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DESCRIPTIVE EPIDEMIOLOGY OF INSECTS INFESTING DOMESTIC SHEEP (*Ovis aries*) OF DISTRICT TOBA TEK SINGH, PUNJAB, PAKISTAN

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During a cross-sectional prospective epidemiological survey, a total of 2412 sheep were screened for the prevalence of insects. Out of which, 333 (13.80%) were harbored for insects including lice (36.57%), fleas (3.23%) and flies (1.62%). Among the identified species of lice, *Haematopinus spp.* (44.14%) was predominant followed in order by *Damalinia ovis* (26.42%) and *Linognathus spp.* (17.71%). The flea *Ctenocepahlides (Ct). felis* was more common (4.50%) than *Ct. canis* (3.30%). *Stomoxys calcitrans* (3.90%) was the only prevalent specie of fly in the study area. Infestation rate was higher in young sheep (72.68%) as compared to adults (27.32%) and level of infestation was significantly higher in females (75.37%) than males (24.62%). Amongst various breeds of sheep, Cholistani (19.81%) had the highest prevalence followed by Kajli (13.49%), Thalli (12.94%) and Lohi (11.80%). Prevalence of flies (37%) and lice (47%) was highest in December and January, respectively; whereas,that of fleas (39%) reached a peak in April. Among various associated determinants, stall feeding, closed housing, tethered animals and non-cemented floor were found positively associated ($P<0.05$) with insect infestation. The results showed that insect abundance and the variety of genera were wide in this part of Pakistan. This also causes concern over the emergence of insect-borne diseases in domestic animals.
Keywords: Insects prevalence, lice, fleas, sheep breeds, determinants

INTRODUCTION

Livestock, the backbone of Pakistan's agricultural economy, is at risk of decline in production due to parasitism. Among domesticated ruminants, sheep (*Ovis aries*) is a major source for meat, wool, skin and farm-yard manure production for the indigenous population of Pakistan (Durrani *et al*., 2008). Sheep have high social economic value against crop failure, for cultural festivities and religious sacrifices (Adedimiyi *et al*., 1992). Ectoparasitism is one of the many factors influencing small ruminant productivity (James-Rugu and Iwuala, 2000; Olivares-Pérez *et al*., 2011). The major insects parasitizing sheep include flies (Diptera), fleas (Siphonaptera), lice (Pthiraptera) and bugs (Hemiptera) in descending order of significance (Soulsby, 1982). The economic impact of insects is greatly increased due to their detrimental effects on skin, wool, blood composition, physical condition, growth rate, milk and meat production and reproductive efficiency (lambing interval) (Devendra and Mcleroy, 1987; Rehman *et al*., 2011; Lashari and Tasawar, 2011). In addition, the role of insects as vectors for a wide range of viral, bacterial, protozoan and rickettsial diseases in the livestock population further increases their significance and in severe cases may lead to death with consequent socio-economic implications (Dipelu and Ayoade, 1982; Soulsby, 1982; Radostits *et al.*, 1994; Colebrook and Wall, 2004; Akhtar *et al*., 2011). Dermatitis, (vesicular or popular), intense pruritis and hyper keratinized skin resulting from severe insect attack lead to much reduction in the grazing time which ultimately negatively influences productivity. In rural areas where co-habitation of animals and humans is common, the potential of acquiring insect-borne pathogens by humans is increased substantially (Soulsby, 1982). In addition, the insects parasitizing animals have been reported to infest the farm workers or managers (Fasulo *et al*., 2005). Moreover, animals, including sheep, have been reported to act as a reservoir of disease causing agents of humans such as Leptospirosis (Memish and Mah, 2001). Despite these grave consequences, epidemiology of insect infestation in sheep has not been determined in most of regions of the Punjab, Pakistan. The present study was planned in a focused district of Toba Tek Singh in order to identify the probable insect species infesting the sheep population. The results should be helpful in controlling the insect population infesting sheep of the targeted district. The findings can also be applied on provincial government sheep farms to reduce the epidemics of insects and insect-borne pathogens.

MATRIALS AND METHODS

***Study area*:** The detailed geography, climatic conditions and seasonal variations of T.T. Singh district has been described elsewhere (Iqbal *et al*., 2013). A physical map of the study area is shown in Fig.1.

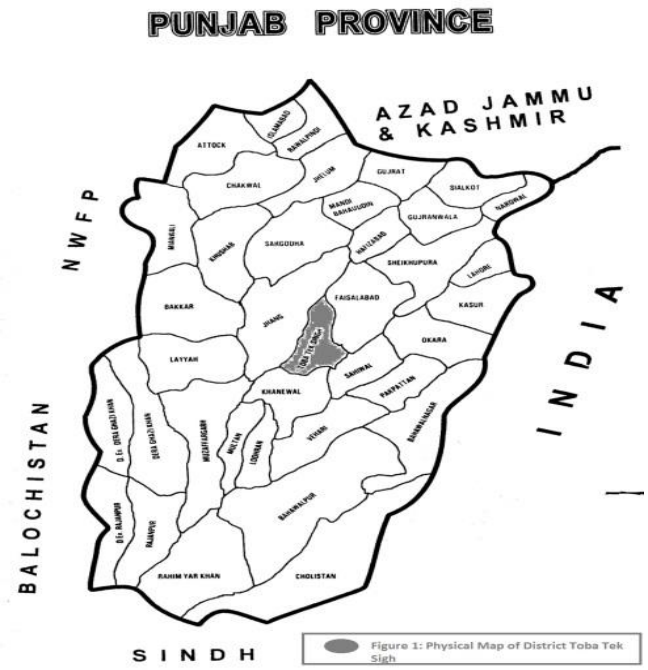

Figure 1. Physical map of Punjab Province of Pakistan with highlighted study area (District T.T. Singh)

***Selection of study population*:** A two-stage cluster random sampling was used to identify the number of farms (primary units) and animals (secondary units) to be selected (Thursfield, 2007). A pilot study of the questionnaire was used to refine the questions and the multiple choices. A sampling frame was constructed representing all the sheep farms in the district based on the following criteria: a) farm to farm distance not less than 10Km; b) number of animals per farm/herd = >10. Based on proportional allocation, 150 farms of sheep were selected. All the animals of the selected herds were treated as the sampling unit.

***Prevalence and associated determinants*:** Visits to the selected farms were made fornightly for a period of one year, to collect information about the prevalence of insects and associated determinants. The animals were categorized on the basis of their age and sex. In sheep, adults (>6 months) and young-stock (0-6 months) of both the sexes were selected for sampling purpose. The breeds of sheep included were Kajli, Lohi, Cholistani and Thalli. Month-wise prevalence (%) of insects was observed between April 2010 and March 2011. Temperature, relative humidity and rain fall data of the study area for the year 2010-11 was obtained from the Meteorological Department, University of Agriculture Faisalabad, Pakistan. During this study, different types of feeding system (grazing/stall feeding), housing system (closed/semi closed/open), floor structure (non-cemented/partially cemented/cemented) and animal restraint (tethered/free) were observed. In addition, an association of all these factors with insect infestation in domestic sheep was also recorded.

***Collection and identification of specimens*:** The selected animals were screened fortnightly by examination for the presence of insects using a magnifying glass. Infested animals were segregated for collection of samples/specimens. Infestation and management history for these animals was recorded and other information regarding farm were obtained, including (i) owner's name; (ii) total number of animals on farm; (iii) species and sex of animals; (iv) time and date of inspection; and (v) clinical signs and body temperature if relevant (Wall and Shearer, 1997). Specimens of lice and fleas were collected using forceps or by gloved hand and flies using nets (Soulsby, 1982). Specimens were preserved in glycerin alcohol (95 parts of alcohol and 5 parts glycerin) in McCartney bottles (Soulsby, 1982). All specimens were taxonomically identified by using description and keys given by Furman and Catts (1982), and Wall and Shearer (1997).

***Statistical analyses*:** The data obtained for prevalence of insect infestation and its influencing determinants including age, sex, breed, species, climate and husbandry were analyzed using multiple logistic regression. Association between prevalence with its possible influencing determinants was measured by odd's ratios (ORs). All the data were analyzed using SAS (2010) software package.

RESULTS

Out of 2412 screened sheep, 333 (13.80%) harbored insects including lice (36.57%), fleas (3.23%) and flies (1.62%). Among the identified species of lice, *Haematopinus spp.* (44.14%; 147/333; P<0.05; OR= 2.49) was predominant followed in order by *Damalinia ovis* (26.42%; 88/333; OR=1.49) and *Linognathus spp.* (17.71%; 59/333). *Ctenocepahlides (Ct). felis* was more common (4.50%; 15/333; P<0.05; OR=1.36) than *Ct. canis* (3.30%; 11/333). *Stomoxys calcitrans* (3.90%; 13/333) was the only prevalent fly specie in the study area. Infestation rates were higher in young sheep (72.68%; 242/333; P<0.05; OR=2.66) as compared to adults (27.32%; 91/333); whereas, the level of infestation was significantly higher in females (75.37%; 251/333; P<0.05; OR=3.06) than in males (24.62%; 82/333). Amongst various breeds of sheep, Cholistani (19.81% (65/328); OR=1.46) had the highest infestation followed in decreasing order by Kajli (13.49%; 112/830; OR=1.75), Thalli (12.94%; 90/695; OR=1.11) and Lohi (11.80%; 66/559) (Table 1). Month wise prevalence of flies (37%) and lice (47%) was highest in December and January, respectively, while fleas (39%) were more common during April (Fig. 2). Association of various determinants of insect prevalence was also determined during the research period as depicted in Table 1. Sheep having a non-cemented floor in their farms were found positively associated (46.54%;

Table 1. Prevalence and associated determinants of insects infesting domestic sheep of district T.T. Singh

Over all prevalence			13.80% (333/2412)				
Associated determinants	**Variables**	**Levels**	**Prevalence (%)**	**P-value**	**Odds Ratio**	**Confidence interval 95%**	
						Lower limit	**Upper limit**
Host	**Age**	Young	72.67% (242/333)	0.000	2.66	67.70	77.26
		Adult	27.33% (91/333)	-	-	22.74	32.30
	Sex	Female	75.37% (251/333)	0.000	3.06	70.53	79.91
		Male	24.62% (82/333)	-	-	20.22	29.47
	Breed	Kajli	13.49% (112/830)	0.793	0.96	11.30	15.95
		Thalli	12.94% (90/695)	0.015	1.53	10.61	15.60
		Cholistani	19.81% (65/328)	0.006	1.68	15.77	24.40
		Lohi	11.80% (66/559)	-	-	9.32	14.68
Agent	**Fleas**	*Ctenocepahlides (Ct). felis*	4.50% (15/333)	0.490	1.36	2.64	7.16
		Ct. canis	3.30% (11/333)	-	-	1.75	5.67
	Lice	*Haematopinus spp.*	44.14% (147/333)	0.000	2.49	38.87	49.52
		Damalinia ovis	26.42% (88/333)	0.032	1.49	21.90	31.36
		Linognathus spp.	17.71% (59/333)	-	-	13.90	22.10
	Fly	*Stomoxys calcitrans*	3.90% (13/333)	-	-	2.19	6.42
	Feeding system	Grazing	62.76% (209/333)	0.000	1.69	54.47	67.83
		Stall feeding	37.24% (124/333)	-	-	32.17	42.53
Management	**Floor pattern**	Non- cemented	46.54% (155/333)	0.000	2.21	43.01	53.72
		Partially cemented	32.13% (107/333)	0.016	1.51	27.28	37.29
		Cemented	21.13% (71/333)	-	-	16.90	25.65
	Animal keeping	Tethered	60.36% (201/333)	0.002	1.52	55.03	65.51
		Open	39.64% (132/333)	-	-	34.49	44.97
		Close	48.34% (161/333)	0.000	2.21	43.01	53.72
	Housing system	Semi-close	29.72% (99/333)	0.080	1.36	25.00	34.81
		open	21.62% (73/333)	-	-	17.45	24.29

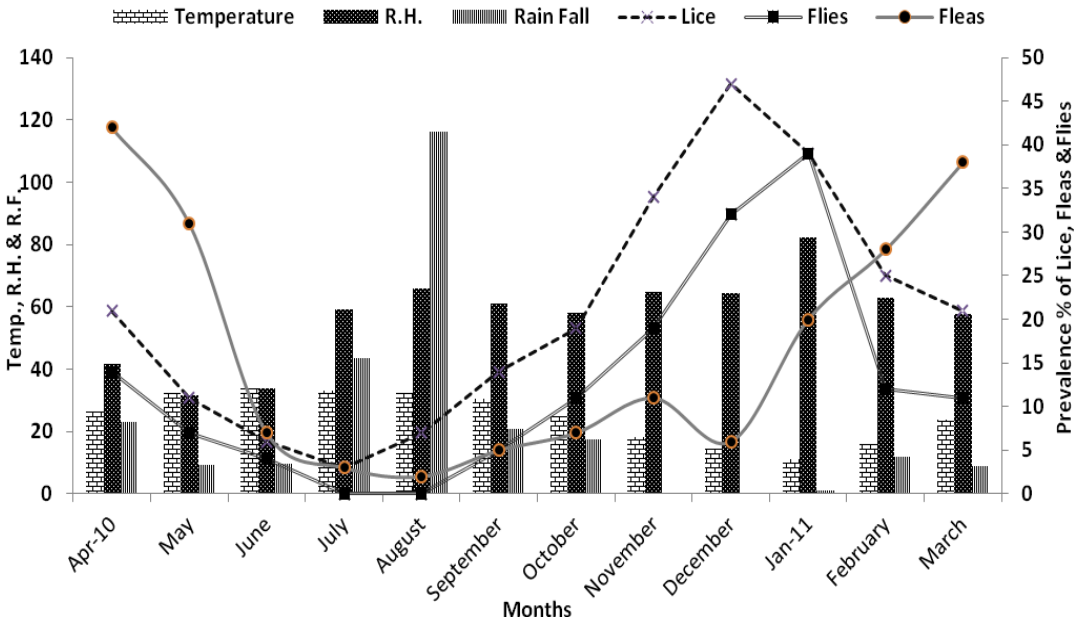

Figure 2. Seasonal prevalence of insects infesting domestic sheep of district T.T. Singh

155/333; P<0.05; OR=2.18) with infestation in comparison with those kept on partially cemented (32.13%; 107/333; P<0.05; OR=1.51) and cemented floors (21.13%; 71/333). Insect prevalence was found significantly higher in close housed animals (48.34%; 161/333; P<0.05; OR=2.21) than that of semi closed (29.72%; 99/333; P<0.05; OR=1.36) and open housed (21.62%; 73/333) animals. With respect to feeding and restraint, stall fed (62.76%; 209/333; P<0.05; OR=1.69) and tethered (60.36%; 201/333; P<0.05; OR=1.52) animals were found more significantly affected than field grazing (37.24%; 124/333) and free ranging animals (39.64%; 132/333), respectively.

DISCUSSION

Different insect structures such as jointed appendages, exoskeleton, modified mouth parts, the diversity of ecological niches and life styles, speciation, feeding sources, short generation time and long lineage are factors for the phenomenal success of this Class (Urquhart *et al*., 2006). Moreover, if they are not physically equipped to live in a stressful environment, adaptations in behavior to avoid such stresses are available ensuring their wide distribution on land constituting >70% of the total animal population (Wall and Shearer, 1997). In small ruminant population, epidemiological investigations have shown that lice (Pthiraptera), fleas (Siphonaptera) and flies (Diptera) are widely distributed as ectoparsites globally (Nofstad and Gronstol, 2001; Colwell *et al*., 2002; Urquhart *et al*., 2006; Aktas *et al*., 2004; Iqbal *et al*., 2006; Kakar and Kakarsulemankhel, 2008; Iqbal *et al*., 2012; Durrani *et al*., 2012). Mixed infestations of *Haematopinus* with *Linognathus* (Gabaj *et al*., 1993) and *Bovicola* with *Linognathus* (Nafstad and Gronstol, 2001; Colwell *et al*., 2002) have also been well documented.

Higher temperature and humidity, especially in Asia and Africa may be factors which favor insect growth and development (Ju *et al*., 2010). Other contributing determinants may include standards of animal housing, husbandry, drug administration protocols (Blackwell *et al*., 2008), season, habitat type (Teel *et al*., 1996), altitude (Perret *et al*., 2004; Jouda *et al*., 2004), breed, sex, lactation stage and nutritional status (Springell, 1974).

A relatively higher prevalence of lice on hosts during the dry period might be associated with poor feed conversion ratio (Rony *et al*., 2010) which leads to higher susceptibility of hosts to parasitic infections (Lapage, 1962). The monthly fluctuations in the prevalence of insect infestation in the current study do not differ from previous reports (Khan *et al*., 1993; Rizwan *et al*., 1995; Azam *et al*., 2002; Hussain *et al*., 2006) from Punjab, or other parts of the world (Araujo *et al*., 1998) falling within the same temperature zones. The optimum temperature range for the activity, growth, development and reproduction of various types of insects is 0–48°C which allows various tropical and sub-tropical countries such as Pakistan to fall in the susceptible zone.

The current study found a higher prevalence of insects in younger and female sheep as compared to adult and male ones which might be attributed to (a) a weaker immune system that is less well developed cannot cope with insect infestation, (b) softer skin that facilitates passage for insect mouth parts (Cummins and Graham, 1982; Milnes and Green, 1999; Sanjay and Prasad, 2004; Sajid *et al*., 2009; Kabir *et al*., 2011). In Pakistan, sheep are used to provide milk and meat, for breeding and sacrificial purposes and males are preferred for latter three. Hence, additional care of male animals may make them less prone to insect infestation and may explain the significantly lower prevalence in males compared to females. Secondly, stress in females due to milking, pregnancy and parturition leads to its hormonal disturbances such as higher levels of prolactin and progesterone which render the individual more susceptible to any infection (Lloyd, 1983). This higher level of susceptibility to infection weakens their immune status, which ultimately allows higher infestation of insects in females (Yacob *et al*., 2008; Sajid *et al*., 2009; Kabir *et al*., 2011)**.** Breed was not found to be a significant risk factor (P≥0.05) influencing the prevalence of insects. This may be because the nutritional level, management practices and environmental conditions (Suarez and Tawfik, 2003) for all breeds are similar. The present study found a higher prevalence in stall-fed animals than those grazing or free roaming. The probable associated risk factors may include: (a) increased prevalence of the questing stages of insects on the host or in the microclimate (shed) (Soulsby, 1982), (b) stress of the confinement in the stall-fed system associated with the hormonal (progesterone) imbalance leading to higher insect infestation (Lloyd, 1983), (c) lack of host capacity to gad (in order to avoid insect attack) in tethered animals which increases the success rate of insects parasitizing hosts (Radon *et al*., 2001). Similarly, a closed housing system is more favorable for the insect propagation (Geden *et al*., 1990) because the cracks and crevices in the walls of closed animal sheds provide a place for female insects to oviposition (Jouda *et al*., 2004), and lowered exposure of larval stages of insects to sunlight ultimately increases their population (Hussain *et al*., 2006). Housing plays an important role in the development of fleas since it enables eggs to develop in litter containing organic matter with many hosts available on emergence. Manure accumulates in animal houses resulting in increased warmth and humidity, which favors the proliferation of fleas (Obasaju and Otesile, 1980) and the abundance of organic matter, provides nutrition and protection for the developing larvae. This was confirmed by finding of eggs and larvae at a depth of up to 3 cm in the litter of intensive farms (Kaal *et al*., 2006). The variable humidity during the study period with constant temperature does not affect the prevalence of

insect infestations other than fleas. Thus, in conclusion, the changes in the environment and suitability of the climate, lack of knowledge, poor management and hygiene makes it necessary to develop integrated insect control programmes at both international and national levels.

***Recommendations*:** In the light of results of the present study, the proposed recommendations for the sheep breeders are: (a) preventive therapy may be useful to minimize insect infestations before the onset of their breeding season; b) females and young animals should be given special attention as they are more prone to insect infestation; c) husbandry practices like non-cemented floor, closed housing, tethering and stall feeding should be discouraged as they have positive association with the development of the insects.

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