Ectoparasites of sheep in three agro-ecological zones in central Oromia, Ethiopia

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A cross-sectional study was conducted to determine the prevalence and risk factors for ectoparasites infestation in sheep in three agro-ecological zones in central Oromia, Ethiopia, from October 2009 to April 2010. The study revealed that 637 (48.1%) of the 1325 sheep examined were infested with one or more ectoparasites. The ectoparasites identified were *Bovicola ovis* (27.2%), *Melophagus ovinus* (16.4%), *Ctenocephalides* sp. (2.3%), *Linognathus africanus* (1.2%), *Linognathus ovillus* (0.3%), *Sarcoptes* sp. (1.2%), *Amblyomma variegatum* (4.4%), *Rhipicephalus evertsi evertsi* (1.9%), *Rhipicephalus pravus* (1.9%), *Rhipicephalus (Boophilus) decoloratus* (1.1%), *Rhipicephalus sanguineus* (0.9%), *Rhipicephalus praetextatus* (1.1%) and *Hyalomma truncatum* (1.6%). Statistically significant difference was observed in prevalence of *B. ovis* amongst study agroecological zones: highland 36.6%, midland 20.9% and lowland 14.0%. Significantly higher prevalence was recorded in highland agroecological zone. A significantly (OR = 0.041, $p < 0.001$) higher prevalence of *M. ovinus* in the highland (31.7%) than in both the lowland (0%) and midland (1.9%) was observed. The risk of tick infestation in the lowland and midland was 9.883 times and 13.988 times higher than the risk in the highland, respectively. A significantly higher prevalence of *Ctenocephalides* species was encountered in both the lowland (OR = 4.738, $p = 0.011$) and midland (OR = 8.078, $p = 0.000$) than in the highland agro-ecological zone. However, a significant difference ($p = 0.191$) amongst agro-ecological zones was not found for the prevalence of *Linognathus* and *Sarcoptes* species. Statistically significant variation ($p > 0.05$) was never recorded in the prevalence of all the identified species of ectoparasites between male and female sheep hosts. However, a significantly ($p = 0.006$) higher prevalence of *B. ovis* was recorded between young and adult sheep. The risk of *B. ovis* infestation was 1.45 times higher in young than the adult sheep. Furthermore, a significantly ($p < 0.001$) higher prevalence of *M. ovinus*, *B. ovis* and *Sarcoptes* sp. was found between sheep with poor and a good body condition. The ever increasing threat of ectoparasites on overall sheep productivity and tanning industry in Ethiopia warrants urgent control intervention. Further studies on the role of ectoparasites in transmission of diseases to sheep, zoonotic importance, comparative prevalence and load, and the importance of sheep as alternative hosts in different agro-ecological zones, breeds and management systems in Ethiopia are recommended so as to design applicable control programme in the country.

Introduction

Ethiopia is home to 23.6 million sheep (CSA 2008), but the immense potential these numbers represent has yet to be realised due to a multitude of factors. Ectoparasites are very common and widely distributed in all agro-ecological zones in Ethiopia (Kumsa & Mekonnen 2011; Kumsa *et al*. 2012a). They are one of the major hindrances to the productivity of sheep in the country. Ectoparasites cause a wide range of health problems that confront the productivity of sheep. Lice, sheep keds, ticks, fleas and mange mites are reported to cause great preslaughter defects responsible for downgrading and rejection of sheep skins. It is reported that 35% of sheep and 56% of goat skin rejections in Ethiopia are attributed to ectoparasites (Kassa 2006). All these established facts imply that ectoparasites pose serious economic losses to the farmer, the tanning industry and the country as a whole (Berhanu *et al.* 2011; Chanie, Negash & Sirak 2010).

In Oromia, there are an estimated 9 401 844 sheep, representing 36.2% of the national sheep population (CSA 2008). The Oromia region supplies an estimated 32.9% of sheep skins to the central market of the country. The export of processed and semi-processed skins constitutes the second largest industry in Ethiopia. However, several recent reports indicate that over the last 10 years, the quality of raw materials has deteriorated with an increase of skin conditions associated with lice, keds, ticks and mange mite infestations (Berhanu *et al*. 2011; Chanie *et al.* 2010; Ermias 2000; Haffize 2001; Molu 2002; Sertse & Wossene 2007b). Despite these facts, few studies have been conducted on ectoparasites of sheep in the region. There is paucity of information in different agro-ecological zones of the region. Thus, the present study was undertaken with the objectives to determine the prevalence, identify the species and risk factors of ectoparasites of sheep in three agro-ecological zones in Oromia regional state in Ethiopia.

Materials and methods

Study area

The study was conducted from October 2009 to April 2010 on ectoparasites of sheep in three agro-ecological zones of Oromia regional state, Ethiopia. The selected study districts were Adami Tulu-Jiddo-Kombolcha, Akaki, and Sululta, representing lowland, midland and highland agro-ecological zones, respectively. Farming systems in these districts are characterised by mixed crop-livestock production systems. The livestock in the study areas are traditionally managed under extensive production systems.

Adami Tulu-Jiddo-Kombolcha is one of the districts of the east Showa zone of Oromia region which is found in the mid Rift Valley at 7°52′N and 38°42′E. The area is located 163 km south-east of Addis Ababa with an average altitude of 1650 m a.s.l. It experiences a bimodal, unevenly distributed pattern of rainfall with a long rainy season from July to September and a short rainy season from February to April, and with an average annual rainfall of 760.9 mm. The average minimum and maximum temperatures are 16.6 °C and 29.4 °C. The livestock populations of the area are estimated to be 212 415 cattle, 34 899 sheep, 116 585 goats, 25 619 equines and 130 247 poultry.

Akaki, the second study district, is located at an average altitude of 1900 m a.s.l., south-east of Addis Ababa. It is one of the districts of the Eastern Showa administrative zone of Oromia. Akaki district lies between 8°44′N and 35°58′E. The area has an annual rainfall ranges from 800 mm to 1000 mm with two rainy seasons, a short rainy season that occurs between March and May, and the main rainy season between June and September. The average minimum and maximum temperatures are 13.5 °C and 25.8 °C. The livestock population of the area is 69 107 cattle, 18 970 sheep, 23 409 goats, 23 937 equines and 126 865 poultry.

Sululta, the third study district, representing a highland altitude, is found in the central highlands of Ethiopia with location between 9°13′–10°57′N and 37°57′–39°33′E. It is located 40 km north of Addis Ababa at an average altitude of 2550 m a.s.l. Sululta is one of the districts of North Showa zone of Oromia region. The area receives mean annual rainfall that varies between 834 mm and 1447 mm. The mean minimum and maximum temperatures of the area are 4.4 °C and 22.5 °C. The district's livestock population is estimated at 210 210 cattle, 80 900 sheep, 16 491 goats, 32 862 equines and 75 936 poultry.

Study design

A cross-sectional study was used to investigate the occurrence of ectoparasites in sheep and associated risk factors. Simple and systematic random sampling methods were employed. The study districts were selected because of their representation of different agro-ecological zones. Five, seven, and six peasant associations from Adami Tulu-Jiddo-Kombolcha, Akaki, and Suluta districts, respectively, were randomly selected using a lottery system. The study animals were randomly selected using a systematic sampling technique from traditionally managed sheep populations in the respective areas.

Sample size determination

Sample size was determined as described by Thrusfield (2005). Accordingly, 50% expected prevalence of ectoparasites infestations in each study agro-ecology, 5% acceptable error and 95% confidence level were applied to determine the sample size of study sheep in each study agro-ecology. Based on this and the livestock population of each study agro-ecology 299, 364 and 662 sheep from lowland, midland and highland, respectively, were examined for ectoparasites.

Clinical examination

A total of 1325 sheep from the three agro-ecological zones were clinically examined for the presence of external parasites and gross skin lesions. The sex, age and body condition of each sheep was recorded. The animals were categorized into two age groups, as young (up to one year) and adult (older than one year), as described by Gatenby (1991). Age was determined as indicated by owners and estimated by dentition. Body condition scores were determined by modifying the system of Gatenby (1991) for sheep as either poor or good. A poor body condition score was given for sheep which were extremely thin, having prominent spinous and transverse processes into which a finger could be easily pushed and had less depth of loin muscle. A good body condition score was given for sheep when the spinous and transverse processes were smooth, rounded and well covered and with full loin muscle.

Clinical examination of each sheep was performed by multiple fleece partings in the direction opposite to that in which hair or wool normally rests, followed by physical inspection of the skin. The skin was palpated across all parts of the animal for the presence of parasites, and gross lesions suggestive of a clinical form of parasitic infestations. Animals found infested were considered positive.

Ectoparasite collection and identification

Sheep keds, ticks, lice and fleas were collected manually from their sites of attachment. The ticks were removed from the host skins whilst retaining their mouth parts for identification using forceps. Coat brushing techniques were used for collection of lice. They were placed in labelled universal bottles containing 70% ethanol and identified under a stereoscopic microscope according to the descriptions of Okello-Onen, Hassan and Essuman (1999) and Walker *et al.* (2003) (ticks) and Urquhart *et al.* (1996) and Wall and Shearer (1997) (lice, fleas and keds).

In addition, skin scrapings were taken from sheep suspected of mange. This was done by clipping the hair around affected areas, scraping the edges of the lesion with a scalpel blade as described by Urquhart *et al*. (1996) until capillary oozing was evident. The scraped materials were transferred to a container and were taken for laboratory examination. A few drops of 10% potassium hydroxide were added to the skin scrapings, allowed to stand for 30 min and examined under a light microscope at 40X magnification (Cole 1986). The mange mites were identified according to the morphological keys of Wall and Shearer (1997).

Data analysis

Microsoft Excel was used for data management. Statistical software SPSS version 15.5 for windows was used for data analysis. Descriptive statistics such as prevalence and 95% confidence intervals were used to summarise the proportions of infested and non-infested sheep. The effects of different epidemiological risk factors on the prevalence and distribution of ectoparasites were analysed using binary logistic regression method. Statistical significance was set at $p < 0.05$.

Ethical considerations

Ethical approval for the collection of ectoparasites from sheep was obtained from the animal research ethics board (Agreement # 07/160/550/2009) of the College of Veterinary Medicine and Agriculture of Addis Ababa University.

Results

Overall prevalence

A total of 1325 sheep from the three agro-ecological zones were examined for the presence of ectoparasites. An overall prevalence of 48.1% (637) of ectoparasites was recorded in sheep of the three agro-ecological zones. The overall prevalence of species of ectoparasites identified were *Bovicola ovis* (27.2%), *Melophagus ovinus* (16.4%), *Ctenocephalides* spp. (2.3%), *Linognathus africanus* (1.2%), *Linognathus ovillus* (0.3%), *Sarcoptes* spp. (1.2%), three genera and seven species of ixodid ticks, *Amblyomma variegatum* (4.4%), *Rhipicephalus evertsi evertsi* (1.9%), *Rhipicephalus pravus* (1.9%), *Rhipicephalus* (*Boophilus*) *decoloratus* (1.1%), *Rhipicephalus sanguineus* (0.9%), *Rhipicephalus praetextatus* (1.1%), and *Hyalomma truncatum* (1.6%) were identified. *Bovicola ovis* was the most common ectoparasite on the sheep (Table 1).

Prevalence by agro-ecological zone

The overall prevalence of ectoparasites in lowland, midland and highland regions was 38.5%, 47.3% and 52.9%, respectively. The prevalence of each species of ectoparasites in each agro-ecological zone is shown in Table 1. The binary logistic regression analysis results of the effect of agro-ecological zone on prevalence of ectoparasites of sheep are shown below (Tables 3–8). Significantly (OR = 0.041, $p < 0.001$) higher prevalence of *M. ovinus* in the highlands than both the lowlands and midlands was observed (Table 3). A statistically significant difference in the prevalence of *B. ovis* was observed between lowlands and highlands (OR = 0.235, $p < 0.001$), midlands and highlands (OR = 0.460, $p < 0.001$), and lowlands and midlands (OR = 0.510, $p = 0.002$) (Table 4). Significantly higher prevalence was recorded in the highland agroecological zone. A significantly higher prevalence of tick infestation in both lowlands (OR = 9.883, $p < 0.001$) and midlands (OR = 13.988, $p < 0.001$) than the highland agro-ecological zone was recorded (Table 6). However, statistically significant variations in the prevalence of *Linognathus* species and *Sarcoptes* spp. amongst the agro-ecological zones were not observed ($p > 0.05$) (Table 5 and 7). A significantly higher prevalence of *Ctenocephalides* species was encountered in both the lowland (OR = 4.738, $p = 0.011$) and midland (OR = 8.078, $p = 0.000$) zones than in the highland agro-ecological zone (Table 8).

Prevalence by sex, age and body condition

The overall prevalence of ectoparasites in male and female sheep was, respectively 48.9% and 47.7%. The prevalence for each species of ectoparasites on a sex basis is shown in Table 2. Statistically significant variation was not ($p > 0.05$) observed in the prevalence of ectoparasites between male and female sheep, as shown in Tables 3–8.

TABLE 1: Prevalence of ectoparasites on sheep by agro-ecology in central Oromia.

Species of ectoparasites	Lowland ($n = 299$)		Midland ($n = 364$)		Highland ($n = 662$)		Overall ($n = 1325$) (%)	95%CI
	n	%	*n*	%	*n*	%		
Melophagus ovinus	0	0.0	7	1.9	210	31.7	16.4	14.5–18.3
Bovicola ovis	42	14.0	76	20.9	242	36.5	27.2	24.8–29.6
Linognathus africanus	6	2.0	6	1.6	4	0.6	1.2	0.8–2.2
Linognathus ovillus	0	0.0	2	0.5	2	0.3	0.3	0.4–1.7
Sarcoptes spp.	124	41.5	4	1.1	0	0.0	9.7	0.6–1.8
Rhipicephalus (Boophilus) decoloratus	4	1.3	5	1.4	6	0.9	1.1	0.5–1.7
Amblyomma variegatum	12	4.0	42	11.5	4	0.6	4.4	3.3–5.6
Rhipicephalus evertsi evertsi	5	1.7	20	5.5	0	0.0	1.9	1.2–2.6
Rhipicephalus praetextatus	5	1.7	10	2.7	0	0.0	1.1	0.5–1.7
Rhipicephalus pravus	17	5.7	8	2.2	0	0.0	1.9	1.2–2.6
Rhipicephalus sanguineus	2	0.7	10	2.7	0	0.0	0.9	0.4–1.4
Hyalomma truncatum	10	3.3	7	1.9	4	0.6	1.6	0.8–2.4
Ctenocephalides spp.	9	3.0	17	4.7	4	0.6	2.3	1.5–3.1

n, used as means of numbers; CI, confidence interval.
$n = 1325$.

The overall prevalence of ectoparasites in young and adult sheep was respectively 50.9% and 46.3% (Table 1). A statistically significant difference was not ($p > 0.05$) observed in the prevalence of *M. ovinus*, *Linognathus* species, tick infestations, *Sarcoptes* spp. and *Ctenocephalides* species infestation between young and adult sheep (Table 3, 5, 6, 7 and 8). However, a significantly (OR = 1.450, $p = 0.006$) higher prevalence of *B. ovis* was observed in young than in adult sheep (Table 4). The risk of *B. ovis* infestation was 1.45 times higher in young than the adult sheep.

The overall prevalence of ectoparasites in sheep with poor and good body condition was 62.8% and 42.4%, respectively (Table 2). The binary logistic regression analysis results of the effect of body condition scores on prevalence of ectoparasites of sheep are shown in Tables 3–8. In this study, a significantly higher prevalence of *M. ovinus* (OR = 0.379, $p = 0.000$), *B. ovis* (OR = 2.251, $p = 0.000$) and *Sarcoptes* spp. (OR = 6.074, $p = 0.003$) was recorded in sheep with poor than good body condition (Table 3, 4 and 7). Sheep with poor body condition were 2.251 times more at risk of infestation than those with good condition. However, a significant variation was not ($p > 0.05$) observed in the prevalence of *Linognathus* species, ticks and *Ctenocephalides* species between sheep with poor and good body condition (Table 5, 6 and 8).

Discussion

In this study an overall prevalence of 48.1% of ectoparasites indicate the great importance and widespread occurrence of ectoparasites in sheep in the study districts. This finding is in line with previous reports of high prevalence of ectoparasites in small ruminants from different parts of Ethiopia (Mulugeta 2008; Sertste & Wossene 2007a; Teshome 2002) and other countries of the world (Mohammed & Ali 2006; Rahbari, Nabian & Bahohar 2009). This finding is most probably attributable to several important factors including conducive environment, malnutrition and poor husbandry systems, poor awareness of farmers and inadequate veterinary services in study districts (Mekonnen, Hussein & Bedane 2001; Mekonnen *et al*. 2007; Pegram, Hoogstral & Wassef 1981).

The prevalence of lice (28.7%) recorded in the present study is higher than the findings of Haffize (2001), who reported 2% in sheep in central Ethiopia. But this prevalence is lower than those recorded in the eastern part of Amhara region, namely 39.8% in sheep (Sertste & Wossene 2007a) and 30.5% in sheep in the south-eastern parts of Tigray (Mulugeta 2008). Such variations in prevalence might arise from differences in agro-ecology, the season during which the study was conducted, the management and health care of sheep in the study areas and the sensitivity of the diagnostic techniques employed. Louse infestations may indicate some other underlying problems such as malnutrition and chronic diseases (Chalachew 2001; Wall & Shearer 1997). The highest prevalence of *B. ovis* recorded in the highland agro-ecological zone in the current study is in line with the earlier reports of Mulugeta (2008), Sertste and Wossene (2007a) and Bekele, Tariku and Abebe (2011). This is due to the requirements of low temperatures by this louse. The observation of significantly higher prevalence of *B. ovis* in young sheep is explained by the chances of transfer of lice from ewes to lambs. Similarly, it has been indicated that young animals are generally more susceptible to ectoparasites due to underdeveloped immunity, a higher ratio of accessible surface to the body volume and poor grooming behaviour (Wallaga 1997).

The prevalence of *M. ovinus* recorded in the present work is comparable with the findings of Sertste and Wossene (2007a) who reported 12.5% infestation and Mulugeta (2008) infestation levels of 19.1%. The significant variation amongst agro-ecological zones of this parasite is in line with earlier studies made in other parts of Ethiopia (Molu 2002; Mulugeta 2008; Numery 2001; Sertse & Wossene 2007a). *Melophagus ovinus* is restricted to cooler highland areas in tropical countries.

The findings of three genera and seven species of ixodid ticks on sheep of the current study is in line with the previous works conducted by Wallaga (1997), Abunna *et al.* (2009), Abera *et al.* (2010) and Bekele *et al*. (2011) who reported the infestation of sheep by several species of ixodid ticks in different parts of Ethiopia. The observation of significantly ($p < 0.05$) higher prevalence of ixodid tick infestations in the midland (23.1%) and lowland (17.1%) zones than in the highland (2.1%) agro-ecological zone of the current study is most probably attributable to higher temperatures and relative humidity and prolonged sunlight in the midland and lowland zones that favour the survival and reproduction of these ticks, as has been suggested by Pegram *et al*. (1981) and Kumsa *et al*. (2012a).

The prevalence (1.2%) of *Sarcoptes* spp. recorded in the present study is in agreement with previous observations

TABLE 2: Prevalence of ectoparasites on sheep by sex, age and body condition in central Oromia.

Ectoparasite	Sex				Age				Body condition			
	Male (n = 370)		Female (n = 955)		Young (n = 515)		Adult (n = 810)		Poor (n = 368)		Good (n = 957)	
	n	%	n	%	n	%	n	%	n	%	n	%
Melophagus ovinus	69	18.6	148	15.5	91	17.7	126	15.5	86	23.4	131	13.7
Bovicola ovis	110	29.7	250	26.2	165	32.0	195	24.1	139	37.8	221	23.1
Linognathus spp.	5	1.3	15	1.6	7	1.3	13	1.6	7	1.9	13	1.3
Sarcoptes spp.	1	0.3	15	1.6	6	1.2	10	1.2	12	3.3	4	0.4
Ticks	36	9.7	113	11.8	48	9.3	101	12.5	40	10.9	109	11.4
Ctenocephalides spp.	8	2.2	22	2.3	17	3.3	13	1.6	10	2.7	20	2.1

n, used as means of numbers.
n = 1325.

TABLE 3: Summary results of binary logistic regression for *Melophagus ovinus* on sheep in central Oromia.

Risk factors	Category of risk factor	Coefficients	SE	*P*-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology	Highland†	1.000	1.000	1.000	1.000	1.000	1.000
	Lowland	-20.461	2319.791	0.993	0.000	0.000	-
	Midland	-3.171	0.391	0.000	0.042	0.020	0.090
	Lowland	-17.443	2287.983	0.994	0.000	0.000	-
Sex	Female†	1.000	1.000	1.000	1.000	1.000	1.000
	Male	0.157	0.181	0.389	1.170	0.821	1.668
Age	Adult†	1.000	1.000	1.000	1.000	1.000	1.000
	Young	0.272	0.170	0.393	1.313	0.941	1.833
Body condition	Good†	1.000	1.000	1.000	1.000	1.000	1.000
	Poor	-0.970	0.181	0.000	0.379	0.266	0.541

SE, standard error; *P*-values, probability values; OR, odds ratio; CI, confidence interval.
n = 1325.
†, Reference category.

TABLE 4: Summary results of binary logistic regression for *Bovicola ovis* on sheep in central Oromia.

Risk factors	Category of risk factor	Coefficients	SE	*P*-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology	Highland†	1.000	1.000	1.000	1.000	1.000	0.000
	Lowland	-1.450	0.191	0.000	0.235	0.161	0.341
	Midland	-0.776	0.155	0.000	0.460	0.340	0.624
	Lowland	-0.674	0.216	0.002	0.510	0.334	0.779
Sex	Female†	1.000	1.000	1.000	1.000	1.000	0.000
	Male	0.078	0.144	0.591	1.081	0.814	1.434
Age	Adult†	1.000	1.000	1.000	1.000	-	1.000
	Young	0.372	0.134	0.006	1.450	1.115	1.886
Body condition	Good†	1.000	1.000	1.000	1.000	1.000	1.000
	Poor	0.811	0.141	0.000	2.251	1.708	2.965

SE, standard error; *P*-values, probability values; OR, odds ratio; CI, confidence interval.
n = 1325.
†, Reference category.

TABLE 5: Summary results of binary logistic regression for *Linognathus* spp. on sheep in central Oromia.

Risk factors	Category of risk factor	Coefficients	SE	*P*-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology	Highland†	1.000	1.000	1.000	1.000	1.000	1.000
	Lowland	0.768	0.587	0.191	2.155	0.682	6.809
	Midland	0.915	0.545	0.093	2.497	0.858	7.266
	Lowland	-0.148	0.555	0.790	0.863	0.291	2.561
Sex	Female†	1.000	1.000	1.000	1.000	1.000	1.000
	Male	-0.091	0.531	0.863	0.913	0.322	2.585
Age	Adult†	1.000	1.000	1.000	1.000	1.000	1.000
	Young	-0.219	0.486	0.652	0.803	0.310	2.083
Body condition	Good†	1.000	1.000	1.000	1.000	1.000	1.000
	Poor	0.354	0.485	0.465	1.425	0.551	3.688

SE, standard error; *P*-values, probability values; OR, odds ratio; CI, confidence interval.
n = 1325.
†, Reference category.

TABLE 6: Summary results of binary logistic regression for ticks on sheep in central Oromia.

Risk factors	Category of risk factor	Coefficients	SE	*P*-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology	Highland†	1.000	1.000	1.000	1.000	1.000	1.000
	Lowland	2.291	0.313	0.000	9.883	5.351	18.253
	Midland	2.638	0.298	0.000	13.988	7.801	25.081
	Lowland	-0.347	0.202	0.086	0.707	0.476	1.050
Sex	Female†	1.000	1.000	1.000	1.000	1.000	1.000
	Male	-0.112	0.215	0.603	0.894	0.586	1.363
Age	Adult†	1.000	1.000	1.000	1.000	1.000	1.000
	Young	-0.391	0.198	0.048	0.677	0.459	0.997
Body condition	Good†	1.000	1.000	1.000	1.000	1.000	1.000
	Poor	0.041	0.210	0.844	0.960	0.636	1.447

SE, standard error; *P*-values, probability values; OR, odds ratio; CI, confidence interval.
n = 1325.
†, Reference category.

TABLE 7: Summary results of binary logistic regression for *Sarcoptes* spp. in sheep in central Oromia.

Risk factors	Category of risk factor	Coefficients	SE	*P*-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology	Highland†	1.000	1.000	1.000	1.000	1.000	1.000
	Lowland	17.639	1478.740	0.990	45743526.889	0.000	-
	Midland	16.699	1478.740	0.991	17880733.618	0.000	-
	Lowland	0.939	0.601	0.118	2.558	0.787	8.315
Sex	Female†	1.000	1.000	1.000	1.000	1.000	1.000
	Male	-1.667	1.056	0.114	0.189	0.024	1.496
Age	Adult†	1.000	1.000	1.000	1.000	1.000	1.000
	Young	-0.101	0.543	0.852	0.904	0.312	2.619
Body condition	Good†	1.000	1.000	1.000	1.000	1.000	1.000
	Poor	1.804	0.601	0.003	6.074	1.872	19.714

SE, standard error; *P*-values, probability values; OR, odds ratio; CI, confidence interval.
n = 1325.
†, Reference category.

TABLE 8: Summary results of binary logistic regression for *Ctenocephalides* spp. on sheep in central Oromia.

Risk factors	Category of risk factor	Coefficients	SE	*P*-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecological	Highland†	1.000	1.000	1.000	1.000	1.000	1.000
	Lowland	1.556	0.608	0.011	4.738	1.439	15.604
	Midland	2.089	0.561	0.000	8.078	2.691	24.252
	Lowland	-0.534	0.428	0.213	0.586	0.253	1.357
Sex	Female†	1.000	1.000	1.000	1.000	1.000	1.000
	Male	-0.178	0.429	0.678	0.837	0.361	1.939
Age	Adult†	1.000	1.000	1.000	1.000	1.000	1.000
	Young	0.725	0.385	0.059	2.065	0.972	4.389
Body condition	Good†	1.000	1.000	1.000	1.000	1.000	1.000
	Poor	0.206	0.405	0.611	1.229	.556	2.718

SE, standard error; *P*-values, probability values; OR, odds ratio; CI, confidence interval.
n = 1325.
†, Reference category.

made in other parts of the country by Kedir (2002) who reported 0.7% infection in sheep from Dire Dawa, Worku (2002) rates of 2.1% in sheep from Sidama zone and Sertse and Wossene (2007a) infection rates of 0.4% in sheep from the eastern part of Amahara. The higher prevalence of *Sarcoptes* spp. in sheep with poor (3.3%) body condition than those with good (0.4%) body condition is in agreement with the previous works of Habte (1994), Chalachew (2001), Haffize (2001), Kedir (2002), Molu (2002), Sertse and Wossene (2007a) and Bekele *et al*. (2011). Animals with poor body condition are more susceptible to mange mites (Fthenakis *et al*. 2001; Heath *et al.* 1996).

Ctenocephalides species was encountered as one of the ectoparasites of sheep of the present study. This observation is similar to previous studies of Mulugeta (2008) and Bekele *et al*. (2011), who reported fleas from sheep in different parts of Ethiopia. The higher prevalence of *Ctenocephalides* species in the lowlands (3.0%) and midlands (4.7%) than in the highlands (0.6%) was most probably associated with the high humidity, usually above 70%, required by fleas. Similar observations were also reported by Chalachew (2001), Teshome (2002), Yalew (2007), Sertse and Wossene (2007a), Mulugeta (2008), Chanie *et al*. (2010) and Bekele *et al*. (2011).

Several health problems, welfare issues and losses in productivity due to blood loss, pain, lameness, irritation, debilitation, mechanical damage, inflammation and hypersensitivity, secondary complications and transmission of pathogenic agents to sheep in the current study areas are possibly associated with the ectoparasites identified, as has been described by Kok and Fourie (1995), Jongejan and Uilenberg (2004) and Mekonnen *et al*. (2007). For instance, Walker *et al*. (2003) have described *R. (B.) decoloratus* as a vector of *Borrelia theileri* in ruminants and horses. In addition, Kumsa *et al*. (in press) recently reported molecular detection of zoonotic bacteria pathogenic to humans from *M. ovinus* and *B. ovis* of sheep and other lice of ruminants in Ethiopia. The other ectoparasites such as ticks are well-known vectors of piroplasmosis and rickettsial diseases of ruminants, zoonotic rickettsial, and viral diseases (Kumsa *et al*. 2012a; Mekonnen *et al*. 2007; Pegram *et al*. 1981; Walker *et al*. 2003). In view of these facts, ectoparasites should play a role in the transmission of pathogenic organisms to sheep of the study areas.

Conclusion

In view of the findings of the present study it is possible to conclude that several species of ticks, lice, fleas and *M. ovinus* represent common health and productivity problems of sheep in Central Oromia. The growing threat of ectoparasites on overall sheep productivity and tanning industry in Ethiopia warrants urgent control intervention. As a result, detailed studies on the significance and role of different species of ectoparasites as vectors of diseases of sheep in different agro-ecological zones, breeds and management systems warrant urgent attention. Animal owners and veterinarians in Ethiopia should consider ectoparasite control in sheep as part of the ectoparasite control in other species of animals.

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Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this paper.

Authors' contributions

B.K. (Addis Ababa University) was the project leader and designer in addition to draft preparation of the manuscript, editing and providing valuable comments on the manuscript. K.B. (Alage Agricultural Technical Vocational and Educational Training College) was responsible for data collection and laboratory work. M.G. (Addis Ababa University) made conceptual and editorial contributions and performed some statistical work.

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