

**ADDIS ABABA UNIVERSITY
COLLEGE OF HEALTH SCIENCE
SCHOOL OF VETERINARY MEDICINE**

**EPIDEMIOLOGICAL STUDY ON ECTOPARASITES OF SMALL RUMINANTS IN
THREE SELECTED AGRO-ECOLOGICAL AREAS IN OROMIA REGIONAL
STATE AND THEIR IMPACT ON TANNING INDUSTRY, ETHIOPIA**

By

KEBEDE BEYECHA

**JUNE, 2010
DEBRE ZEIT, ETHIOPIA**

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fulfillment of the requirements for the Degree of Master of Science in Tropical Veterinary
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LIST OF ABBREVIATIONS

CI	Confidence Interval
CSA	Central Statistical Agency
DVM	Doctor of Veterinary Medicine
EEA	Ethiopian Export Agency
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
ICTTD	International Consortium on Ticks and Tick borne Diseases
ILRI	International Livestock Research Institute
Kg	Kilogram
Km	Kilometer
LLPTI	Leather and Leather products Technology Institute
masl	Meter above sea level
mm	Millimeter
MoARD	Ministry of Agriculture and Rural Development
MSc	Master of Science
NAHDI	National Animal Health Diagnostic and Investigation Center
°C	Degree Celsius
OARD	Office of Agriculture and Rural Development
PA	Peasant Association
QSAE	Quality and Standards Authority of Ethiopia
Spp.	Species
SPSS	Statistical Package for Social Science
UK	United Kingdom
UNIDO	United Nations Industrial Development Organizations
USD	United State Dollar
USA	United State of American

ABSTRACT

A cross-sectional study was conducted in three selected agro-ecologies of Oromia regional state and Modjo and Ethiopia tanneries, Ethiopia between October, 2009 and April, 2010 with the objectives of determining the prevalence of ectoparasites in sheep and goats, investigating the effect of risk factors on ectoparasite prevalence distribution and assessing the pickled and wet blue skin defects. Simple and systematic samplings were used. The results of cross-sectional clinical examination indicated that out of 1325 sheep and 979 goats examined, 637 sheep (48.1%) and 487 goats (49.7%) were infested with one or more ectoparasites. The ectoparasites identified on sheep were *Damalinia ovis* (27.2%), *Melophagus ovinus* (16.4%), ticks infestation (11.2%), *Ctenocephalides* species (2.3%), *Linognathus* species (1.5%), and sarcoptic mange (1.2%). In goats, ticks infestation (24.6%), *Linognathus* species (16.5%), sarcoptic mange (8.8%), and *Ctenocephalides* species (5.1%) were identified type of ectoparasites. The overall prevalence of ectoparasites in lowlands, midlands and highlands was, respectively 38.5%, 47.3% and 52.9% in sheep and 49.5%, 56.4% and 33.0% in goats. Statistically significant difference ($p < 0.05$) was observed in prevalence of *D. ovis* among agro-ecologies (highland (36.6%), midland (20.9%) and lowland (14.0%)) and *M. ovinus* between midland (1.9%) and highlands (31.7%). The risk of tick infestation of sheep in lowland and midland was 9.883 times and 13.988 times, respectively higher than highlands. There was also significant difference in prevalence of *Ctenocephalides* between lowland and highland (OR= 4.738, $p = 0.011$) and midland and highland (OR= 8.073, $p = 0.000$). However no statistically significant difference ($p > 0.05$) was observed in *Linognathus* and sarcoptic mange of sheep. In goats, there was statistically significant difference ($p < 0.05$) in prevalence of ticks among agro-ecologies, *L. stenopsis* between lowland and highland and sarcoptic mange between lowland and midland. Both in sheep and goats no statistically significant difference in prevalence of all identified ectoparasites ($p > 0.05$) was observed between male and females. Statistically significant difference in prevalence of *D. ovis* was observed between young (32.0%) and adult (24.1%) sheep ($p < 0.006$). In goats, the risk of *Ctenocephalides* in young was 2.430 times higher than adults. There was also statistically significant difference ($p < 0.000$) in prevalence of sarcoptic mange between young and adult goats. In prevalence of *M. ovis*, *D. ovis* and sarcoptic mange, statistically significant difference ($p < 0.05$) was observed between poor and good body condition sheep. There was also significant difference in

prevalence of sarcoptic mange between poor and good conditioned goats (OR = 7.565, $p = 0.000$). A study on 716 pickled sheep skins and 716 wet blue goat skins showed cockle ('ekek') was the second dominant defect both on pickled skins (60.2%) and wet blue skins (45.1%). Other major skin defects observed in this study were scratches, scars, and flaying. There was significant association between cockle and scars ($\chi^2 = 15.257$, $p = 0.000$) and cockle and scratches ($\chi^2 = 6.965$, $p = 0.008$) on pickled sheep skins. There was also significant association on wet blue goat skins between the cockle and scratches ($\chi^2 = 10.598$, $p = 0.001$); however no significant association was observed between cockle and scars ($\chi^2 = 1.983$, $p = 0.195$). This current study also indicates that the proportion of skins with cockle were higher in lower grades than top grades. The results of questionnaire survey revealed that sixty eight owners (91.8%) in lowland, 74 (91.13%) midland and 68 (91.89%) highland knew one or more parasitic skin diseases on sheep and goats. Half of interviewed farmers (lowland) believed that mange had effects on the value of affected skins, while the majority of the respondents in all surveyed agro-ecologies did not consider that keds, lice and ticks affected the sale of skins. The overall findings of the study indicate the need of strategic ectoparasite control program in the study area.

Keywords: Agro-ecology; Ectoparasites; Goat; Oromia Region; Prevalence; Sheep; Skin defect; Tannery

1. INTRODUCTION

Ethiopia is a country with the largest livestock population in Africa. This livestock has been contributing considerable portion to the economy of the country, and still promising to rally around the economic development of the country. It is eminent that livestock products and by-products in the form of meat, milk, eggs, cheese, and butter supply the needed animal protein that contribute to the improvement of the nutritional status of the people. Livestock also plays an important role in providing export commodities such as live animals, hides, and skins to earn foreign exchanges to the country. The livestock production contributes about 30-35% of agricultural GDP (Ayele *et al.*, 2003). Current estimate of Ethiopian livestock population indicates that the country owns 47 million cattle, 26.12 million sheep, 21.7 million goats, 1.78 million horses, 5.57 million donkeys, 0.38 million camels, 39.6 million poultry, and 4.69 million beehives (CSA, 2008).

In Ethiopia, small ruminants are kept in a wide range of production systems reflecting the diversity of the Ethiopian climate which covers from the humid highland to arid and semi-arid environments; which are managed by smallholder farmers under extensive low input traditional management system and adjunct to crop production. Owing to their high fertility, short generation interval and adaptation even in harsh environments, sheep and goats are considered investments and insurance to provide income to purchase food during seasons of crop failure and to meet seasonal purchases such as improved seed, fertilizer and medicine for rural household (). They are important contributors to food production in Ethiopia, providing 35% of meat consumption and 14% of milk consumption (Zelalem and Fletcher, 1993).

Hides and skins account for 12-16% of the total value of exports. The potential supply of hides and skins depend on the scale of meat production (FAO, 1998). The off take (slaughter) rate currently used by MoARD are 8% for cattle, 35% for sheep, and 38% for goats. About 90-95% of the skin production is derived from urban as well as rural backyard slaughter and the remaining 5-10% from major urban slaughter houses and export abattoirs. The current utilization of hide and skin is estimated to be 48% for cattle hide, 75% for goat skin and 97% for sheep skin. Ethiopian highland sheep skin is estimated to comprise 70% of the total sheep

skin production of the country (Mahmud, 2000). More than twenty tanneries found in different parts of the country receive and process 14.3 million skins annually (Mahmud, 2000; Alem, 2002).

Despite their physiological adaptation and ability to thrive under harsh environmental conditions and their importance as components of the Ethiopian farming system, the full exploitation of these resources is hindered and hence their contribution to food production, rural and export income are far below than expected potential. This is because small ruminant production in Ethiopia is constrained by the compound effects of inadequate feeds, wide spread of diseases and poor managements (Zewdu, 1995; Tembeley, 1998; Moges and Hagos, 2003; Belachew and Jemberu, 2003).

Ectoparasitic and other skin diseases have wide spread distribution and particularly affect larger number of sheep and goats in Ethiopia especially in the last 10 years. They cause mortality, decreased production and reproduction of animals, and downgrading and rejection of skins (Craig, 1998; Amsalu, 2000; Fthenakis *et al.*, 2000; El-Bakey, 2001; Ftheninakis *et al.*, 2001; Eze, 2002; Kassa, 2002; Dimri and Sharman, 2003). Ectoparasites such as lice, keds, ticks and mange mites are among the major diseases of small ruminant causing serious economic loss to the farmer, the tanning industry and the country as a whole (FAO, 1995; FAO, 1998; Amsalu, 2000; Tefera, 2004; Kassa, 2006; Mersha, 2007). The characteristic gross appearances of skin affected by skin diseases include thickened skin, encrustations, vesicles, papules, nodules, and areas of superficial erosions and ulcerations (Jones *et al.*, 1997).

Skins from sheep and goat and hides from cattle have been important economic products contributing for the largest share to the total and agricultural export commodities of the country. This fact gives the advantage of earning a large foreign currency from the export of skins and hides (OIE, 1998; Ayele *et al.*, 2003). However in recent years this rank has been relegated to fifth level mainly because of rejection and downgrading inflicted on skin and hide defects due to infestation by ectoparasites (Belachew, 2004; Kassa, 2005; Kidanu, 2006)). Skin diseases, scratch and scar, flay cuts and holes, putrefaction and heat, and poor substances are the main problems related to skin and hide quality the tanneries are facing, creating an

estimated loss to the Ethiopian economy of about USD 14 million/year (Kassa, 2006). According to tanneries report, ectoparasite associated skin diseases cause 35% of sheep skin and 56% of goat skin rejection (FAO, 1998).

In the Oromia regional state, about 9,401,844 sheep and 7,685,529 goats are estimated to be found (CSA, 2008), which represents 36.16% and 36.59% of the national sheep and goat population, respectively. The skin supply to the central market of the country from the Oromiya region is estimated to be 32.9% of sheep skins and 26.4% of goat skins (Mahmud, 2000). Few studies had been conducted with regard to small ruminant ectoparasites in the region and particularly no such study had been conducted in this currently selected study areas; the problem of parasitic skin diseases is evident in various areas of the region which have been causing serious threat to small ruminant production; moreover, the tanneries which are found in the region have repeatedly reported emphasizing the problem of quality deterioration of sheep and goat skins after processing in the tanning industries due to the presence of external parasites (Gashaw, 1986; Shenkutie, 1987; Nigatu, 1992; FAO, 1998; Ermias, 2000; Haffize, 2001; Molu, 2002); there are no detailed studies in different agro-climatic zones of the region that indicate the type of ectoparasites observed, their magnitude, factors influencing their distribution and their relative importance for farmer and tanning industry. Information of this finding could be used in making appropriate prevention and control measures against the parasite infestations. Therefore, this present study was undertaken with the following objectives:

- To determine the prevalence of ectoparasites in small ruminants in selected agro-ecological areas of Oromia region.
- To determine the effects of risk factors on prevalence distribution of small ruminant ectoparasites in the study area.
- To assess skin defects due to parasitic skin diseases on pickled and wet blue skins in study tanneries.

2. LITERATURE REVIEW

2.1. Arthropod parasites

Arthropods are invertebrates containing over 80% of all known animal species and occupying almost every known habitat. They parasitize a wide range of hosts including other arthropods.. These parasites, with a few exceptions, live on or burrow into the surface of their host's epidermis and are generally described as ectoparasites (Wall and shearer, 1997). The phylum Arthropoda can be well defined by the presence of seven features: segmented bodies, exoskeleton, stigmatization, jointed legs, dorsal blood vessel, haemocoel and ventral nerve cord. However within the phylum, there is considerable variation in morphology. The economically important arthropods belong to two major groups, the Insecta (flies, lice and fleas) and Arachnida (ticks and mites) (Soulsby, 1982).

The host provides a number of important resources for the parasite, most vitally, 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's 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, 1997).

Despite a benefit of a close association with the host, there is a considerable variation in the amount of time spend on the host by various types of ectoparasites. Some ectoparasites such as many species of lice live in continuous association with their host throughout their life cycle and are therefore, highly dependent on the host. The majority of ectoparasites, however, has only intermittent contact with their hosts, and is free-living for the major portion of their life cycles. In some cases, ectoparasites, such as many species of mite, are highly host specific; only one host species is exploited and in some instances, the parasite can exist only on one defined area of the host. Other species are able to exploit a wider range of hosts (Bowman and Lynn, 1999).

Arthropod parasites may have a variety of direct and indirect effects on their hosts. The direct harm comprises blood loss, myiasis, skin inflammation and pruritus (release of cytokines by stimulated keratinocytes and type I hypersensitivity to salivary and fecal antigens) and toxicity. The indirect losses include disturbance as a result of irritation as they attempt to feed or ovipositor, self-wounding and, they may act as either mechanical or biological vectors of pathogens. These effects result in reduced time spent in feeding, decreased performance, loss of condition, reduced growth, weight gain, milk and wool production, and damage skin and could even lead to death of the animal (Kettle, 1984; Kaufmann, 1996; Wall and Shearer, 1997; Hendrix, 1998; Nelson and Slen, 2004).

2.2. Lice

Lice are small, about 0.5-8mm in length, wingless insects, dorsoventrally flattened, with stout legs and claws for clinging tightly to fur, hair and feathers; the sensory organs are poorly developed, the eyes are vestigial or absent. The lice belong to the order Phthiraptera which includes two important suborders: Anoplura (sucking lice) and Mallophaga (chewing lice) (Bay and Harris, 1988; Urquhart *et al.*, 1996). Both chewing lice and sucking lice affect small ruminants. The important lice species in sheep and goats are found in the genus *Damalina* and *Linopgnathus*. *D. ovis*, *L. ovillus* (face louse), *L. africanus*, and *L. pedalis* (foot louse) infest sheep. In goats, *L. stenopsis*, *D. caprae*, *D. limbata* and *D. crassiceps* are reported (Soulsby, 1982; Sewell and Brochesby, 1990).

2.2.1. Lifecycle

Life cycles of all lice are similar (Radostits *et al.*, 1994; Peter, 1995); they spend their entire life on the host. Female lice generally deposit one to two eggs per day, cementing them firmly to individual hairs or feathers. Nymphs hatch from the eggs and then feed and moult through three to five stages and mature lice appear. The life cycle of most lice species varies from 2-4 weeks under optimum conditions. They cannot survive off the host and transfer to new hosts is by body contact, particularly under condition of close confinement (Bay and Harris, 1988; Heath *et al.*, 1995; Peter, 1995; Bowman and Lynn, 1999).

2.2.2. Pathology

The effect of lice is usually a function of their density (Peter, 1995). The irritation from louse infestation causes animals to rub and scratch their body, leading to restlessness, damage to the fleece and skins (Kettle and Lukeirn, 1984; Georgi *et al.*, 1985; Wall and Shearer, 1997). In sheep, *D. ovis* is usually considered to be the most pathogenic; the infestations occur over all areas of the body but the upper sides of animal are favored; they move rapidly over the wool fiber but is usually found near the skins. In contrast to sucking lice (*L.stnopsis*), chewing lice have lesser significances in causing skin lesions or in impairing the general health of goats (Maming and Scott, 1985; Bay and Harris, 1988; Jubb *et al.*, 1993). The lesions consist of papules, crusts and secondary excoriations; epidermal pustules containing eosinophils and perivascular or diffuse dermatitis with eosinophils, plasma cells and lymphocytes are present (Kettle, 1984; Peter, 1995). *Damalinia ovis* is also associated with the development of cockle (Jubb *et al.*, 1993; Heath *et al.*, 1996). Sucking lice are also notorious for transmission of typhus and relapsing fever for humans (Sewell and Brochesby, 1990)

2.2.3 Epidemiology

Lice spend their entire lives on their host and are generally highly host specific, many species even preferring specific sites on their host's body, only leaving their host to transfer to a new one. Anoplura are exclusive to mammals where as Mallophaga are found in greatest variety on birds and are often called "bird lice", but some of them are very common on livestock such as sheep and cattle. Lice have a tightly defined band of humidity and temperature preference and respond to humidity and temperature gradients by showing increased rates of turning in favorable microclimates which tend to keep them in favorable areas (Heath *et al.*, 1995; Wall and Shearer, 1997). When temperature is cooler than optimum, eggs do not develop while hotter temperature prevent egg laying and kill the lice; they usually move away from direct light towards dark objects. In the flock, there are often carrier animals that stay heavily infested all year round. The level of lice infestation show seasonal periodicity; heavy infestations usually occur in the moist and cool temperature of winter months and decline in the dry and hot

conditions of summer (Kettle, 1984; Asp and Tauni, 1988; Radostits *et al.*, 1994; Urquhart *et al.*, 1996).

2.3. Keds

The sheep ked, *Melophagus ovinus*, is a member of the parasitic Dipterans order, Hippoboscidae family. It is a wingless, hairy, leathery insect, 6-7mm long. The head is short, broad and not freely movable, the thorax is brown and broad, and having grayish-brown abdomen. The legs of *Melophagus ovinus* are characteristically strong and armed with stout claws. Adult keds are permanent ectoparasites and feed on the blood of sheep which also sometimes parasitize goats (Soulsby, 1982; Maming and Scott, 1985).

2.3.1. Life cycle

Keds live their entire life cycle in the host but able to move from one host to another rapidly within the flock (Sewell and Brochesby, 1990). The female ked live for 4-5 months and lays 10-15 larvae during this time; thus build up of infestations is slow. 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 (Bay and Harris, 1988; Wall and Shearer, 1997). A single larva is laid at a time and deposited on the host and pupates within a few hours. Larvae are attached to the wool fiber some distance above the skin. The young keds usually emerges in 20-22 days but this period may be prolonged for up to 35 days in winter season. The complete life cycle takes 5-6 weeks in optimum warm conditions (Radostits, *et al.*, 1994).

2.3.2. Pathology

Although the degree of infestations usually encountered cause only irritations, the resulting scratching, biting and rubbing themselves against fences, stones, shrubs, and other sources cause severe damage to the skin and wool (Urquhart *et al.*, 1996). Keds are blood feeders and feed several times each day and therefore, very heavy infestations may cause severe anemia

(Sewell and Brochesby, 1990). Skin puncture made by blood sucking keds are cause for the development of cockle in the finished sheepskin (Health *et al.*, 1995; FAO, 1998). Cockle is an inflammatory response of the skin against the presence of keds and their saliva which is recognized after the wool or hair has been removed from the skin. It is detectable after depletion of the hair or wool where they present as numerous small raised nodules on the grain surface of the skin (Asp and Tanui, 1988; Pfeffer *et al.*, 1996). In addition, the faeces of the keds stain the wool and consequently reduce its value and give it a peculiar musty odor (Radostits *et al.*, 1994; Wall and Shearer, 1997).

2.3.3 Epidemiology

The spread of keds is mainly through contact and their movement from ewe to lamb is an important route of infestation. The predilection sites of sheep keds infestation are the neck, around the tail, shoulder, back and ventral part of the body (Asp and Tanui, 1988; Jubb *et al.*, 1993). 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. The parasite is mainly seen in colder and wetter areas and infestations may be lost when sheep are moved to hot and dry areas. Keds are most active in cooler months and more common on coarse rather than fine woolen breeds (Kettle, 1984; Radostits *et al.*, 1994). Those sheep which are 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. *Melophagus ovinus* is now established in most temperate sheep rearing areas including Europe, North America, South Africa and Australia but is restricted to higher altitudes in the tropics (Urquhart *et al.*, 1996; Bowman and Lynn, 1999).

2.4. Mange mites

Mange mites belong to phylum Arthropoda, class Arachinda and Order Acarina. The mites are small and highly adaptable animals capable of living in a wide range of habitats. Infestation by mites is called acariasis and can result in severe dermatitis, known as mange (Wall and Shearer, 1997). Mange is a wide spread and important ectoparasite disease of animal, which may cause

significant economic losses (Radostits *et al.*, 1994). The major mite species that infest small ruminants and cause mange belong to the four genera; *Sarcoptes*, *Psoroptes*, *Chorioptes* and *Demodex* (Soulsby, 1982; Sileshi *et al.*, 1998).

Mites are small, usually less than 1 mm in length. The body shows no segmentation, although it can have various sutures and grooves; the typical mite body can be divided into two sections, the anterior (gnathosoma) which is composed of mouthparts and a posterior (idiostoma) which contains brain and other organs. The legs are usually six-segmented; adults and nymphal mites have four pairs of legs but larvae have only three pairs. In adults and nymphs, the legs are arranged in two sets, two pairs of anterior legs and two pairs of posterior legs (Wall and Shearer, 1997). Adults of *Sarcoptes* mite have round or oval body with mouthparts short and square, and whitish gray or reddish color. Their body is soft and bears spines of 0.25 to 0.5 mm in lengths which are very thin and microscopic. The anterior legs don't pass the mouthparts interiorly and the posterior legs also do not pass the body boundary posteriorly; the pedicles are long and unsegmented, and armed with caruncles (suckers), however on the 3rd pair of legs in male and on 3rd and 4th pair of legs in the female there are bristles instead of caruncles. *Psoroptes* mites have a large ovoid body with no dorsal spines and conical and pointed rostrum (mouthpart). Their legs are longer and project beyond the body margins. They have long and segmented pedicles; caruncles are found on 1st, 2nd and 4th pair of legs but the on 3rd pair of legs end with bristles (Soulsby, 1982).

2.4.1. Life cycle

The ectoparasitic mites inhabit the skin, where they feed on blood, lymph, skin debris or sebaceous secretions, which they ingest by puncturing the skin, scavenge from the skin surface or imbibe from epidermal lesions (Wall and Shearer, 1997). Although, like the ticks, mites are obligate parasites, they differ from them in that most species spend their entire life cycles, from egg to adult, on the host so that transmission is mainly by contact. Moreover, all the three stages, larvae, nymphs and adults, are capable of migrating and hence inert materials can act as a carrier. Adult mites do not usually survive more than two weeks away from the host, but in

optimum conditions, they may remain alive for up to three weeks (Kaufmann, 1996; Urquhart *et al.*, 1996).

The life cycle of mange mites varies according to the type of species and sites of localization. Fertilized female mites lay eggs, from which six-legged larvae hatch, but a few species are ovoviviparous. The larva moults to become an eight-legged nymph; there may be between one and three nymphal stages, known respectively as the protonymph, deutonymph, and tritonymph. The nymph then moults to become an eight-legged adult. The number of eggs produced per female is highly variable but lifetime reproductive outputs may be as low as 16 eggs per female. The life cycle of many parasitic mite species may be completed in less than four weeks and in some species may be as short as eight days; hence these mites have the potential for explosive increases in their population size (Bowman and Lynn, 1999).

2.4.2. Pathology

According to Wall and Shearer (1997), mite infestation may result in direct epidermal damage leading to inflammation; erythema, pruritus, scale, lichenification and crust formation; the production of cutaneous hypersensitivity (type I), loss of blood or other tissue fluid. Some cases of mange in small ruminants may end up with fatal Death may be due to dehydration, a direct result of the feeding of huge number of mites, and inability to move and feed due to severe lesions on the face, muzzle and on the joints. The mortality rate is higher in younger and in poor condition animals (Sewell and Brookesby, 1990; Olubunmi, 1995). In infestations which do not end fatally, a marked regression of lesions with healing of the skin and re-growth of the wool or hair occurs during the dry season. Exposure of lesion and mite to direct sunlight and desiccation may reduce the survival potential of mite populations (Fthenakis *et al.*, 2000).

Sarcoptic mange in sheep and goats is caused by *Sarcoptes scabiei* var *ovis* and *S. scabiei* var *caprae*, respectively (Okoh and Gandame, 1992; Olubunmi, 1995; Gibbs and Paul, 1998). Sarcoptes are highly specialized for life within the skin (Sewell and Brochesby, 1990). The burrowing and feeding activities of *Sarcoptes scabiei* cause intense itching, inflammation, hair loss, and formation of crusts, which are primarily made of dried exudates. It usually starts on

relatively hairless part of the skin and may latter generalize (Bowman and Lynn, 1999). 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 (Asp and Tauni, 1988; Radostits *et al.*, 1994). *Sarcoptes* mites are economically the most important cause of mange in both goat and sheep (Rahbari *et al.*, 2009).

The psoroptic mange, commonly known as sheep scab, is highly contagious and economically important parasitic diseases of sheep. *Psoroptes ovis* and *Psoroptes cuniculi* are the causative agents of sheep and goat psoroptic mange, respectively. *Psoroptes* mites prefer areas covered by wool or hair and migrate to all parts of the skin (Soulsby, 1982). They do not burrow in the epidermis but remain at the base of the hairs and pierces the skin; this manner of feeding results in exudation and exfoliation, serum, which hardens to form a scab (Sewell and Brochesby, 1990; Henderson, 1991). In sheep, the cutaneous lesions may occur on any part of the body, but characteristically in badly affected sheep, they are most obvious on sides. In goats, lesions can vary from a dry crusty scab on the external ear canal (otic acarisis) with no clinical signs to severe lesions covering much part of the body (Jackson, 1991; Smith and Sharman, 1994; Asegedeche *et al.*, 1999; Bowman and Lynn, 1999).

Although specific names have been given to *Chorioptes* found in cattle (*C. bovis*), sheep (*C. ovis*), horse (*C. equi*), and goats (*C. caprae*) which are causes for cases of chorioptic mange; they are now all considered to belong to the single species, *Chorioptes bovis* (Radostits *et al.*, 1994). Alike *Psoroptes*, they have mouth parts which do not pierce the skin of the host but are adapted solely for chewing, and feeding on shed scales and other skin debris (Urquhart *et al.*, 1996). Chorioptic mange in sheep usually infests the scrotum and may cause decrease in fertility; it causes testicular degeneration by raising the temperature of the scrotal contents. In goats, the chorioptic lesions are commonly confined to the lower part of the leg whereby crusty lesions may be found behind the fetlock of all four limbs (Jackson, 1991; Radostits *et al.*, 1994; Peter, 1995).

Mites of *Demodex* species live as commensally in the skin of most mammals and are exceptional in being selective for particular sites, the hair follicles and sebaceous glands where

they spend their lives; for the most part they are non-pathogenic and form a normal part of the skin fauna (Radostits *et al.*, 1994). Demodicosis, Follicular mange, is more severe in goat which is caused by *Demodex caprae* than sheep which is caused by *Demodex ovis* and is rarely debilitating, and is of greatest importance as a cause of down-grading or rejection of goat skins (Jackson, 1991). In goats, non-pruritic papules and nodules develop especially over the face, neck, shoulders, and sides. The nodules contain a thick, waxy, grayish material that can be easily expressed, hence mites can be found in these exudates (Cynthia *et al.*, 2005).

2.4.3. Epidemiology

The spread of mange mites is usually by close physical contact. Infestation may also occur by indirect transfer since mites have been shown to be capable of surviving off the host for short periods; sheds, boxes, and pasture fencing may be considered as sources for occurrence of re-infestations (Radostits *et al.*, 1994; Wall and Shearer, 1997). Mange affects all age groups and runs a more chronic course in adults than younger animals. Sheep and goats that are housed, in poor condition, and affected with debilitating diseases are usually more affected with mange mites (Kaufmann, 1996; Urquhart *et al.*, 1996).

The distribution of mange mites varies according to the season; they are adapted to definite ranges of temperature and humidity. Heavy infestations usually occur in the moist and cool temperature of winter months and may decline in the dry and hot conditions of summer (Radostits *et al.*, 1994). Though the majority of animals become infested while the mites are active and multiplying, the quiescent phase is very significant in the epidemiology of the disease; for apparently normal animal carrying this phase in reservoir sites may be introduced to healthy flocks during summer and autumn and initiate outbreaks when the cold season arrive. Reservoir sites such as infra-orbital fossa, inguinal pouches, scrotum, under tail, under ears, inter-digital pouches, perineum, and skin folds are foci for mites; they may be served as potential dry season hiding places where the mites tend to migrate to the general body surface with the onset of cold season (Urquhart *et al.*, 1996).

2.5. Ticks

Ticks are obligate, blood feeding ectoparasites of vertebrates, particularly mammals and birds. They are primarily parasites of wild animals and only about 10% of species feed on domestic animals. Ticks belong to the phylum Arthropoda and order Acarina (Latif and Walker, 2004); there are two major families of ticks, the Argasidae and the Ixodidae. Argasidae ticks are often known as soft ticks due to absence of scutums on their bodies, while the second family, Ixodidae, with scutums is frequently called hard ticks, and contains almost the species of ticks of veterinary importance (Okello-Onen *et al.*, 1999; Walker *et al.*, 2003; Sileshi *et al.*, 2007). Barker and Morel (2004) have described about 899 tick species that infest vertebrates including Argasidae (185 species), Ixodidae (713 species) and Nuttalliellidae (1 species). The classification of ticks according to FAO (1984) is as follows.

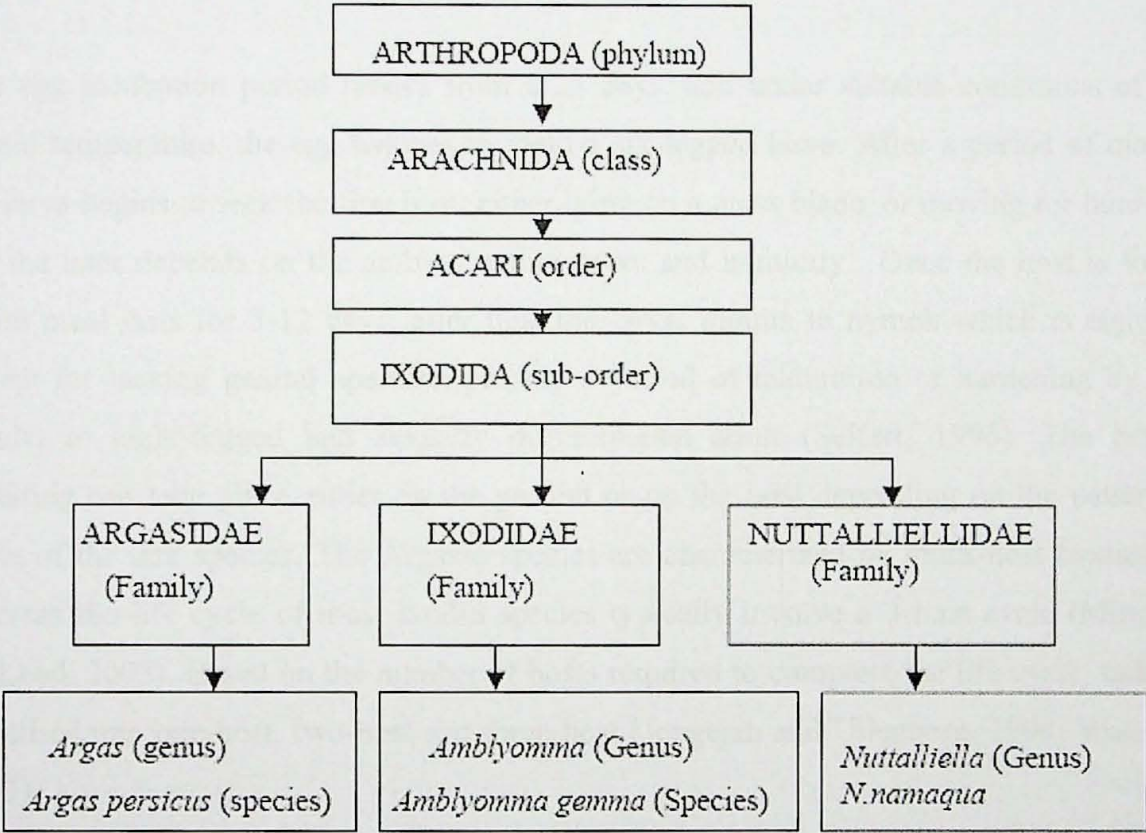


Figure 1: The classification of ticks

2.5.1. Life cycle

High reproductive potential is an important feature in the biology of ticks. Mating in ixodid ticks usually takes place on the host, except in the case of *Ixodes* where it may also occur when the ticks are still on the vegetation (Walker *et al.*, 2003). The adult female tick on the host sucks up considerable amount of blood and copulates with the male while feeding (Seifert, 1996). During mating the male crawls under the female, and after manipulating the female genital opening with its mouth parts, transfers the sperm theca, a sac containing the spermatozoa, into the opening, presumably with aid of its front legs. The female mate only once before they are ready to fully engorge with blood; when they finally engorge, they detach from the host and have enough sperm to fertilize all their eggs (Walker *et al.*, 2003). The engorged female drops off and deposits up to 18,000 eggs in a mass (ranges from 10,000-20,000 eggs) (Urquhart *et al.*, 1996).

The egg incubation period ranges from 6-23 days, and under suitable conditions of hot and humid temperature, the egg hatches to yield a six-legged larva. After a period of maturation, the larva begins to seek the first host, either lying on a grass blade, or moving for hunt activity; but the later depends on the ambient temperature and humidity. Once the host is found, the blood meal lasts for 3-12 days; after this, the larval moults to nymph which is eight-legged, except for lacking genital aperture, passing a period of maturation or hardening by feeding, moults to eight-legged and sexually differentiated adult (Seifert, 1996). The process of moulting can take place either on the ground or on the host depending on the pattern of life cycle of the tick species. The Argasid species are characterized by multi-host feeding pattern whereas the life cycle of most ixodid species typically involve a 3-host cycle (Minjauw and McLeod, 2003). Based on the number of hosts required to complete the life cycle, ticks can be classified into one-host, two-host and three-host (Jongejan and Uilenberg, 1994; Walker *et al.*, 2003).

One-host tick is less common type of life cycle but it occurs in the entire *Boophilus* genus and in some other genera. Larvae hatch after several weeks of development and crawl on to vegetation to quest for a host; when they have completed feeding, they remain attached to the host and molting occurs there. The nymphs then feed on the same host and remain attached, and after another molt, the adults hatch and then feed on the same host for mating. Thus, all

three feedings of any individual tick occurs on the same individual host. The life cycle of one-host ticks is usually rapid, for *Boophilus* it takes three weeks for the feedings on the host and two months for egg laying and larval development (Walker *et al.*, 2003). All the developmental stages occur on a single vertebrate attacked by the larvae. Oviposition by females, incubation and host finding by the larvae occur on the ground. The ticks leave the host at the engorged adult stage (Soulsby, 1982; Morel, 1989).

In two-host ticks, the three stages develop on two different individuals that may or may not belong to the same species. In the first phase, the engorged larvae moult on the host and the nymph reattaches on the same host; at the end of the blood meal, the nymph detaches and metamorphoses on the ground. Engorgements of the adults occur during the second parasitic phase. There are only two searches for the host, which eliminates the risks linked with the need for nymphal attachment. The two-host life cycle is similar to one-host life cycle but only the larvae and nymphs feed on the same individual host, and the adult will feed on another host (Morel, 1989).

Walker *et al.* (2003) stated that three-host tick is the commonest type of life cycle and is relatively considered as primitive. Host finding occurs three times and the ticks require three hosts for development, irrespective of the host species. There are three parasitic phases, separated by two phases on the ground when metamorphoses occurs (Morel, 1989). After hatching larvae begin to seek the first host, either lying in wait on a grass blade or moving to hunt actively; once the host is found, the blood meal lasts for 3-12 days or more depending on the species and ambient condition, then detaches from the host and falls on the ground, seek shelter and hide in sites such as soil or vegetation. The metamorphosis takes 2-8 weeks depending on microclimatic conditions and it ends with the emergence of a nymph; after a period of hardening, the activities of the instars are similar to those of the preceding larval instars in terms of movement and selected host; it undergoes a complete metamorphoses resulting in the adult female or male. The entire life cycle of three host ticks may take from six month to several years and thus it is slow (Peter, 1995; Walker *et al.*, 2003)

2.5.2. Pathology

The local injury due to tick infestations developed at the site of attachment may predispose to secondary bacterial infection and/or screwworm myiasis (Jubb *et al.*, 1993; Brossard, 1998); with powerful mouth parts, ticks damage the skin of animals and lead to reduction in the leather quality and consequently to considerable economic loss (Asp and Tauni, 1988; Uilenberg, 1997; Brossard, 1998). Deep and painful bite wound is more severe in those ticks having long mouthparts, *Amblyomma* and *Hyalomma* species; deep bite often leads to abscess formation due to infection induced by pyogenic bacteria (Camus and Bare, 1991; Jubb *et al.*, 1993). The irritation and painful phenomenon that followed tick bite result in worry or annoyance, hence the host expend much of its time and energy in effort to avoid this effect rather than grazing (Morel, 1989). The damage incurred by long mouthed tick species results in the rejection and downgrading of skins. Skin damage on sheep skin is primarily found along the belly area or where the fleece is thinner; lamb skins are particularly more susceptible to it. Ticks produce marks that look like hole and pinpricks on the grain or scars that mostly occur in the belly (Soulsby, 1982).

Ticks are vectors and potential reservoir of various infectious diseases (Gary and Potgieter, 1982; Oliver, 1989; Jongejan, 1999). They can be a cause for toxicosis and tick paralysis. Some species of ticks known to introduce toxin through their salivary secretions into the host bloodstream while feeding; the toxins act like neurotoxin either producing ascending paralysis or responsible for tick-borne toxicosis. Ticks like *Dermacentor andersoni*, *Hemaphysalis punctata*, *Hyalomma aegypticum*, *Rhipicephalus evertsi evertsi*, *Rh. simus*, and *Amblyomma cajannense* reported to be responsible for tick paralysis, while *Hyalomma truncatum* and *Rhipicephalus appendiculatus* able to cause tick toxicosis, sweating sickness, that is seen in Southern and East Africa (Brossard, 1988; Morel, 1989; Sere, 1997; Uilenberg, 1997).

2.5.3. Epidemiology

Ixodid ticks, particularly three-host ticks spend 94-97% of their life cycle off-host in the external environment (Needham and Reel, 1991), this implies that they are exposed to and

under the influence of many factors like habitat structure and climate (Randolph, 2004). The most important ecological factors that influence the occurrence of ticks include temperature, which is dynamic factor (oogenesis activity) and relative humidity, which is a statistic factors (survival). Each species has its particular threshold temperature below that diapause occurs in all instars (Morel, 1989). The habitat of ticks is composed of a variety of living and non-living factors; they are adapted to two extremely contrasting components of their habitat, the physical environment and their host. During the time of moulting and questing in the physical environment they are in danger of drying out, starving and freezing as well as exposed to predator. The larvae are most susceptible because they have high surface area relative to their small volume (Walker *et al*, 2003; Latif and Walker, 2004). Most ticks do not tolerate direct sunlight, dryness, or excessive rainfall. Their activity is restricted during cold period, but increases dramatically during hot and humid weather (Hendrix, 1998).

The temperature and rainfall influences the hatchability pattern and molting period (Dipeolu, 1984). Temperature affects the proportion of the developmental stages of ticks. Progress of the rate of development is directly related to temperature (FAO, 1984). In tropical grazing area where suitable grass covers does not exist, it has been generally accepted since temperatures are suitable for development throughout a large part of the year, that the distribution of ticks is mainly governed by rainfall. The various genera of ticks have different thresholds of temperature and humidity within which they are active and fed and their distribution is governed by these thresholds (Urquart *et al*, 1996). The relative humidity and air temperature are also main factors that influence tick activity. In temperate climate, tick activity is usually confined to the period between spring and autumn where there is sufficient rainfall and warm temperature. In tropical and sub-tropical climates, it is greatest during the rainy season although different species have different microclimate requirements (Hunter, 1994).

Vegetation is not only the rest of various elements that make up the environment, but it also determines, by its compositions, the various microclimates at different level. It is the best ecological integration which influences the biological phenomena (Morel, 1989). According to Dipeolu (1984) the molting period of larvae and nymphs kept in the open environment as well as the total duration of the life cycle was lower than those of ticks kept in the shade. In

addition, the survival of larvae and nymphs of all tick species studied was lowest during the peak of rain and highest during the dry season. The survival was also generally higher among larvae and nymphs kept in the shade than those kept in the open environment.

2.6. Blowflies

The infestation of tissue of the animal by the larval stage of dipterous flies, usually known as maggots, is termed as myiasis. Cutaneous myiasis (blowfly strike) of sheep and goats may be caused by screwworm flies; *Cochliomyia hominivorax* (Nearctic and Neotropical region), *Chrysoma bezziana* (Afrotropical oriental regions) and *Wahlgrtia magnifica* (Eastern palaearctic region) and genera of *Lucilia*, *Calliphora*, *Pharmia* and *Protophormia*. Cutaneous myiasis of goats by species of *Lucilia*, or other *Calliphoria* blowflies is less common than in sheep, probably because of the more open hair of sheep (Wall and shearer, 1997). The fly larvae feed directly on the host's necrotic or living tissue (Bay and Harris, 1988).

The life cycle of blowflies passes through four stages; egg, larvae, pupa and adults; though the species have similar life cycle, the stages vary in period length. Under favorable conditions of food, temperature and moisture, the entire life cycle is completed in 10 to 20 days (Kimberling, 1988). The incidence of blowfly strike varies widely depending largely on the climate; warm humid weather being more conducive for occurrence of high incidence. The flies are attracted to sheep that have undergone prolonged wetting so that bacterial decomposition of the skin has occurred (Hunter, 1994; Radostits *et al.*, 1994). The main predisposing host factors for sheep myiasis are trauma, shearing, tail-docking, castration wounds, fecal and urine soiling, bacterial dermatitis, and foot rots. The factors predisposing to myiasis in descending order in goats are open wound, shearing, caeseous lymphadenitis, foot rot, fecal staining, ophthalmic or facial eczema, horn fracture, rumen fistula and posterior paralysis (Kimberling, 1988; Amin *et al.*, 1997; Wall and shearer, 1997).

The direct pathological effect of myiasis may vary considerably and depends on the species of ectoparasites involved, the number of larvae and the site of infestation. In many cases infestation by small number of fly larvae may have little or no discernible clinical effects

ranging from irritation, discomfort and pruritus, resulting in reduced feeding, weight loss, reduced fertility and loss of general conditions. However, heavy infestation may lead rapidly to host death from direct tissue damage, hemorrhage, bacterial infection, dehydration, anaphylaxis and toxemia (Wall and Shearer, 1997). Myiasis from a range of species also has been shown to produce a marked immunological response in the host and the maggots produce enzyme that digest the skin and produce large open wounds (Hunter, 1994); open wounds produced cause severe scarring of the skin, which grossly affect the appearance of the final leather (Kimberling, 1988).

2.7. Fleas

Fleas, order Siphonapetra, small usually between 1 and 6 mm in length, blood-feeding insects. In contrast to lice, the flea body is laterally compressed. The flea has 4 life stages, egg, larva, pupa, and adult; under favorable conditions a generation can be completed in 2 to 3 weeks. Mating takes place on the host and eggs are laid on the host; since they are not attached, the eggs drop to the ground and hatch in from two days to several weeks, development occurs most commonly in the bedding of the resting areas of the host. The larvae are very small worm-like legless insects with chewing mouthparts; in several weeks they pass through 3 larval stages, feeding on organic debris. The pupal stage lasts approximately one week, and then the newly emerged adult flea is readily to feed on blood within 24 hours (Soulsby, 1982; Wall and Shearer, 1997).

Flea infestation may be more widespread in summer and autumn than in winter and spring. Fleas are rare cause of dermatitis in sheep and goats; however, infestation with *Ctenocephalides felis felis* has been reported. Although blood-meal size is small, repeated feedings, and high infestations can cause significant blood loss. High flea population may cause ulcers on the head and ears. Pruritus and self-inflicted excoriations occur in sheep, and papules, crusts, pruritus and excoriations are in goats (Yeruhan *et al.*, 1989; Cole, 1996).

2.8. Sheep and goat skins

2.8.1. Skin production and processing

In Ethiopia, small ruminants are reared in all agro-climatic zones. The highland area comprises 70% of the sheep and 30% of the goat population, while the lowland pastoral and agro pastoral areas have 30% of the sheep and 70 % of the goat population. The annual off take rate for small ruminants is estimated to be 35% for sheep and 38% for goats. In Ethiopia, the potential supply of hide and skins depend on the scale of meat production. The demand for meat is influenced by many factors; some of these include; size of the population, per capita income, price of the meat and share in household expenditure, economic development and export opportunities. Although skin is a byproduct of meat production, it is a major export commodity and raw material for local industries (FAO, 1998). The overall yield of skin in relation to the slaughtered animal is approximately 10% for small ruminants (Kyomo, 1997). According to FAO (1992) estimate, Ethiopia produce 14,958 metric tone sheep skin and 14,310 metric tone goat skin annually.

The major regions that supply sheep skins are Amhara, Oromiya, SNNP, and Addis Ababa accounting for 34.5%, 32.9%, 16.6%, and 7.9% of the central market sheep skin supplies, and 45%, 26.4% and 11.7% of the goat skins originate from the Amhara, Oromiya, and SNNP regions, respectively. It is estimated that 8% and 92% of the sheep skin are fresh and wet salted, respectively, and 12%, 13%, and 75% of the goat skin are fresh, air dried and wet salted, respectively (Mahmud, 2000).The tanning industries receive and process 14.3 million skin annually. There are now more 20 tanneries that process hide and skin from pickled up to crust and finished leather. Ethiopian highland sheep skins have international reputation for their unique natural substance of fineness, flexibility, strength, and compactness of texture; they are suitable for production of high quality dress gloves, sport gloves and garments (Mahmud, 2000; Alem, 2002).

2.8.2. Types of skin defect

Numerous endogenous and exogenous factors cause significant alterations in the skin, an organ with a limited spectrum of responses to injury (FAO, 1995; Jemberu, 2001). Skin quality is primarily defined by the absence of damage to the grain layer of the skin (Hadly, 2001).The

quality of finished leather is related to number of surface and structural defects that skins acquire during the life of the animal, slaughtering, storage and transportation stages. Top quality leathers, known as aniline, are produced from skins having few or no visible defects; they are generally soft, full in substance, and visibly display the attractive grain patterns of the natural skin. Skin defects may be classified into those acquired during the life of the animal, called pre-mortem defects, and those that occur during and after slaughter, called post-mortem defects. Pre-mortem defects include skin diseases, scratches, scars, brand marks, old age and poor substances. The postmortem defects are including bruises, gouge marks, flay cut, bad bleeding, putrefaction, hair slip, and insect damages (Kidanu, 2001; Kassa, 2006).

Pre-mortem defects may arise from natural or acquired causes. Breed, sex, and age of the animal have significant effect on quality of the leather. The skins of sheep breed types of Ethiopian highlands and goats from some parts of lowlands of Ethiopia are considered to have fine grain with strong fiber structure (Jemberu, 2001). Thinner, finer and stronger leather are likely to be made from female animal skins. Skins from older animals have coarse grain and thicker substance. The younger the animal, the better the quality and the finer the grain. Animals with poor nutrition yield skin of poor substance and lesser area than well fed animals (Kidanu, 2001). The diseases that affect skin quality include bacterial, like dermatophilosis; viral, pox and warts; parasitic diseases (Asp and Tauni, 1988; FAO, 1995; FAO, 1998).

Postmortem defects can occur due to faulty procedures during slaughtering, preservation, storage and transportation of skins. Inadequate bleeding during slaughtering causes rapid development of bacteria along the blood vessels, as a result of bacterial spread from the blood vessels, skin fibers in the vicinity are destroyed, and open channels following the course of the blood vessels are formed through the skin surface; these defects show up in the final stage as a groove on the grain surface following the patterns of the damaged blood vessels (FAO, 1995; Jemberu, 2001). Delays in cleaning, drying or curing cause damage through putrefaction. Folding of dry skins leads to rupture of fibers and development of cracks (FAO, 1995). Rubbing, wetting, and insects are causes of skin damages that occur due to incorrect storage and transportation of skins. Preservation methods such as salting or frame drying are not fully

practiced by farmers, collectors, and skin traders; as a result hide and skins suffer from hair slip, mould, and bacterial attacks (Kidanu, 2001).

2.9. Diagnosis approaches for parasitic skin diseases

In making a diagnosis of ectoparasite infestations or their associated dermatitis, it is important to have an idea of the parasite involved and its life cycle. Some parasites live in intimate relationship with the host's skin, however, visiting parasites, may be on the skin only for a short period of time and a diagnosis is often made by implication. Hence a working knowledge of the clinical sign of the skin disease is usually also required. The ideal approach to diagnosis of skin diseases is a logical progression from history to an overall clinical examination, to a detailed examination of the skin, and finally to confirmatory testing or diagnosis by response to treatment (Jackson, 1991; Smith and Sherman, 1994; Kaufmann, 1996; Wall and Shearer, 1997).

2.9.1. History

According to Jackson (1991) and Kaufmann (1996), the main points to be noted during history taking includes; date when symptoms first appeared, symptoms observed by the owner, contact with other flock, spread of the disease within the flock, previous health history of affected animals, other disease problems within the flock at past and present, response to treatment (including traditional and/or home remedies) and detailed management such as feeding, deworming, etc.

2.9.2. Clinical examination

Close observation allow identification of most external parasite infestations and their skin associated clinical signs, thus many conditions could be diagnosed with reasonable certainty (Smith and Sherman, 1994). The entire skin surface of the patient should be examined for presence of parasites and lesions; condition of the skin which includes the elasticity of the skin, temperature, thickness, color and consistency should be noted, and response of the animal to

palpation of affected area should also be observed (Jackson, 1991). The appearance and location of lesions are the basis for diagnosis; primary lesions are papules, vesicles, pustules and nodules; secondary lesions include scabs, crusts and alopecia which are the result of self trauma or superimposed bacterial infections (Smith and Sherman, 1994).

During clinical examination unidentified ectoparasites or their eggs are collected, fixed and stored in 70% alcohol and identification can be made with the help of an identification key (Soulsby, 1982; Urquhart *et al.*, 1996; Wall and Shearer, 1997; Okello-Onen *et al.*, 1999). Many of the larger ectoparasites, such as blowfly larvae and ticks, may be collected directly from the host using appropriately sized forceps. Small specimens may be pickled up with the end of moistened paintbrush. Unattached mites and ticks can be removed by combing or brushing of the animal over a white enamel tray or sheet of paper. Brushing over moistened white blotting paper or paper towel may help to identify flea infestations (Wall and Shearer, 1997; Bowman and Lynn, 1999).

Hairs collected by coat brushing and plucking should be mounted in a mineral oil, such as liquid paraffin, and examined microscopically for evidence of ectoparasites. Eggs of some parasites, such as lice may be found attached to the hair shaft and adult ectoparasites, such as lice and various mites, may be also found by this method. The hair bulb and lower third of the shaft should be examined for evidence of follicular mite (Urquhart *et al.*, 1996). To insure that the mouthparts are not left behind, embedded living ticks may be removed most effectively by dabbing the ticks and the surrounding skin with alcohol; this relaxes the tick, allowing it to be pulled out intact. Alternatively, the tick can be covered with a layer of petroleum jelly which prevents respiration, and after about 30 minutes, the tick will drop off (Morel, 1989; Smith and Sherman, 1994; Wall and Shearer, 1997).

2.9.3. Skin scraping examination

Examination of skin scrapings is essential in the diagnosis of mange mites. Multiple sites should be scrapped to increase the likelihood of parasite detection. Superficial skin scraping (epidermal surface examination) after removing hair coat by gentle clipping can be used to

identify surface mites, while deep skin scraping (deep epidermal examination) until capillary bleeding occurs is useful in the diagnosis of burrowing and follicular mites (Jackson, 1991; Wall and Shearer, 1997).

There are three options for examination of skin scrapings. In direct smear; 10% potassium hydroxide treated skin scrapings are placed on clean and dry glass slide, then the scrapings are macerated with scalpel or spatula and cover it with cover slip and examine under lower power of microscope (Smith and Sherman, 1994). The second option is sedimentation method; the skin scrapings are kept in 10 % potassium hydroxide or sodium hydroxide for 2-4 hours to digest the debris, or the digestion process may be expedited by providing a gentle heat to the sample, then transfer to centrifuge tube and centrifuge at 3000 rpm for 10 minutes, and the supernatant is discarded and one drop of sediment is placed on the middle of clean slide and cover it with cover slip, and examine under low power of microscope (Bowman and Lynn, 1999). In sugar flotation method, third option; skin scrapings are kept in 10 % potassium hydroxide for 2-4 hours to digest the debris, and transfer it to centrifuge tube, and centrifuge at 3000 rpm for 10 minutes, then the supernatant is discarded and distilled water is added into the centrifuge tube to fill it half and mix the content, and the centrifuge tube is filled with saturated sugar solution, centrifuge for 10-15 minutes at 3000 rpm, by the gravitation force parasites will come over the contents of the centrifuge tube, and then one drop of fluid is taken from top of the centrifuge tube and placed on the middle of clean and dry glass slide, and cover it with a cover slip and examine under low power of microscope (Chauhan and Agarwal, 2006).

2.9.4. Histopathology

Although this indirect technique is not as useful as a direct identification for the diagnosis of ectoparasitic dermatitis, it may be valuable in some circumstances, such as parasitic bite lesions. Small whole thickness strips of skin 25mm by 5mm are taken from normal and abnormal area and the skin strip should be fixed in normal saline (Jackson, 1991). According to Wall and Shearer (1997), histological changes often associated with ectoparasitic infections may include; eosinophils-rich dermal infiltrate, collagen degeneration usually associated with

dermal eosinophils infiltration, focal dermal necrosis, which occur in tick bite lesions, and eosinophilic pustule formation, which occur in cases of sarcoptic infestations.

2.9.5. Serology

Serological technique for the diagnosis of sheep scab and lice is currently being investigated, and may lead to the development of a commercial assay (Heath, 1994; Wall and Shearer, 1997). To improve the traditional microscopic diagnosis, an Enzyme Linked Immunosorbent Assay (ELISA) technique for the specific determination of antibodies against psoroptic antigens with sensitivity of 93.7% and specificity of 96.5% was developed, to monitor psoroptic mange of sheep and cattle (Falconi, *et al.*, 2002). ELISAs are in routine use by researchers for detection of *Sarcoptes scabiei* (OIE, 2002).

2.10. Distribution of small ruminant ectoparasites in Ethiopia

Though ectoparasites are found widely distributed throughout the world, the frequency with which they occur varies from one area to the other. Among sheep and goats examined for ectoparasites in selected farms in Nsukka, Nigeria, about 18.5% sheep and 61.70% goats were found infested (Ugochukwu and Apeh, 1985). In Sao Paulo, 89.5% of the respondents reported the presence of one or more ectoparasites in sheep; *Cochliomyia hominivorax* (72.5%) was the most frequent ectoparasite, *Dermatobia hominia* (45%), *Amblyomma cajennense* and *Boophilus microplus* (31.3%), and *Dermatobia ovis* (13.8%) (Madeira *et al.*, 2000). Tick infestation rate in sheep and goats was 43.0% and 26.5%, respectively, in Borno and Yobe states, Nigeria; they were found infested with ixodid ticks (James-Rugu, 2004).

Reports on parasitic skin diseases of small ruminants in Ethiopia are scanty and if present are also very fragmented. Studies conducted at various localities of the country and tanneries report on magnitude of skin damages due to skin disease especially ectoparasites indicate that small ruminants skin disease are becoming growing threat for small ruminants production and export of skin in Ethiopia. The occurrence and spread of the diseases in Ethiopia have been shown to be correlated with the host factors, climatic factors, poor management, feed scarcity and

inadequate veterinary services (Zelalem, 1994; Haffize, 2001; Molu, 2002; Tefera, 2004; Mulugeta, 2008).

Lice infestation in Ethiopia is the most frequently reported and the most important skin disease of small ruminants (Tembeley, 1998). It was reported within sheep (*Damalinia ovis* and *Linognathus* species) with an overall prevalence of 2% 39.8%, and 30.5%, respectively from Central Ethiopia (Haffize, 2001), Eastern part of Amhara (Tefera, 2004), and Southeastern Tigray (Mulugeta, 2008). In goats, 1.52% in Central Ethiopia, 14.5% in Kombolcha (Numery, 2001), 29.2% in Eastern part of Amhara, and 26.7% in Southeastern Tigray was recorded.

Keds, *Melophagus ovinus*, were reported as the most important ectoparasites observed in sheep. They were more common in the highlands of Ethiopia than in midlands, and no cases have been recorded in lowlands of the country (Asegedeche *et al.*, 1999). However, information on their magnitude and distribution in Ethiopia is scarce. Overall prevalence of sheep keds recorded in Eastern Amhara and Southeastern Tigray was 12.5% (Tefera, 2004) and 19.1% (Mulugeta, 20008), respectively. On the other hand among raw sheep skins which were examined at Sebeta tannery, 32.7% had *Melophagus ovinus* (Ermias, 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 (Amsalu *et al.*, 2000). Of the different species of mange mite that affecting sheep and goats, *Sarcoptes* species is the most prevalent in Ethiopia (Sherman, 1998). According to Zelalem (1994), Chalachew (2001), Teshome (20002), Tefera and Abebe (2006), and Yalew (2007), *Sarcoptes* and *Demodex* species were common among goats, while *Psoroptes* and *Sarcoptes* were common among sheep. Demodectic mange in goats was reported with prevalence of 0.74 % in Wolayta (Chalachew, 2001), 1.37% in Central Ethiopia (Haffize, 2001), 3.5% in the Southern rangelands of Oromiya, and 0.95% in Sidama (Teshome, 2002). It was also reported in sheep with prevalence of 0.8% in Central Ethiopia (Haffize, 2001) and 0.88% in the Southern rangelands of Oromiya (Molu, 2002),). The levels of mange mite infestation in various areas of Ethiopia are summarized in Table 1 and 2 below.

Table 1: Prevalence of sarcoptic mange in different areas of Ethiopia

<i>Study site</i>	<i>Prevalence (%)</i>		<i>Source</i>
	Sheep	Goat	
Hararge	2.33	4.66	Gashaw, 1986
Dire Dawa	22.70	43.10	Zelalem, 1994
Kombolcha	*	33.27	Numery, 2001
Selected sites of Tigray	30.32	31.77	Kedir, 2002
Southern rangelands of Oromiya	0.22	0.20	Molu, 2002
Northern Amhara	4.00	*	Moges and Hagos, 2003
Southeastern Tigray	1.3	12.5	Mulugeta, 2008

*The study does not include the species

Table 2: Prevalence of psoroptic mange in different areas of Ethiopia

<i>Study site</i>	<i>Prevalence (%)</i>		<i>Source</i>
	Sheep	Goat	
Hararge	4.67	6.15	Gashaw, 1986
Bale Robe	20.00	*	Shenkutie, 1987
Addis Ababa	32.87	*	Nigatu, 1992
Mekele	1.15	*	Habte, 1994
Debre Zeit and Nazereth	1.8	2.59	Haffize, 2001
Southern rangelands of Oromiya	0.15	0.37	Molu, 2002
Sidama Zone	1.63	0.95	Teshome, 2002

* The study does not include the species

Reports from the different areas indicate that ticks are also among the parasitic skin diseases affecting small ruminants. The ticks identified were *Amblyomma* species, *Hyalomma* species, *Boophilus decoloratus*, and *Rhipicephalus* species (Haffize, 2001; Sileshi *et al.*, 2001; Alekaw, 2003; Tefera, 2004; Sileshi *et al.*, 2007; Mulugeta, 2008). Table 3 shows an overall prevalence of tick infestation in the different areas of Ethiopia.

Table 3: Prevalence of ticks in different areas of Ethiopia

Study site	Prevalence (%)		Source
	Sheep	Goat	
Dire Dawa	66.5	32.2	Zelalem, 1994
DebreZiet and Nazereth	0.96	1.81	Haffize, 2001
Southern rangelands of Oromiya	5.27	9.54	Molu, 2002
Sidama Zone	23.8	10.0	Teshome, 2002
Eastern Amhara	7.18	22.2	Tefera, 2004
Southeastern Tigray	16.0	29.7	Mulugeta, 2008

2.11. Impacts of parasitic skin diseases

2.11.1. Effects on production

Arthropods pose a threat to the rearing of small ruminants directly through their pathogenic effect and are reported to cause severe morbidity and mortality. Cutaneous myiasis can be very important cause of losses in sheep in most countries where large numbers are kept. It causes serious mortality in sheep; up to 30% of a flock may die (Radostits *et al.*, 1994). It is considered that sarcoptic mange adversely affects the production of infested animals (Fthenakis *et al.*, 2000). Barbary sheep population (*Ammotragus lervia*) of the Sierra Espuna Regional Park (Murcia, Spain) suffered an outbreak of sarcoptic mange between 1991 and 1995 which contributed to a population decrease of 86% (Gonzalez-Candela *et al.*, 2004).

Kassa (2002) reported that two of the treated and all of the untreated goats died of the mange in experimentally infested goats. Based on the opinion of people, the morbidity and mortality rates of mange mite and tick and tick-borne diseases in small ruminant in Shinelle zone (Somali region) were reported to be 58.4% and 38.7%, and 28.7% and 11.6%, respectively (Bekele *et al.*, 2003). Mange of sheep and goats was estimated to have killed about 60% of the diseased small ruminant stock (69.3% of sheep and 57.3% of goats) in one year's times in Amhara region (Amsalu *et al.*, 2000).

2.11.2. Effect on productivity

Ectoparasites seriously affect meat, milk, wool and skin production. A study which was done on the effect of *Psorptes ovis* on the weight gain of sheep (Kirkwood, 1980) indicated that the weight gain for infested sheep was only 1.6 kg while the control group gained 7.7 kg; this is an approximate 30% weight loss for lambs with an average weight of 12 kg. Live weight gains were significantly higher in healthy sheep compared to those with ectoparasites (Dimri and Sharma, 2003). Fthenakis *et al.*, (2000) reported that lambs infested with sarcoptic mange showed weight loss, when treated with moxidectin had up to 15% greater final weight and up to 23.7% more growth than infested controls. Similarly, most of the treated goats had increased weight gain while untreated goats that died of sarcoptic mange have showed loss of body (Kassa, 2002). Ewes treated with moxidectin also produced up to 24% more milk than sarcoptic mange infested ones (Fthenakis *et al.*, 2000). Wool yield was significantly higher in healthy sheep compared to those parasitic diseases; furthermore, keds free sheep produced 11% more wool than infested ewes (Dimri and Sharma, 2003; Nelson and Slen, 2004).

Infestation with sheep ked leads to a vertical ridging of the skin called cockle. The total annual devaluation of sheep skin in the USA due to cockle is about 4 million USD and the overall annual loss due to sheep ked is estimated to be 40 million USD (Wall and Shearer, 1997). There is no good evidence that lice damage the fleece directly; rather the irritation damages the fleece through rubbing and biting. The available information indicates that, in New Zealand, the principal effect of lice is to decrease the washed yield and quality of the fleece (Heath, 1994; Pfeffer *et al.*, 1996). Sheep treated with insecticides or shearing had better skin quality

(skin grade of 2-3.3) in three months trial period and all the skins of infested group with *Melophagus ovinus* and *Damalinia ovis* were graded as rejects (skin grade of 5.5-6.3) because of cockle (Kassa *et al.*, 1998). Goats that died of sarcoptic mange showed poor skin quality while most of the treated goat had better skin quality (Kassa, 2002).

According to Kidanu (2001) in the past 10-15 years, defects from the diseases and other causes have reached very significant level especially in sheep and goat skin quality dropping and increasing rejections. Tanneries reported 35% of sheep skin and 56% of goat skin are rejected due to external parasites. Out of the reject group of the processed skin, about 80-90% defects were believed to be due to external parasites (Gizaw, 1987; FAO, 1998). Skin problems caused by lice, keds, mange and ticks are among the major pre-slaughter defects that reduce skin qualities and results in rejections (Tefera and Abebe, 2006). In Ethiopia, skin defect known as 'ekek', an Amharic term meaning an allergic dermatitis which causes itching, observable after removal of the hair or wool, is usually associated with *Damalinia ovis* and *Melophagus ovinus* in pickled sheep skin and *Sarcoptes* species in wet blue goat skin; which is reported to be the most prevalent and responsible for huge losses incurred in tanneries (Kassa *et al.*, 1998; Ermias, 2000; Numery, 2001; Tefera and Abebe, 2006).

3. MATERIALS AND METHODS

3.1. Description of the study area

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

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

Akaki, the second study area, is located at an average altitude of 1900 masl Southeast of Addis Ababa. It is one of the districts found in Eastern Showa administrative zone of Oromia region. Akaki woreda lies between 8°44' N latitude and 35°58'E longitude location. The area experiences an annual rainfall ranges from 800-1000mm with two rainy seasons; the short rainy season occurs between March and May, while the main rainy season is between June and September. The average minimum and maximum temperatures are 13.5°C and 25.8°C, respectively. The livestock population of the area is 69,107 cattle, 18,970 sheep, 23,409 goats, 23,937 equines and 126,865 poultry (OARD, Personal communication).

The third study area representing a highland altitude was Sululta which is found in Central highlands of Ethiopia with location between 9°13'-10°57' N latitude and 37°57'-39°33' E longitude. It is located 40 km North of Addis Ababa at an average altitude of 2550 masl.

Sululta woreda is one of the districts of North Showa zone of Oromia region. The area receives mean annual rainfall of a minimum of 834mm and a maximum of 1447mm. The mean minimum and maximum temperatures of the area are 4.4⁰C and 22.5⁰C, respectively. The district's livestock population is estimated to be 210,210 of cattle, 80,900 of sheep, 16,491 of goats, 32,862 of equines and 75,936 of poultry (OARD, Personal communication).

The study on pickled and wet blue skin for defects was conducted in Modjo and Ethiopia tanneries. They are found in and around a Modjo town, which is about 73km Southeast of Addis Ababa. The Modjo tannery processes a daily capacity of about 6000 skins, while the daily actual production of Ethiopia tannery ranges from 12,000-15,000 skins. Both tanning industries obtain raw skins from different parts of the country; however, Oromiya region and Addis Ababa town are the main skin suppliers. They process raw skins to the pickled, wet blue, crust and finished forms. The tanneries export their products to different European and Asian countries.

3.2. Study population

The study of ectoparasites was carried out on indigenous sheep and goats that were managed under extensive production system. Pickled sheep and wet blue goat skins processed in Modjo and Ethiopia tanneries were also used as study materials for identification of skin defects.

3.3. Study design

The study type used for the present study was a cross-sectional study design. Simple and systematic random sampling methods were used. The study districts were selected purposively based on their representation of different agro-ecologies. Five, seven and six peasant associations were randomly selected among peasant associations having the selected agro-ecology from Adami Tulu-Jiddo-Kombolcha, Akaki and Sululta, respectively using a lottery system. The study animals were randomly selected using systematic sampling technique from traditionally managed small ruminant population in the respective areas.

In cross-sectional study on pickled and wet blue skins for defects, the study tanneries were selected randomly using a simple sampling technique among the tanning industries found in and around Modjo town. The study pickled and wet blue skins were selected randomly by applying a systematic type of sampling method from sheep and goat skins of different area origins which processed in selected study tanneries.

3.4. Sample size determination

The sample size for the current study was determined as per the method described by Thrusfield (2005). The following formula was applied for sample size calculation:

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

Where, n = required sample size

P_{exp} = expected prevalence

d = desired absolute precision

For this study on ectoparasites in small ruminants, the expected prevalence of parasite infestations used was 50% in each study agro-ecology, 5% acceptable error and 95% confidence level were applied to determine the sample size of study animals in each study agro-ecology. Based on the formula given above the sample size were 384 animals. Since the ectoparasite status was studied in two different hosts (sheep and goats), the sample size was multiplied by two. Therefore, the minimum sample size for each study agro-ecology was 768 sheep and goats. But the minimum sample sizes calculated for sheep and goats in each study agro-ecology were proportionally determined based on the numbers of sheep and goats found in respective study areas. Accordingly, a total number of animals used for this study were 2304 of which 1325 were sheep and 979 were goats.

In regard to the study on type and magnitude of skin defects on pickled and wet blue stages of skin in two selected tanning industries, the sample size was determined based on the estimated proportion of ectoparasite associated defects of 63% (FAO,1998), acceptable error 5% and confidence level 95%. Therefore, based on the above mentioned formula the minimum sample size was 358 skins for each stage in each study tannery. Accordingly, the total number of semi-

processed skins used for this study was 1432, of which 716 were pickled sheep skins and 716 were wet blue goat skins.

3.5. Data collection methods

3.5.1. Clinical examination

A total of 2304 study animals of which 1325 were sheep and 979 were from the three agro-ecological zones were clinically examined for the presence of external parasites and gross skin lesions. The species, sex, age and body conditions of each selected study animal were recorded during clinical examination. The animals were categorized into two age groups as young (up to one year) and adult (older than one year) as described by Gatenby (1991) for sheep and Steel (1996) for goats, age was determined as indicated by owners and judged by dentition methods. The body condition scores were determined by modifying the system described in Gatenby (1991) for sheep and Steel (1996) for goats of poor and good. Poor body condition score was given for sheep and goats which were extremely thin and those having smooth and less prominent spinous and transverse processes in which finger can be pushed and had moderate depth of loin muscle. The good body condition score was given for sheep and goats in which the spinous process only stickup very slightly and those having smooth, rounded and well covered transverse processes, and full loin muscle.

Clinical examination on each study animal was performed by multiple fleeces parting in the direction opposite to that in which hair or wool normally rests and followed by physical examination of skin; inspection and palpation of the skin across all parts of the animal for the presence of parasites and gross lesions that indicating the clinical form of parasitic infestations. Those animals found infested were considered as positive. The parasites were identified on the basis of their morphological structure as described by Soulsby (1982), Wall and Shearer (1997), and Walker *et al.* (2003).

3.5.2. Parasites and skin scrapings specimen collection

During clinical examination those unidentified ectoparasites and/or their larvae were collected for laboratory examination. External parasites such as ticks, lice, and fleas were collected manually from their sites of attachment. The ticks were removed from the host skins while retaining their good condition for identification using steel forceps. The coat brushing techniques were used for collection of lice. They were placed in labeled universal sample bottles containing 70% ethanol. All collected samples were properly labeled with all relevant and required information and taken to the parasitological department of NAHDIC. They were identified using stereomicroscope examination following the identification procedures described by Morel (1989), Okello-Onen *et al.* (1999), and Walker *et al.* (2003) for ticks, Soulsby (1982), Urquhart *et al.* (1996), and (Wall and Shearer (1997) for lice and fleas.

During the field work, the other specimens collected were skin scrapings which were taken from goats and sheep clinically suspected with cases of mange. This was done by clipping the hair around affected areas, scraping the edges of the lesion with scalpel blade as described in Soulsby (1982) until capillary oozing was evident in such away that blade was being held are an angle so that the materials scrapped fell on a paper held underneath. Then, the scrapped materials were transferred to a container and they were taken for laboratory examination. Skin scrapings were processed according to the method described in Cole (1996). The sample was treated with a few drops of 10% potassium hydroxide, allowed to stand for 30 minutes and was examined under light microscope with a 40X magnification. The mange mites were identified according to the identification keys described in Smith and Sherman (1994), Wall and Shearer (1997) and Bowman and Lynn (1999).

3.5.3. Post-tanning examination

The major activities involved during the tanning process are raw to pickled stage, trimming, soaking, dewooling, fleshing, deliming, bathing, scudding, and pickling. After the follow-up skin passed through tanning process reached the pickled stages, their specific identities were checked and then they were sorted by size and examined in natural light by selectors for any defects, and graded into seven grades according to the criteria given by QSAE (2001) (Annex

3). Any relevant information such as skin size and grading were recorded on data collection sheet (Annex 5).

A total of 1432 processed skins of which 716 were of pickled sheep and 716 were of wet blue goat were examined for the presence of skin defects. During examination each selected skin was sorted by size and examined for defects in natural light by skin selector and defects on each skin was recorded and skins were graded into seven grades as per the criteria given by QASE (2001) (Annex 3).

3.5.4. Questionnaire survey

A questionnaire format (Annex 1) was prepared and administered to randomly selected individuals in attempt to obtain information on shoat ownership patterns, importance of rearing small ruminants, and awareness about ectoparasites associated with skin diseases, the extent of the problem caused by these diseases and control measures taken against these disease conditions. The total number of sheep and goat owners used for a questionnaire study type was two hundred forty one of which seventy four were from lowlands, eighty one from midlands and eighty six from highlands.

3.6. Data management and analysis

Microsoft Excel was used for data management. Statistical software SPSS version 15.5 for windows was used for data analysis. Descriptive statistics such as frequency distribution, percentages and 95% confidence intervals were used to summarize the proportions of infested and non-infested animals, with regard to ectoparasites of small ruminants, and proportions of defects observed on pickled sheep skins and wet blue goat skins. The effects of different epidemiological risk factors on the prevalence and distribution of ectoparasites were analyzed using binary logistic regression method. Chi-square test was used to test associations between cockle and scratch and cockle and scar on pickled sheep skins and wet blue goat skins.

4. RESULTS

4.1. Prevalence study

During the study period, a total of 2304 animals of which 1325 were sheep and 979 were goats from the three agro-ecological zones were examined for the presence of ectoparasites. Results of the study showed that an overall prevalence of 48.1% and 49.7% were recorded in sheep and goats, respectively. These shoats were infested with one or more ectoparasites. The ectoparasites identified on sheep were *Melophagus ovinus*, *Damalinia ovis*, *Linognathus* spp., ticks, *Sarcoptes* spp. and *Ctenocephalides* spp. In goats, *Linognathus* spp., *Sarcoptes*, ticks, and *Ctenocephalides* spp. were types of ectoparasites identified. *L. stenopsis* on goats and *L. africanus* and *L. ovis* on sheep were identified *Linognathus* species. In the study areas seven species of ixodid ticks were identified in both sheep and goats. These were *Amblyomma variegatum*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus pravus*, *Boophilus decoloratus*, *Rhipicephalus sanguineus*, *Rhipicephalus praetextatus*, and *Hyalomma truncatum* (Table 4).

Table 4: Prevalence of different ectoparasites observed on sheep and goats

<i>Ectoparasites</i>	<i>Sheep (n = 1325)</i>		<i>Goat (n = 979)</i>	
	Prevalence (%)	95% CI	Prevalence (%)	95% CI
<i>Melophagus ovinus</i>	16.4	14.5-18.3	-	-
<i>Damalinia ovis</i>	27.2	24.8-29.6	-	-
<i>Linognathus</i> spp.	1.5	0.8-2.2	16.5	14.2-18.8
<i>Sarcoptes</i> spp.	1.2	0.6-1.8	8.8	7.0-25.9
<i>Bo.decoloratus</i>	1.1	0.5-1.7	1.6	0.8-2.4
<i>Am.variegatum</i>	4.4	3.3-5.6	11.8	9.8-13.8
<i>Rh.evertsi evertsi</i>	1.9	1.2-2.6	5.9	4.4-7.4
<i>Rh. praetextatus</i>	1.1	0.5-1.7	1.3	0.6-2.0
<i>Rh. pravus</i>	1.9	1.2-2.6	4.3	3.0-5.6
<i>Rh. sanguineus</i>	0.9	0.4-1.4	1.8	1.0-2.6
<i>Hy. truncatum</i>	1.6	0.8-2.4	0.4	0.1-0.7
<i>Ctenocephalides</i> spp.	2.3	1.5-3.1	5.1	3.7-6.5
Overall	48.1	45.4-50.8	49.7	46.5-52.8

In the study, gross skin lesions observed had characteristic of ectoparasitic skin diseases with red papules, vesicles, superficial erosions and ulcers, crust formation, thickening and wrinkling of the skin and losses of hair. The neck, rump, shoulder and sides were the major attachment sites for *Melophagus ovinus* infestations with proportions of 48.3%, 42.4%, 42.2%, and 30.6%, respectively. In case of *Damalinia ovis* infestations, the main predilection sites observed on infested sheep during study period were the shoulder (54.2%), the sides (44.8), the neck (36.62%), and the back (29.8%). The preferred feeding sites by ticks were head/ears, scrotal/udder, ano-vulva, tail, brisket, dewlap, neck and leg. For *Linognathus* species, sites of infestation were shoulder (71.4%), neck (66.7%), and the sides (38.4%). Head/ears and the

groin areas were observed as the main sites for sarcoptic mange. The two common sites of *Ctenocephalides* species infestations were the belly and sternum regions.

4.1.1. Prevalence of ectoparasites by agro-ecology

In all study agro-ecologies, a total of 1325 sheep were examined for presence of parasitic skin diseases of which 299 were the lowlands, 364 midlands, and 662 highlands. The overall prevalence of sheep ectoparasites in lowlands, midlands and highlands was 38.5%, 47.3% and 52.9%, respectively (Annex 6). Agro-ecology specific proportions of ectoparasites of sheep are shown in Figure 2.

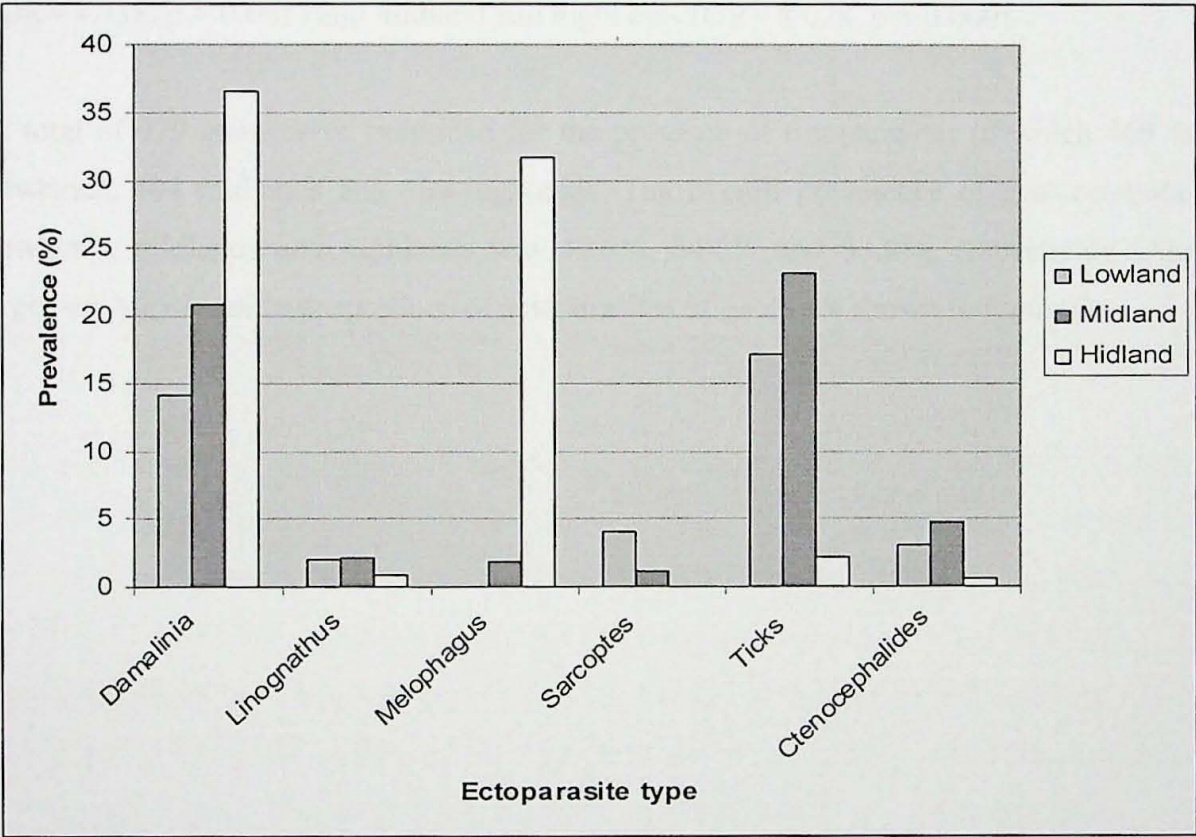


Figure 2: Prevalence of ectoparasites of sheep observed by different agro-ecological zones

The binary logistic regression analysis results of the effect of agro-climates on prevalence of ectoparasites of sheep as shown for Tables 8-13. The prevalence of *Melophagus ovinus* among the agro-ecologies showed statistically significant difference between midland and highland (OR = 0.041, $p = 0.000$) but, there was no significant difference ($p > 0.05$) between lowlands and highlands and between midlands and lowlands. In prevalence of *Damalinia ovis*, statistically significant difference was observed between lowland and highland (OR= 0.235, $p = 0.000$), midland and highland (OR= 0.460, $p = 0.000$) and lowland and midland (OR=0.510, $p = 0.002$). The prevalence of tick infestation showed statistically significant difference between lowland and highland (OR= 9.883, $p = 0.000$) and midland and highlands (OR= 13.988, $p = 0.000$). In *Linognathus* and sarcoptic mange, the prevalence difference among different agro-ecologies was statistically insignificant ($p > 0.05$). Statistically significant difference was observed in prevalence of *Ctenocephalides* spp. infestations between lowland and highland (OR= 4.738, $p = 0.001$) and midland and highlands (OR= 8.078, $p = 0.000$).

A total of 979 goats were examined for the presence of ectoparasites of which 469 were the lowlands, 404 midlands and 106 highlands. The overall prevalence of goat ectoparasites in lowlands, midlands and highlands was 49.5%, 54.5% and 33.0%, respectively (Annex 7). Agro-ecology specific proportions of ectoparasites of goats are shown in Figure 3.

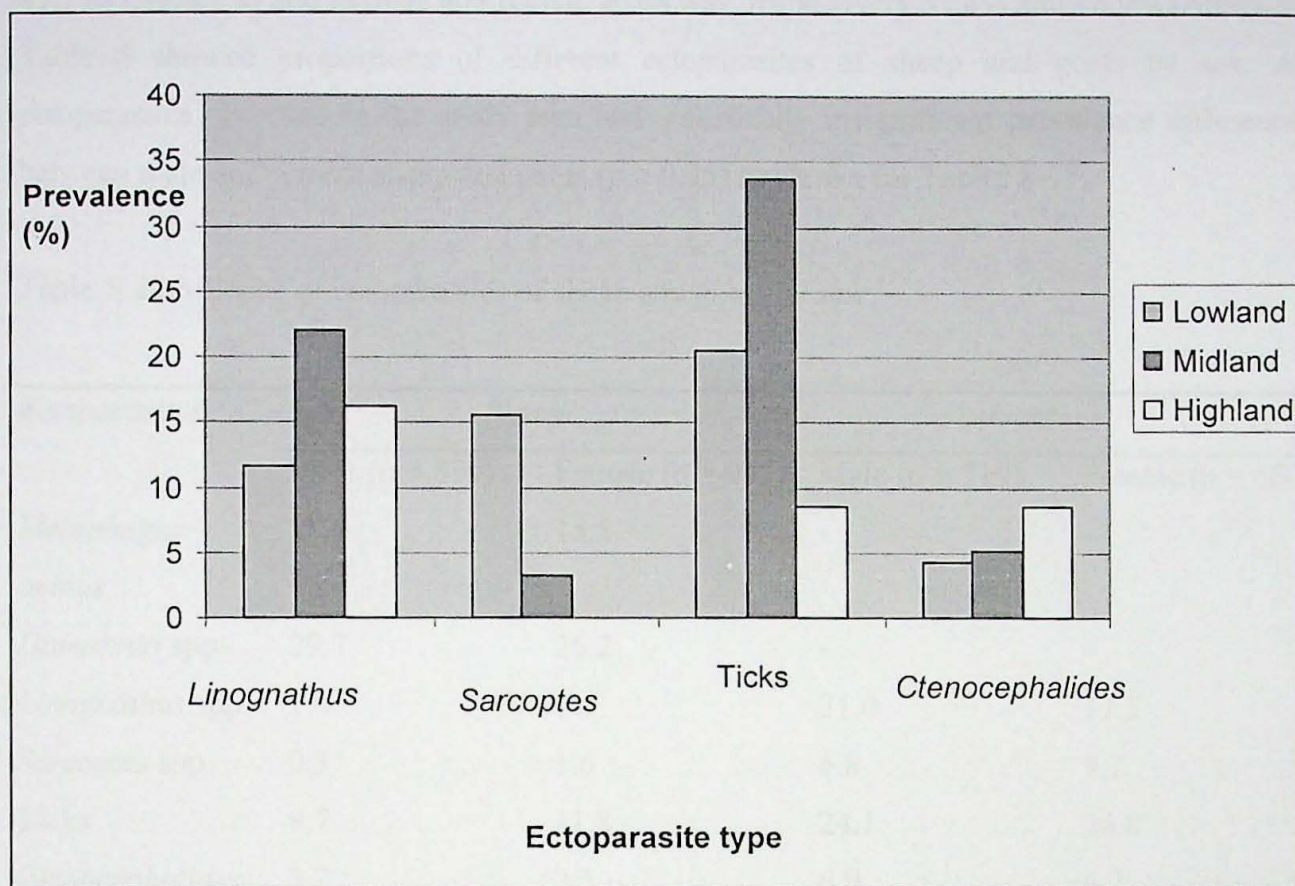


Figure 3: Prevalence of ectoparasites of goats observed by different agro-ecological zones

The binary logistic regression analysis results of the effect of agro-ecologies on prevalence of ectoparasites of goats as shown for Tables 14-17. Statistically significant difference in prevalence of *Linognathus stenopsis* was observed between lowlands and midlands (OR= 0.477, $p = 0.000$). As for the prevalence of tick infestation, significant difference was observed between lowland and highland (OR= 2.841, $p = 0.005$), midland and highland (OR= 5.635, $p = 0.000$) and lowland and midlands (OR= 0.504, $p = 0.000$). Significant difference in prevalence of sarcoptic mange was also observed between the lowland and midlands (OR= 7.864, $p = 0.000$). No statistically significant difference in prevalence of *Ctenocephalides* infestation was observed between study agro-ecologies ($p > 0.05$).

4.1.2. Prevalence of ectoparasites by sex, age and body conditions

The overall prevalence of ectoparasites in male and female sheep was, respectively 48.9% and 47.7 % (Annex 8) and in male and female goats was, respectively 51.4% and 48.9% (Annex 9). Table 5 showed proportions of different ectoparasites of sheep and goats by sex. All ectoparasites observed in the study area had statistically insignificant prevalence differences between male and female sheep and goats ($p > 0.05$) as shown for Tables 8-17.

Table 5: Prevalence of ectoparasites of sheep and goats by sex

<i>Ectoparasites</i>	<i>Sheep</i>		<i>Goat</i>	
	Male (n = 370)	Female (n = 955)	Male (n = 319)	Female (n = 660)
<i>Melophagus ovinus</i>	18.6	15.5	-	-
<i>Damalinia</i> spp.	29.7	26.2	-	-
<i>Linognathus</i> spp.	1.4	1.6	21.0	17.3
<i>Sarcoptes</i> spp.	0.3	1.6	6.8	9.7
Ticks	9.7	11.8	24.1	24.8
<i>Ctenocephalides</i> spp.	2.2	2.3	6.9	4.2

The overall prevalence of ectoparasites in young and adult sheep was, respectively 50.9% and 46.3% (Annex 8) and in young and adult goats was, respectively 48.2% and 51.0% (Annex 9). Age specific proportions of different ectoparasites in sheep and goats are shown in Table 6. There was no statistically significant difference in prevalence of *M. ovinus*, *Linognathus*, ticks, sarcoptic mange and *Ctenocephalides* ($p > 0.05$) between young and adult sheep. But significant difference in the prevalence of *Damalinia ovis* was observed between young and adult sheep (OR = 1.450, $p = 0.006$) as shown for Tables 8-13. In goats, statistically significant difference in prevalence of sarcoptic mange (OR= 0.266, $p = 0.000$) and *Ctenocephalides* infestation (OR= 2.430, $p = 0.005$) was observed between young and adults as shown for Tables 14-17.

Table 6: Age group specific prevalence of ectoparasites

<i>Ectoparasite</i>	<i>Sheep</i>		<i>Goat</i>	
	Young (n = 515)	Adult (n = 810)	Young (n = 444)	Adult (n = 535)
<i>Melophagus ovinus</i>	17.7	15.6	-	-
<i>Damalinia</i> spp.	32.0	24.1	-	-
<i>Linognathus</i> spp.	1.4	1.6	16.9	16.1
<i>Sarcoptes</i> spp.	1.2	1.2	5.9	11.2
Ticks	9.3	12.5	22.7	26.2
<i>Ctenocephalides</i> spp.	3.3	1.6	7.4	3.2

The overall prevalence of ectoparasites in poor and good conditioned sheep was, respectively 62.8% and 42.4% (Annex 8) and in poor and good conditioned goats was, respectively 53.5% and 48.3% (Annex 9). Table 7 showed body condition-specific prevalences of ectoparasites in sheep and goats. The binary logistic regression analysis results of the effect of body condition scores on prevalence of ectoparasites of sheep as shown for Tables 8-13. Statistically significant differences in the prevalences of *Melophagus ovinus* (OR=0.379, $p = 0.000$), *Damalinia ovis* (OR=2.251, $p= 0.000$) and sarcoptic mange (OR= 6.074, $p= 0.003$) was observed between poor and good conditioned sheep. However, there was no significant difference in prevalence of *Linognathus*, ticks and *Ctenocephalides* between poor and good condition sheep ($p > 0.05$). In goats, similar logistic regression results (Tables 14-17) made showed statistically significance difference in prevalences of tick infestations (OR= 0.582, $p = 0.003$) and sarcoptic mange (OR= 0.565, $p = 0.000$) between poor and good body conditioned goats. However, no significant variations ($p > 0.05$) were observed in the prevalences of *Linognathus* and *Ctenocephalides* infestations between poor and good body conditioned goats.

Table 7: Body condition specific prevalence of ectoparasites

<i>Ectoparasites</i>	<i>Sheep</i>		<i>Goat</i>	
	Poor (n = 368)	Good (n = 957)	Poor (n = 271)	Good (n = 708)
<i>Melophagus ovinus</i>	23.4	13.7	-	-
<i>Damalinia</i> spp.	37.8	23.1	-	-
<i>Linognathus</i> spp.	1.9	1.4	16.7	16.4
<i>Sarcoptes</i> spp.	3.3	0.4	20.3	4.4
Ticks	10.9	11.4	18.1	27.1
<i>Ctenocephalides</i> spp.	2.7	2.1	4.4	5.4

Table 8: Summary results of binary logistic regression for *Melophagus ovinus*

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-climate							
	Highland*	1	1	1	1	1	1
	Lowland	-20.461	2319.791	0.993	0.000	0.000	.
	Midland	-3.171	0.391	0.000	0.042	0.020	0.090
	Lowland	-17.443	2287.983	0.994	0.000	0.000	.
Sex							
	Female*	1	1	1	1	1	1
	Male	0.157	0.181	0.389	1.170	0.821	1.668
Age							
	Adult*	1	1	1	1	1	1
	Young	0.272	0.170	0.393	1.313	0.941	1.833
Body condition							
	Good*	1	1	1	1	1	1
	Poor	-0.970	0.181	0.000	0.379	0.266	0.541

* Reference category SE = Standard error OR = Odds ratio

Table 9: Summary results of binary logistic regression for *Damalinia ovis*

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	
	Lowland	-1.450	0.191	0.000	0.235	0.161	0.341
	Midland	-.776	0.155	0.000	0.460	0.340	0.624
	Lowland	-0.674	0.216	0.002	0.510	0.334	0.779
Sex							
	Female*	1	1	1	1	1	
	Male	0.078	0.144	0.591	1.081	0.814	1.434
Age							
	Adult*	1	1	1	1		1
	Young	0.372	0.134	0.006	1.450	1.115	1.886
Body condition							
	Good*	1	1	1	1	1	1
	Poor	0.811	0.141	0.000	2.251	1.708	2.965

* Reference category SE = Standard error OR = Odds ratio

Table 10: Summary results of binary logistic regression for *Linogathus* species in sheep

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	1
	Lowland	0.768	0.587	0.191	2.155	0.682	6.809
	Midland	0.915	0.545	0.093	2.497	0.858	7.266
	Lowland	-0.148	0.555	0.790	0.863	0.291	2.561
Sex							
	Female*	1	1	1	1	1	1
	Male	-0.091	0.531	0.863	0.913	0.322	2.585
Age							
	Adult*	1	1	1	1	1	1
	Young	-0.219	0.486	0.652	0.803	0.310	2.083
Body condition							
	Good*	1	1	1	1	1	1
	Poor	0.354	0.485	0.465	1.425	0.551	3.688

* Reference category SE = Standard error OR = Odds ratio

Table 11: Summary results of binary logistic regression for tick infestation in sheep

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	1
	Lowland	2.291	0.313	0.000	9.883	5.351	18.253
	Midland	2.638	0.298	0.000	13.988	7.801	25.081
	Lowland	-0.347	0.202	0.086	0.707	0.476	1.050
Sex							
	Female*	1	1	1	1	1	1
	Male	-0.112	0.215	0.603	0.894	0.586	1.363
Age							
	Adult*	1	1	1	1	1	1
	Young	-0.391	0.198	0.048	0.677	0.459	0.997
Body condition							
	Good*	1	1	1	1	1	1
	Poor	-0.041	0.210	0.844	0.960	0.636	1.447

* Reference category SE = Standard error OR = Odds ratio

Table 12: Summary results of binary logistic regression for sarcoptic mange in sheep

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	1
	Lowland	17.639	1478.740	0.990	45743526.889	0.000	.
	Midland	16.699	1478.740	0.991	17880733.618	0.000	.
	Lowland	0.939	0.601	0.118	2.558	0.787	8.315
Sex							
	Female*	1	1	1	1	1	1
	Male	-1.667	1.056	0.114	0.189	0.024	1.496
Age							
	Adult*	1	1	1	1	1	1
	Young	-0.101	0.543	0.852	0.904	0.312	2.619
Body condition							
	Good*	1	1	1	1	1	1
	Poor	1.804	0.601	0.003	6.074	1.872	19.714

* Reference category SE = Standard error OR = Odds ratio

Table 13: Summary results of binary logistic regression for *Ctenocephalides* in sheep

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	1
	Lowland	1.556	0.608	0.011	4.738	1.439	15.604
	Midland	2.089	0.561	0.000	8.078	2.691	24.252
	Lowland	-0.534	0.428	0.213	0.586	0.253	1.357
Sex							
	Female*	1	1	1	1	1	1
	Male	-0.178	0.429	0.678	0.837	0.361	1.939
Age							
	Adult*	1	1	1	1	1	1
	Young	0.725	0.385	0.059	2.065	0.972	4.389
Body condition							
	Good*	1	1	1	1	1	1
	Poor	0.206	0.405	0.611	1.229	.556	2.718

* Reference category SE = Standard error OR = Odds ratio

Table 14: Summary results of binary logistic regression for *Linognathus* species in goats

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	1
	Lowland	-0.343	0.302	0.256	0.710	0.392	1.283
	Midland	0.396	0.292	0.174	1.486	0.839	2.632
	Lowland	-0.739	0.190	0.000	0.477	0.329	0.693
Sex							
	Female*	1	1	1	1	1	1
	Male	0.206	0.184	0.262	1.229	0.857	1.762
Age							
	Adult*	1	1	1	1	1	1
	Young	0.101	0.179	0.572	1.106	.780	1.570
Body condition							
	Good*	1	1	1	1	1	1
	Poor	0.101	0.179	0.572	1.106	.780	1.570

* Reference category SE = Standard error OR = Odds ratio

Table 15: Summary results of binary logistic regression for tick infestation in goats

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	1
	Lowland	1.044	0.368	0.005	2.841	1.381	5.846
	Midland	1.729	0.365	0.000	5.635	2.754	11.530
	Lowland	-0.685	0.159	0.000	0.504	0.369	0.689
Sex							
	Female*	1	1	1	1	1	1
	Male	-0.081	0.167	0.629	0.923	0.665	1.280
Age							
	Adult*	1	1	1	1	1	1
	Young	-0.057	0.157	0.717	0.945	0.695	1.285
Body condition							
	Good*	1	1	1	1	1	1
	Poor	-0.542	0.183	0.003	0.582	0.406	0.833
* Reference category		SE = Standard error		OR = Odds ratio			

Table 16: Summary results of binary logistic regression for sarcoptic mange in goats

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	1
	Lowland	19.546	3654.077	0.996	308272364.274	0.000	.
	Midland	17.484	3654.077	0.996	39199480.596	0.000	.
	Lowland	2.062	0.336	0.000	7.864	4.067	15.206
Sex							
	Female*	1	1	1	1	1	1
	Male	0.229	0.291	0.432	1.257	0.710	2.226
Age							
	Adult*	1	1	1	1	1	1
	Young	-1.325	0.287	0.000	0.266	0.152	0.466
Body condition							
	Good*	1	1	1	1	1	1
	Poor	2.024	0.263	0.000	7.565	4.520	12.662
* Reference category		SE = Standard error		OR = Odds ratio			

Table 17: Summary results of binary logistic regression for *Ctenocephalides* in goats

Risk factors		Coefficients	SE	P-values	OR	95% CI for OR	
						Lower	Upper
Agro-ecology							
	Highland*	1	1	1	1	1	1
	Lowland	-0.714	0.421	0.090	0.490	0.215	1.118
	Midland	-0.453	0.419	0.279	0.636	0.280	1.444
	Lowland	-0.261	0.326	0.423	0.770	0.407	1.458
Sex							
	Female*	1	1	1	1	1	1
	Male	0.352	0.300	0.241	1.422	0.790	2.562
Age							
	Adult*	1	1	1	1	1	1
	Young	0.888	0.313	0.005	2.430	1.315	4.490
Body condition							
	Good*	1	1	1	1	1	1
	Poor	-0.308	0.343	-0.308	0.343	-0.308	0.343

* Reference category SE = Standard error OR = Odds ratio

4.2. Tannery findings

The number of semi-processed skins examined in both Modjo and Ethiopia tanneries for presence of defects was 1432 of which 716 were pickled sheep skins and 716 were wet blue goat skins. Cockle (‘ekek’), scars, scratches, fly cuts and holes, putrefaction, poor substances, and cracks were skin defects observed on pickled and wet blue skins (Annex 10). Defects such as knife cuts, poor bleeding, machine defects, putrefaction and heat, and cracks were technical defects due to faulty flaying, preservation, handling and processing of skin. Percentages of major skin defects observed at the study tanneries are shown in Figure 4.

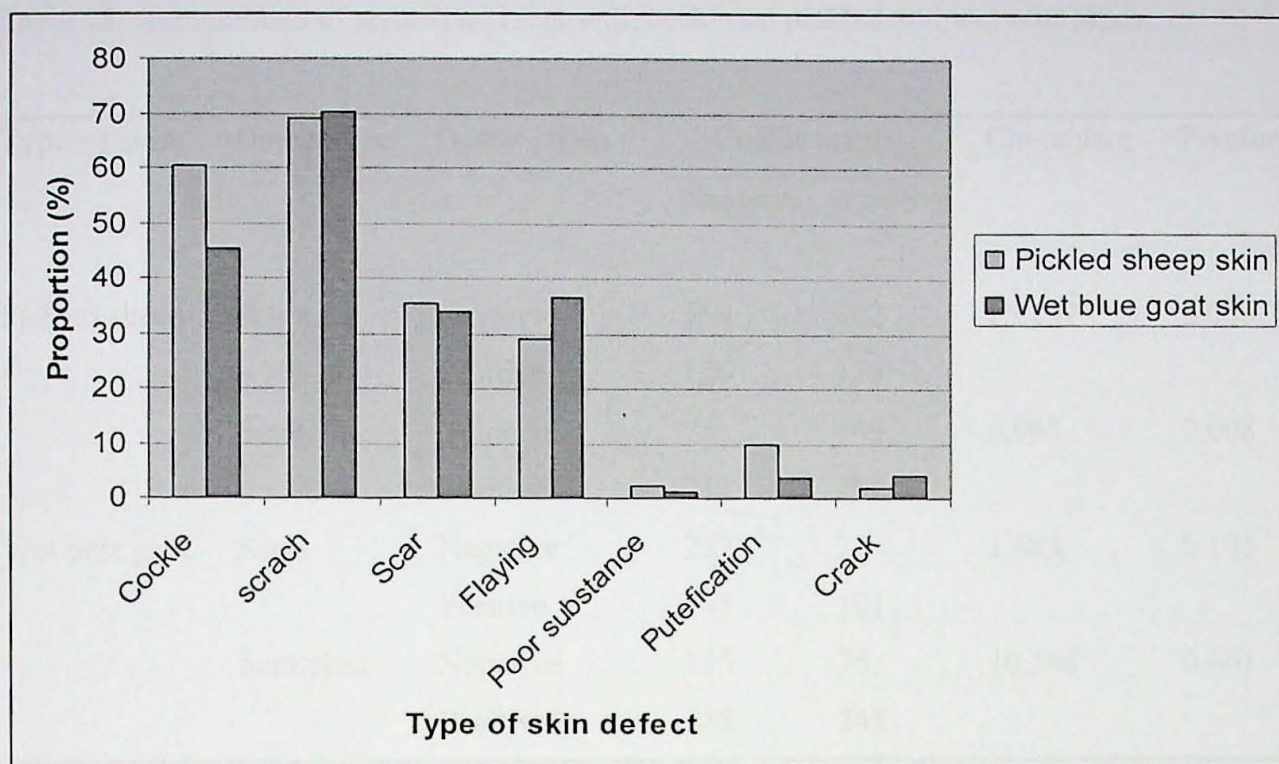


Figure 4: Proportions of defects observed on pickled sheep skins and wet blue goat skins

Cockle ('ekek') was responsible for 60.2% of the pickled sheep skins and 45.1% of the wet blue goat skins downgrading and rejection. Grading of the 431 pickled sheep skins and 323 wet blue goat skins indicated that the proportions of skins with cockle ('ekek') were higher in lower grades than in the top grades with 6.9% and 8.7%, 13.9% and 20.0%, 30.4% and 28.2%, 34.3% and 25.4%, and 15.3% and 17.6% proportions of pickled sheep skins and wet blue goat skins with 'ekek' observed on grades 1-3, 4, 5, 6, and 7, respectively.

Significant associations were observed between cockle and scars ($\chi^2 = 15.257$, $p = 0.000$) and between cockle and scratches ($\chi^2 = 6.965$, $p = 0.008$) on pickled sheep skin. In wet blue goat skins, significant association were observed between cockle and scratches ($\chi^2 = 10.598$, $p = 0.001$) however, between cockle and scars no significant association was observed ($\chi^2 = 1.683$, $p = 0.195$) (Table 18).

Table 18: Associations of scratch and scar with cockle on pickled and wet blue skins

Type of skin	Defect type	Defect status	Cockle status		Chi-square	P-value
			Negative	Positive		
Pickled sheep	Scars	Negative	159	302	15.257	0.000
		Positive	126	129		
	Scratches	Negative	72	149	6.965	0.008
		Positive	213	282		
Wet blue goat	Scars	Negative	252	22	1.683	0.195
		Positive	141	101		
	Scratches	Negative	135	75	10.598	0.001
		Positive	258	248		

4.3. Questionnaire survey

Two hundred forty one farmers who owned sheep and /or goats were interviewed. The responses of questionnaire administered to sheep and goat owners were summarized by agro-climate (Annex 11). In study areas, small ruminants were the major important species of animals kept by farmers for different purposes; two hundred sixteen farmers (89.6%) ranked for income generation and insurance first, 183 (75.9%) home meat was ranked second, 166 (66.8%) skin production was ranked third. Sixty eight owners (91.8%) in lowland, 74 (91.13%) midland and 68 (91.89%) highland knew one or more parasitic skin diseases on sheep and goats. Majority of the respondents from lowland, midland, and highland areas had mainly encountered mange, ticks and keds, respectively. About 51.1% of owners indicated that young ones were more affected by ticks than adults, while 55.0% respondents indicated adults were more affected by lice and keds than young but 43.4% responded that they had encountered mange in all age groups.

Of all respondents in three surveyed districts, 27 (11.2%) livestock owners had indicated an observation on ectoparasite infestations as a general which could have effect on growth and /or productivity of sheep and goats. About 47 (19.5%) respondents expressed knowledge of parasitic skin diseases in general in affecting the market price of skins. In case of effects of each ectoparasite infestation, half of interviewed persons (lowland) believed that mange had effects on the value of affected skins, while the majority of the respondents in all surveyed agro-climates did not consider that keds, lice, and ticks affected the sale of skins. From all surveyed areas, only two farmers had indicated the involvement of ectoparasites as vectors for various diseases conditions. Only about 94 farmers (39%) had used modern veterinary care services provided at public veterinary clinic in the areas. Concerning the ethno-veterinary knowledge by livestock owners, the traditional practices of surveyed areas revealed very little information and only 7.8% of farmers had used traditional medicine for treatment of some ectoparasites.

5. DISCUSSION

Results presented in this study revealed about 48.1% and 49.7% of overall prevalences of ectoparasites in sheep and goats, respectively which suggested the importance of these ectoparasites problems in small ruminants in the study areas. The absence of improved husbandry practices and veterinary services, favorable climatic conditions, low input of feeds, and very less level of awareness of livestock owners on the effects of ectoparasitic diseases might have strongly contributed for wide occurrence of infestation by ectoparasites. This fact was noted during the questionnaire survey where only few respondents were observed to appreciate the effect of ectoparasites other than mange mites as damaging skins and debilitating effects. The present findings are in agreements with the previous reports from both Ethiopia (Zelalem, 1994; Haffize, 2001; Teshome, 2002; Tefera, 2004; Kassa, 2006; Tefera and Abebe, 2006; Mersha, 2007; Mulugeta, 2008) and other countries (Ugochukwu and Aphe, 1985; Craig, 1998; Maderia *et al.*, 2000; EI-Bakey, 2001; Mohammed and Ali, 2006), who indicated the widespread of ectoparasitic diseases and their importance in small ruminants.

The results of study indicated that lice infestations were observed as the first and second most prevalent ectoparasites on sheep and goats with overall prevalence of 28.7% and 16.5%, respectively (Table 4). From the 380 sheep positive for lice, 27.2% of them were infested with *Damalinia ovis* and 1.5% with *Linognathus* species. While, all positive goats for lice (161) were infested only with *Linognathus stenopsis*. The prevalences of lice recorded in the present study are higher than the findings of Haffize (2001) who reported 2% in sheep and 1.5% in goat in Central Ethiopia, Numery (2001) 14.5% in goats in Kombolcha and Molu (2002) 1.5% in goats in Southern rangelands of Oromiya. But, these prevalences are relatively lower than those recorded in Eastern part of Amhara region that of 39.8% in sheep and 29.2% in goats (Tefera, 2004), Wolayta Soddo of 26.64% in goats (Yalew, 2007), Southeastern parts of Tigray of 30.5% in sheep and 26.7% in goats (Mulugeta, 2008). Such differences in prevalences might arise from differences in agro-climate, season during which the study was conducted, management and health care of sheep and goats in the study areas and the sensitivity of the diagnostic method used. The specificity and sensitivity of visual inspection by a skilled inspector by flock basis have been established to be 60 % and 100 %, respectively but, the test

sensitivity on individual animal will be much lower than the aggregate sensitivity (Pearse and Gardener, 1994). According to Morcombe *et al.* (1996), visual inspection for lice is known to have low sensitivity which varies with the number of lice per individual animal, skill of the inspector and the number of animals examined.

Lice infestations may indicate some other underlying problems such as malnutrition and chronic diseases (Kaufmann, 1996; Wall and Shearer, 1997). The possible reasons for such high prevalence of lice in the study area include management problems, poor feeding, and inadequate utilization of veterinary services. These lice conditions were observed during the study period where small ruminants were allowed to graze on devastated areas with little vegetation cover, mixed with other species of animals and kept under dirty barns. Besides this, due to poor awareness of the farmers on the pathogenic importance of the ectoparasitic diseases, only few owners reported to use modern veterinary service to treat lice infestation. The irritation caused by even modest population of lice leads to scratching and rubbing, and causing damage to the skin and severe infestation with *Linognathus* species may cause anemia (Kettle and Lukerin, 1984; Kaufmann, 1996; Foryet, 2001). *Damalinia* species is mobile and can spread over the entire body causing considerable irritation, restless, interrupted feeding and loss of body condition. It is also responsible for the development of nodular hypersensitivity reaction lesion (cockle) in pickled skins (Health *et al.*, 1995; Wall and Shearer, 1997; Tefera and Abebe, 2006).

According to Kettle (1984), *Damalinia ovis* requires suitable temperature and fiber of appropriate diameter to which eggs can be attached during oviposition. Eggs of *D. ovis* develop and hatch over the range of 33- 39⁰ C and are virtually independent of relative humidity range of 7- 75 %. The temperature at the skin surface of sheep is 37.5⁰ C, thus this is the temperature at which maximum oviposition of *D. ovis* occurs. In the present study, statistically significant difference in prevalence of *D. ovis* was recorded among prevalences in highland (36.6%), midland (20.9%), and lowland (14.0%) agro-climates. The odds of *Damalinia* infestation in lowland and midland was, respectively 0.235 times and 0.460 times higher than the highlands. This observation is in line with the reports of Tefera and Abebe (2006). High prevalence of the parasite on highland agro-climate can be explained by

requirements of *D. ovis* for its oviposition. Significantly, higher difference in prevalence of *D. ovis* was recorded in young (32.0%) than adults (24.1%). Young sheep were 1.45 times at risk of having *Damalinea* infestation as compared with adults. This may be explained by the chances of transfer of lice from dam to lambs. Similarly, it has been indicated that young animals are generally more susceptible to ectoparasitic diseases because of higher ratio of accessible surface to the body volume and poor grooming behavior (Noble and Noble, 1982; Lehman, 1993). The prevalence of *D. ovis* was significantly higher ($p < 0.05$) in poor (37.8%) than good (23.1%) body conditioned sheep. Sheep having poor condition were 2.251 times at risk of having the infestation than those with good condition. Animals in poor condition bodies carry heaviest infestations of lice (Urquhart *et al.*, 1996). Considering the high prevalence of *D. ovis* in the study area and mobile nature of the parasite, the economic importance of lice for livestock owners and tanning industry could be immensely very high.

Linognathus species infestation was found to be more prevalent in goats than sheep. Statistically significant difference ($p < 0.05$) in prevalence of *Linognathus* infestation of goats was recorded in midland (22.0%) than lowlands (11.7%). The risk of the infestations in lowland was 0.477 times higher than midlands. This may be attributed to the narrow temperature range required for lice breeding, when temperature is cooler than optimum. The eggs do not develop in hotter temperatures for they usually prevent egg laying and kill the lice (Radostits *et al.*, 1994).

In this study, *Melophagus ovinus* was recorded as the second leading most important ectoparasites in sheep with an overall prevalence of 16.4%. The prevalence of *M. ovinus* in the present work is relatively comparable with the findings of Tefera (2004) who reported 12.5% and Mulugeta (2008) of 19.1%. Presence of keds leads to development of irritations and staining of the wool by their faeces; the irritation results in animal biting and rubbing resulting in damaging the fleece and development of a vertical ridging of the skin called cockle (Kettle, 1984; Kaufmann, 1996; Urquhart *et al.*, 1996; Kassa, 2006). The prevalence of *M. ovinus* was 31.7 % in highland and 1.9% in midland, however no case of *M. ovinus* was observed in the lowlands. This finding on the distribution of *M. ovinus* agrees with previous studies conducted in other parts of Ethiopia (Kassa *et al.*, 1998; Asegedech *et al.*, 1999; Tefera and Abebe, 2006;

Mulugeta, 2008). A similar result was also obtained by questionnaire survey whereby only interviewees from highland considered sheep keds as a problem but, no respondents from lowland and midlands reported their existence in their flocks. Similarly, it has been indicated that in hot and humid tropics the parasite is restricted to cooler highland; infestations may be lost when sheep are moved to hot dry areas (Kettle, 1984; Radostits *et al.*, 1994). The observed odds of *Melophagus* infestation explain poor conditioned sheep of 0.379 times at risk than good conditioned bodies.

In goats, tick infestations were observed as the most prevalent among all ectoparasites identified in the study area with an overall prevalence of 24.6% while, they were the third prevalent in sheep with prevalence of 11.2%. In both goats and sheep, four genera of hard ticks were observed in the study areas namely, *Amblyomma*, *Rhipicephalus*, *Boophilus*, and *Hyalomma*. The tick species identified from different agro-climatic areas were *A. variegatum*, *Rh. evertsi evertsi*, *Rh. pravus*, *Rh. sanguineus*, *Rh. praetextatus*, *B. decoloratus*, and *Hy. truncatum*. These findings are in line with the previous works conducted by Morel (1980), Belete (1987), Gulilat (1997), Sileshi (1996), Wallaga (1997), Sileshi *et al.* (2001), and Tefera (2004), who indicated these tick species infest both sheep and goats.

The present study indicates significantly ($p < 0.05$) higher prevalence of tick infestations in sheep in midland (23.1%) and lowland (17.1%) than highland (2.1%). The risk from tick infestation in lowlands and midlands was, respectively 9.883 times and 13.988 times higher than highlands. Significantly higher prevalence of tick infestations in goats was recorded in midlands (33.7%) and lowlands (20.5%) than in highlands (8.5%). The risk of tick infestations in lowlands and midlands was, respectively 2.841 times and 5.635 times higher than in highlands. This may be attributed to higher temperature, relative humidity and prolonged sunlight that favors the survival and reproduction of ticks (Pangui, 1994). A similar observation was obtained during the questionnaire survey where by only a few respondents considered ticks as a problem in their flocks in the highlands whereas about half of the respondents from midlands and lowlands recognized ticks as causes of problems in their flocks. Poor conditioned goats were 0.585 times higher at risk of having tick infestations than good conditioned ones.

The result of current study on sarcoptic mange revealed an overall prevalence of 1.2% in sheep and 8.8% in goats. This finding is in close agreement with previous observations made in other parts of the country by Zelalem (1994) who reported 0.7% in sheep and 6.8% in goats from Dire Dawa, Chalachew (2001) of 6.9% in goats from Wolayta, Worku (2002) of 2.1% in sheep and 4.3% in goats from Sidama zone and Tefera (2004) of 0.4% in sheep and 6.1% in goats from Eastern part of Amhara. All these findings support the observations by farmers in the study areas in which mange infestations are more prevalent in goats than sheep. A similar observation was reported by Olubummi (1995) in Nigeria.

There was significant difference in prevalence of goat sarcoptic mange between lowland (15.6%) and midland (3.2%) agro-ecological areas. Goats in lowlands were 7.864 times at risk for sarcoptic mange than those in the midlands. Interviewed farmers also noted that mange was more of a problem of goats in lowlands. According to Pangui (1994), high temperature, relative humidity and sunlight favor mange mite infestations. The higher temperature, humidity and sunlight which prevail in lowlands and midlands may have accounted for the differences in prevalences. The prevalences of the sarcoptic infestation were higher in poor conditioned goats of 20.3% and sheep of 3.3% respectively, than good conditioned goats of 4.4% and sheep of 0.4%. These findings are in agreement with the previous works of Nigatu (1992), Zelalem (1994), Molu (2002), Tefera (2004), and Kassa (2006). The susceptibility of poor conditioned animals to mange may be responsible for such findings (Pangui, 1994; Radostitis *et al.*, 1994; Fthenakis *et al.*, 2000). The burrowing and feeding activities of *Sarcoptes* mites cause intense itching, inflammation, hair loss, loss of condition and death (Olubunmi, 1995). The economic impact of mange could be certainly high judging from poor condition of affected animals, losses of affected skins, deaths due to the disease and cost of treatments.

Flea infestation of *Ctenocephalides* species was one of the ectoparasitic problems encountered in small ruminants in the study area. It is generally true those ruminants including sheep and goats, horses and pigs do not have host specific species of fleas (Urquhart *et al.*, 1996). Thus, most species of fleas are feed on any available animals. The *Ctenocephalides* species occasionally infest sheep and goats, and the clinical signs include papule, crusts, pruritus and excoriation (Cole, 1996; Wall and Shearer, 1997). In present study, the prevalence of

Ctenocephalides species was 2.3% in sheep and 5.1% in goats. In sheep, the prevalence of *Ctenocephalides* in lowlands (3.0%) and midlands (4.7%) was significantly higher than in the highlands (0.6%). This finding agrees well with work of Tefera and Abebe (2006). In goats, it was observed that significantly higher prevalence of *Ctenocephalides* species was recorded in young of 7.4% than in adults of 3.2%. The observed odds indicated that young goats were 2.430 times more at risk than adults.

The result of post-tanning study on pickled sheep and wet blue goat pelts showed that the major defects responsible for skin downgrading and rejections were cockle ('ekek'), scratches, scars, and technical defects due to flaying, preservation and handling of the skins. 'Ekek' was found to be the second most prevalent defect both on pickled sheep and wet blue goat skins. It was responsible for 60.2% of the pickled sheep and 45.1% of the wet blue goat skin downgrading and rejection. This could be attributed to the different agents involved in development of 'ekek' lesions in sheep and goats. In 'ekek' affected skins, the most commonly affected parts of the skins were the neck, shoulder, sides and belly. The present finding with regard to 'ekek' proportion was much higher than observation of Asp and Tauni (1988) in which 30 % of pickled skin in Awash tannery were positive for 'ekek' but, lower than the report (88.5%) in pickled skin at Sebeta tannery (Ermias, 2000) and 71.16% in wet blue goat skin at Kombolcha (Numery, 2001). All finding confirm the complaints in many tanneries regarding the growing increase in proportions of defects due to 'ekek'.

A chi-square analysis performed on 716 pickled sheep and 716 wet blue goat skins indicated that there was a significant associations ($p < 0.05$) between 'ekek' and scratch both on pickled sheep and wet blue goat skins. Asp and Tauni (1988) and Ermias (2000) reported similar observations on pickled sheep skins processed in Awash and Sebeta tanneries, respectively. This association could be attributed to the itching and rubbing against bushes, thorns, posts and barbed wires of sheep and goats infested by lice, keds and mange mites (Asp and Tauni, 1988; Urquhart *et al.*, 1996; Kassa, 2005) leading to scratches on their skins. There was also a significant association between 'ekek' and scars on pickled sheep skins. This could be attributed to the development of secondary bacterial complications at sites where ectoparasites feed, causing lesions which upon healing leaves scars (Noble and Noble, 1982; Asp and Tauni,

1988). This study also revealed that the proportion of skins with ‘ekek’ were higher in lower grades (grade 4, 5, 6 and rejects) compared with the first three best grades. These findings are in agreement with the previous reports of Asp and Tauni (1988), Ermias (2000), Numery (2001), Tefera (2004) and Kidanu (2006). The impact of ‘ekek’ on the tanning industry is significant. This is mainly due to the fact that ‘ekek’ lesion can not be detectable at the raw skin stage and selection can not be made prior to processing; the defect appears only after processing the skin at the pickled stage. The tanning industry loses three times with regard to each ‘ekek’ affected skin; first through the purchase of raw skin of undetectable inferior quality, secondly by the cost of processing of these skins, and thirdly by the fact that such skins are downgraded after processing and therefore are unsuitable for sale in the more profitable export markets (FAO, 1998; Hadly, 2001; Kassa, 2005).

6. CONCLUSIONS AND RECOMMENDATIONS

The findings of the current study clearly indicated that ectoparasites are among the major causes of sheep and goat production constraints and quality deteriorations of exported skins in study areas. Keds, lice, ticks, mange mites and fleas were the most common ectoparasites infesting sheep and goats of the study areas. The high overall prevalence of ectoparasites recorded in small ruminants in the present study implies the presence of significant economic losses associated with the poor condition of affected animals, deaths, skin damages. Therefore, it deserves serious attention in the study areas.

The present study also found that cockle, scratches, scars, and flaying were the major skin defects observed in the tanneries. Cockle ('ekek') was found responsible for high downgrading and rejection of skins implicating a huge economic loss. Even though there are different grading system standards for raw, pickled and wet blue skins, only the pickled skin grading standards were observed to be used by tanneries for both pickled and wet blue stages of skin. It is always necessary to identify the common defects occurring in the tanneries and the ectoparasites involved in downgrading of skin quality in order to ensure that they are the primary cause of damage and hence design control measures.

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

- The subject of ectoparasites, particularly in the Oromia region, and generally in Ethiopia, needs to be addressed within the broader responsible context;
- Strategic treatment using appropriate ectoparasicides combined with other all possible control options should be initiated by the government. To this effect, farmers, tanners, and other concerned stakeholders should join hands in an effort to play roles in the effectiveness of forwarded integrated control programs;
- Further detailed studies should be carried out to determine the effects of each ectoparasite type on quality of skins;
- There should be an adaptation of standard grading system of each skin stages by tanneries. To this effect, particular attention should be paid to training of skin selectors

on grading system together with price by grade so as to reduce costs of processing of inferior skins, and encourage farmers to keep the health of their animals and thereby produce quality product;

- Awareness creation among the community the about impact and importance of ectoparasitic diseases, in order to improve the existing small ruminant productivity; thus effective extension programs should be implemented.

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8. ANNEXES

Annex1: Questionnaire format for sheep and /or goat owners

Region_____Zone_____District/Agro-climate_____PA_____

Village_____Name of owner _____Date _____

1. Family income source by Rank:

Crop sale _____

Animal sale _____

Animal product sale _____

Others if any (specify) _____

2. Livestock ownership patterns:

Sheep _____

Goat _____

Cattle _____

Horse _____

Donkey _____

Mule _____

Poultry _____

Camel _____

3. Why do you rear sheep and/or goats? (Rank):

Income generation and insurance _____

Home meat consumption _____

Skin production _____

Wool production _____

Home milk consumption _____

4. Management type:

Mixed farming _____

Pastoral _____

5. Which species are more important in your area?

Sheep _____

Goat _____

Sheep = Goat _____

6. How do you manage sheep and/or goat?

Separately _____

Mixed with other species of animal _____

7. Do you know any skin disease(s) that affect(s) sheep and/or goat?

Yes _____ No _____

If yes, can you mention it (them)?

8. Which parasitic skin disease(s) do you know that affect(s) sheep and/or goats in your area?

	<u>Yes</u>	<u>No</u>
Lice	_____	_____
Ticks	_____	_____
Mange mites	_____	_____
Keds	_____	_____
Fleas	_____	_____

9. Your Knowledge on degree of infestation(s) by species:

	<u>Sheep</u>	<u>Goat</u>	<u>Sheep = Goat</u>	<u>I don't know</u>
Lice	_____	_____	_____	_____
Ticks	_____	_____	_____	_____
Mange mite	_____	_____	_____	_____
Keds	_____	_____	_____	_____

10. Which age groups are more affected?

	<u>Young</u>	<u>Adult</u>	<u>Young = Adult</u>	<u>I don't k now</u>
Lice	_____	_____	_____	_____
Ticks	_____	_____	_____	_____
Mange mites	_____	_____	_____	_____
Ked	_____	_____	_____	_____

11. Knowledge on the seasonal occurrence of the infestation(s):

	<u>Wet</u>	<u>Dry</u>	<u>Dry = Wet</u>	<u>I don't know</u>
Lice	_____	_____	_____	_____
Ticks	_____	_____	_____	_____
Mange mite	_____	_____	_____	_____
Ked	_____	_____	_____	_____

12. Knowledge about importance of external parasitic infestation(s):

12.1. Which infestation(s) has/ have/ effect on growth, productivity and /or sell of sheep and /or goat?

	<u>Yes</u>	<u>No</u>
Ticks	_____	_____
Mange mite	_____	_____
Lice	_____	_____
Keds	_____	_____

12.2. Which parasitic skin disease(s) do you know that has/have/ effect on the market price of skin?

	<u>Yes</u>	<u>No</u>
Ticks	_____	_____
Mange mite	_____	_____
Lice	_____	_____
Keds	_____	_____

12.3. Do ectoparasites have role as vectors for transmission of other diseases?

Yes _____

No _____

13. How do you treat parasitic skin diseased animals?

	<u>Yes</u>	<u>No</u>
Modern treatment	_____	_____
Traditional treatment	_____	_____

If yes, please mention any traditional remedy you used:

14. Do you inform us any control measures practiced in your area? (Other than treatment options mentioned above)

If yes,

Annex 2: Grading of raw skins in relation to defects

Skin origin	Grade	Characteristics
Lamb, Sheep, Goats	Grade 1	No visible defect which are likely to depreciate the skin, appearing beyond 5cm from the edges
	Grade 2	Defects assessed to a total of 1-3 defect units
	Grade 3	Defects assessed to a total of 3-6 defect units
	Grade 4	Defects assessed to a total of more than 8 defect units, the unusable area being at the most equal to 50% of the area
	Rejects	Skins of which more than 50% of the area is unusable

Source: QSAE (2001) ES 39: 2001

Annex 3: Grading of pickled skins in relation to defects

Skin origin	Grade	Characteristics
Lamb, Sheep, Goats	Grade 1	No visible defects which are likely to depreciate the skin
	Grade 2	One defect assessed to a total of 1-2 defect units appearing within 5 cm from the edges
	Grade 3	Defects assessed to a total of 3-6 defect units
	Grade 4	Defects assessed at more than 7 defect units, appearing in not more than 20 % of the total area of the skin
	Grade 5	Defects assessed at more than 7 defect units appearing in not more than 50 % of the total area of the skin
	Grade 6	Culls of which the unusable area being at the most equal to 50 % of the total area of the skin
	Rejects	Culls of which more than 50 % of the area is unusable

Source: QSAE (2001) ES 39: 2001

Annex 4: Grading of wet blue chrome tanned leather

Grades	Characteristics
Grade 1	Skins with good grain appearance and of full substance with two or three minor defects outside the butt and shoulder area which do not depreciate the quality of the skin
Grade 2	Skins with good grain appearance with closed minor defects possibly along belly and back and two or three similar defects randomly spread on the butt and shoulder area, this skin have a cutting value of about 90 %
Grade 3	Skins with good grain appearance with closed minor defects possible along belly and back and two or three similar defect randomly spread on butt and shoulder areas, this skin will have a cutting value of about 80 %
Grade 4	Skins with a cutting value of at least 70 % major defects visible on neck portion with minor defects on butt and shoulder
Grade 5	Skins having at least 60 % cutting value with random, minor skin blemishes all over the skin
Grade 6	Skins having similar defects as grade 5, but having a cutting value of about 50 %
Grade 7	Skins having the same grain characteristics as grade 6, but slightly poorer in substances and having cutting value of not less than 25 %
Grade 8	Skins with empty substances with major deformation in shape and highly irregular in grain character with 10-25 % cutting value
Rejects	Skins with less than 10 % cutting value

Source: QSAE (2001) ES 206: 2001

Annex 5: Tannery skin selection by size and grade recording format

Lot No. _____ origin of the skin _____

Grades	Size					Total
	Extra small	Small	Medium	Large	Extra large	
1						
2						
3						
4						
5						
6						
Rejects						
Total						

Source: Modjo and Ethiopia tanneries P.L.C. (2010, Personal communication).

Annex 6: Frequency distribution of ectoparasites of sheep by agro-ecologies

Ectoparasite	Agro-ecology		
	Lowland(n=299)	Midland (n=364)	Highland (n=662)
<i>M.ovinus</i>	0	7	210
<i>D.ovis</i>	42	76	242
<i>L.africanus</i>	6	6	4
<i>L.ovillus</i>	0	2	2
Sarcoptic mange	124	4	0
<i>Bo.decoloratus</i>	4	5	6
<i>Am.variegatum</i>	12	42	4
<i>Rh.evertsi evertsi</i>	5	20	0
<i>Rh.praetextatus</i>	5	10	0
<i>Rh.pravus</i>	17	8	0
<i>Rh.sanguineus</i>	2	10	0
<i>Hy.truncatum</i>	10	7	4
<i>Ctenocephalides</i>	9	17	4
species			
Overall	115 (38.5%)	172 (47.3%)	350 (52.9%)

Annex 7: Frequency distribution of ectoparasites of goat by agro-ecologies

Ectoparasite	Ago-ecology		
	Lowland (n=469)	Midland (n=404)	Highland (n=106)
<i>L.stenopsis</i>	55	89	106
Sarcoptic mange	73	13	0
<i>Bo.decoloratus</i>	3	10	3
<i>Am.variegatum</i>	30	80	6
<i>Rh.evertsi evertsi</i>	17	41	0
<i>Rh.praetextatus</i>	8	5	0
<i>Rh.pravus</i>	23	19	0
<i>Rh.sanguineus</i>	12	6	0
<i>Hy.truncatum</i>	3	1	0
<i>Ctenocephalides</i> spp.	20	21	9
Overall	232 (49.5%)	220 (54.5%)	35 (33.0%)

Annex 8: Frequency distribution of ectoparasites of sheep by sex, age, and body condition

Ectoparasite	Sex		Age		Body condition	
	Male (n= 370)	Female (n= 955)	Young (n= 515)	Adult (n=810)	Poor (n= 368)	Good (n= 957)
<i>Melophagus ovinus</i>	69	148	91	126	86	131
<i>Damalinia ovis</i>	110	250	165	195	139	221
<i>Linognathus</i> spp.	5	15	7	13	7	13
Sarcoptic mange	1	15	6	10	12	4
Ticks	36	113	48	101	40	109
<i>Ctenocephalides</i> spp.	8	22	17	13	10	20
Overall	181 (48.9%)	456 (47.7%)	262 (50.9%)	375 (46.3%)	231 (62.8%)	406 (42.4%)

Annex 9: Frequency distribution of ectoparasites of goat by sex, age, and body condition

Ectoparasite	Sex		Age		Body condition	
	Male (n= 319)	Female (n= 360)	Young (n= 444)	Adult (n= 535)	Poor (n= 271)	Good (n= 708)
<i>L. stenopsis</i>	67	114	75	86	45	116
Sarcoptic mange	22	64	26	60	55	116
Ticks	77	164	101	140	49	192
<i>Ctenocephalides</i> spp.	22	28	33	17	12	38
Overall	164 (51.4%)	323 (48.9%)	214 (48.2%)	273 (51.0%)	145 (53.5%)	342 (48.3%)

Annex 10: Proportions of various defects observed on pickled and wet blue skins

Defect type	Percentage (%)	
	Pickled sheep skins	Wet blue goat skins
Cockle ('Ekek')	60.2	45.1
Scars	35.6	33.8
Scratches	69.1	70.7
Fly cuts and hole	28.9	36.5
Poor substances	2.2	1.3
Purifications	9.8	3.9
Old age	-	0.1
Cracks	1.7	4.1

Annex 11: Summary of questionnaire surveyed result

Description	Number of respondents by agro-climate		
	Lowland	Midland	Highland
1. Income sources by rank			
Crops			
1	30	43	56
2	19	16	12
3	0	0	0
Animals			
1	44	16	26
2	30	65	60
3	0	0	0
4	0	0	0
Animal products			
1	0	0	0
2	14	0	25
3	58	73	46
4	0	0	0
Others			
1	0	6	4
2	0	0	0
3	0	0	0
4	0	0	0
2. Categories of livestock ownership pattern			
Small ruminant			
No	0	0	0
1-5	12	18	10
6-10	28	38	29
>10	34	25	47
Large ruminant			
No	18	5	7
1-5	16	52	43
6-10	21	20	24
>10	19	4	12
Equine			
No	23	54	48
1-5	43	27	35

6-10	2	0	3
>10	6	0	0
Poultry			
No	37	26	19
1-5	27	31	29
6-10	10	18	21
>10	0	6	17
3. Rank of reasons for keeping and managing small ruminants			
Income generation and insurance			
1	74	69	73
2	0	6	0
3	0	0	0
Home meat consumption			
1	0	12	13
2	59	64	60
3	0	0	0
Home milk consumption			
1	0	0	0
2	9	0	0
3	6	81	0
4	0	4	0
Skin production			
1	0	0	0
2	0	6	13
3	49	55	62
4	5	0	0
Wool production			
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	8
4. Important species in the area			
Sheep	9	54	86
Goat	53	14	0
Equally	12	18	0
5. Management system			
Separately	62	25	47
Mixed with other species	12	56	39
6. Parasitic skin diseases known			
Ticks	64	74	31
Lice	33	45	39
Mange	68	60	15

Keds	0	0	58
Fleas	12	29	8
7. Species commonly infested			
Ticks			
Sheep	6	21	3
Goat	14	16	0
Equally	7	9	0
Lice			
Sheep	13	19	7
Goat	14	4	0
Equally	0	7	0
Mange			
Sheep	12	12	0
Goat	35	21	0
Equally	3	0	0
Keds			
Sheep	0	0	45
Goat	0	0	0
Equally	0	0	0
8. Age groups commonly infested			
Ticks			
Young	10	13	0
Adult	6	15	1
Equally	0	12	0
Lice			
Young	11	9	5
Adult	8	14	13
Equally	3	8	5
Mange			
Young	6	8	0
Adult	4	10	0
Equally	27	6	0
Keds			
Young	0	0	12
Adult	0	0	31
Equally	0	0	1
9. Seasonal occurrence of the infestation			
Ticks			
Wet	14	12	1
Dry	8	17	0
Both	0	2	0
Lice			

Wet	0	3	0
Dry	12	9	18
Both	4	11	3
Mange			
Wet	12	2	0
Dry	5	7	0
Both	6	3	0
Ked			
Wet	0	0	4
Dry	0	0	1
Both	0	0	0
10. Knowledge about importance of parasitic skin diseases			
Effect on animal growth and / or productivity	12	9	6
Effect on market price of live animals and their products /skins/	33	10	4
As vectors of diseases	0	2	0
11. Methods of treatment /control practices/ used			
No	33	35	44
Modern	29	32	33
Traditional	12	7	0
Others	0	3	8

9. CURRICULUM VITAE

1. Biographical Data

❖ Name	Kebede Beyecha Gemechu
❖ Date of Birth	November 8, 1978
❖ Place of Birth	Arsi, Ethiopia
❖ Sex	Male
❖ Qualification	Doctor of Veterinary Medicine
❖ Nationality	Ethiopia

2. Educational Background

- ❖ Heben Degagga Primary and Junior school (1986-1993)
- ❖ Arsi Negelle Senior Secondary school (1994-1997)
- ❖ Higher education at Addis Ababa University, Faculty of Natural Science from 1998 - 1999 and Faculty of Veterinary Medicine from 2000- 2004 in Degree of Doctor of Veterinary Medicine

3. Work Experience

- ❖ Instructor at Agarfa Agricultural Technical Vocational and Educational Training College, Department of Animal Production (Oct 2004-Nov 2006)
- ❖ Instructor at Alage Agricultural Technical Vocational and Educational Training College, Department of Animal Health (Dec 2004-Aug 2008)

4. Research Activity

- ❖ A study on Ethno veterinary knowledge and practices in Moyale District of Liben Zone, Somali region (2004, DVM Thesis)

5. Personal profile

I. Language Skills

- ❖ Amharic, Afan Oromo and English (Speaking, Reading and Writing)

II. Basic computer skills

6. Volunteers Experience

- ❖ Participation in Family Planning Data Collection Campaign in Borena Zone organized by Oromiya Development Association (Jul 8- Sep 5, 1999)

7. Professional Memberships

- ❖ Ethiopian Veterinary Association (EVA)

10. SIGNED DECLARATION SHEET

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

Name of student	<u>Kebede Beyecha</u>
Signature	_____
Date of submission	<u>June 23, 2010</u>

This thesis has been submitted for examination with our approval as university supervisors:

<u>Academic advisors</u>	<u>Signature</u>
Moses N. Kyule (BVM, MSc, MPVM, PhD, Associate Professor)	_____
Bersissa Kumsa (DVM, MSc, Associate Professor)	_____