56.3% in goat population of the selected districts. Prevalence rate was higher in district Muzaffargarh (68.32%) than in district Layyah

(31.68%). The rate of tick infestation was higher during July-August and lower during November-December.

The proportion of herds having 20-40 goats/ herd was significantly higher than other groups. A significant tick infestation was found in all herd size, however, herds having 40-60 goats/herd (OR=2.61) showed highest infestation. Among 109 (80.1%) settled farms and 27 (19.8%) nomadic herds (OR=6.41), highest infestation was found in nomadic herds. Regarding farming system, a significantly higher number of goat herds was associated with the large animals. However, a non-significant association was found in goat herds reared with large ruminants or separately. In the present investigation, most of the farmers were found to adopt open housing system followed in order by partially closed and closed housing system. Association of tick infestation with closed housing goat herds was significantly higher as compared to open or partially closed. Goats kept as tethered (rope-tied and fed indoors at all times) showed significantly higher infestation than those non-tethered. Uncemented floor pattern was found significantly higher in most of the goat herds which predisposed to higher risk of tick infestation as compared to cemented or bricked. Frequency distribution of tick infestation in several categories of goat herds has been presented in Table 1.

Table 1. Determinants of herd management of goat (*Capra hircus*) influencing tick (Acari: Ixodidae) infestation in Layyah and Muzaffargarh district of Punjab, Pakistan

Parameters	groups	No. of farms	Farms visited	% of farms	Ticks +ve animals	Animals examined	% of infestation	P-value	Lower limit	Upper limit	Odds ratio
Herd Size	10-20 goat/ herd	33	136	24.3	198	504	39.3	0.0011	32.5	42.84	
	20-40 goat/ herd	65	136	47.8	1271	2200	57.8	0.0007	47.55	62.45	2.11
	40-60 goat/ herd	19	136	14.0	786	1250	62.9	0.0006	56.43	69.57	2.61
	60-80 goat/ herd	14	136	10.3	645	1130	57.1	0.0007	50.54	63.41	2.05
	>80 goat/ herd	5	136	3.7	278	560	49.6	0.0010	40.71	53.22	1.52
Nature of groups	settled farms	109	136	80.1	1790	3990	44.9	0.0033	36.13	53.53	6.41
	nomadic herds	27	136	19.9	1388	1654	83.9	-	76.04	90.96	-
Farming	Integrated with large animals	89	109	81.7	2390	4206	56.8	0.0507	50.08	62.58	1.08
	Separate	20	109	18.3	788	1438	54.8	-	46.63	60.71	-
	Open	73	109	67.0	1766	3613	48.9	0.0013	42.08	56.26	-
Housing	Closed	9	109	8.3	456	623	73.2	0.0006	66.68	82.65	2.86
	Partially closed	27	109	24.8	956	1408	67.9	0.0012	59.29	73.37	2.21
Animal keeping	Tethered	15	109	13.8	1034	1390	74.4	0.0016	66.59	82.08	2.86
	Free	94	109	86.2	2144	4254	50.4	-	41.61	58.06	-
Floor pattern	Uncemented	89	109	81.7	2435	3310	73.6	0.0006	64.74	79.92	18.94
	Cemented	8	109	7.3	98	765	12.8	0.0026	6.35	19.32	-
	Bricked	12	109	11.0	645	1569	41.1	0.0020	34.68	49.65	4.75

In nomadic herds, trend of neglecting tick infestation was higher ($P < 0.05$) as compared to that in the settled farms. However, in both systems consulting with a veterinarian for tick infestation and use of allopathic drugs was least ($P < 0.05$). Most of the farmers consulted with quacks or relied on their own to treat tick infestation (self-medication). Ethnoveterinary

practices like use of petroleum was higher than oils and/or plant extracts while in allopathic drugs, ivermectin was used more lavishly than cypermethrin. Farmers' response rates relating to their attitude towards tick infestation and possible treatment options in settled and nomadic goat farms combined with tick infestation rates per category are provided in Table 2.

Table 2. Farmers' response to tick (Acari: Ixodidae) infestation in settled farms and nomadic population of domestic goat (*Capra hircus*) in districts Layyah and Muzaffargarh, Punjab, Pakistan

A: Settled Goat Farms											
Parameters	Groups	No. of farms	Farms visited	% of farms	Ticks +ve animals	Animals examined	% of infested animals	P-value	Lower limit	Upper limit	Odds ratio
Trend of Therapy	Neglecting tick infestation	12	109	11.0	1256	1845	68.1	0.0001	60.43	73.57	6.43
	Attending tick infestation	97	109	89.0	534	2145	24.9		18.16	28.5	
Consultancy	Veterinarians	13	97	13.4	77	560	13.8	0.0029	7.45	20.26	
	Quacks	56	97	57.7	256	964	26.6	0.0011	17.29	35.42	2.27
	Self-reliance	28	97	28.9	201	621	32.4	0.0009	22.83	42.63	3
Therapeutic approaches	Ethnoveterinary medicine	26	97	26.8	239	689	34.7	0.0004	26.05	43.68	2.09
	Allopathic	71	97	73.2	295	1456	20.3		13.91	27.14	
Choice of drugs	Ivermectin	52	71	73.2	239	869	27.5	0.0008	19.74	34.92	3.6
	Cypermethrin	19	71	26.8	56	587	9.5	0.0041	2.64	15.09	
	Oils	14	26	53.8	183	578	31.7	0.0007	20.32	41.01	4.39
	Plant extracts	5	26	19.2	4	13	30.8	0.0007	21.58	40.79	4.21
	Petroleum	7	26	26.9	52	98	53.1	0.0001	41.61	65.28	10.72
B: Nomadic Goat Herds											
Trend of Therapy	Neglecting tick infestation	11	27	40.7	891	994	89.6	0.0002	83.5	93.84	2.84
	Attending tick infestation	16	27	59.3	497	660	75.3	-	69.42	79.48	-
Consultancy	Veterinarians	2	16	12.5	19	69	27.5	0.0021	20.19	35.08	-
	Quacks	8	16	50.0	291	368	79.1	0.0003	68.97	89.46	9.95
	Self-reliance	6	16	37.5	187	223	83.9	0.0001	75.38	91.54	13.69
Therapeutic approaches	Ethnoveterinary medicine	12	16	75.0	399	489	81.6	0.0002	72.3	90.11	3.3
	Allopathic	4	16	25.0	98	171	57.3	-	45.65	72.98	-
Choice of drugs	Ivermectin	3	4	75.0	79	129	61.2	0.0007	53.73	68.66	1.91
	Cypermethrin	1	4	25.0	19	42	45.2	0.0024	32.91	57.42	-
	Oils	7	12	58.3	208	278	74.8	0.0003	65.8	83.19	3.6
	Plant extracts	2	12	16.7	2	4	50.0	0.0015	42.73	59.68	1.21
	Petroleum	3	12	25.0	189	207	91.3	0.0001	85.38	97.27	12.71

DISCUSSION

Ticks have been found notorious for their sustainable distribution in various agro-geo climates of Pakistan over the last decade (Sajid, et al., 2007; 2008; 2009; 2011; 2017; Karim et al., 2017; Sajid et al., 2018; Hassan et al., 2018; Rashid et al., 2019;). The probable reasons of higher threat of ticks and tick-borne diseases in developing countries (including Pakistan) may include but are not limited to warmer seasons and higher average temperatures, which promote

the growth and propagation of ticks (Soulsby, 1982; Iqbal et al., 2013; Patel et al., 2013; Rizwan et al., 2019), the lack of appropriate husbandry practices i.e. animal housing standards and protocols used for the treatment of tick infestations (Sajid et al., 2011), maintenance of infestation from free-range grazing hosts to domesticated livestock, lack of knowledge and resources. This has led to increased threat of emerging and re-emerging tick-borne diseases in the region e.g. Crimean Congo Haemorrhagic Fever (CCHF). In Pa-

kistan, frequency and distribution of tick infestation has been reported almost in every province (Kakar & Kakarsulemankhel, 2008; Durrani & Shakoori, 2009; Perveen et al., 2010). In a recent survey conducted by Karim et al. (2017) from representative samples of all provinces of Pakistan, 19 tick species were identified from livestock. From Kaghan valley, Khan (1993) reported 12.3% prevalence of tick infestation in goats and identified seven species of ticks. Twelve species of ticks were identified from different districts (Dir, Bannu, Swat, Peshawar, Swat and Mardan) of KPK (Siddiqi & Jan, 1986). About 16 species of ticks were collected from goat and sheep population in another study conducted by Hussain and Kumar (1985) in five different agro-ecological zones of Sindh, Pakistan. Rehman et al. (2017) identified four species of ticks which were *Hyalomma anatolicum*, *R. microplus*, *H. dromedarii* and *R. turanicus*. Semi-arid and arid agro-ecological zones of Pakistan showed higher (Rehman et al., 2017) while northern zone showed lower (Irshad et al., 2010) prevalence of tick infestation than present study. Batool et al. (2019) reported lower prevalence of ticks in the northern, southern, western and central zones than that of the present study. In Uttarakhand, India (Gopalakrishnan et al., 2017), Eastern Hararghe, Ethiopia (Desalegn et al., 2015), the prevalence of tick infestation is lower than the one found in our study. In Tamil Nadu (India), *H. bispinosa* was found to be a major tick species infesting goats followed in order by *R. haemophysaloides*, *H. anatolicum* and *H.m. isaaci* (Vathsala et al., 2008).

The results of the present study are in line with the results of Rony et al. (2010), Kabir et al. (2011), Atif et al. (2012), Mustafa et al. (2014), Sultana et al. (2015), Sajid et al., (2017) who also recorded high infestation of ticks in summer. The highest prevalence of tick infestation in summer might be due the weather being hot and humid which propagates the tick infestation and survival. Similar to our study, fluctuations in the rate of tick infestation were reported in different areas of Toba Tek Singh (Iqbal et al., 2013), lower Punjab (Sajid et al., 2011), semi-arid and arid zones of Pakistan (Rehman et al., 2017). Variations in the rate of tick infestation within the same or different geographical regions can be due to differences in husbandry practices including tick control strategies and awareness of the farmers (Ghosh et al., 2007).

Iqbal et al. (2013), Sajid et al. (2013) and Rehman et al. (2017) reported that closed (traditional) housing system was associated with higher prevalence of

tick which are in-line with our study. The prevalence of tick infestation was also reported higher in other housing type like wooden, uncemented than concrete (Muhammad et al., 2008; Farooqi et al., 2017). The higher rate of tick infestation in closed housing system might be due to increased humidity in heaps and reduced exposure to sunlight as well as presence of cracks and crevices in animal sheds providing an optimal environment for tick propagation (Jouda et al., 2004; Muhammad et al., 2008). Like our study, Iqbal et al., (2013), Sajid et al. (2013) and Rehman et al. (2017) reported that uncemented floor pattern is significantly associated with high tick infestation. The possible reason for higher rate of tick infestation in uncemented floor may be the mat depth (depth of soft soil) which helps to provides more niches, maintain humidity and a better microclimatic condition required for tick survival and development (Macleod, 1935; Milne, 1948).

Similar to our results, Sajid et al. (2013) found a higher prevalence in tethered animals than in free living. The possible associated risk factors for higher prevalence in tethered animals may be high prevalence of ectoparasites in shed or microclimate (Soulsby, 1982), hormonal imbalance due to stress of animals held in confinement (Lloyd, 1983) and lack of host capacity to avoid insect attack (Radon et al., 2001). The study conducted by Ramzan et al., (2018) revealed that 28.3% illiterate farmers use only chemicals for the control of tick infestation, 22.6% farmers adopted cultural practices for the control of ticks, while 10.3% used both chemical and cultural practices for control of ticks. They also reported that only 43.3% of the farmers visited a qualified veterinarian for the examination of their animals.

Several factors responsible for tick infestation in livestock population have been observed around the world (Abunna et al., 2012; Fentahun et al., 2012; Kumsa et al., 2012; Moshaverinia et al., 2012; Shemshad et al., 2012; Beyecha et al., 2014). There are many studies available on the epidemiological determinants reported to be positively or negatively associated or not associated with tick infestation in ruminants (Vathsala et al., 2008; Fentahun et al., 2012; Kumsa et al., 2012; Shemshad et al., 2012; Iqbal et al., 2013; Patel et al., 2013; Beyecha et al., 2014). Rehman et al. (2017) reported that traditional rural housing systems, absence of acaricidal treatments and rural poultry are the major factors responsible for high tick infestation. They also reported that sex, age,

breed, species and grazing played significant role in the rate of tick infestation.

Most of local livestock farmers of Pakistan rely on ethnobotanical knowledge to cure animal diseases which is based on traditional methods, skills, practices and beliefs. According to documentation of ethnoveterinary practices in district Jhang, Pakistan 33 indigenous plants were used for the treatment of different infectious and non-infectious ailments (Badar et al., 2017). About 231 plants reviewed showed a variety of bioactive properties like repellent, toxic, antioviopositant, antifeedant and ability to immobilize tick species (Wanzala, 2017). Sindhu et al, (2010) reported 35 plant species representing 25 families used in Mansehra district, Pakistan to treat the ailing animals. In Mansehra district, oil of *Cedrus deodara* is commonly used for treatment of tick infestation.

Most of the dairy farmers of Pakistan used injectable ivermectin among allopathic acaricide formulation for the control of ticks. Sajid et al. (2011) found that *in vivo* efficacy of cypermethrin treated groups regarding both mortality of adult ticks and re-infestation rates is significantly higher as compared to ivermectin treatment. It has been reported that the use of a limited number of acaricide over the period of time might be responsible for lower efficacy (Ogden et al. 2005). In a study conducted by Dipeolu (1983), it was concluded that inefficacy of the acaricide in field con-

dition limited due to rapid build-up of the tick population on the pasture plots rather than inability of acaricide to control ticks on the animals.

Purchase of acaricides without prescription or license (due to over-the-counter availability) and their inappropriate dosage and administration in small ruminants by the farmers of quacks (personal observation) could be one of the major predisposing factors of the reduced acaricidal efficacy which might be associated with an increase in the tick prevalence over the period of time. During the previous decade, mass-scaled acaricidal campaigns in livestock population as a part of emergency response to CCHF epidemic might be one of the reinforcing factors towards the development of resistance in tick population (personal observation).

In conclusion, (a) nature of farm (b) implementation of standard farming practices for the control of goat ticks i.e. open housing system, free animal keeping, cemented floors and walls of shed; (c) consultancy with veterinarians (d) trends of therapy (e) therapeutic approach and (f) choice of drug are the significant components to minimize the tick-burden from goat population in Pakistan.

CONFLICT OF INTEREST

None declared by the authors.

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