

**STUDY ON THE PREVALENCE OF OVINE ECTOPARASITES AND
ASSOCIATED RISK FACTORS IN SELECTED ECTOPARASITE CONTROLLED
AND UNCONTROLLED AREAS OF ARSI ZONE, OROMIYA REGION**



MSc Thesis

By

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of Parasitology and Pathology**

JUNE, 2014

BISHOFTU, ETHIOPIA

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As members of the Examining Board of the final MSc open defense, we certify that we have read and evaluated the Thesis prepared by: **Hailegebreal Bedada** Entitled: **Study on the Prevalence of Ovine Ectoparasite and Associated Risk Factors in Selected Ectoparasite Controlled and Uncontrolled Areas of Arsi Zone, Oromiya Region**. And recommend that it be accepted as fulfilling the thesis requirement for the degree of: Masters of Tropical Veterinary Parasitology.

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STATEMENT OF AUTHOR

First, I declare that this thesis is my private work and that all sources of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for an advanced MSc degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University/College library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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Table of Contents	PAGE
STATEMENT OF AUTHOR	i
ACKNOWLEDGMENTS.....	ii
LIST OF TABLES	v
LIST OF FIGURES.....	vi
ANNEXS.....	vii
ABBREVIATIONS	viii
<i>ABSTRACT</i>	ix
1. INTRODUCTION.....	1
2. LITERATURE REVIEW	3
2.1. Importance of ectoparasites.....	3
2.2. Major ectoparasites of sheep	4
2.2.1. <i>Mange mites</i>	5
2.2.2. <i>Tick infestation</i>	11
2.2.3. <i>Sheep Keds</i>	13
2.2.4. <i>Lice infestation</i>	15
2.3. Economic importance of Ectoparasites	19
2.4. Management Strategies of Ectoparasites.....	22
2.4.1. <i>Physical Control</i>	22
2.4.2. <i>Biosecurity</i>	24
2.5.3. <i>Biological Control</i>	24
2.4.4. <i>Chemical Control</i>	25
2.5. The Status of Sheep Parasitic Skin Diseases in Ethiopia	25
2.5.1. <i>Mange mites</i>	26
2.5.2. <i>Lice</i>	28
2.5.3. <i>Ticks</i>	29
2.5.4. <i>Sheep Ked</i>	30
3. MATERIAL AND METHODS	31
3.1. Study Area and Population.....	31
3.2. Sampling Method and Sample Size Determination.....	33
3.3. Study Design	34
3.4. Clinical Examinations	35

3.5. Sample Collection	35
3.6. Questionnaire Survey	36
3.7. Laboratory Examination.....	37
3.8. Data Analysis	37
4. RESULTS.....	38
4.1. Questionnaire Study Outputs.....	38
4.2. Results of Clinical and Laboratory Examination of Sheep for Ectoparasites.....	43
4.2.1. Prevalence of Ectoparasites by Control Status	45
4.2.2. Prevalence of Ectoparasites by Sex.....	47
4.2.3. Prevalence of Ectoparasites by Age	47
4.2.4. Prevalence of Ectoparasites by Body Condition	48
4.2.5. Prevalence of Ectoparasites by Hair Size/Type	49
4.2.6. Prevalence of Ectoparasites by Management	49
5. DISCUSSION	51
6. CONCLUSION AND RECOMMENDATIONS	57
7. REFERENCES.....	59
8. ANNEXS.....	70

LIST OF TABLES**PAGE**

Table 1: Overall prevalence of mange from different parts of the country.....	26
Table 2: Overall prevalence of lice from different parts of the country.....	28
Table 3: Overall prevalence of tick from different parts of the country.....	29
Table 4: Overall prevalence of keds from different parts of the country.....	30
Table 5: Agro-climatic zone of the study area (Arsi).....	32
Table 6: Description of each district of study area for sheep ectoparasites.....	34
Table 7: Response on the effects of ectoparasites on the sale of infected sheep and their skin.....	41
Table 8: Response of skin collectors on the parameters they set to collect sheep skin.....	44
Table 9: Prevalence of ectoparasites in controlled and uncontrolled areas.....	45
Table 10: Summary of binary logistic regression of ectoparasites according to control status.....	47
Table 11: Prevalence of ectoparasites in controlled and uncontrolled area by sex.....	48
Table 12: Prevalence of ectoparasites in controlled and uncontrolled area by age.....	49
Table 13: Prevalence of ectoparasites in controlled and uncontrolled area by body condition.....	49
Table 14: Prevalence of ectoparasites in controlled and uncontrolled area by hair type.....	50
Table 15: Prevalence of ectoparasites in controlled and uncontrolled area by management..	51

LIST OF FIGURES	PAGE
Figure1: Map of Arsi Zone.....	33
Figure 2: Response on seasonal occurrence of tick, keds and mange in uncontrolled area ...	40
Figure 3: Proportions of respondent treatment method prefer to treat ectoparasite in controlled area.....	41
Figure 4: Proportion of respondent treatment method prefer to treat ectoparasites in uncontrolled area.....	42
Figure 5: Overall prevalence of ectoparasites in controlled and uncontrolled area.....	47

ANNEXS	PAGE
Annex 1: Laboratory procedures	71
Annex 2: Format for field sample collection.....	72
Annex 3: Body condition score.....	73
Annex 4: Questionnaire for sheep owners.....	75
Annex 5: Questionnaire for the hide and skin collectors.....	80
Annex 6: Summary of questionnaire study of controlled and uncontrolled area.....	81
Annex 7: Summary of questionnaire study of hide and skin collector of both area.....	88
Annex 8: Summary results of binary logistic regression for overall ectoparasite.....	92
Annex 9: Summary results of binary logistic regression for ectoparasite in controlled area.....	92
Annex 10: Summary results of binary logistic regression for ectoparasite in uncontrolled area.....	93
Annex 11: Summary results of binary logistic regression for lice in controlled area.....	93
Annex 12: Summary results of binary logistic regression for lice in uncontrolled area.....	94
Annex 13: Summary results of binary logistic regression for <i>M. ovinus</i> in controlled area.....	94
Annex 14: Summary results of binary logistic regression for <i>M. ovinus</i> in uncontrolled area.....	95
Annex 15: Summary results of binary logistic regression for tick in controlled area.....	95
Annex 16: Summary results of binary logistic regression for tick in uncontrolled area.....	96
Annex 17: Picture of flock of sheep infested with <i>B. ovis</i> and collected skin.....	97

ABBREVIATIONS

ACTESA	Alliance for Commodity Trade in Eastern and Southern Africa
CACC	Central Agricultural Census Commission
FEDD	Financial and economic development department
GDP	Gross Domestic Product
ILRI	International Livestock Research Institute
IPM	Integrated Parasite Management
MoARD	Ministry of Agriculture and Rural Development
MoTI	Ministry of Trade and Industry
NWRD	Natural water resource development
UNECA	United Nations Economic Commission for Africa
UNIDO	United Nations Industrial Development Organization

ABSTRACT

A cross-sectional study was conducted from October 2013 to May 2014 with the objectives to estimate the prevalence of ectoparasites of sheep in ectoparasites controlled and uncontrolled area, assess major risk factors as well as evaluate effect of ectoparasites on livelihood of farmer in ectoparasites controlled and uncontrolled areas of Arsi Zone, Oromiya Region. A total of 969 sheep (646 sheep from controlled area and 323 sheep from uncontrolled area) were examined for presence of ectoparasites. Accordingly, from controlled area 371 (57.43%) and from uncontrolled area 285 (88.24%) were infested with one or more ectoparasites. The ectoparasites identified from controlled area were *B. ovis* 48.9%, *Linognathus spp* 0.93%, sheep keds 7.4%, 2.32% *B(R). decoloratus*, 1.46% *A. variegatum*, 1.08 % *A. gemma*, 4.59% *R. evertsi evertsi*, and 0.31% mixed tick infestation and 12.5% mixed infestation. The ectoparasites identified from uncontrolled area were *B. ovis* 81.4%, *Linognathus spp* 0.9%, 1.79% *B(R). decoloratus*, 2.62% *A. variegatum*, 9.29% *R. evertsi evertsi*, 4.3% mixed tick infestation and 32.2% mixed infestation. The risk of ectoparasite infestation in sheep of uncontrolled area were 5.644 times higher than controlled area sheep (OR=5.644, p=.000). Significantly higher prevalence of lice, tick and keds infestation in the uncontrolled area than the controlled area was recorded. The risk of lice, keds and tick infestations in uncontrolled area was 7.061, 3.836 and 2.074 times higher than controlled area respectively. Age and management related variation was not observed in the prevalence of ectoparasite in both controlled and uncontrolled area. Significantly (OR=0.455, p=0.000) higher prevalence of overall ectoparasite infestation in the female sheep of controlled area than the male was observed. Female sheep in controlled area were 1.129 times at higher risk for lice infestation than male. Significantly higher prevalence of keds in controlled (OR=0.081, p=0.000) and in uncontrolled area (OR=0.715, p=0.000) on wooly than hairy sheep was recorded. The logistic regression results showed significant higher prevalence of tick infestations in female sheep (OR=1.861, p=0.000) and poor body condition sheep (OR= 0.478, p=0.015) of uncontrolled area. Female sheep and poor body condition sheep of uncontrolled area were 1.861 and 0.478 times at higher risk for tick infestation than male and good body condition sheep respectively. Favorable climatic

conditions, poor husbandry and animal management, lack of awareness by farmers, and weak animal health extension services are believed to have contributed for widespread distribution and occurrences of ectoparasites. Higher prevalence of ectoparasites observed in the controlled area put under question the effectiveness of ectoparasites control in selected districts of Oromiya Region. The growing threat of ectoparasites to small ruminant production and the tanning industry needs well-coordinated, appropriate and urgent control intervention.

Key words: Controlled/uncontrolled, Arsi Zone, Ectoparasites, Sheep, Oromiya.

1. INTRODUCTION

Ethiopia is currently considered the tenth largest livestock producer and biggest exporter of livestock in Africa. Small ruminants represent the most important part of the Ethiopian livestock system; about 24.2 million sheep are estimated to be found in the country (CSA, 2012). In Ethiopia sheep is reared in all agro climatic zones. The highland area comprises 70% of the sheep, while the lowland pastoral and agro pastoral area have 30% of the sheep population (Degume, 2002). Agriculture is the mainstay of the Ethiopian economy. It employs over 80% of the adult population and account for 45% of the GDP and 85% of the export earnings. Livestock production performs several functions primarily as source of household incomes, food and animal drought power for livestock producers (UNECA, 2012). However, the current levels of contributions of sheep in Ethiopia, either the macro or micro level is below the expected potential. Among major constraints hindering the productivity of sheep in the country are diseases, among which sheep skin diseases caused by ectoparasites accounts a wide range of health problems that confront the productivity. Ectoparasites are very common and widely distributed in all agro-ecological zones in Ethiopia (Berhanu *et al.*, 2007; Kumsa *et al.*, 2012; Yacob, 2014).

Skin diseases caused by lice, keds, ticks, and mange mites; are among the major diseases of sheep causing serious economic loss to small holder farmer, the tanning industry and the country as a whole. Skin diseases cause mortality, decreased production and reproduction; in addition to these, currently skin diseases affecting the tanning industry very seriously causing enormous down grading and rejection of skins and hides (Bayou, 1998; ESGPIP, 2010; Yacob, 2013). It is reported that 35% of sheep skin rejections in Ethiopia are attributed to ectoparasites (Bayou, 1998; Kassa 2005). 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.*, 2007; ESGPIP, 2009; Chanie, *et al.*, 2010).

The control program against ectoparasites and skin diseases have been designed by the Ministry of Agriculture and Rural Development of Ethiopia (MoARD) in 2005 and launched in Tigray, Amhara and Afar regions. In Oromia regional state this activity started in 2010 and still ongoing. Despite such national and regional efforts and emphasis given to the control programs against ectoparasites as some reports from north-west Amhara region indicate the problem seems to be still alarming (Sisay *et al.*, 2013; Yacob, 2014).

According to Demissie *et al* (2000); Asnake *et al* (2013) and Yacob (2014), in many part of the Ethiopia, skin diseases due to ectoparasite have prevented many farmers from keeping sheep and becoming serious threat to sheep production. Despite the large population of sheep in the region, ectoparasites are also among serious problems in Arsi zone of Oromiya region (Hailu, 2010). Even though the Oromiya Regional State has started control program against ectoparasites in some selected districts of east and west Arsi zone, the impact of this control program on the status of ectoparasitism was not yet studied.

Therefore, the objectives of this study were;

- Estimate the prevalence and burden of major ectoparasites of sheep in selected districts of ectoparasite controlled and uncontrolled areas of Arsi zone in Oromiya Regional State.
- Identify and assess the major risk factors associated with the infestation of these ectoparasites of sheep of the study area.
- To assess the effect of ectoparasites on livelihood of the farmers and skin cost during collection and brought to the tannery

2. LITERATURE REVIEW

2.1. Importance of ectoparasites

As a result of their activity, arthropod ectoparasites may have a variety of direct and indirect effects on their hosts. The effect of skin parasitism usually depends on the size of invading population, on the manner on which the parasite ekes out its existence and the state of nutrition of the host animal when infected (Peter, 1995). The damage ectoparasite inflict may be mechanical, but the situation is complicated also by host reactions to the presence of the particular parasite, their secretion and excretion (Peter, 1995). Young animals are generally more susceptible to ectoparasites because of higher ratio of accessible surface to the body volume and poor grooming behavior (Lehmann, 1993).

According to Wall and Shearer (2001), the direct and indirect harm caused by ectoparasites on the host includes;

Blood loss: although each individual ectoparasite only removes a small volume of blood from a host, in large numbers the blood removed by feeding may be directly debilitating and anemia is common in heavily infested hosts. In one study in USA over 90 kg of blood was estimated to have been removed by ticks from a cow over a single season.

Myiasis: the infestation of the living tissues with fly larvae causes direct damage to carcasses or skin.

Skin inflammation and pruritus: various ectoparasite infestations cause pruritus, often accompanied by hair and wool loss (alopecia) and occasionally by skin thickening (lichenification). The presence of ectoparasite on or in burrowing into the skin can stimulate keratinocytes to release cytokines (IL-1) which leads to epidermal hyperplasia and cutaneous inflammation. The antigen produced by ectoparasites (e.g. salivary and faecal) can in some individual stimulate an immune response leading to hypersensitivity.

Toxic and allergic responses: caused by antigen and anticoagulant in the saliva of blood feeding arthropod.

Disturbance: the irritation caused, particularly by flies as they attempt to feed or oviposit, commonly result in a varieties of behaviors such as head shaking, stamping, skin twitching, tail switching or scratching. Sheep under attack from nasal bot flies may be seen pressing their nostrils to the ground before running short distance and repeating the action. These activities may result in reduced growth and loss of conditions because the time spent in avoidance behaviors is lost from grazing or resting.

Self-inflicted wounding: the activities of particular ectoparasites, such as warble flies, may cause dramatic avoidance responses in the intended host, known as gadding. The madly panicking animals may cause serious self-injuries following collision with fence and other objects.

Social nuisance: large number of flies may breed in animal dung, particularly in and around intensive husbandry units. The activities of flies may cause considerable social problems. Adult flies and their feces may also decrease the esthetic appearance and values of farm facilities and produce, such as hens' eggs, and cause irritation and annoyance to employees.

In addition to these effects, one of the most important roles of ectoparasites is in their action as vector of pathogens acting as either mechanical or / and biological vectors of protozoa, bacteria, viruses, cestodes and nematodes (Bay and Harris, 1988; Wall and Shearer, 2001). The direct damage caused by most ectoparasites is directly proportional to their abundance. This is not the case, however, for disease vectors, where even very low numbers of infected vectors may cause considerable economic and welfare problems.

2.2. Major ectoparasites of sheep

Ectoparasites, most of which are arthropods, are those parasites that live on the body of the host. Some spend their entire life on the host; others spend only parts of their life on the host, while still others only occasionally visit the host (Richard, 2001). Various ectoparasites cause significant infestations in many kinds of domestic animals including livestock, pets, laboratory animals, poultry, fish and bees. Many of these ectoparasites are host specific, while others parasitize wide range of hosts. The host supplies a source of food, which may be

blood, lymph, tear or sweat or the debris of the skin, hair or feather. The host body also provides the environment on which ectoparasites live, generating warmth, moisture and within the skin or hair, a degree of protection from the external environment. The host may also provide transportation from place to place for the parasite, a site at which to mate and, in many cases, the means of transmission from host to host (Wall and Shearer, 2001).

Ectoparasites are not associated with heavy mortalities in small ruminants but they are important causes of unthriftiness and loss of production in affected animals. According to Lughano and Dominic, (1996), the common ectoparasites of veterinary importance in Ethiopia are mange mite, lice, ticks and sheep keds.

2.2.1. Mange mites

Mange is a contagious skin disease, characterized by crusty, pruritic dermatitis and hair/feather loss, and caused by a variety of parasitic mites burrowing in or living on the skin (Lughano and Dominic, 1996; OIE, 2008). Mites can cause extensive and visible damage but cannot be seen by the naked eye. Mites inhabit the skin of mammals and birds, where they feed on blood, skin debris or sebaceous secretions, which they ingest by puncturing the skin, scavenging from the skin surface or imbibe from epidermal lesions. Most ectoparasitic mites spend their entire lives in intimate contact with the host. Mange is a widespread and most important ectoparasitic disease of animals, which may cause significant welfare problems and economic losses (Wall and Shearer, 1997; ESGPIP 2009).

The distribution of mites on animals varies according to season, the infection being quiescent in reservoir sites such as axillae, groin, infra-orbital fossa and auditory canal during spring, summer and early autumn (Urquhart *et al.*, 1996) and most outbreaks occur in cold months. High temperature, humidity and sunlight favor mange mite infestations (Pangui, 1994). Moist conditions favour the proliferation of the mite while desiccation is detrimental. As Lughano and Dominic (1996); Wall and Shearer (2001) poor nutrition and intercurrent infection increase the susceptibility of animals to mange mite. Clinically affected and carrier animals

are the source of infection. Transmission occurs by direct contact and contaminated fomites can be source of infection. Overcrowding of animals in house, markets, dips, and communal grazing land facilitates rapid spread of the parasite. Kids and lambs are more severely affected than adult animals (Lughano and Dominic, 1996). Some forms of mange such as demodectic mange, are the result of underlying diseases or immunosuppression. The disease affects all age groups and runs a more chronic course in adults than younger animals (Wall and Shearer, 1997).

According to Wall and Shearer (2001), the effects of mite infestations are:

- Direct epidermal damage leading to inflammation; this result in skin erythema, pruritus, scale formation, lichenification (thickening) and crust formation (inflammatory exudates) formation;
- The production of cutaneous hypersensitivity (especially type 1 hypersensitivity);
 - Loss of blood or other tissue fluid;
 - Mechanical or biological transmission of pathogens.

According to Sewell and Brockesby, (1990) mange cases due to *Sarcoptes* and *Psoroptes* are often fatal. The mortality rate is higher in younger and in poor condition animals. Death may be due to dehydration, a direct result of the feeding of huge number of mites, inability to move and feed due to severe lesions on the face, muzzle and on the joints or to secondary cases such as pneumonia or bacterial septicemia introduced through self-inflicted bite and scratch wounds (Roberts *et al.*, 1971). The clinical signs of erythema, pruritus and scale or crust formation are due to the inflammatory response of the skin and resulting excoriation. This response is stimulated by feeding, burrowing or the production of antigenic material by the mite (Wall and Shearer, 1997). According to Kassa *et al* (1998); Yacob *et al* (2008 part I); Bayou (1998), four genera of mites namely, *sarcoptes*, *psoroptes*, *demodex* and *chorioptes* were reported to affect sheep in Ethiopia.

Sarcoptic Mange

Sarcoptic mange occurs in all species of animal and is caused by mite *Sarcoptes scabiei* that has a number of host adapted sub species, distinguished by presence or absence of patches of dorsal and / or ventral spine, that affect different hosts but this host specificity is not complete and transference from one host species to another can occur (Radostits *et al.*, 1994).

This is chronic mange that may affect large areas of the body (ESGPIP 2009). Sarcoptic mange in sheep is caused by *Sarcoptes scabiei* var *ovis* (Okoh *et al.*, 1992; Olubunmi, 1995).

The female mites burrow deeply into the skin, laying eggs inside the burrows. The eggs hatch into the larval stage. The larval mites then leave the burrows, move up to the skin surface, and begin forming new burrows in healthy skin tissue. Developmental instars include egg, larva, protonymph, and tritonymph. Adult mites emerge on the surface of the skin after approximately 2 weeks. The male mite is reported to die after mating, although this has been disputed (Sewell and Brockesby, 1990; Radostits *et al.*, 1994; Shelley and Bart, 2007; OIE, 2008). *Sarcoptes* mange usually start on relatively hairless part of the skin and may latter generalize (Bowman, 1999; ESGPIP 2009). The course of Sarcoptic mange is rather more acute than the other forms of mange and may involve the entire body surface in a short time (Radostits *et al.*, 1994). The lesions resulting from infestations by these mites are a consequence of the reaction of the animals' immune system to the mites' presence. Because of the intensity of the animals' immunological response, it takes only a small number of mites to produce widespread lesions and generalized dermatitis (Shelley and Bart, 2007). As the skin becomes more damaged it loses its power to protect the animal against secondary bacterial infections (ESGPIP 2010).

Sarcoptic mange is highly contagious and the spread of *S. scabiei* is usually by close physical contact. As a result single cases are rarely seen in groups of animals kept together. Infestation may also occur by indirect transfer, since the mites have been shown to be capable of surviving off the host for short periods (Lughano and Dominic, 1996). The length of time that *S. scabiei* can survive off the host depends on environmental conditions but may be

between 2 and 3 weeks (Wall and Shearer, 1997). According to (Olubunmi, 1995) and (Shelley and Bart, 2007) sarcoptic mange was noticed throughout the year but the incidence was higher during the wet cold months where the moistness and temperature is optimum condition for mites' development.

Psoroptic Mange

Psoroptic mange, known as sheep scab, is highly contagious disease of sheep which caused by the mite, *Psoroptes ovis*. *Psoroptes* spp are non-burrowing mites puncture the epidermis, suck lymph and stimulate a local inflammatory reaction (Lunghon and Dominic, 1996; ESGPIP, 2009). The mite migrates to all part of the skin and prefers areas covered by wool or hair (Soulsby, 1982).

The whole life cycle is completed in 3 weeks (Soulsby, 1982). Infestation by these mites is always superficial on the epidermis, but the piercing of the skin by the mites lead to exudation and exfoliation, causing scabs to form (Sewell and Brockesby, 1990). *Psoroptes* spp infestation in sheep causes a highly contagious infection (also known as sheep scab) which is characterized by intense pruritus, restlessness, scratching and rubbing on the object and raised tufts of wool.

Sheep scab can affect sheep of all age group but may be particularly severe in young lambs.

Mites are usually more active in winter and the oviposition rate is higher at lower temperatures. In summer the disease progress more slowly, lesions are not obvious and can be missed. The disease can become latent in summer, apparently disappearing, with mites taking refuge in protected sites (Wall and Shearer, 1997). Some observers suggest that infra-orbital, inguinal pouches, scrotum, under tail, ears, inter digital pouches, perineum, and skin folds are foci for mites and serve as potential dry season hiding places where the mites tend to migrate to the general body surface with the onset of cold season (Roberts and Meleney, 1971). The short life cycle can contribute to a very rapid buildup of *P. ovis* populations. Scab mites are spread by direct contact and can survive for a period of up to 10 – 14 days off their

hosts (depending on the environmental conditions), allowing clean animals to become infested from contaminated housing (Wall and Shearer, 1997).

Chorioptic Mange

Chorioptic mange (tail, leg, scrotum mange) those on cattle, horse, and goats and sheep are now considered to be one species; *Chorioptic bovis* (Radostits *et al.*, 1994). This condition is often referred to as leg mange or foot mange because of the distribution of the lesions, which are usually limited to the lower limbs extending up the limbs to affect the scrotum in males or udder in females (ESGPIP, 2010). Chorioptic mange is generally characterized by the production of crusts and flaking especially on the backs of the feet, dermatitis, hair loss, and scabbiness in small areas around the feet, legs, and tail head. The skin underneath the affected areas becomes swollen and inflamed. Infestations by this mite are usually localized, although in some cases the lesions can spread to cause a more generalized dermatitis resembling sarcoptic mange (CAPC, 2013).

The life cycle of *Chorioptic bovis* is similar to *P. ovis*: egg, hexapod larva, followed by octopod protonymph, tritonymph and adult. *Chorioptes bovis* has mouthparts which do not pierce the skin of the host, but which are adapted for chewing skin debris. The complete life cycle takes about 3 weeks, during which time adult females may produce up to 17 eggs. Mites may survive for up to 3 weeks off the host, allowing transmission from housing and bedding as well as by direct contact (Peter, 1995; Wall and Shearer, 2001).

Demodectic Mange

Demodectic mange enters the hair follicles and sebaceous glands producing a chronic inflammation with proliferation and thickening of the epidermis and loss of hair. It can be a major cause of downgrading skin quality at the tannery. Demodex live as commensals,

embedded head down hair follicle, sebaceous and meibomian glands of the skin where they spend their entire lives. For the most part they are nonpathogenic and form a normal part of the skin fauna. Species of *Demodex* are unable to survive off their hosts (Richard, 2001; Wall and Shearer, 2001; OIE, 2008; ESGPIP, 2009). The disease is more severe in cattle and goats while it causes little concern in sheep; spreads slowly and transfer of mite is through contact probably early in life (Radostits *et al.*, 1994).

Species of *demodex* are unable to survive off their host. All stages of the life cycle (eggs, larvae, nymphs, adults) reside within the lumen of hair follicles and within sebaceous gland ducts; some species are more commonly found in the stratum corneum. One follicle may harbor all life cycle stages concurrently. Development from egg to adult takes approximately 20 to 35 days and is completed entirely on the host. Six-legged larvae hatch from fusiform-shaped eggs and undergo several molts to become eight-legged nymphs and ultimately adults. Adults are eight-legged, slender, and elongated mites; their appearance is often described as cigar-shaped (Wall and Shearer, 2001; CAPC, 2013).

Demodex species are very host specific, only rarely inhabiting more than one species of congeneric mammal host. However, it is not uncommon for a host species to harbor two to four different species of parasitic *Demodex*. Transfer between hosts occurs only by very close contact between individuals (most probably mother to neonate), Neonates are thought to typically acquire mites from the dam via direct skin-to-skin contact, but most individual animals do not develop clinical disease. Their very thin cuticles mean that demodecids cannot survive away from their hosts for more than a few hours; Most *Demodex* species are considered normal fauna (CAPC, 2013).

2.2.2. Tick infestation

Ticks are obligate, blood feeding ectoparasites of vertebrates, particularly mammals and birds and the most important group of ectoparasites, primarily because they feed on blood and tissue fluids in order to develop and because of the wide range of pathogenic agents that they transmit. In addition, they cause local irritation at the site of feeding, blood loss from severe infestations, wounds as sites for secondary infection, and tick paralysis (Wall and Shearer, 2001; William *et al.*, 2001). Ticks are divided into two families: Argasidae (soft bodied ticks), a relatively small group comprising 170 species, and Ixodidae (hard ticks); a larger group comprising over 650 species. Hard ticks are more common ectoparasites of mammals, in part because of their widespread distribution and prolonged association with the host while blood-feeding. Ticks are primarily parasites of wild animals and only about 10% of species feed on domestic animals, primarily sheep and cattle (Wall and Shearer, 2001). Ixodid ticks are one of the most economically important ectoparasite of livestock in tropical and sub-tropical part of the world. Because of the direct and indirect effect on their host, ticks are considered to be not only a significant threat to successful livestock production, but also serious interfere with economy of the country (Zenebe, 2005). More than 60 species of ticks infesting both domestic and wild domestic animals have been recorded in Ethiopia (Feseha, 1983). Among these about 37 species and sub-species are very wide spread and important parasites of livestock (Dalglish *et al.*, 1990). In Ethiopia, tick and tick borne diseases cause considerable losses to the livestock economy, ranking third among the prevalent parasitic diseases, after trypanosomes and endo-parasitism (Pegram *et al.*, 1981; Zeleke and Bekele, 2004)

Ticks undergo four life stages: egg, larva (3 pairs of legs), nymph (4 pairs of legs and no genital pore), and adult (4 pairs of legs and a genital pore). The life cycle of ticks vary widely. Some species pass their entire life on the host, others pass different stages of the life cycle on successive hosts, and others are parasitic only at the certain stages (William *et al.*, 2001). Hard ticks require three blood meals for development and to complete the life cycle. Each stage blood feeds once, detaches from the host, and molts to the subsequent life stage

on the ground. Often the larva, nymph, and adult feed on different hosts (i.e., three host ticks). Some species of hard ticks are one-host ticks (all stages feed on the same individual host). Most of the life cycle of one-host ticks occurs on the host with only gravid females, egg masses, and host-seeking larvae present on the ground. Females and immature hard ticks become greatly distended when blood-fed; females, for instance, often ingest more than 100 times their body weight. Blood meals are used for molting to the next stage or production of eggs. Eggs are laid in a mass of 100–10,000 in 3–30 days (depending on species and temperature); they are deposited on the soil, in a crevice, or beneath leaves. Males generally obtain small blood meals and expand little in size. Hard ticks feed relatively slowly and remain on the host 3–14 days before detaching. After feeding as immatures, molting occurs after an interval that varies between species and with temperature (Wall and Shearer, 2001; William *et al.*, 2001).

Most ticks spend more time off the host, but are totally dependent on the host for sustenance. They are subjected to microenvironment condition when on the ground and thus tend to be more endemic in specific types of area. Ticks can exist for a very long period of time without feeding (Wall and Shearer, 2001). Temperature and relative humidity are two primary factors limiting tick distribution abundance and survival. Most hard ticks lose water when exposed to low relative humidity (< 80%), and a humid microhabitat is essential for off-host survival.

High humidity is favourable for the maintenance of tick population. William *et al* (2001) concluded that two factors related to abundance of ticks are the presence of suitable hosts and an area that provides protection for the hosts and conservation of moisture with the presence of a forest canopy and vegetative ground cover. Wild animals act as reservoirs of ticks which can infest livestock grazing in the same areas. Direct contact is the principal mode of transmission but animals can be infested by various stages of tick which have dropped on the pasture by the other livestock or wild animals (Lughano and Dominic, 1996). In area where the humidity is low, ticks resist desiccation by spending shorter periods questing for hosts. They also enter diapause at unfavorable time of the year. Dormancy is initiated by change in day length and temperature (Wall and Shaerer, 2001).

2.2.3. *Sheep Keds*

Sheep keds, *M. ovinus*, are biting flies which are leathery, dorso-ventrally flattened and tick-like in appearance. Both sexes are completely wingless, even the halteres are absent. They are brown in color and 5-8mm in length. The abdomen is indistinctly segmented and is generally soft and leathery. They have strong claws on their feet to help them cling to wool and hair.

Keds, more often called sheep ticks, are wingless flies brown in color. They spend their entire life cycle more commonly on sheep and occasionally on goats. The ked spends its entire life on the sheep; it can live up to 6 months, during which time the female produces around 10 to 15 young at the rate of one every 8 days. A single egg is ovulated at a time. The egg hatches inside the body of the female and the larva is retained and nourished within the female during its three larval stages, until it is fully developed and ready to pupariate (Gregory, 2011). The skin turns brown within a few hours after birth and forms a hard puparium around the larva (Justin and Dave, 2006). These cases are often called eggs, nits, or keds. The larvae pupate within a few hours, and then remain at this stage for 19 – 36 days.

Adult keds emerge from the pupal cases in 2 to 5 weeks, depending on temperature; reproduction is continuous, though slow during the winter, producing several generations per year (Justin and Dave, 2006). Adults are capable of mating within only a few hours of hatching from the pupa, they crawl over the skin and feed by inserting their sharp mouthparts into capillaries and sucking blood, much like a mosquito. This results in considerable irritation, which causes the animal to rub, bite, and scratch. Another effect observed from animals infested with keds is the condition known as “cockle” (Wall and Sheare, 2001).

Keds cannot live off the sheep very long and transmission is by direct contact. The keds will remain close to the body of the sheep except in warm weather (> 21 °C) when they may be found at the top of the wool fibres, so transmission is more likely in the summer. The eggs hatch inside the female and develop through the 3 larval stages inside the fly. Once “born” the larvae pupate and can be seen in the wool as reddish-brown 3 to 4 mm long pupae. This form is very resistant to insecticides. Adult keds emerge in 3 weeks although this may be

longer in the winter months. However, ked populations only build up slowly as a female only gives birth to 20 larvae in her lifetime. The ked feeds on blood through biting the skin, and heavy infestations will cause anaemia (Andria *et al.*, 2006). In addition, keds in large numbers can cause anemia, which can weaken the animal and make it more susceptible to other diseases (Justin and Dave, 2006).

The female ked live for 4-5 months and lays 10-15 larvae during this time (Radostits *et al.*, 1994) thus buildup of infestations is slow. The parasite is mainly seen in colder and wetter areas and infestations may be lost when sheep are moved to hot dry areas. Keds are most active in cooler months and are common on coarse rather than fine woolen breeds. Sheep in poor conditions suffer most from infestation and goats may also be infested. Resistance is acquired in time and resistant sheep grow better and produce more wool. Keds dislodged from the host can live for up to 2 weeks in mild moist condition but most die in 3-4 days and probably do not play a part in re-infestation of sheep (Radostits *et al.*, 1994). The spread of sheep keds is mainly through contact and the movement of keds from ewe to lamb is an important route of infestation (Wall and Shearer, 1997). The predilection sites of infestation are the neck, around the tail and ventral part of the body (Urquhart *et al.*, 1996).

Skin puncture made by blood sucking keds cause development of “cockles” in the finished sheepskin (Bayou, 1998). Cockle is an inflammatory response of the skin to the presence of keds and their saliva which is recognized after the wool or hair has been removed from the skin. Staining of the wool by the feces of the keds reduces its value and gives it a peculiar musty odor (Radostitis *et al.*, 1994; Wall and Shearer, 2001). The keds may transmit *Trypanosoma melophagium* and the *Rickettsia melophagi*, which are harmless blood parasites of the sheep

2.2.4. Lice infestation

The lice belong to the order Phthiraptera which is divided into four suborders; Anoplura, Amblycera, Ischnocera and Rhynchophthirina. Rhynchophthirina is a very small sub order that include just two species, one of which is a parasite of elephants and the other warthogs.

Amblycera and Ischnocera are known as chewing lice while Anoplura are described as sucking lice (Wall and Shearer, 1997). Lice infest a wide range of domestic livestock, including pigs, cattle, goats, and sheep, and cause a chronic dermatitis (pediculosis) (Wall and Shearer, 2001; Kufman, *et al.*, 2012). Sheep are parasitized by several species of sucking lice and biting (or chewing lice) which economically important. Lice have been known to be injurious itself to sheep on account of depresses wool production (Al-Saffar and Muhammad, 2008). The important species in sheep and goats are found in the genus *Damalina* and *Linognathus*. Sucking lice are obligate hematophagous (blood-feeding) ectoparasites of mammals. As a group, the chewing lice have more diverse feeding habits ranging from hematophagy to the ingestion of host fur, feathers, or sloughed skin of mammals or birds.

The skin-piercing, stylet-like mouthparts of the sucking lice are better adapted for a hematophagous diet than are the mandibular mouthparts of chewing lice. Sucking lice have a powerful pharyngeal (cibarial) pump that creates suction for imbibing blood and the midgut typically has discrete structures called mycetomes that harbor microorganisms for aiding blood meal digestion (William *et al.*, 2001).

Lice usually are unable to survive for more than 1-2 days off their host and tend to remain with a single host animal throughout their lives. Most species of louse are highly host specific and many species specialize in infesting only one part of their host body (Wall and Shearer, 2001 and Kufman, *et al.*, 2012) and transfer to new hosts is by body contact, particularly under condition of close confinement (Sewell and Brockesby, 1990; Peter, 1995). To allow them survive as permanent ectoparasites, lice show a number of adaptations which enable them to maintain a life of intimate contact with their hosts. Lice are very small insects, but are visible to the naked eye (Kufman *et al.*, 2012), about 0.5-8 mm in length, dorsoventrally flattened, wingless and possess stout legs and claws for clinging tightly to fur, hair and feathers. They feed on epidermal tissue debris, parts of feathers, sebaceous

secretions and blood (Wall and Shearer, 1997; Radostits *et al.*, 1994). Both immature and adult stages suck the blood or feed on the skin. Louse-infested animals may be recognized by their dull, matted coat or excessive scratching and grooming behavior (Wall and Shearer, 2001; Kufman, *et al.*, 2012).

Lice respond to warmth, humidity and chemical odors (Wall and Shearer, 1997). Lice are generally transmitted from one animal to another by contact. Transmission from herd to herd is usually accomplished by transportation of infested animals, although some lice may move from place to place by clinging to flies. Lice are most often introduced to herds by bringing in infested animals. The development of all the stages of lice is highly temperature dependent requiring a fairly narrow temperature range with the optimum between 33° C to 37° C and 70–90% humidity. Temperatures above 41°C and 46°C are lethal for eggs and adults respectively (Justin and Dave, 2006; Changbunjong *et al.*, 2009; Edward *et al.*, 2010; Taylor, 2012). Also louse populations vary seasonally, depending largely on the condition of the host. Most sucking and biting lice begin to increase in number during the fall and reach peak populations in late winter or early spring. Summer populations are usually minimal, causing no obvious symptoms. Animals under stress will usually support larger louse populations than normally found (Changbunjong *et al.*, 2009; Kufman *et al.*, 2012; Taylor, 2012).

The skin's microclimate is a significant factor in determining the size of the louse population on the sheep. In summer, thinness of hair coats in coupled with high surface temperatures and increased exposure to sunlight is not favorable for survival of lice during this period (Changbunjong *et al.*, 2009). The cooler temperatures of late autumn and winter allow population numbers to increase and peak numbers are reached in late winter and early spring. Shearing will lead to a marked drop in louse number. Lice do not in general survive off the host for very long. However under ideal conditions some species, usually the chewing lice such as the foot louse of sheep, may survive away from the host for up to 2-4 weeks (Kufman *et al.*, 2012). In general, The effects of climate change and other factor such as changes in animal management and husbandry systems, over-reliance on antiparasitics and development of resistance and increase in animal trafficking or movements may also contribute to changes

in the prevalence, or emergence, of lice infestation in certain localities (Changbunjong *et al.*, 2009; Taylor, 2012). When sheep are in poor condition because of other factors (internal parasites etc.) they tend to be more prone to high louse infestations. Because lice are highly mobile and readily transfer from one sheep to another, poor dipping techniques or incomplete mustering ensures a source of re-infestation (Edward *et al.*, 2010).

The effect of lice is usually a function of their density. A small number of lice may present no problem and in fact may be a normal part of skin fauna. However, they have massive potential for increase (Wall and Shearer, 1997). All species cause irritation of the skin and stimulate scratching, rubbing, and licking leading to restlessness, damage to the fleece and skin and milk production. The saliva and feces of the lice contains substances, which are capable of causing allergies, giving rise to severe irritations, followed by the skin thickening and sometimes self trauma (Peter, 1995). While there is disagreement on the effect of lice on the weight gain, animals in poor conditions, improperly fed and exposed to cold and debilitating diseases carry heaviest infestations. Such animals may benefit from removal of the lice while animals in good conditions and well fed may not show increased weight gain after treatment (Radostits *et al.*, 1994). Reduction in the value of the wool clip is economically the most important consequence of ovine pediculosis, but additional hazards in warm countries is that the fleece and skin damage by the rubbing and soiled by louse feces, is an attractant for blow flies strike (Urquhart *et al.*, 1996).

Bovicola spp

There are a number of morphologically similar host specific species, the species that affect small ruminants are *Bovicola ovis* on sheep; *Bovicola caprae* on goat. The sheep chewing lice, *Bovicola ovis*, is one of the most common lice found on sheep. Biting lice are brown in color and mobile. They feed by chewing on the skin surface and surface debris. Biting lice produce itching, irritation and possible hair loss. An allergic skin hypersensitivity reaction to lice is another cause for “Cockle” in processed sheep skins (Kufman *et al.*, 2012). It is a

small species, about 1 mm in length, pale colored louse that have a rounded head with a pair of three segmented antennae (Bay and Harris, 1988; Wall and Shearer, 2001).

B. ovis has typical life cycle. When environmental conditions are favorable; female *B. ovis* lay two eggs every three days. The eggs are white, microscopic and are attached to the wool fiber usually within 6–12 mm of the skin. Immature lice (nymphs) hatch from the eggs after about 10 days at which time they are much smaller than the adults. There are three nymphal stages or instars, which occupy seven, five and nine days respectively. The third instar nymph moults to an adult louse. Females reach egg laying maturity within four days of moulting. Lice spend their entire life on the skin or wool of sheep. The life cycle takes about 34 days at a minimum. Female lice live about 27 days and males about 48 days. However, there are reports of lice surviving for over 120 days (Edward *et al.*, 2010). Like keds, *B. ovis* is also associated with the development of cackle (Heath *et al.*, 1996).

Lignonathus spp

Out of more than 50 species of *Linognathus* described, six occur on domestic animals the species that parasitize sheep and goats includes; the face louse *Linognathus ovis*, the foot louse, *linognathus pedalis*; the goat sucking louse, *Linognathus stenopsis*; and the closely related species, *Linognathus africanus* on sheep and *Linognathus stenopsis* and *Linognathus africanus* on goats (Wall and Shearer, 2001). Members of this family do not have eyes or ocular points. The second and third pairs of legs are larger than the first pair and end in stout claws. In species of *Linognathus* the thoracic sternal plate is absent or weakly developed. Paratergal plates are absent from the abdomen (Wall and Shearer, 1997). Adult female lay a single egg per day. Eggs hatch in 10- 15 days; giving rise to nymph which requires about 2 weeks passing through three nymphal stages. The egg to adult life cycle requires about 20 – 40 days (Wall and Shearer, 2001).

The face louse, *L. ovis*, usually occurs in colonies on the ear and face of sheep. The preferred sites for *L. pedalis* are the feet, legs and scrotum. At high densities however, both species may spread over the entire body. *L. pedalis* can survive for several days off the host. So the infestation may be picked up of contaminated pasture (Wall and Shearer, 1997). The damage caused is due to irritation which interferes with feeding causing decreased weight gain, scratching result in wool loss, cuts and bruises. Excretion of the lice soils the wool (Bay and Harris, 1988). Sucking lice are also notorious for transmission of typhus and relapsing fever for humans (Sewell and Brockesby, 1990).

Sucking lice suck blood and can contribute to anemia as well as skin irritation (Kufman *et al.*, 2012). Lice bites are very irritating for the host skin. Sheep react scratching and rubbing intensively against objects and licking or biting the affected parts. This behavior can cause skin injuries susceptible of infection with secondary bacteria. Wool loss and reduced weight gain can be considerable. Lice infestations can also affect hide and leather quality resulting in reduced income. Milk production of dairy sheep and goat can also drop due to heavy lice infestations (Philipsson *et al.*, 2011).

2.3. Economic importance of Ectoparasites

Africa has a population of 205 million sheep approximately 17% of the world total (FAO, 1990). Sheep serve primarily as sources of meat, but also provide milk, skins and manure.

The ownership of small ruminants in Africa differs from that of cattle. Only a small percentage of the population own cattle, and rear them mainly in the arid and sub-humid zones. Most people in rural areas own small ruminants. The ownership of small ruminants is regarded as an investment (Ademosun, 2009).

The contribution of agriculture to the gross domestic product (GDP) of sub-Saharan Africa as a whole is estimated to be 32%. Livestock production contributes 25% to the region's agricultural GDP, mainly through meat, milk, eggs, wool, hides and skins (Philipsson *et al.*,

2011). Livestock play important roles in the production of food and for other purposes. The diversified use of livestock on average contributes to between 10% and 50% of the GDP of countries in the tropical developing world. About 70% of the world's rural poor depend on livestock for their livelihood (FAO, 2005a). Livestock, therefore, are of great socio-economic and cultural value in various societies around the world. The main constraint hindering the productivity of sheep in most sub-saharan countries are diseases; poor nutrition; poor breeding policies and poor management (FAO, 2005; Yacob, 2014). Among the diseases of sheep skin diseases caused by ectoparasites accounts a wide range of health problems that confront the productivity of small ruminants (Kumsa *et al.*, 2012a; Yacob, 2013).

According to Dawit *et al* (2012) small ruminant production is an important agricultural enterprise and constitutes about 30% of the total livestock population of the country. However, their contribution to food consumption, rural income and export economy is below the expected potential, because small ruminant husbandry is constrained by compound effect of disease, poor feeding, and poor management. Ethiopian sheep skins traditionally have good reputation for quality in the world leather market due to their fine grain and compact structure. Skin parasites of sheep such as ticks, lice, mites and keds are the major agents causing serious economic loss to small holder farmers, the tanning industry, and the country as whole. Ectoparasite infestation is one of the most important health constraints in sheep production in Ethiopia, not only to skin/hide quality, but just as or more importantly in transmitting tick and insect borne diseases, limiting growth rate and often causing mortality.

The economic impact of tick infestations is enormous worldwide. In 1984, the United Nations Food and Agricultural Organization (FAO) estimated the global cost of Ixodidae tick infestations to be \$US 7.0 billion annually. Ticks are directly or indirectly involved in causing substantial financial losses to livestock industry of Ethiopia accounts for 75% of the animal exports (Pegram *et al.*, 1981). A conservative estimate of 1 million birr loss annually was made through rejection and down-grading of hides and skins in Ethiopia (Zelege and Bekele, 2004). Apart from the direct effects of tick infestations on animal production and

productivity, ticks are inevitably efficient vectors of many pathogens protozoa, viruses, bacteria and rickettsia to man and domestic animals (Radostits *et al.*, 2000).

Annually 16.2 million pieces of skins are produced in the country, based on the sheep off take rates of 33% (MoARD, 2008; FAO, 2010). According the FAO statistical yearbook (2010) report about 1.56×10^5 tones meat were produced by small ruminants in Ethiopia. The leather industry sector is one of the fast growing economic sectors in Ethiopia (MoARD, 2008). Until recently, Ethiopia's second largest earner of foreign income was the hides and skins sector where small ruminants, and in particular sheep, were very important (Asnake *et al.*, 2013). However, the percentage of skins having defects that downgrade quality has increased tremendously. Tanneries state that currently only 10 to 15% of harvested skins qualify for top grades, with the rest downgraded; this occurred mainly due to deterioration of skin with skin disease called "ekek" that is mainly due to lice, keds, and mange infestations (ESGPIP, 2009). Sheep keds have been reported to cause an 8% reduction in weight gain, 15% reduction in wool production and 30% reduction in value of sheep skin. The feeding by sheep keds cause dense, hard nodules to develop in the skin condition known as cockle. These nodules are not easily penetrated by deys; they weaken and discolor the skin resulting in a downgrading in the leather (Gregory, 2011).

Hides and skins and leather and leather products were supplied to domestic and export markets and contributed significantly to the Ethiopian economy by providing 14– 18% of the foreign exchange earnings, but has lost revenue due to decline in quality and fall in export price (CSA, 2007). Hide and skin production obtained from sheep 33%, goats 50%, cattle 13% and camel 4% (ACTESA, 2011). According to Yesehak, (2000) study conducted at Sebeta tannery on sheep skin on routine production system indicate 89% 'ekek' in pickled sheep pelts. According to data from MoTI, the leather and leather product exports increased from 67 million USD to 104 million USD between 2004/05 and 2010/11. On average the leather and leather products industry contributed 5.9% to the total export earnings for the years 2004/05-2010/1(UNIDO 2012). Quality of hides and skins is a major problem faced by tanners in Ethiopia (UNECA, 2012). According to (Bayou, 1998) reports from tanneries, in

Ethiopia hide and skin problem due to external parasites causes 35% of sheep skins to be rejected. According to Amsalu *et al* (2000) the estimated economic loss due to drop in quality of sheep and goat skin is around USD 14 million per year.

2.4. Management Strategies of Ectoparasites

Integrated Parasite Management (IPM) is the integration of chemical, biological and cultural control methods to reduce parasite populations below an economic threshold. IPM basically involves the selection and use of several methods to reduce, rather than eliminate, ectoparasite population with expected ecological, economic, and sociological costs and benefits. In addition, IPM programs seek to maximize the effectiveness of parasite control actions whilst conserving beneficial insects and minimizing pesticide residue (James, 1998). IPM in practice is a combination of the strategic use of chemicals, grazing management, nutrition, breeding programs and management practices. The application of IPM will however be dependent on the livestock production system in use, the biology of the parasites associated with the system and being targeted by IPM, the relationship between the parasite populations and the damage to the production system and the extent to which these influence the ability of the farmer to implement control options (Kirby, 2004).

2.4.1. Physical Control

Modification of the parasite off host environment may significantly reduce ectoparasites abundance (Wall and Shearer, 2001). Altering the landscape to increase sunlight and lower humidity may render an area less hospitable to ectoparasite. Landscape management involves vegetative modifications to render the environment less suitable for ectoparasite survival and for reservoir hosts. Management of the habitat should focus on the areas frequently used by the animals. Plants can be pruned to provide open space between the ground and base of the plant (Kirby, 2004). Similarly, changing the suitability of the on-host environment may help reduce the susceptibility of the host to ectoparasite attack. Tick and mite infested pasture can

be avoided in some circumstance; grazing practices which reduce contact with tick, such as pasture spelling, which remove all major hosts for over a year, may cause the tick population to collapse (Wall and Sheare, 2001). Shearing significantly reduces the lice and ked burdens by removing a large proportion of the parasites and exposing those remaining to the lethal effects of desiccation (environmental factors). After shearing a greater proportion of the population are found at sites on lower body regions such as under the neck, lower flanks and upper legs (shoulder) and in areas where the wool has not been closely shorn (James *et al.*, 1998). Shearing is one of the best measures to knock down lice populations. A huge number of lice (close to 90%) are eliminated with the clip and most lice remaining on the shorn animals won't survive without the humid and warm microclimate of long wool. However, a few lice usually manage to survive in less exposed areas of the body (e.g. the ears) and will restart the infestation. If possible all sheep in a flock should be shorn at the same time: this will have the strongest knock down effect on the lice population. If it is not possible, shorn sheep should be kept separated from unshorn ones (Kufman *et al.*, 2012). Sheep keds population can be reduced by approximately 75% by shearing prior to lambing. If ewes are not shorn prior to lambing, keds will move from the ewes and infest lambs. The infested lambs, which will not be shorn until the following spring, can serve as a reservoir for re-infesting the flock (Gregory, 2011).

Contact control measures hinges of the fact that ectoparasites are spread from animal to animal when in close contact with one another such as during feeding, breeding, or transporting. Lice, keds and tick as well as the eggs of lice and keds dropping off onto bedding or being rubbed off, along with hair, onto fences and facilities may also be responsible for transmission. Sucking lice die within a few hours when off the host but some biting lice may live for several days if not exposed to direct sunlight or cold weather, and some eggs may hatch and infect other animals in contact. For this reason, premises vacated by infested stock should either be treated with insecticide, or should stand empty for 10 days before being used by clean stock (Vorster and Mapham, 2012).

2.4.2. Biosecurity

It is important to determine ectoparasite infestation in sheep is due to inadequate treatment, resistance, a combination of the two, or the introduction of new infestation. Enhanced biosecurity measures with regards to fencing and animal movement (quarantine) is therefore strongly advocated (Vorster, and Mapham, 2012). An important measure to avoid infestation of clean flocks is ensuring proper fencing to keep away potentially infested stray or neighboring sheep. Stock introduced in a farm (including rams) must be quarantined or closely inspected for ectoparasites and, if positive, they must be shorn and treated with an acaricides (Hybuc, 2007).

2.5.3. Biological Control

Organisms which are predators, parasites, competitors and pathogens of the ectoparasite can be used as biological controls (Wall and Sheare, 2001). Briggs *et al* (2006) described the use of a fungal pathogen, *Metarhizium anisopliae*, for the biological control of louse *Bovicola*. They concluded that the strategic seasonal use of this fungal pathogen on animals, applied in early winter, may be of value in suppressing the winter increase in lice populations and preventing them from increasing to clinically significant levels. The effective control of sheep lice with conventional pesticides can be hampered in some cases by the dense water repellent fleeces of sheep preventing contact between lice and the pesticide. This has prompted some interesting research into the use of entomopathogenic nematodes. These are motile parasites able to actively seek out insect hosts such as lice in the fleece of sheep. A study by James *et al* (2010) investigated whether the nematodes, *Steinernema carpocapsae*, *Steinernema riobrave*, *Steinernema feltiae* and *Heterorhabditis bacteriophora* were able to infect and kill *Bovicola ovis*. All were shown to infect and kill lice in Petri dish assays at 30 °C. It was concluded that *Steinernema riobrave* may likely be the most effective against *Bovicola ovis* when applied to live sheep due to its greater tolerance to high temperatures and its foraging strategy.

Ixodiphagus hookeri, parasitizes blacklegged ticks in a few areas of New England with superabundant deer and tick populations. However, studies indicate that the usefulness of this wasp to control *I. scapularis* is very limited. Insect parasitic nematodes have been studied as possible biological control agents. Engorged female *I. scapularis* are susceptible to certain types of nematodes, but these nematodes are too sensitive to the colder autumn temperatures when the ticks are present. The application of entomopathogenic fungi, however, is a promising approach for controlling ticks. Several fungi have been shown pathogenic to *I. scapularis*. A perimeter treatment of existing commercial formulations of the fungus *Beauveria bassiana* and with *Metarhizium anisopliae* at residential sites has been shown to control *I. scapularis* in small experimental trials (Kirby, 2004).

2.4.4. Chemical Control

Ectoparasiticides can be delivered to the parasite by topical preparation applied to the host coat, systemic preparation and environmental preparations (Wall and Sherare, 2001). Chemical application methods for ectoparasite control include dipping, spraying, pour-on, spot-on, and injectables, as well as dusts and self-applicators (Vorster and Mapham, 2012). Injectable treatments are very effective for the blood-feeding ectoparasites. Thus pour on formulations may be necessary in controlling these species. Treated animals should be examined after about 14 days, regardless of treatment method, to determine if a second or continued treatment is necessary (Kirby, 2004).

2.5. The Status of Sheep Parasitic Skin Diseases in Ethiopia

Reports on skin diseases of sheep in Ethiopia are scanty and if present are also very fragmented. Studies conducted at various areas of the country and tanners report on magnitude of skin pelts damage due to skin disease especially ectoparasites indicate that sheep skin disease are becoming growing threat for sheep production and export of skin in Ethiopia. The main parasitic skin diseases reported in Ethiopia includes:

2.5.1. Mange mites

Mange of sheep was reported from different areas of the country with different magnitude ranging from 0 % to 67.7 % (Table 1). According to Demissie *et al.*, (2000) the incidence of mange has increased during the past 10 years to a level preventing farmers from keeping sheep and goats in some areas of Amhara region bordering Afar, Tigray and Sudan. Different species of mange mite were recorded from different part of the country. Of the mange mite affecting sheep, Sarcoptes is the most prevalent species in Ethiopia. Reports conducted from different part of the country indicated; Sarcoptes was reported to have prevalence of 2.9% in southern Ethiopia (Asnake *et al.*, 2013); 0.5% in Bahir Dar (Asmare *et al.*, 2012); 2.5% in Nekemta (Tesfaheywet, and Misgana, 2012); 1.9% in Gondar (Tewodros *et al.*, 2012); 1.99% in Wolayita (Desie *et al.*, 2010); 0.4% in Amhara region (Tefera, 2004) and 2.33% in Hararghe (Tekele, 1986). However, the highest prevalence of Sarcoptic mange was 30.32% reported by Kedir (2000) and 30.3% Tigray (Musema, 2002). In Ethiopia sarcoptes are widely distributed in lowland and midland. According to (Yacob *et al.*, 2008 part I; Desie *et al.*, 2010; Mulugeta *et al.*, 2010; Asnake *et al.*, 2013) sarcoptic mange was the main constraint of sheep production in lowland part of the country with the highest prevalence was 2.9% in the lowland part of southern part of the country (Asnake *et al.*, 2013). Similarly this mite was also play a significant role in hampering production and productivity of sheep found in midland part of the country (Yacob *et al.*, 2008 part II).

Table 1: Overall prevalence of mange from different parts of the country

Prevalence %	Study area	Author and year
0	Southern Ethiopia	Asnake <i>et al.</i> , 2013
19.1	In and around Ambo	Tadese <i>et a.</i> , 2013
4	Bahir Dar	Asmare <i>et al.</i> , 2012
1.2	Central Oromiya	Kumsa <i>et al.</i> , 2012a
0	Kombolcha	Tesfaheywet. Z and Lemma. M. 2012
4.5%	Nekemte	Tesfaheywet. Z and Misgana. M. 2012

6.59	Gondar	Tewodros <i>et al.</i> , 2012
1.99	Wolayita	Desie <i>et al.</i> , 2010
0.95	Tigray region	Enquebaber <i>et al.</i> , 2010
0	Tigray region	Mulugeta <i>et al.</i> , 2010
0	Wolayita soddo	Yacob <i>et al.</i> , 2008
0	Amhara region	Tefera <i>et al.</i> , 2004
2.69	Central Ethiopia	Mohammed, 2001
0.73	Dire Dawa	Taddese, 1994
32.7	Addis Abeba	Kebede, 1992
67.7	Bale Robe	Ashine, 1987
7.8	Hararghe	Tekele, 1986

Source: compiled by author from thesis and publications

Records for Psoroptic mange were 1.5% in Bahir Dar (Asmare *et al.*, 2012); 0.95% in Sidama zone (Worku, 2002); 1.8% in central Ethiopia (Mohammed, 2001); 42.9% in Cheffe state farm (Wollo) (Etagegnehu, 1992). Relatively higher prevalence of 4.67 % from Harrarghe (Tekele, 1986), 67.6% from Bale Robe (Ashine, 1987), and 32.87% from Addis Ababa (Kebede, 1992) was recorded. In Ethiopia Psoroptic mange distributed and most common among sheep in lowland areas of north (Kassa *et al.*, 1998; Mulugeta *et al.*, 2011) and South (Diese *et al.*, 2010; Asnake *et al.*, 2013) as well as central low land areas (Yacob *et al.*, 2008 part II). Demodectic mange was reported to occur in Bahir Dar at 0.5% in (Asmare *et al.*, 2012); in Nekemta at 1.5% (Tesfaheywet, and Misgana, 2012); in Gondar at 5.49% (Tewodros *et al.*, 2012); 0.57% at Wolayita (Desie *et al.*, 2010); in central Ethiopia 0.8% (Mohammed, 2001), in the southern range land of Oromia 0.88% (Nura, 2002) and from Harrarghe 0.84% in sheep (Tekele, 1986). As resent reports reveled demodectic mites were reported to be distributed in different agro-ecological zones in Ethiopia as reported by Yacob et al (2008part I) in central lowland of Oromiya; Tefera (2004) midland and highlands of Amhara region and Asnake *et al* (2013), in lowland and midland areas.

2.5.2. Lice

Lice infestations in sheep were reported with overall prevalence of 41.2% (Asnake *et al.*, 2013) from southern Ethiopia; 24% (Tadese *et al.*, 2013) from in and around Ambo; 11.5% (Asmare *et al.*, 2012) from Bahir Dar; 57% (Tewodros *et al.*, 2012) from Gondar; 28.3% (Mulugeta *et al.*, 2010) and 1.3% (Rhamato *et al.*, 2011) from Tigray region; 25.7% (Yacob *et a.*, 2008) from wolayita soddo; and 2% (Mohammed, 2001) from central Ethiopia.

The louse species identified were 67.1% *Linognathus* and 75.5% *B. ovis* from Assela (Hailu, 2010) 5.8% *Linognathus* spp and 18% *B. ovis* from in and around ambo (Tadese *et al.*, 2013); 14.6% *Linognathus* and 36.1% *B. ovis* from southern Ethiopia (Asnake *et al.*, 2013); 8.5% and 2.2% *Linognathus* 3.3% and 3.2% *B. ovis* from Bahir Dar (Asmare *et al.*, 2012 and Dawit *et al.*, 2012); 23.8% *Linognathus* and 33.69% *B. ovis* from Gondar (Tewodros *et al.*, 2012); 25.7% *B. ovis* (Yacob *et al.*, 2008); 2.4% *Linognathus* and 38.6% *B. ovis* from Amhara region (Tefera, 2004). However, examination of sheep pelt showed a much higher infestation rate of 89.5%. Both lice and keds are considered as a cause of “ekek” in Ethiopian sheep pelts (Bayou, 1998).

Table 2: over all prevalence of lice from different part of the country

Prevalence %	Study area	Author and year
41.2%	Southern Ethiopia	Asnake <i>et al.</i> , 2013
24%	In and around ambo	Tadese <i>et al.</i> , 2013
11.5%	Bahir Dar	Asmare <i>et al.</i> , 2012
3.8%	Bahir Dar	Dawit <i>et al.</i> , 2012
57%	Gondar	Tewodros <i>et al.</i> , 2012
1.3%	Tigray region	Rhamato <i>et al.</i> , 2011

75.5%	Assela	Hailu, 2010
0.37%	Tigray region	Enquebrehan <i>et al.</i> , 2010
28.3%	Tigray region	Mulugeta <i>et al.</i> , 2010
25.70%	Wolayita soddo	Yacob <i>et al.</i> , 2008

Source: compiled by author from thesis and publications

2.5.3. Ticks

Reports from different area indicate that ticks are also among the skin diseases affecting sheep in Ethiopia. The overall prevalence of ticks' infestation ranges from 0% to 87.5% in. The highest prevalence of tick infestation was reported from West Harragae 87.5% by (Fufa *et al.*, 2009). Tick genus were observed to infest sheep includes; *Amblyomma*, *Hyaloma*, *Boophilus* and *Rhipiciphalus*. Table shows the prevalence of ticks in the different areas.

Table 3: Overall prevalence of tick from different parts of the country

Prevalence (%)	Study area	Author and year
18.8%	Southern Ethiopia	Asnake <i>et al.</i> , 2013
0	Dire Dawa	Sisay <i>et al.</i> , 2013
37%	Bahir Dar	Asmare <i>et al.</i> , 2012
31.4%	Bahir Dar	Dawit <i>et al.</i> , 2012
80.7%	Bedelle district	Fufa <i>et al.</i> , 2012
21.1%	Gondar	Tewodros <i>et al.</i> , 2012
48%	Tigray region	Rhamato <i>et al.</i> , 2011
16%	Tigray region	Mulugeta <i>et al.</i> , 2010
87.5%	West Harergie	Fufa <i>et al.</i> , 2009
31.78%	Wolaita soddo	Yacob <i>et al.</i> , 2008
3.4%	Amhara region	Tefera <i>et al.</i> , 2004
0.96	Central Ethiopia	Mohammed, 2001

Source: Compiled by author from thesis and publications

2.5.4. Sheep Ked

In Ethiopia, few works are available on ecological distribution of sheep Ked. Recent reports on sheep ked of sheep indicated that the parasite is most common in sheep mainly in cooler high altitudes. Records from different parts of the country were indicated the prevalence of sheep keds ranging from 1.8% to 65%.

Sheep ked infestations were reported with overall prevalence of 14.2% from southern Ethiopia (Asnake *et al.*, 2013); 3% from Bahir Dar (Asmare *et al.*, 2012); 16.4% from Central oromia (Kumsa *et al.*, 2012a); 20.1% from Gondar (Tewodrose *et al.*, 2012); 19.1% from Tigray region (Mulugeta *et al.*, 2010); 65% from Assela (Hailu, 2010) and 12.5% from Amhara region (Tefera *et al.*, 2004).

Table 4: Overall prevalence of keds from different parts of the country

Prevalence %	Study area	Author and year
14.2	Sothern Ethiopia	Asnake <i>et al.</i> , 2013
3	Bahir Dar	Asmare <i>et al.</i> , 2012
16.4	Central Oromia	Kumsa <i>et al.</i> , 2012a
1.8	Bahir Dar	Dawit <i>et al.</i> , 2012
20.1	Gondar	Tewodrose <i>et al.</i> , 2012
6.7	Tigray region	Rhamto <i>et al.</i> , 2011
65	Assela	Hailu, 2010
11.67	Tigray region	Enquebaher <i>et al.</i> , 2010
19.1	Tigray region	Mulugeta <i>et al.</i> , 2010
12.5	Amhara region	Tefera <i>et al.</i> , 2004

Source: Compiled by author from thesis and publications

3. MATERIAL AND METHODS

3.1. Study Area and Population

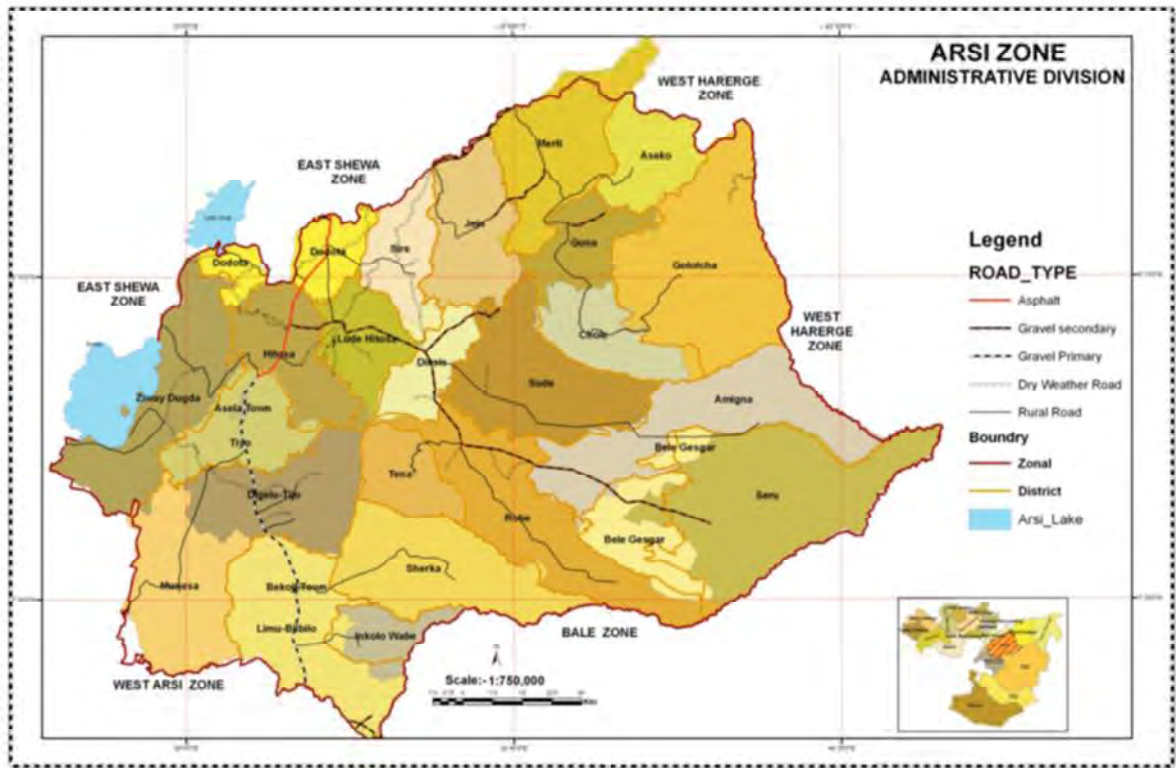
Arsi Zone is found in the central part of the Oromiya Regional State. The zone astronomically lies between 60 45' N to 80 58' N and 380 32' E to 400 50' E. It shares borderlines with the Regional State of Nations, Nationalities and People of Southern Ethiopia and also shares borderlines with East Shewa, Bale and West Hararge Zones. Arsi Zone covers with an estimated area of 21,009 square kilometers. The mean annual temperature of the Zone is found between 20-25⁰C in the low land and 10-15⁰C in the central high land; the mean annual rainfall varies from 633.7 mm to 1059.3 mm. There are a great altitudinal differences between the highest and the lowest places. The lowest point of the zone is 805meters, which is found at the extreme east of Seru district in Wabi Gorge. On the other hand, Mountain peak of Kaka with a height of 4195 meters is the highest peak in the zone. As (table 5) indicates below, Arsi Zone is divided into four agro-climatic zones mainly due to variation in altitude.

Table 5: Agro-climatic zone of the study area

Altitude	Annual mean T⁰	Description	Area (%)
<1500	20-25 ⁰ C	lowland	24.92
1500-2500	15-20 ⁰ C	Warm temperate	49.60
2500-3500	10-15 ⁰ C	Cool temperate	22.74
>3500	<10 ⁰ C	Cool/cold	2.74

Source: Zonal Health, Educational, Natural Water Resource Development, Finance and Economic Development Department and FED Office.

Figure 1: Map of study Zone (Arsi)



Source: Zonal Health, Educational, Natural Water Resource Development, Finance and Economic Development Department and FED Office.

The study on ectoparasites of sheep was conducted in three districts (Tiyo, Diksis and Guna) of Arsi Zone, central part of Oromia regional state, southeast Ethiopia which found 179, 199 and 230 km away from Addis Ababa, respectively. The livestock found in the districts were indigenous breeds with small number of cross breed cattle kept around the towns and exotic poultry breeds distribute through poultry improvement packages. The production system implemented in the study area is mixed crop livestock. According to CSA (2012) Arsi zone has a total population of cattle 2,295,138, sheep 1,207,182, goats 653,327, Equines 593,272, poultry 1,449,583 and 94,456 beehives. Table 6 shows the detailed description of the study areas.

Table 6: Description of each districts of study area for sheep ectoparasites

Description	Study districts		
	Tiyo	Diksis	Guna
Altitude range	2430-3210 masl	2430-2790 masl	2500-3000 masl
Rainfall range	900- 1020 mmHg	780-1100 mmHg	800-1100 mmHg
Temperature range	10-15°C	12-17°C	11-15°C
Livestock population			
Cattle	349,340	123,785	79,012
Sheep	478,345	389,432	86,390
Goats	9856	5672	7156
Equines	98, 326	38,458	24,983
Camels	0	0	0
Poultry	400, 569	371, 001	30,000

Source: CACC, 2012. Other Information source: WoA

3.2. Sampling Method and Sample Size Determination

The study of ectoparasites involves districts, peasant associations (PAs) and sheep as a sampling unit. The districts were be selected purposively based on their representation of ectoparasite controlled and uncontrolled; five PAs from each district having the corresponding control status were also selected randomly. Sheep found in selected PAs were selected randomly from animals grazing in communal pastures.

The required sample size was determined as described by Thrusfield (2007). The expected prevalence of ectoparasite was taken from previous work of Hailu (2010, unpublished) at Assela which was 70% and by setting 95% confidence level and 5% desired level of precision.

$$n = \frac{1.96^2 P_{exp} (1 - P_{exp})}{d^2}$$

Where:

n= required sample size,

P_{exp} = expected prevalence

d= desired absolute precision

Based on the above formula the sample size was calculated to be 969 sheep; 323 sheep were included in the study from each district. Hence, 646 sheep were sampled from the controlled districts (Diksis and Tiyo) and 323 sheep were sampled from uncontrolled district (Guna).

3.3. Study Design

A cross-sectional study was employed from October 2013 to May 2014 to address the objectives of the study. Animals were examined for presence of ectoparasites and skin lesions and after proper restraining specimens were collected from diseased animals. Also the study was consisted of a questionnaire survey.

3.4. Clinical Examinations

969 sheep randomly selected from one uncontrolled district and two controlled districts were clinically examined for presences of ectoparasites and/ or lesions. Before clinical examination, the sex, age, body condition, management and hairiness of the selected sheep was recorded. Body condition score of the animal was made as poor and good; by modifying the system described in Gatenby (1991). Poor body condition score was given to sheep which were extremely thin to those with smooth and less prominent spinous process, transverse process in which finger can be pushed and moderate depth loin muscle. Good body condition score was given for sheep in which the spinous process only stickup very slightly; smooth, rounded and well covered transverse processes and those having full loin muscle and very fat. Age categorization into young (lamb) and adult was performed as described by Gatenby (1991). Accordingly those sheep under 1 year were categorized as young and the rest as adult.

The clinical examination was performed by multiple fleeces parting in the direction opposite that in which hair or wool normally rests and visual inspection and palpation of the skin for parasites and/or lesion on all parts of the animals including the ears and the digits. Those sheep found infested by parasites were considered positive, the sites of infestation on the animal body were recorded and the parasites were identified on the bases of their morphological structure as described in Urquhart *et al* (1996) and Wall and Shearer (2001).

3.5. Sample Collection

Ectoparasites encountered either on the skin surface or attached to the hair were be sampled or collected in 70% alcohol. The sampled animals were clinically inspected for presence of mange mite. From animal showing signs of scales, crusts, alopecia itching, a skin scraping was taken. Scrape the edge of the affected area until blood oozed. Multiple sites were scrapped to increase the likelihood of ectoparasite detection. A few drop of 10% KOH solution were added to the sample, a cover slip applied and cleansing of debris allowed

proceeding for 15-30 minutes before microscopic examination (Smith and Sherman, 1994; Bowman, 1999; Wall and Sheare, 2001).

The neck, shoulder, belly, ribs, back, flank and rump areas of both sides of the body were examined for presence of lice by parting the hair. From clinically positive animals, specimens were collected, preserved in 10% formalin or 70% alcohol and later identified /confirmed in the laboratory. The neck, shoulder, flank, back, belly and rump of both sides of the animal body, were inspected for sheep keds. From clinically infected animals specimens were collected, preserved and dispatched to laboratory for confirmation Urquhart et al (1996). To insure that the mouth parts are not left behind, ticks were gently removed from the attachment site (Wall and Shearer, 2001). All collected samples will be examined /confirmed in the laboratory as per the procedure recommended by Urquhart *et al* (1996) and Wall and Shearer (2001).

3.6. Questionnaire Survey

A structured questionnaire format (Annex 4) were prepared to obtain general information on livestock ownership pattern, importance of keeping sheep, awareness of ectoparasites that affect sheep and their effect on sheep production and market value of the skin and the effect of ectoparasite control program in the area. For the sake of convenience of data and time management a total of 60 individuals who owns sheep were interviewed. For this purpose a total of 20 sheep owners were selected from each district (20 individuals from uncontrolled area and 40 individuals from controlled area). In addition structured questionnaire format (annex 5) were prepared to attain general information on the preconditions were set by skin collectors to purchase skin, the cost of ectoparasite infested skin with respect to healthy one, the way of storing collected skin and what was the tannery looking while receiving the collected skin. Nine (9) skin collectors, three from each district were included in the study.

3.7. Laboratory Examination

Processing of each specimen for the desired test with appropriate laboratory procedures and identification were take place with the help of identification key stated by Soulsby, (1982), Urquhart *et al* (1996) and Wall and Shearer (2001) (Annex 1).

3.8. Data Analysis

Data was recorded and entered to Microsoft Excel sheet and analyzed by Statistical software SPSS version 20. Descriptive statistics such as percentages and 95 % confidence intervals were used to summarize the proportions of infested sheep in controlled and uncontrolled area. The effects of different epidemiological risk factors on the prevalence and distribution of ectoparasites were analyzed using chi square and binary logistic regression method.

Statistical significance was set at $p < 0.05$.

4. RESULTS

4.1. Questionnaire Study Outputs

A questionnaire was prepared in an attempt to obtain the general information on livestock ownership patterns, importance of sheep rearing, awareness about ectoparasites, their effects and the socio-economic significance of parasitic skin diseases, effect of ectoparasite on the market values of the skins and the control practices implemented in the area. The responses of questionnaire administered to sheep owners were summarized by treatment (controlled and uncontrolled) (Annex 6). Response on livestock ownership pattern indicates that in both areas sheep is the major species of animal kept by farmers for various reasons. The major reasons for keeping sheep were 53/60 (88.33%) for income generation and insurance as priority number one 36/40 (90%) in controlled area and 17/20 (85%) in uncontrolled area, priority number two were meat for home consumption 49/60 (81.67%); 34/40 (85%) in controlled area and 15/20 (75%) in uncontrolled area and 53/60 (88.33%) 36/40 (90%) in controlled area and 17/20 (85%) in uncontrolled area were kept sheep for skin as priority number three. In the controlled area 80% of the respondents were manage sheep by mixing with the other species of animals and only 20% of the respondents were manage sheep by separating from the other species of animals. While in uncontrolled area sheep management were 30% and 70% separately and by mixing with the other species of animals respectively.

From the total 60 sheep owners interviewed, 28/40 (70%) and 14/20 (70%) respondents from controlled and uncontrolled area respectively knew one or more skin diseases that affect sheep. The main skin diseases mentioned by respondents were keds and lice in both ectoparasite controlled and uncontrolled districts. The age groups commonly observed to be affected by mange, keds, lice and ticks were all age group. However, according to the respondents 33/40 (82.5%) and 7/40 (17.5%) mange affect adult sheep and all age group in controlled area respectively and in uncontrolled area 17/20 (85%) and 3/20 (15%) mange affect adult and all age group respectively. In controlled area sheep keds 26/40 (65%), 4/40

(10%) and 10/40 (25%) affect adult, young and all age group respectively; but in uncontrolled area 9/20 (45%), 3/20 (15%) and 8/20 (40%) affect adult, young and all age group respectively. In controlled area 18/40 (45%), 5/40 (12.5%) and 17/40 (42.5%) respondent indicated that lice affect adult, young and all. While in uncontrolled area 8/20 (40%) 2/20 (10%) and 10/20 (50%) affect adult, young and all age group respectively. Seasonality in occurrence of mange, keds and tick in controlled area were observed by 57.5%, 52.5% and 72.5% of the respondents respectively and also in uncontrolled area seasonality of mange, keds and tick were observed by 60%, 60% and 45% of respondents respectively (fig 2). The season of occurrence of these diseases was reported as late rainy (cold) season for mange, dry season for keds and rainy season for tick.

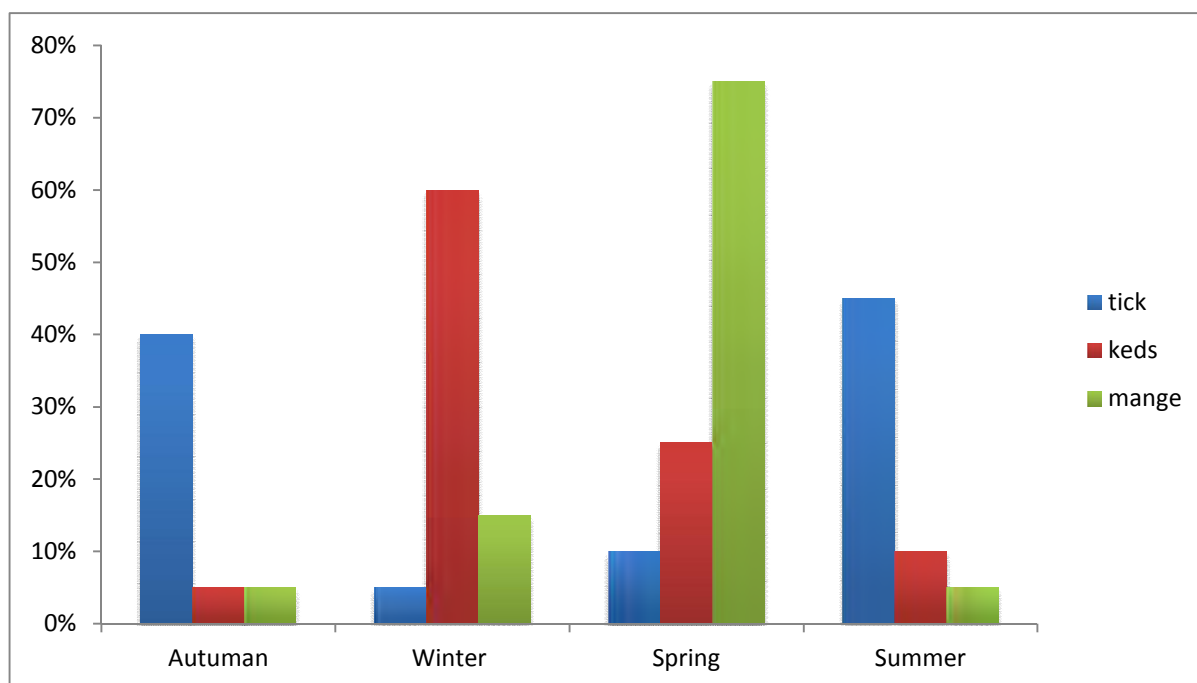


Figure 2: Response on seasonal occurrence of tick, keds and mange in uncontrolled area

Most of respondents from controlled and uncontrolled area believe that mange has effect on the sale of skins and more than 90% of respondents found in both controlled and uncontrolled area believe that mange has effect on the sale of live sheep (Table 7). While the majority of the respondents of both controlled and uncontrolled area do not believe keds, lice and ticks have effect either on the sale of the affected sheep or its skin.

Table 7: Response on the effects of ectoparasites on the sale of infected sheep and their skin.

Ectoparasite	Effect on animal sale				Effect on skin sale			
	Controlled		Uncontrolled		Controlled		Uncontrolled	
	Yes	No	Yes	No	Yes	No	Yes	No
Mange	38	1	18	2	26	1	17	1
Keds	8	23	3	15	5	23	2	12
Lice	3	30	3	13	5	23	3	13
Tick	5	27	2	14	12	28	9	11

Even though modern veterinary service delivery is available in their nearby only 10% in controlled area and 5% in uncontrolled area use modern treatment to control ectoparasites (Fig. 3 and 4). None of the respondents of both controlled and uncontrolled area apply acaricides to treat the infected sheep, but acaricide spray was implemented by the government in controlled area. According to all the respondents found in both controlled and uncontrolled area there were no police which prevent the movement of animals from one area to the other even from uncontrolled area to the controlled.

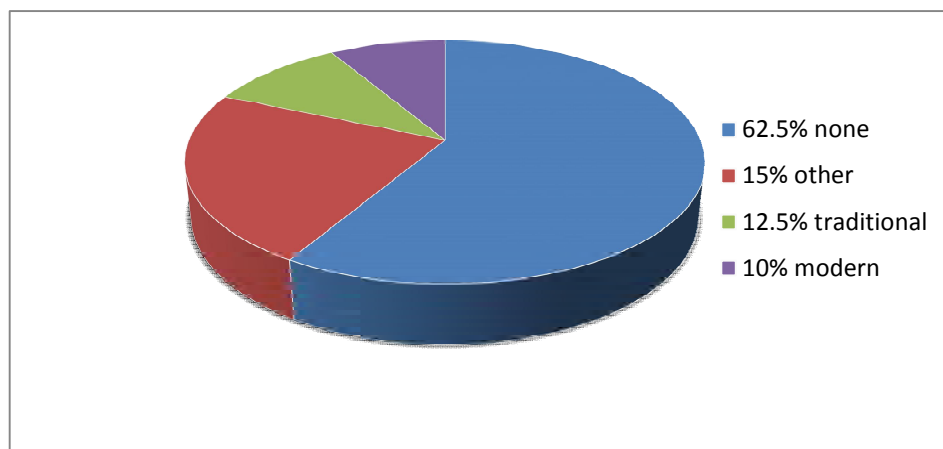


Figure 3: Proportions of respondent treatment method prefer to treat ectoparasite in controlled area.

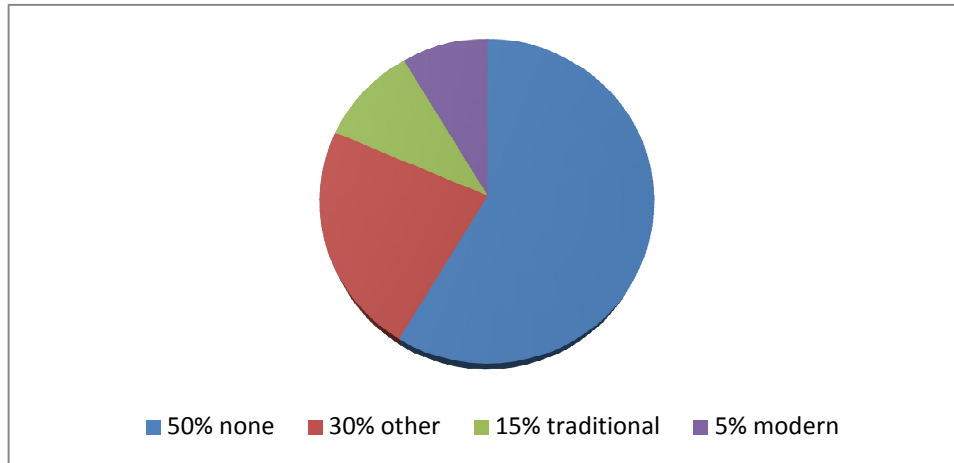


Figure 4: Proportion of respondent treatment method prefer to treat ectoparasite in uncontrolled area.

The responses of questionnaire administered to the hide and skin collectors were summarized by treatment (controlled and uncontrolled) (Annex 7). According to the respondents all of the hide and skin collectors were engaged on collecting hide and skin before three years, 66.7% of controlled area and 50% of uncontrolled area hide and skin collectors were involved in this work over five years. All respondents of hide and skin collectors of both controlled and uncontrolled area were set size of the skin, knife cut, existence of ectoparasite and putrefied skin as a parameter for purchasing (table 8). In addition to the above preconditions mechanical damage, scratch and scar were also among the parameters that all skin collectors of controlled area and 66.67% skin collectors of uncontrolled area used to collect the skin.

Ectoparasites were the main factor that hide and skin collectors looking for; in both controlled as well as uncontrolled area all hide and skin collectors were considering whether the skin infested with mange and lice or not. In both area 33.33% of the collectors of hide and skin collectors were looking over the existence and infestation of the skin with tick, while all of uncontrolled area skin collectors and 66.67% collectors of controlled area were regarding for the infestation of skin with keds.

According to response of all collectors of both controlled and uncontrolled area; tanners established size of the skin, existence of knife cut, infestation of skin with ectoparasites (if the skin is fresh), putrefied skin, mechanical damage, scratch and scar were the main parameters to receive hide and skin from the collectors. All collectors of both controlled and uncontrolled area were respond that tanners were looking for the infestation of skin with mange and lice during receiving the collected skin. From the total 9 hide and skin collectors interviewed, 3/6 (50%) and 2/3 (66.67%) respondents from controlled and uncontrolled area respectively believe that tanners were looking for whether the skin affected by tick or not and according to 2/3 (66.67%) collectors of uncontrolled area were also respond that tanners looking for the existence of skin affected by lice. All hide and skin collectors of both controlled and uncontrolled area were respond that the skin infested with ectoparasites not worth equally as the healthy one. Hence, all hide and skin collectors of controlled and uncontrolled area were respond the value of the skin infested with ectoparasite worth 50% less cost than the healthy skin. As the collectors brought the skin to the tanners, tanners were looking for either the skin affected by the ectoparasites or not. Therefore, the main reason that ectoparasite infested skin was cost less than the healthy one

All the hide and skin collectors of both controlled and uncontrolled area were stored the collected skin by sorting with salt. In both area 33.33% of the collectors were stored the collected skin from four to eight weeks while 66.67% of the collectors of both controlled and uncontrolled area were stored the skin for more than two months.

Table 8: Response of skin collectors on the parameters they set to collect sheep skin

Parameters	Controlled area collectors		Uncontrolled area collectors	
	Yes	No	Yes	No
Skin size	6	0	3	0
Knife cut	6	0	3	0
Ectoparasite	6	0	3	0
Putrefied	6	0	3	0
Mechanical damage	6	0	2	1
Scratch	6	0	3	0
Scar	6	0	3	0

4.2. Results of Clinical and Laboratory Examination of Sheep for Ectoparasites

Out of 646 sheep examined from the controlled districts 371 (57.43%) were infested with one or more ectoparasites. The major ectoparasites identified on sheep from controlled area were 49.85% lice, tick 9.7%, sheep keds 7.4% and 12.5% mixed infestation. In uncontrolled area from 323 sheep examined for ectoparasite infestation 285 (88.24%) were infested with one or more ectoparasites (Table 9). Ectoparasites identified from sheep of uncontrolled district were lice 82.35%, sheep keds 19.2%, tick 17.97% and 32.19% mixed infestation. Lice species recovered from controlled and uncontrolled districts were *B. ovis* 48.9% in controlled area and 81.4% from uncontrolled area; *Linognathus spp* 0.93% from controlled area and 0.9% from uncontrolled area. The tick species identified on sheep from controlled area were 2.32% *R. (B). decoloratus*, 1.46% *A. variegatum*, 1.08 % *A. gemma*, 4.59% *R. evertsi evertsi*, and 0.31% mixed infection. The tick species identified on sheep from uncontrolled area were 1.79% *R. (B). decoloratus*, 2.62% *A. variegatum*, 9.29% *R. evertsi evertsi* and 4.3% mixed infestation.

Table 9: Prevalence of ectoparasites in controlled and uncontrolled areas.

Ectoparasite	Controlled area(n=646)	Uncontrolled area (n=323)	P-value
Lice	49.85(322)	82.35(266)	0.000
<i>B. ovis</i>	48.3(316)	81.4(263)	
<i>Linognathus</i> spp	0.93(6)	0.9(3)	
Tick	9.7(63)	17.97(58)	0.000
R(B). <i>decoloratus</i>	2.32(15)	1.79(6)	
<i>A. variegatum</i>	1.46(9)	2.62(8)	
<i>A. gemma</i>	1.08(7)	-	
<i>R. evertsi evertsi</i>	4.59(30)	9.29(30)	
Mixed infection	0.31(2)	4.3(14)	
<i>M. ovinus</i>	7.4(48)	19.2(62)	0.000
Overall	57.43(371)	88.24(285)	0.000

The common sites of lice infestation on 316 sheep from controlled area were the shoulder, the neck, the flank and the rump with proportion of 63.9%, 62.66%, 56% and 77.1% respectively. The common sites of lice recovered from 263 sheep from uncontrolled area were 64.3% from shoulder, 45.6% from neck, 61.6% from flank and 61.9% from the rump. In *M. ovinus* infested sheep from controlled area the sites commonly parasitized were the shoulder (81.2%), rump (66.67%) the neck (34.4%), and the flank (6.25%) in order of importance. The sites of *M. ovinus* recovered from sheep of uncontrolled area were shoulder (83.8%), (35.5%) the neck (30.65%), the rump and (1.6%) the flank. The major tick attachment sites on the sheep of controlled area were head/ear (26.9%), the tail (38%) the feet (19%) and inter digital space (61.9%) whereas the remaining were found to attach at other sites of the body while the major attachment site of tick recovered from uncontrolled area were head/ear (53.45%), the tail (44.8%) the feet (29.3%) and inter digital space (62%) whereas the remaining were found to attach at other sites of the body.

Lice counted on a sheep of controlled area were range from 0 minimum and 257 maximum while in uncontrolled area the count of lice were 0 minimum and 489 maximum were registered. The minimum count for keds in controlled area were 0 and maximum 64, but in sheep of uncontrolled area 0 minimum and 107 maximum were registered. The count of tick in controlled area 0 minimum and 12 maximum were registered, in uncontrolled area 0 minimum and 17 maximum were registered. Most frequently lice, ked and tick number lies in the range of 51-100, 11-20 and 6-10 counts in controlled area respectively while in uncontrolled area most frequently lice, keds and tick number lies in the range of 101-200, 21-50 and 6-10 respectively.

4.2.1. Prevalence of Ectoparasites by Control Status

The overall prevalence of ectoparasite was significantly higher in uncontrolled area (88.24%) than in controlled area (57.43%) (OR= 5.644, P = 0.000) (Table 10). Control specific prevalence's of ectoparasites identified on sheep were shown in (Fig. 5). The prevalence of *M. ovinus* among the controlled and uncontrolled area were showed significant difference (OR=3.836, p=0.000). A similar logistic regression analysis performed on lice prevalence among the controlled and uncontrolled area revealed significant difference between two areas (OR=7.061, p=0.000). A significant difference in prevalence of ticks (OR=2.074, p=0.000) were also found between controlled and uncontrolled area (table, 10).

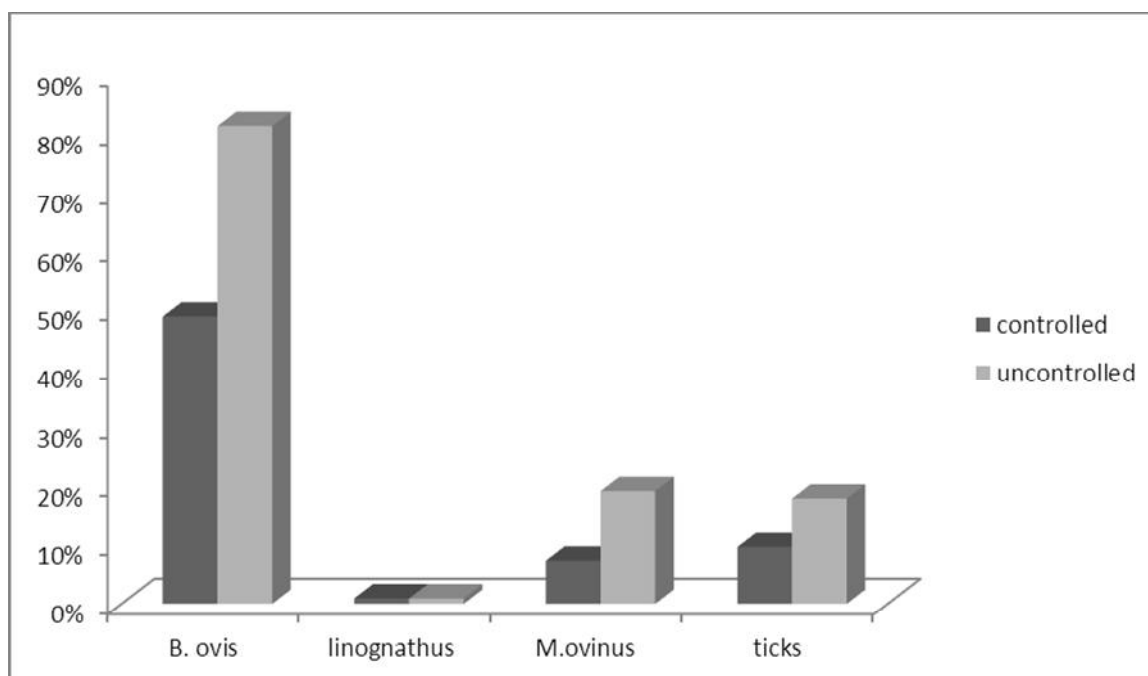


Figure 5: Overall prevalence of ectoparasite in controlled and uncontrolled area.

Table 10: Summary of binary logistic regression of ectoparasites according to control status

Ectoparasites	Control status (risk factor)	SE	p-value	OR	95%CI for OR	
					Lower	upper
Overall	Controlled ^a	1	1	1	1	1
	Uncontrolled	.191	0.000	5.644	3.881	8.207
Lice	Controlled ^a	1	1	1	1	1
	Uncontrolled	.196	0.000	7.061	4.812	10.360
Keds	Controlled ^a	1	1	1	1	1
	Uncontrolled	.223	0.000	3.836	2.478	5.939
Tick	Controlled ^a	1	1	1	1	1
	Uncontrolled	.192	0.000	2.074	1.424	3.021

SE standard error, OR odds ratio, ^a Reference category

4.2.2. Prevalence of Ectoparasites by Sex

The overall prevalence of ectoparasite in female and male was 88.68% and 88.23% and 63.1% and 44.4% in uncontrolled and controlled area respectively (Table 11). Statistically significant variation in the prevalence of ectoparasites was never recorded between male and female sheep of uncontrolled area ($p>0.05$) but the prevalence of ectoparasites was significantly ($OR= 0.455$, $p=0.000$) higher in the female animals than male animals of controlled area (Annex 9). Statistically significant difference in prevalence of lice ($OR=1.129$, $p=0.000$) infestation was observed between female and male sheep of controlled area (Annex 11). Likewise statistically significant difference in prevalence of tick was recorded between male and female sheep of uncontrolled area ($OR=1.861$, $p=0.035$) (Annex 16).

Table 11: Prevalence of ectoparasites in controlled and uncontrolled area by sex

Ectoparasite type	Controlled area		Uncontrolled area	
	Male(n=196)	Female(n=450)	Male(n=102)	Female(n=221)
<i>B. ovis</i>	39.3(74)	54.4(238)	83.3(85)	81(178)
<i>Linognathus</i> spp	1.02(2)	0.88(4)	1.9(2)	0.5(1)
<i>M. ovinus</i>	9.7(19)	6.4(29)	17.6(18)	19.9(44)
Ticks infestation	8.2(16)	10.4(47)	23.5(24)	15.4(34)
Overall	44.4(87)	63.1(284)	88.23(90)	88.68(195)

4.2.3. Prevalence of Ectoparasites by Age

The overall prevalence of ectoparasite in young and adult sheep of controlled and uncontrolled area was 56.9% and 57.8% and 88.2% and 88.3% respectively (Table 12). Statistically significant difference was never recorded ($p>0.05$) in the overall prevalence of lice, tick and *M. ovinus* infestations between young and adult of both area (Annex 11-16).

Table 12: Prevalence of ectoparasite in controlled and uncontrolled area by age

Ectoparasite	Controlled area		Uncontrolled area	
	Young(n=267)	adult(n=379)	Young(n=127)	adult(n=196)
<i>B. ovis</i>	47.6(127)	48.8(185)	83.3(102)	82.2(161)
<i>Linognathus</i> spp	1.5(4)	0.5(2)	2.4 (3)	-
Tick	10.1(27)	9.5(36)	14.9(19)	19.9(39)
<i>M. ovinus</i>	7.5(20)	7.4(28)	16.5(21)	20.9(41)
Overall	56.9(152)	57.8(219)	88.2(112)	88.3(173)

4.2.4. Prevalence of Ectoparasites by Body Condition

The overall prevalence of ectoparasites in good and poor body condition sheep were 58.3% and 56.7% in controlled area, and 90.8% and 86.2% in uncontrolled area respectively (Table 13). The logistic regression results showed statistically significance difference in prevalence of tick infestations (OR=0.478, p=0.015) between sheep with poor and good body condition in uncontrolled area (Annex 16). However, significant variations (p>0.05) were never observed in the prevalence of *B. ovis*, *Linognathus* spp, and *M. ovinus* infestations between sheep with poor and good body condition in both controlled and uncontrolled area.

Table 13: Prevalence of ectoparasite in controlled and uncontrolled area by body condition

Ectoparasite	Controlled		Uncontrolled	
	Poor(n=363)	Good(n=283)	Poor(n=181)	Good(n=142)
<i>B. ovis</i>	47.4(172)	58.3(165)	79(143)	84.5(120)
<i>Linognathus</i> spp	1.1(4)	0.7(2)	1.1(2)	0.7(1)
<i>M. ovinus</i>	7.7(28)	0.7(2)	19.3(35)	19(27)
Ticks	9.1(33)	10.6(30)	22.6(41)	11.9(17)
Overall	56.7(206)	58.3(165)	86.2(1156)	90.8(129)

4.2.5. Prevalence of Ectoparasites by Hair Size/Type

The overall prevalence of ectoparasites in hairy and woolly sheep of controlled area was 55.3% and 59.6% respectively while in uncontrolled area the overall prevalence was 78.9% hairy sheep and 48.7% in woolly (Table 14). Statistically significant difference in prevalence of *M. ovinus* between hairy and woolly sheep was observed in both controlled area (OR=0.081, p=0.000) and uncontrolled area (OR=0.017, p=0.000) (Annex 13 and 14). Statistically significant difference in prevalence of lice infestation between hairy and woolly sheep was also observed in controlled area (OR=0.715, p=0.036) (Annex 11).

Table 14: Prevalence of ectoparasite in controlled and uncontrolled area by hair type

Ectoparasite	Controlled area		Uncontrolled area	
	Hairy(n=322)	Woolly(n=324)	Hairy(n=171)	Woolly(n=152)
<i>B. ovis</i>	44.7(144)	51.8(168)	78.9(135)	84.2(128)
<i>Linognathus</i> spp	0.93(3)	0.92(3)	1.1(2)	0.7(1)
<i>M. ovinus</i>	-	14.8(48)	-	40.8(62)
ticks	11.2(36)	8.3(27)	15.2(26)	21.1(32)
overall	55.3(178)	59.6(193)	78.9(148)	48.7(137)

4.2.6. Prevalence of Ectoparasites by Management

The overall prevalence of ectoparasites in separately reared sheep and sheep reared with other animals in controlled area was 56.7% and 57.6%, while in uncontrolled area 88.9% and 88.1% respectively (Table 15). However, significant variations ($p>0.05$) were never observed in the prevalence of *B. ovis*, *Linognathus* spp, *M. ovinus* and tick infestation between sheep reared separately and those reared with other animal in both controlled and uncontrolled area.

Table 15: Prevalence of ectoparasite in controlled and uncontrolled area by management

Ectoparasite	Controlled area		Uncontrolled area	
	Separately(n=120)	Mixed(n=526)	Separately(n=63)	Mixed(n=260)
<i>B. ovis</i>	43.3(52)	49.4(260)	80.9(51)	81.5(212)
<i>Linognathus</i> spp	1.7(2)	0.7(4)	-	1.2(3)
<i>M. ovinus</i>	5.8(7)	7.8(41)	25.4(16)	17.7(46)
Ticks	11.7(14)	9.3(49)	20.6(13)	17.3(45)
Overall	56.7(68)	57.6(303)	88.9(56)	88.1(229)

5. DISCUSSION

Results presented in this study revealed an overall prevalence of 57.43 % of ectoparasites in controlled area and 88.24% in uncontrolled area. This finding is most probably attributable to several important factors including management problems, conducive environment, malnutrition and poor husbandry systems, poor awareness of farmers and inadequate veterinary services in the study districts (Mekonnen *et al.*, 2007; Mekonnen *et al.*, 2001; Pegram *et al.*, 1981). Even though control campaign was implemented, the prevalence of ectoparasite in controlled area was high in comparison with other areas. Among the factors which might be responsible for high prevalence of ectoparasite in controlled area were; the method of acaricides application (spray). During spray the formulated liquid acaricide might not reach at the base of the skin and all part might not cover with acaricides, therefore some ectoparasite may stay alive to induce re-infestation. Due to no police protect free animals movement from one place to the other and knowledge of farmers on quarantine of newly introduced animal hence; ectoparasite might be get introduction to the controlled area. As a fact that ectoparasite are most often introduced to herds by bringing in infested animals (Kufman *et al.*, 2012). However the overall prevalence was significantly lower in controlled area than uncontrolled area. Sheep of uncontrolled area were 5.644 times at risk for ectoparasite infestation than sheep found in controlled area. The findings of the current study of controlled area is in agreement with the previous reports from different parts of the country (Shibeshi *et al.*, 2013; Taddese *et al.*, 2013; Dawit *et al.*, 2012; Rahmeto *et al.*, 2011; Hailu 2010; Mulugeta *et al.*, 2010; Yacob *et al.*, 2008; Tefera, 2004). The findings of uncontrolled area is comparable with the previous reports from different parts of Ethiopia (Asnake *et al.*, 2013; Asmare *et al.*, 2012; Tewodros *et al.*, 2012) who reported high prevalence and great importance of ectoparasites in sheep.

The overall prevalence of ectoparasite ($p=0.000$) and tick infestation ($p=0.035$) in female sheep of controlled area was significantly higher than male sheep. Female sheep were 0.455 times and 1.861 times at risk for overall ectoparasite infestation and tick infestation than male respectively. This finding probably attributable to several important factors; ewes are

kept by the farmer for long period of time for breeding purpose but male sheep are sold before two years of age, hence the treated ewes might be exposed to re-infestation as they stay for long time and the control campaign is take place in every two years. In addition during breeding season ewes are in close contact with many rams for long time, hence the ewe might get ectoparasite from infested ram. Clinically affected and carrier animals are the source of infection (Wall and Sheare, 2001) and due to no policy which prevent free movement of animals from one place to the other in the country and negligible knowledge of farmer on quarantine newly introduced animals, the ewes kept in the village might obtain ectoparasite from animals introduced to the controlled area. Similarly ewes might be acquiring ectoparasite infestation during nursing from infested lamb which was born after control campaign. Also some species of ectoparasite such as tick spend more time off the host and can exist for a very long period of time without feeding (Wall and Shearer, 2001), due to no more application of environmental treatment females those kept for breeding after control campaign might infested.

Lice infestations were the most prevalent ectoparasites recorded in both controlled and uncontrolled sheep with a prevalence of 49.85% and 82.35% respectively (Table 9). The effects of climate change and other factor such as changes in animal management and husbandry systems, usage of antiparasitics and increase in animal trafficking or movements may also contribute to the changes in the prevalence, or emergence, of lice infestation in certain localities (Kufman *et al.*, 2012). Hence, prevalence of lice infestation was significantly higher in uncontrolled area than controlled area ($p=0.000$) and sheep found in uncontrolled area were 7.061 times at risk for lice infestation than sheep of controlled area. The prevalence of lice recorded in the controlled area is higher than the findings of (Shibeshi *et al.*, 2013) from east wollega, western Ethiopia (5.26%); 3.3% from northwest Ethiopia around Bahir Dar (Asmare *et al.*, 2012); 3.2% from Bahir Dar northwest Ethiopia (Dawit *et al.*, 2012); 1.3% from Tigray region north Ethiopia (Rahmeto *et al.*, 2011); 0.37% Tigray region north Ethiopia (Enquebaher *et al.*, 2010) and 15.3% from southeast part of Tigray region north Ethiopia (Mulugeta *et al.*, 2010). But this prevalence is lower than the recorded in the north part of Amhara region of 57.2 % (Tewodros *et al.*, 2012), and a higher

prevalence of 89.5% report from examination of fresh sheep skin at Sebeta (Yesehak, 2000).

Such differences in prevalence might arise from season during which the study was conducted, variations in management, health care of sheep in the study areas, and the sensitivity of the diagnostic method used. Lice infestation may reflect some other underlying problems such as malnutrition and chronic diseases (Wall and Shearer 2001). The possible reasons for such high prevalence of lice in the study area include management problems, poor feeding, and inadequate veterinary services.

The prevalence of lice was significantly higher in woolly sheep of controlled area than hairy sheep and woolly sheep of controlled area were 0.715 times at risk for lice infestation. Such difference might arise due to the fact that the skin's microclimate is a significant factor in determining the size of the louse population on the sheep. Thinness of hair coats in coupled with high surface temperatures and increased exposure to sunlight is not favorable for survival of lice (Changbunjong *et al.*, 2009). Sheep have heavy fleece provide a habitat which is readily colonized by lice and lice is susceptible to high temperature (Urquhart *et al.*, 1996). *B. ovis* was the most common louse that infesting sheep of both controlled and uncontrolled area. The prevalence of *B. ovis* recorded in uncontrolled area is comparable with work made in other parts of the country by Jemere et al (2011; 83.23%, central Ethiopia).

M. ovinus was the second and third most important ectoparasite observed on sheep of uncontrolled area and sheep of controlled area accounting for 19.2% and 7.4% overall prevalence respectively. The overall prevalence of sheep keds was significantly higher in uncontrolled area ($p=0.000$). Sheep of uncontrolled area were 3.836 times at risk for *M. ovinus* infestation than controlled sheep. According to Radostitis *et al* (1994) in the hot, humid tropics the parasite is restricted to cooler highlands and infestations may be lost when sheep are moved to hot dry areas. Andria *et al* (2006) suggested as an account for this fact; temperature may play an important role in the dynamics of the keds. The finding of higher prevalence *M. ovinus* on woolly sheep of both controlled and uncontrolled area (7.4%) and

(19.2) respectively while its total absence from hairy sheep of both area is suggestive of the fact that wooly breeds are susceptible to ked infestation (Wall and Shearer, 2001). wooly sheep of controlled area and uncontrolled area were 0.081 times and 0.715 times at risk for *M. ovinus* infestation respectively.

The prevalence of *M. ovinus* recorded in the controlled area is comparable with work made in other parts of the country by Rahmeto *et al* (2011; 6.7 % from Tigray region), Shibeshi *et al* (2013; 3.47 % from east wollega, western Ethiopia), Enquebaher *et al* (2010; 11.67 % from Southeast part of Tigray). Similarly the findings of *M. ovinus* in sheep of uncontrolled area is in agreement with previous works conducted in different part of the country by Mulugeta *et al* (2010; 19.1% from southeast part of Tigray region north Ethiopia), Asmare *et al* (2012; 14.2% northwest Ethiopia around Bahir Dar), Bersisa *et al* (2012; 16.4% from central oromiya) and 20.1 % of sheep keds in Gondar from northwest Ethiopia by Tewodros *et al* (2010).

Tick infestations with an overall prevalence of 9.7% from controlled area and 17.97% from uncontrolled area were the second highest and third highest identified ectoparasites respectively. The current study were conducted in highlands of Arsi with an overall prevalence of tick in both controlled and uncontrolled area were less than most studies accompanied in the country this might be due to higher temperatures and relative humidity and prolonged sunlight favour the survival and reproduction of ticks, as has been suggested by Pegram *et al* (1981) and Kumsa *et al* (2012). The overall prevalence of tick in uncontrolled area was significantly higher than controlled area ($p=0.000$). Tick findings of controlled area is in agreement with the previous observations reported by Tefera (2004), who reported that tick species are one of the most common ectoparasites of sheep in Amhara region. Tick findings of uncontrolled area is in agreement with the previous observations reported by Mulugeta *et al* (2010; 16% from southeast part of Tigray); Tewodros *et al* (2012; 21.2%, from northwest Ethiopia Gondar); Asnake *et al* (18.8%; from southern part of the country); and 19.2% of tick prevalence reported from Ambo (Tadese *et al.*, 2013). Heavy tick

burden cause sufficient worry to interfere with feeding which may lead to loss of production and weight gain. They also cause anemia and loss of production (Radostits *et al.*, 1994; Wall and Shearer, 1997). Hence, the prevalence of tick infestations in poor sheep of uncontrolled area was significantly ($p=0.015$) higher than sheep with good body condition and sheep with poor body condition score were 0.478 times higher at risk of infestation by ticks than those sheep with good condition. This finding coincides with the previous reports of Tefera (2004), Mulugeta *et al.* (2010) and Tewodros *et al.* (2012).

Tick infestations on sheep have both cutaneous and systemic effects. The cutaneous effects of ticks feeding on sheep includes development of papule, pustules, ulceration and alopecia while the systemic effects includes; introduction of surface bacteria into the skin, causing abscesses or systematically leading to bacteraemia and septicemia, tick paralysis due to neurotoxin or transmission of microorganism (Wall and Shearer, 1997). Despite such effects of tick on sheep their effect as a cause of downgrading and rejection of skin in the tanneries was minimal. Because the major tick attachment site were ear/head, legs and belly region which are less valuable part of the skin for tanning and are usually trimmed off before tanning.

The common sites of infestation for lice were the skin of shoulder, neck, rump and flank. This finding is in agreement with a finding of Mersha (2011; from menze area). According to Mersha (2011) *M. ovinus* were parasitized flank, shoulder, rump, and neck respectively in order of importance but the current finding were indicated shoulder, rump, neck and flank in controlled area were importance order. However, the finding of Mersha (2011) on ked was in agreement with the current finding from uncontrolled area. The count range of lice by Mersha (2011; 0-1050) were much higher than current finding (0-257) in controlled area and (0-489) in uncontrolled area. Similarly the keds count range recorded by Mersha (2011; 0-178) was higher than current finding (0-64) in controlled area and (0-107) in uncontrolled area. Most frequent range of lice infestation was 51-100 in controlled area was in agreement with finding of Mersha (2011) but the frequent range of lice infestation of uncontrolled area

was higher than Mersha finding (101-200). Likewise the current finding on frequent range of keds of uncontrolled area was in agreement with Mersha finding (18-34).

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. (2012) 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 piroplasmiasis 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.

6. CONCLUSION AND RECOMMENDATIONS

This study was conducted to identify the major ectoparasites prevalence and associated factors on sheep of controlled and uncontrolled area. The most important ectoparasite identified in this study were lice, sheep keds and tick. Lice were the most abundant ectoparasite in both area followed by sheep keds and tick in uncontrolled area and tick and sheep ked in controlled area. Age and management were not found as a risk factor of all ectoparasite infestation in the current study. However, sex, body condition and hair type were important factors for different ectoparasite infestation in the current study. Ectoparasites are among the major causes of sheep production constraints and quality deteriorations of exported skin in the Ethiopia. In view of the findings of the present study it is possible to conclude that even though control campaign were implemented several species of ticks, lice, and *M. ovinus* represent common health and productivity problems of sheep in both controlled and uncontrolled areas of Arsi zone.

Based on the above conclusive remarks the following recommendations are forwarded:

- Strategic and appropriate application of acaricides (dipping than spraying) during control campaign for effective ectoparasite control is required.
- Effective extension system and programs that could raise public awareness on management of animals, effect of ectoparasites and control methods should be implemented.
- Control programs should be designed and implemented with the participation of all stakeholders (farmers, tanners, government and other concerned bodies) and there should be strong coordination between neighboring regions and/or districts with strict follow up and control.
- Even though control campaign was implemented the prevalence of ectoparasite is still high hence, the regional government should be find out the causes and set solution.

- Further detailed study on economic loss associated with ectoparasites should be conducted.

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8. ANNEXS

Annex 1. Laboratory procedures

Mange mite identification

Examination of skin scrapings is essential in the diagnosis of mange. In longstanding cases mites are often very few in number and extremely difficult to find and their absence from the skin scraping doesn't negate a diagnosis (Jackson, 1991). Multiple sites should be scrapped to increase the likelihood of ectoparasite detection. Superficial skin scraping (epidermal surface examination) after removing coat hair by gentle clipping can be used to identify surface mites while deep skin scraping (deep epidermal examination) until capillary ooze occurs is useful in the diagnosis of burrowing and follicular mites such as *Sarcoptes scabiei* and *Demodex* spp. (Hendrix, 1998; Wall and Shearer, 2001). A few drop of 10% KOH solution or liquid paraffin are added to the sample, a cover slip applied and cleansing of debris allowed proceeding for 15-30 minutes before microscopic examination. Large samples may be processed by boiling 10 minute in 10% KOH solution, centrifuging and performing sugar flotation on the sediment (Smith and Sherman, 1994; Bowman, 1999).

Tick identification

According to (Wall and Sheare 2001) the procedure for identifying ticks is as follows; the preserved specimens of tick collected from the field are poured in to petridish and separated from material such as hair, scale or dry skin. Ticks which are dirty should cleaned their scutum by gently rubbing with cotton. Each tick are placed on clean petridish on the stage of a stereoscopic dissecting microscope and identified. Specimens should not be allowed to dry completely. Low power objective is use to separate genera and sexes of ticks. To identify at the species level medium or high power objective is used. The key morphological structures such as gnathosoma, capitulum, basis capituli, eyes, anal grooves, coxae, festoons,

Where

- ✓ Sex F (female) and M (male)
- ✓ Age A (adult) and Y (young)
- ✓ B.c (body condition) P (poor) and G (good)
- ✓ Mgt (management) M (mixed with other animals) and S (separately reared)
- ✓ Hair H (hairy) and W (woolly)
- ✓ Lice 1 (head, neck and shoulder), 2(wither), 3(ribs and belly), 4(flank and back) and 5(rump)
- ✓ Keds 1(neck), 2(shoulder), 3(belly), 4(flank) and 5(rump)
- ✓ Ticks 1(ear), 2(belly and ribs), 3(tip of tail), 4(under tail), 5(udder/testicle) 6(inter digital space)
- ✓ Mange 1(head and neck), 2(shoulder), 3(belly), 4(back), 5(udder/testicle) and 6(limb)

Annex 3: body condition score

Whole body	
➤ Emaciated	
➤ Boney processes can be easily felt	
Spine	
➤ Dorsal spinous processes are sharp and prominent	
➤ Easily felt through skin	BCS-1
Loin	
➤ No fat cover	
➤ Loin muscle very shallow	
Transverse processes	
➤ Transverse processes sharp	

-
- Easy to pass fingers underneath them
-

Whole body

- Thin

- More difficult to feel between each process

Spine

- Dorsal spinous processes still prominent, but not as sharp

Loin

- Loin eye muscle fuller

BCS-2

- Virtually no fat cover

Transverse processes

- Transverse processes rounded on edge

- Slight pressure needed to push underneath them
-

Whole body

- Average

Spine

- Spinous processes smoother and less prominent

- Some pressure required to feel between them

BCS-3

Loin

- Loin muscle full, some fat cover

Transverse processes

- Transverse processes smooth

- Firm pressure needed to push fingers under edge
-

Whole body

- Fat

- Fat accumulation over tail head

Spine

- Considerable pressure needed to feel dorsal spinous processes

BCS-4

Loin

- Loin eye muscle full with discernible fat cover

Transverse processes

- Transverse processes can't be felt
-

Whole body

➤ Obese

➤ Fat pad over tail head

Spine

➤ Dorsal spinous processes can't be felt

BCS-5

➤ Depression often present where they would normally be felt

Loin

➤ Loin eye muscle very full

➤ Thick covering of fat

Transverse processes

➤ Transverse processes can't be felt

Source: Gatenby, (1991)

Annex 4: Questionnaire for sheep owners

Date _____ Zone _____ district _____ Kebele _____

Village _____ Owner Name _____

1. Family income source (Rank)

Crop Animal product sale

Animal sales others

2. Livestock ownership pattern (number of animals owned).

Sheep Camel

Goats Equines

Cattle Poultry

3. Why do you keep sheep? (Rank)

For income generation and insurance

Meat for home consumption

Milk for consumption

Wool production

Skin production

others

4. Management type

Mixed farming

Sem-intensive

Pastoral

intensive

5. Which species are more important for this area?

Sheep

Goats

Equally

6. How do you manage sheep?

Mixed with other species of animals

Separately

7. Do you know any skin diseases that affect sheep?

Yes

No

8. If yes, can you mention them?

9. which age groups are more affected

	young	adult	all
Lice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ticks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Keds	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mange	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. Is there seasonal variation in the occurrence of the diseases?

Diseases	Yes	No	I don't know
Lice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ticks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Keds	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mange mite	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11. If yes, in what season the disease is mostly encountered?

	Autumn	winter	spring	summer
Lice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Keds	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ticks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Mange Mite

12. Which skin diseases have effect on sell of sheep?

Yes

No

Lice

Keds

Ticks

Mange Mite

13. If your answer for Q12 is yes how they affect? -----

14. Do they have effect on the sell of skin?

Yes

No

Lice

Keds

Ticks

Mange Mite

15. How do you treat skin diseased animals?

Modern treatment

other

Traditional treatment

none

16. Which skin diseases are treated traditionally?-----

17. What is the name of traditional remedy used? And its effect (recovery/ Partial recovery)--

18. How many times you use acaricides and during what time (annually)?-----

20. Are there other control methods other than treatment? If yes please mention -----

21. Dose the importance of ectoparasite decrease due to control program?

Yes

No

not satisfactory

22. Is there any rule which prevents animal movement from one area (district) the other?

Yes

No

23. Do you think that ectoparasite is among the major problem of sheep in this area? If yes what is the better alternative to reduce the impact of this disease? -----

Annex 5: questionnaire for the hide and skin collectors

Date _____ zone _____ district _____ kebele _____ PA _____
name _____

1. For how many years engaged on the collection of skin of small ruminants _____

2. What factors are you looking for during purchasing sheep skin?

3. Have you ever set ectoparasite as one of the factors you look for?

Yes

No

4. If your answer for the Q3 is yes how do you treat infested skin?

5. Does both ectoparasite infested skin and healthy one have equal cost?

Yes

No

6. If you reply yes for the Q5 verify the cost difference between infested skin and healthy skin

7. How do you store the collected skin?

8. For how long time do you store the collected skin?

9. Where do you sold the collected skin?

10. Have you encountered any difficulty to sell the collected skin to the tanners?

Yes

No

11. What does the tanners looking for while receiving the skin?

Annex 6. Summary of questionnaire study of controlled and uncontrolled area

Description	Number of respondents by treatment (spray)	
	controlled	Uncontrolled
1. Rank of income		
Crop		
➤ 1	30	17
➤ 2	6	3
➤ 3	4	0
Animal		
➤ 1	4	2

➤ 2	34	15
➤ 3	2	1
Animal product		
➤ 1	0	0
➤ 2	0	0
➤ 3	30	18
Others		
➤ 1	6	1
➤ 2	0	2
➤ 3	4	1

2. Number of animals owned

Sheep

➤ No	0	0
➤ 1-5	4	1
➤ 5-10	14	5
➤ >10	24	14

Goat

➤ No	30	10
➤ 1-5	4	7
➤ 5-10	6	3
➤ >10	0	0

Cattle

➤ No	7	0
➤ 1-5	12	3
➤ 5-10	16	5
➤ >10	5	12

Equine

➤ No	14	4
➤ 1-5	19	14
➤ 5-10	7	2

➤ >10	0	0
Poultry		
➤ No	4	2
➤ 1-5	8	9
➤ 5-10	17	5
➤ >10	11	4
Camel		
➤ No	40	20
➤ 1-5	0	0
➤ 5-10	0	0
➤ >10	0	0
3. Reason of keeping sheep		
For income and insurance		
➤ No	0	0
➤ 1	36	17
➤ 2	4	3
➤ 3	0	0
Meat for home consumption		
➤ No	0	0
➤ 1	6	5
➤ 2	34	15
➤ 3	0	0
Home milk		
➤ No	40	20
➤ 1	0	0
➤ 2	0	0
➤ 3	0	0
Wool production		
➤ No	40	20
➤ 1	0	0
➤ 2	0	0

➤ 3	0	0
Skin production		
➤ No	0	0
➤ 1	0	0
➤ 2	4	3
➤ 3	36	17
4. More important species in these area		
➤ Sheep	40	20
➤ Goat	0	0
5. Sheep management system		
➤ Mixed	32	14
➤ Separately	8	6
6. Knowledge of sheep skin disease		
➤ Yes	30	12
➤ No	10	8
7. Known skin disease		
➤ Mange	16	5
➤ Keds	24	9
➤ Tick	5	3
➤ Lice	4	1
➤ Other	16	18
8. Age group more commonly affected		
Lice		
➤ Young	0	2
➤ Adult	15	9
➤ Both	7	9
Mange		
➤ Young	0	0

➤ Adult	23	14
➤ Both	6	3
Keds		
➤ Young	5	3
➤ Adult	19	14
➤ Both	9	3
Tick		
➤ Young	10	2
➤ Adult	20	13
➤ Both	10	2

9. Seasonality of the disease

Lice		
➤ Yes	0	2
➤ No	0	4
Keds		
➤ Yes	7	5
➤ No	5	3
Tick		
➤ Yes	9	2
➤ No	5	3
Mange		
➤ Yes	12	8
➤ No	7	3

10. Season of the occurrence

Lice		
➤ Dry	12	3
➤ Rainy	0	1
➤ Cold	2	0
Keds		
➤ Dry	27	8
➤ Rainy	0	0

➤ Cold	2	1
Mange		
➤ Dry	1	3
➤ Rainy	0	0
➤ Cold	22	12
Tick		
➤ Dry	1	0
➤ Rainy	24	14
➤ cold	0	0

11. ectoparasite that affect animal

sell

Lice	4	2
➤ Yes	15	18
➤ No		
Keds	5	2
➤ Yes	15	17
➤ No		
Mange	29	17
➤ Yes	0	3
➤ No		
Tick	7	3
➤ Yes	22	17
➤ No		

12. Ectoparasite that affect skin sell

Lice

➤ Yes	4	10
➤ No	20	2
Keds		
➤ Yes	4	2
➤ No	18	18
Mange		

➤ Yes	11	15
➤ No	0	0
Tick		
➤ Yes	18	3
➤ No	12	17
13. Method used to treat ectoparasite	4	1
➤ Modern	5	2
➤ Traditional	23	13
➤ None	8	4
➤ other		
14. Usage of acaricides		
➤ Yes	0	0
➤ No	40	20
15. Frequency of acaricides usage		
➤ Annually		
➤ Twice per year	0	0
➤ No	0	0
	40	20
16. Control method other than treatment		
➤ Culling	0	0
➤ Isolation	0	0
➤ Shearing	0	0
➤ No	40	20
17. Police of animal movement		
➤ Yes	0	0
➤ No	40	20

Annex 7. Summary of questionnaire study of hide and skin collector of both area

Description	Number of respondent by treatment (spray)	
	Controlled area	Uncontrolled area
1. Experience of collecting		
➤ 0-3 year	0	0
➤ 3-5 years	2	1
➤ 5-10 years	2	2
➤ >10 years	2	0
2. Parameter for purchasing		
Size		
➤ Yes	6	3
➤ No	0	0
Knife cut		
➤ Yes	6	3
➤ No	0	0
Ectoparasites		
➤ Yes	6	3
➤ No	0	0
Putrefied		
➤ Yes	6	3
➤ No	0	0
Mechanical damage		
➤ Yes	6	2
➤ No	0	1
Scratch		
➤ Yes	6	3
➤ No	0	0
Scar		
➤ Yes	6	3
➤ No	0	0

3. Type of ectoparasite looking for

Mange

➤ Yes	6	3
➤ No	0	0

Keds

➤ Yes	4	3
➤ No	2	0

Lice

➤ Yes	6	3
➤ No	0	0

Tick

➤ Yes	2	1
➤ No	4	2

4. infested and uninfested have

cost difference

➤ Yes	6	3
➤ No	0	0

5. How cost infested one

➤ Equal to healthy one	0	0
➤ < 25% than healthy	0	0
➤ < 50% than healthy	6	3
➤ < 75% than healthy	0	0

6. Storage of collected skin

➤ No	0	0
➤ Sort with salt	6	3
➤ Other	0	0

7. How long stored

➤ 1-4 week	0	0
➤ 4-8 weeks	2	1
➤ > 2 months	4	2

8. Factors tanners looking during
receive these skin

Size		
➤ Ye	6	3
➤ No	0	0
Knife cut		
➤ Yes	6	3
➤ No	0	0
Ectoparasites		
➤ Yes	6	3
➤ No	0	0
Mechanical damage		
➤ Yes	3	1
➤ No	3	2
Scratch		
➤ Yes	6	3
➤ No	0	0
Scar		
➤ Yes	6	3
➤ No	0	0
putrefied		
➤ Yes	6	3
➤ No	0	0
	6	3
	0	0

9. Type of ectoparasite tanners
looking

Mange		
➤ Yes	6	3
➤ No	0	0

Keds		
➤ Yes	6	2
➤ No	0	1
Lice		
➤ Yes	6	3
➤ No	0	0
Tick		
➤ Yes	3	2
➤ No	3	1

10. Cost of infested skin at tannery

➤ Equal to healthy	0	0
➤ 25% < healthy	1	0
➤ 50% < healthy	5	3
➤ 75% < healthy	0	0

Annex 8: Summary results of binary logistic regression for overall ectoparasite

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Control status	Controlled ^a	1	1	1	1	1
	Uncontrolled	.191	.000	5.644	3.881	8.207
Age	Young ^a	1	1	1	1	1
	Adult	.150	.547	.914	.682	1.225
Sex	Male ^a	1	1	1	1	1
	Female	.163	.013	1.504	1.092	2.027
Body condition	Good ^a	1	1	1	1	1
	Poor	.147	.313	1.160	.870	1.546
Hair type	Hairy ^a	1	1	1	1	1
	Woolly	.146	.230	.840	.631	1.117
Management	Separately ^a	1	1	1	1	1
	Mixed	.187	.958	.990	.687	1.427

SE standard error, OR odds ratio, ^a Reference category

Annex 9: Summary results of binary logistic regression for ectoparasite in controlled area

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Age	Young ^a	1	1	1	1	1
	Adult	.168	.566	1.101	.793	1.530
Sex	Male ^a	1	1	1	1	1
	Female	.178	.000	.455	.321	.645
Bodycondition	Good ^a	1	1	1	1	1
	Poor	.163	.670	1.072	.779	1.476
Hair type	Hairy ^a	1	1	1	1	1
	Woolly	.162	.296	.844	.615	1.160
Management	Separately ^a	1	1	1	1	1
	Mixed	.208	.617	.901	.599	1.356

SE standard error, OR odds ratio, ^a Reference category

Annex 10: Summary results of binary logistic regression for ectoparasite in uncontrolled area

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Age	Young ^a	1	1	1	1	1
	Adult	.358	.914	1.040	.516	2.096
Sex	Male ^a	1	1	1	1	1
	Female	.375	.952	1.023	.490	2.133
Bodycondition	Good ^a	1	1	1	1	1
	Poor	.363	.196	1.598	.785	3.254
Hair type	Hairy ^a	1	1	1	1	1
	Woolly	.356	.310	.697	.347	1.400
Management	Separately ^a	1	1	1	1	1
	Mixed	.448	.911	1.051	.437	2.529

SE standard error, OR odds ratio, ^a Reference category

Annex 11: Summary results of binary logistic regression for lice in controlled area

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Age	Young ^a	1	1	1	1	1
	Adult	.166	.464	.522	.367	.741
Sex	Male ^a	1	1	1	1	1
	Female	.179	.000	1.129	.816	1.562
Body condition	Good ^a	1	1	1	1	1
	Poor	.161	.609	1.086	.792	1.489
Hair type	Hairy ^a	1	1	1	1	1
	Woolly	.160	.036	.715	.522	.978

Management	Separately ^a	1	1	1	1	1
	Mixed	.206	.287	.803	.536	1.203

SE standard error, OR odds ratio, ^a Reference category

Annex 12: Summary results of binary logistic regression for lice in uncontrolled area

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Age	Young ^a	1	1	1	1	1
	Adult	.367	.887	1.053	.513	2.162
Sex	Male ^a	1	1	1	1	1
	Female	.408	.340	1.476	.633	3.282
Bodycondition	Good ^a	1	1	1	1	1
	Poor	.363	.491	1.284	.630	2.618
Hair type	Hairy ^a	1	1	1	1	1
	Woolly	.365	.273	.670	.328	1.371
Management	Separately ^a	1	1	1	1	1
	Mixed	.450	.912	.952	.394	2.300

SE standard error, OR odds ratio, ^a Reference category

Annex 13: Summary results of binary logistic regression for *M. ovinus* in controlled area

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Age	Young ^a	1	1	1	1	1
	Adult	.320	.644	.863	.461	1.614
Sex	Male ^a	1	1	1	1	1
	Female	.325	.127	1.641	.869	3.101
Body condition	Good ^a	1	1	1	1	1
	Poor	.311	.782	.918	.499	1.688
Hair type	Hairy ^a	1	1	1	1	1
	Woolly	.397	.000	.176	.081	.384
Management	Separately ^a	1	1	1	1	1

Mixed .431 .444 .719 .309 1.673

SE standard error, OR odds ratio, ^a Reference category

Annex 14: Summary results of binary logistic regression for *M. ovinus* in uncontrolled area

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Age	Young ^a	1	1	1		
	Adult	.344	.723	1.130	.575	2.219
Sex	Male ^a	1	1	1	1	1
	Female	.356	.888	.951	.474	1.910
Body condition	Good ^a	1	1	1	1	1
	Poor	.330	.923	.969	.507	1.849
Hair type	Hairy ^a	1	1	1	1	1
	Woolly	.733	.000	.017	.004	.071
Management	Separately ^a	1	1	1	1	1
	Mixed	.395	.149	1.767	.815	3.830

SE standard error, OR odds ratio, ^a Reference category

Annex 15: Summary results of binary logistic regression for tick in controlled area

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Age	Young ^a	1	1	1		
	Adult	.273	.614	1.148	.672	1.961
Sex	Male ^a	1	1	1	1	1
	Female	.309	.344	.747	.408	1.367
Body condition	Good ^a	1	1	1	1	1
	Poor	.267	.523	1.185	.703	1.999
Hair type	Hairy ^a	1	1	1	1	1

	Woolly	.269	.204	1.406	.831	2.380
Management	Separately ^a	1	1	1	1	1
	Mixed	.323	.441	1.283	.681	2.417

SE standard error, OR odds ratio, ^a Reference category

Annex 16: Summary results of binary logistic regression for tick in uncontrolled area

Risk factors		SE	p-value	OR	95%CI for OR	
					Lower	Upper
Age	Young ^a	1	1	1	1	1
	Adult	.299	.599	.855	.475	1.537
Sex	Male ^a	1	1	1	1	1
	Female	.295	.035	1.861	1.044	3.316
Bodycondition	Good ^a	1	1	1	1	1
	Poor	.305	.015	.478	.263	.868
Hair type	Hairy ^a	1	1	1	1	1
	Woolly	.289	.345	.762	.432	1.341
Management	Separately ^a	1	1	1	1	1
	Mixed	.351	.621	1.189	.598	2.368

SE standard error, OR odds ratio, ^a Reference category

Annex 17. Picture of flock of sheep infested with *B. ovis* and collected skin



