A STUDY ON ECTOPARASITES OF SMALL RUMINANTS IN THREE SELECTED AGRO ECOLOGICAL SITES OF TIGRAY REGIONAL STATE AND THEIR IMPACT ON THE TANNING INDUSTRY

BY

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1. INTRODUCTION

Agriculture is the mainstay of the Ethiopian economy, where over 80 % of the country's population is engaged in. It accounts for 45 % of the GDP and 85 % of the value of exports (Ayele *et al.,* 2003). Self-sufficiency in food production, increase in rural income and foreign currency earning in the country through improving the quality and quantity of export items are among the main objectives of agricultural development policy in Ethiopia.

Livestock in Ethiopia is an essential component of the overall farming system. Various estimates show that the livestock sub-sector contributes 12-16 % of the total and 30-35 % of agricultural GDP, respectively (MEDaC, 1998; AAPBMDA, 1999). The sector's contribution to the national output is underestimated because traction power and manure for fertilizer are not valued. Contributing 12-16% of the total export earning, the sub-sector is the second major source of foreign currency through export of live animals, hides and skins (MEDaC, 1998). The sector also employs about one-third of the country's rural population (EARO, 2000). Therefore, livestock can serve as a vehicle for improving food security and better livelihood, and contribute significantly to agricultural and rural development (Ayele *et al*., 2003).

Small ruminants constitute about 30 % of the total livestock population of Ethiopia (Gryseels and Anderson, 1983). Small ruminants are important contributors to food production in Ethiopia, providing 35 % of meat consumption and 14 % of milk consumption (Wondwossen, 1997). Among exports of livestock products, skins and hides have the largest share of exports followed by live animals (Ayele *et al.,* 2003). The small ruminant population of Ethiopia is about 18.1 million sheep and 14.8 million goats (CSA, 2006). Owing to their high fertility, short generation interval and adaptation even in harsh environments, sheep and goats are considered as an investment and insurance to provide income for the purchase of food during seasons of crop failure and to meet seasonal purchases such as improved seeds, fertilizer and medicine for rural household. Further more wool and manure are also important by products of small ruminant production (MoARD, 2005).

The current utilization of hides and skins is estimated to be 77.3 % for cattle hide, 58.4 % for goats skin and 29.7 % for sheep skin with expected off take rate of 33 %, 35 % and 7 % for sheep, goats and cattle respectively (MoARD, 2008). Even though small ruminants are important components of the farming system in Ethiopia, their contributions are far below the expected potential. This is because small ruminant production in Ethiopia is constrained by the compound effect of diseases, poor feeding and poor managements (Getachew, 1995; MOARD, 2005).

Parasitic skin diseases of small ruminants caused by lice, keds, ticks and mangemites are among the major diseases causing serious economic loss to small holder farmer, the tanning industry and the country as a whole. Infestation with parasitic skin diseases cause blood loss, irritation which result in downgrading and rejection of skins, poor growth, decreased production and reproduction and mortality (MOARD, 2005). The major observed economic loss due to mange, lice and keds is associated with skin damage. In 1996/97 six tanneries that are found in and around Addis Ababa have rejected 2,037,745 pieces of skins which caused loss of USD 6.3 million (Bayou, 1998) and in 1998/99 three tanneries that are found in Amhara Regional State have reported 443,602 pieces of skin rejection per annum which worth USD 1.4 million loss (MoARD, 2005). According to Bayou (1998), parasitic skin diseases cause 35 % of sheep skin and 56 % of goat skin rejections. Even though deterioration in quality of skin is evident from all parts of the country; Tigray was cited among the regions which provide the country's worst skin (Alem, 1998).

The small ruminant population of Tigray Regional State is estimated to be 1,022,779 sheep and 1,588,779 goats (TBoARD, 2006). A skin supply to central market from Tigray Regional State is estimated to be 1,066,144 sheep and goats skins per annum (TBoARD, 2006).
However, due to skin diseases the regional small ruminant production and productivity and skin quality have been affected seriously, and the problem is worse in drought prone parts of the region where the small ruminant production is high and plays a significant role in food security.

To combat this problem control program have been designed by MoARD in 2005 to be implemented in Tigray, Amhara and Afar regions. But because of lack of coordination from

MoARD and among the regions themselves, the regions failed in starting the control program at the same time of the year.

Thus, Tigray Regional State has started implementing the program alone in 2006. But Amhara and Afar regions have started the program in 2007. In addition to that there was no coordinated work in bordering areas of these regions. Furthermore there is no livestock movement control between these regions. This type of uncoordinated treatment campaign against ectoparasites of small ruminants has created a gap in controlling of the disease. More over, the tannery in the region has reported repeatedly to TBoARD emphasizing the problem of quality deterioration of sheep and goat skins after processing in the tannery due to external parasites, and requesting the bureau to continue and strengthen the control program. Hence, the problem of parasitic skin diseases of small ruminants is still active and serious in some parts of Tigray Regional State, bordering Amhara, Afar, Sudan and Eritrea. Even though the problem of skin diseases are evident in the region there are no detailed studies that indicate the type of parasites involved, their magnitude and relative importance for the farmers and the tanning industry.

Therefore, the specific objectives of study were:

- Determine the prevalence of ectoparasites in small ruminants in different agro climatic areas of the region.
- Assess the effect of major ectoparasites of small ruminants on the quality of processed skin.
- Identify the magnitude and type of skin defects due to skin diseases on pickled sheep and wet blue goat skins in Sheba tannery Tigray Regional State.
- Determine the economic impact of ectoparasites of sheep and goats to the tanning industry in Tigray regional state.

2. LITERATURE REVIEW

2.1. Ectoparasitism

Ectoparasites are organisms, which inhabit the skin or out growth of the skin of the host for various periods (Hopla *et al.,* 1994). The presence of external parasites on the host is termed as infestation. The association between arthropod ectoparasite and vertebrate hosts may take on variety of forms. In some cases the parasite may be totally dependent on the host, alternatively, the parasite may feed, or live only occasionally on the host, without being dependent on it (Wall and Shearer, 1997). The effect of skin parasitism usually depends on the size of invading population, on the manner on which the parasite ekes out its existence and the state of nutrition of the host animal when infected. The damage ectoparasite inflict may be mechanical, but the situation is complicated also by host reactions to the presence of the particular parasite, their secretion and excretion (Peter, 1995).

Young animals are generally more susceptible to ectoparasites because of higher region of accessible surface to the body volume and poor grooming behavior (Lehmann, 1993).

2.2. Major ectoparasites that causes skin diseases in small ruminants

Ectoparasitic skin diseases in small ruminants are caused by different parasites. The major parasites include:

2.2.1. Sheep ked (*Melphagus ovinus*)

Keds are brown and hairy wingless biting flies about 5-7 mm in length resembling a tick (Urquhart *et al.,* 1996) with a short head and broad, flattened, brownish thorax and abdomen. Keds live their entire life cycle on the host but able to move from one host to another rapidly within the flock (Sewell *et al.,* 1990). Adult keds are permanent ectoparasites and feed on the blood of sheep and sometimes goats (Wall and Shearer, 1997). The female ked live for 4-5 months and lays 10-15 larvae during this time (Radostitis *et al.,* 1994) thus build up of infestation is slow. Single larvae are deposited on the host and pupate within a few hours.

The larvae are attached to the wool fiber some distance above the skin and many larvae and pupae are removed during shearing. The young keds usually emerges in 20-22 days but this period may be prolonged for up to 35 days in winters (Urquhart *et al.,* 1996). The complete life cycle takes 5-6 weeks in optimum warm conditions.

The parasite is mainly seen in colder and wetter areas and infestations may be lost when sheep are moved to hot dry areas. Keds are most active in cooler months and are common on coarse rather than fine woolen breeds. Sheep in poor conditions suffer most from infestation and goats may also be infested. Resistance is acquired in time and resistant sheep grow better and produce more wool. Keds dislodged from the host can live for up to 2 weeks in mild moist conditions but most die in 3-4 days and probably do not play a part in re-infestation on sheep (Radostitis *et al*., 1994).

The spread of sheep ked is mainly by direct contact and the movement of keds from ewe to lamb is an important route of infestation. The predilection sites of infestation are the neck, around the tail and ventral part of the body (Urquhart *et al.,* 1996). The keds may transmit *Trypanosoma melophagium* and the *Rickettsia melophagi,* which are harmless blood parasites of sheep.

Although the degree of infestations usually encountered cause only irritations (Radostitis *et al.*, 1994), the resulting scratching, biting, and rubbing themselves against fences, stones, shrubs, and other things causes severe damage to the skin and wool (Urquhart *et al.,* 1996). Furthermore, both sexes are blood feeders and feed several times each day therefore very heavy infestations may cause severe anaemia (Sewell *et al.,* 1990; Urquhart *et al.,* 1996; Wall and Shearer, 1997) and reduction in weight gain (Foreyt, 2001). Skin punctures made by blood sucking keds causes development of nodules called “cockles” in the finished sheep skins (Health *et al.,* 1995; Bayou, 1998; Foreyt, 2001). Cockle is an inflammatory response of the skin to the presence of keds and their saliva which is recognized after the wool or hair has been removed from the skin. Staining of the wool by the faeces of keds reduces its value and gives it a peculiar musty odor (Noble *et al.,* 1982).

2.2.2. Lice infestation (pediculosis)

Both biting and sucking lice affect small ruminants. The important species in sheep and goats are found in the genus *Damalinia* and *Linognathus.* The important species in sheep being *Linognathus ovillus* (sucking face louse), *Linognathus arficanus, L. pedalis* (sucking foot louse) and *Damalinia ovis* (biting louse). In goats *L. stenopsis* (sucking blue louse), *L. africanus, Damalinia caprae* (biting louse), *Damalinia limbata* and *D. crassiceps* are reported.

Lice usually are unable to survive for more than 1-2 days off their hosts and tend to remain with a single host animal throughout their lives. Most species of lice are highly host specific and many species specialize in infesting only one part of their host body (Wall and Shearer, 1997) and transfer to new hosts is by body contact, particularly under condition of close confinement (Peter, 1995; Urquhart *et al.,* 1996). To allow them survive as permanent ectoparasites, lice show a number of adaptations which enable them to maintain a life of intimate contact with their hosts. They are small insects, about 0.5-8 mm in length, dorsoventrally flattened, wingless and possess stout legs and claws for clinging tightly to fur, hair and feather. They feed on epidermal tissue debris, parts of feathers, sebaceous secretions and blood (Wall and Shearer, 1997).

Life cycles of all lice are similar (Radostitis *et al*., 1994; Peter, 1995; Wall and Shearer, 1997). Lice undergo incomplete metamorphosis, which refers Eggs, Nymphs and Adults. In their life cycle, lice hatch from the eggs (nymphs) are tiny replicates of the adults, they change several times but undergo only minor changes in appearance (Urquhart *et al.,* 1996; Bowman *et al*., 2003). The eggs are laid attached to the coat fiber and there are three nymphal stages before mature lice appear. The life cycle of most species varies from 2-4 weeks under optimum conditions. The rate of development is greatly influenced by temperature and moisture, which are known as Absolute Dynamic Bionomic Factors (Kassa, 2007). That is lice breed within narrow temperature range; when temperature is cooler than optimum, eggs do not develop while hotter temperature prevent egg laying and kill the lice (Radostitis *et al*., 1994). 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 (Wall and Shearer, 1997). In the flock, there are often carrier animals that stay heavily infested all year round (Urquhart *et al*., 1996).

All species *cause* irritation of the skin and stimulate scratching, rubbing, and licking leading to restlessness, damage to the fleece and skin and decrease in milk production. The saliva and faeces of the lice contains substances, which are capable of causing allergies, giving rise to severe irritations, followed by the skin thickening and sometimes self trauma (Peter, 1995; Foreyt, 2001). Being highly active, *Damalinia* species is usually considered to be most pathogenic in sheep and it can cause great irritation so that the sheep are restless and have their grazing interrupted. Like keds, *D. ovis* is also associated with the development of cockle (Health *et al.*, 1996) which is characterized by formation of brown, or gray discoloration or small nodules of 5-10 mm in size which may be found intact or broken to form ulcers on the dermis which result with scar formation on the leather (Kassa, 2007). In goats the sucking louse *Linognathus stenopsis*, is more pathogenic than the biting lice (Jubb *et al.*, 1993).

While there is disagreement on the effect of lice on the weight gain, animals in poor conditions, improperly fed and exposed to cold and debilitating diseases carry heaviest infestations. Such animals may benefit from removal of the lice while animals in good condition and well fed may not show increased weight gain after treatment (Radostitis *et al.*, 1994). Reduction in the value of the wool clip is economically the most important consequence of ovine pediculosis, but additional hazards in warm countries is that the fleece and skin, damaged by rubbing and soiled by louse faeces, is an attractant for blow flies strike (Urquhart *et al.*, 1996).

2.2.3. Mange mites

The ectoparasitic mites of mammals and birds 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. Most ectoparasitic mites spend their entire lives in intimate contact with their host, so that transmission from host to host is primarily by physical contact. The generalized veterinary term for an infestation by mites in an animal is called acariasis and can result in severe dermatitis, known as mange or scabies, which may cause significant welfare problems and economic losses (Wall and Shearer, 1997).

Mange is a widespread and most important ectoparasitic disease of animals. Mange infestation is spread mainly by direct contact between hosts and all the three stages: the larvae, the nymph and the adult are capable of migrating and inert materials such as bedding and grooming tools 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 (Radostitis *et al*., 1994).

Female mites produce relatively large eggs, from which a small, six-legged larva hatches. A few species are ovoviviparous, producing live offsprings. 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. At least one of these nymphal stages is usually inactive and development proceeds without feeding. The nymph then moults to become adult (Wall and Shearer, 1997). The number of eggs produced per female is highly variable but lifetime reproductive outputs may be as low as 16 eggs per female. Nevertheless, the life cycle of many parasitic species may be completed in less than 4 weeks and in some species may be, as short as 8 days. Hence, the mites have the potential for explosive increases in their population size (Wall and Shearer, 1997).

High temperature, humidity and sunlight favor mange mite infestations (Pangui, 1994). The disease affects all age groups and runs a more chronic course in adults than younger animals. Animals in poor condition are most susceptible to mange (Radostitis *et al*., 1994). Mange cases due to *Sarcoptes* and *Psoroptes* are often fatal. The mortality rate is higher in younger and poor condition animals (Sewell *et al*., 1990; Olubunmi, 1995).

Death may be due to dehydration, a direct result of the feeding of huge number of mites, inability to move and feed due to severe lesions on the face, muzzle and on the joints or to secondary causes such as pneumonia or bacterial septicemia introduced through self inflicted bite and scratch wounds (Roberts, 1971; Urquhart *et. al*., 1996). In infestatations, 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 dry season. Exposure of lesion and mite to direct sunlight and desiccation may reduce the survival potential of mite populations.

Some forms of mange such as demodectic mange, are the result of underlying diseases or immunosuppression (Wall and Shearer, 1997). According to these authors the effects of mite infestations are:

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

The clinical signs of erythema, pruritus and scale or crust formation are due to the inflammatory response of the skin and resulting excoriation. This response is stimulated by feeding, burrowing or the production of antigenic material by the mite (Wall and Shearer, 1997).

Some observers suggest that infra-orbital, inguinal pouches, scrotum, under tail, ears, inter digital pouches, perineum, and skin folds are foci for mites and serve as potential dry season hiding places where the mites tend to migrate to the general body surface with the onset of cold season (Roberts, 1971). According to the study reports, mange was noticed throughout the year but the incidence was higher during the wet cold months where the moistness and temperature is optimum condition for mite development (Olubunmi, 1995). Mange in sheep and goats is caused by four genera of mites, namely *Sarcoptes, Psoroptes, Chorioptes* and *Demodex* (Soulsby, 1982).

Sarcoptic mange

Sacroptic mange occurs in all species of animals and is caused by mite *Sarcoptes scabiei* that has a number of subspecies that affect different hosts but this host specificity is not complete and transference from one host species to another can occur (Radostitis *et al*., 1994). *Sarcoptes* may be transmitted to unusual host in which it might burrow in to the skin and set up a typical mange lesion (Kaufmann, 1996). *Sarcoptes* mites are economically the most important cause of mange in sheep and goats. Sarcoptic mange in sheep and goats is caused by *Sarcoptes scabiei var ovis* and S*arcoptes scabiei var caprae* respectively (Okoh *et al*., 1992). Sarcoptic mites are highly specialized for life with in the skin.

Female mites burrow in to the skin and lay eggs in tunnels they made. Mating takes place on the surface of the skin (Sewell and Brockesby, 1990). The life cycle from egg to egg laying female may take 10-14 days (Kaufmann, 1996). The feeding activity of *Sarcoptes* causes intense itching and scratching due to a marked irritation, which causes self inflicted lesions that aggravates the conditions (Jackson, 1991). Sarcoptic mange usually start on relatively hairless part of the skin and may latter generalize (Bowman *et al*., 2003). 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 (Blood *et al*., 1983). It is highly contagious and the spread of *Sarcoptes scabiei* is usually by close physical contact. As a result single cases are rarely seen in groups of animals kept together. Infestation may also occur by indirect transfer, since the mites have been shown to be capable of surviving off the host for short periods. The length of time that *Sarcoptes scabiei* can survive off the host depends on environmental conditions but may be between 2 and 3 weeks (Wall and Shearer, 1997). Mange caused by *Sarcoptes* was noticed throughout the year but the incidence was higher during the wet cold months where the moistness and temperature is optimum condition for the mites' development (Blood *et al*., 1983).

Psoroptic mange

Psoroptic mange, also known as sheep scab, is highly contagious disease of sheep and goats. It is caused by the mites, *Psoroptes communis var ovis* in sheep, which affects sides of the body and *Psoroptes communis var caniculi* in goats, which affects the external ear canal. Psoroptic mange mites are non-burrowing and feed on tissue fluids. The mite migrates to all parts of the skin and prefers areas covered by wool or hair. The whole life cycle is completed in 3 weeks (Kaufmann, 1996). Infestation by these mites is always superficial on the epidermis, but the piercing of the skin by the mites lead to exudation and exfoliation, causing scabs to form (Sewell *et al*., 1990). 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 with no clinical signs to severe lesions covering much part of the body and causing death's (Soulsby, 1982).

The overall biology of Psoroptic mites resembles that of *Sarcoptes.* The only difference is that *Psoroptes* do not burrow in to the skin. Eggs are laid on the skin surface and hatch out in 1-5

days to larval stages. Larvae after feeding moult in to nymphs where finally nymphs moult to adults (Kaufmann, 1996).

Psoroptic mange can affect all ages of sheep but may be particularly severe in young lambs. Mites are usually more active in winter and the oviposition rate is higher at lower temperatures. In summer the disease progress more slowly, lesions are not obvious and can be missed. The disease can become latent in summer, apparently disappearing, with mites taking refuge in protected sites (Wall an Shearer, 1997).

Psoroptic mites pierce the skin and suck the host's tissue fluids causing irritation, inflammation then discharging lymph fluid, which dries to form yellowish crusts and scabs. As a result the affected animals become irritated, rub and bite themselves, resulting in wool drop off (alopecia) and sometimes secondary bacterial infection following severe inflammation (Bowman *et al.*, 2003).

Choriopitc mange

Chorioptic manges (tail, leg, or scrotum mange), which attacks cattle, horse, goats and sheep are now considered to be one species; *Chorioptes bovis* (Radostitis *et al*., 1994). The life cycle of *Chorioptes bovis* is similar to that of *Psoroptes* and is completed in 3 weeks and transmission is by direct contact and contaminated materials. However, C*horioptes* does not survive off the host for more than a few days (Peter, 1995). In goats, lesions of chorioptic mange are usually confined to lower parts of the leg and crusty lesions may be found behind fetlock of all four limbs (Kaufmann, 1996). In sheep it affects the scrotum and may cause decrease in fertility (Radostitis *et al*., 1994).

Demodectic mange

Demodectic mange mites (hair follicle mites) are tiny elongated mites that infest hair follicles of all species of domestic animals. *Demodex* species live as commensals, embedded head down in the hair follicles, sebaceous (oil) glands and meibomian glands of the skin where they spend their entire lives and are unable to survive off their hosts. For the most part they are non pathogenic and form a normal part of the skin fauna (Wall and Shearer 1997). The disease causes little concern but in cattle, there may be significant damage to the hide and rarely deaths due to gross secondary bacterial invasion. In gross pathology of the semi-processed skin there is clearly raised caseous nodule formation and histologically, there is a hyperplastic dermatitis characterized by the presence of demodectic mange lesions, but there is a severe folliculitis with parasite remnant in the hair follicles which cause follicular disruption (Asegedech,1999) cited by Kassa (2005). The disease may also be severe in goats. The important signs of the disease in goats are the appearance of small nodules and pustules which may develop in to larger abscesses from which large number of *Demodex* mites may be expressed (Jackson, 1991). Lesions induced by *Demodex* mites are of two types (Blood *et al*., 1983):

- Squamous demodicosis, where hair follicles are distended with mites and cellular debris, follicular epithelium is atrophic and widespread alopecia is evident;
- Pustular (follicular) demodicosis, which results from secondary bacterial complications like staphylococcus species.

The entire lifecycle is spent on the host, where eggs hatch into nymph (protonymph and deutonymph) and then moults to adult stages and the whole life cycle is completed in 18-24 days (Kaufmann, 1996). The disease spreads slowly and transfer of mite is through contact probably early in life (Radostitis *et al*., 1994).

2.2.4. Tick infestations

Ticks are obligate, blood feeding ectoparasites of vertebrates, particularly mammals and birds. They belong to three families *Ixodiadae, Argasidae* and *Nutelielidae. Ixodidae*, known as hard ticks, contain almost all the species of ticks of veterinary importance.

The second family *Argasidae*, known as, soft ticks, contains relatively small number of species of veterinary importance (Wall and Shearer, 1997; Okello-onen *et al.*, 1999). According to Wall and Shearer (1997), ticks are primarily parasites of wild animals and only about 10 % of the species feed on domestic animals, primarily sheep and cattle.

Apart from their role as a vector and potential reservoir of infestations ticks can cause direct losses of productivity in domestic animals. Tick bite may be directly debilitating to domestic animals, causing mechanical damage, irritation, inflammation and hypersensitivity and, when present in large numbers, feeding may cause death from severe anemia (Kaufmann, 1996).

According to Wall and Shearer (1997), some species of ticks cause tick paralysis and it is possible that others will elaborate toxins other than those causing paralysis. Heavy tick burden cause sufficient worry to interfere with feeding which may lead to loss of production and weight gain. They also cause greater morbidity and mortality during periods of drought, and delays in fattening so that animals are held longer before they can be sold (Radostitis *et al*., 1994).

Although many ticks favor a particular host, they are usually not completely host specific and may parasitize a wide variety of animals. The life cycle of ticks vary widely. Some species pass their entire life on the host, others pass different stages of the life cycle on successive host, and others are parasitic only at the certain stages. Most ticks spend more time off the host, but are totally dependent on the host for sustenance. They are subjected to microenvironment condition when on the ground and thus tend to be more endemic in specific types of area. Ticks can exist for a long period of time without feeding (Peter, 1995).

Sheep ticks are of great economic importance, but not to the extent that they are in cattle (Kaufmann, 1996). These parasites cause tick-worry, blood loss and damage at feeding sites, which results in skin damage. Damage on sheep skin is primarily found along the belly area or where the fleece is thinner.

Lamb skins are particularly susceptible to skin damage. Secondary bacterial infection of the bite increases the severity of the damage. Wounds left from tick bites are susceptible to additional attack by blowflies and screwworm flies that deposit eggs on the wound and produce a fatal, cutaneous myositis (Bowman *et al.*, 2003). Ticks produce tick marks that look like holes, pinpricks on the grain or scars that mostly occur in the belly (Soulsby, 1982; Asp and Tauni, 1988).

2.2.5. Blowfly strike (Cutaneous myiasis)

Myiasis is the infestation of an organ or tissue of the host animal by the larvae stage of dipterious flies, usually known as maggots or grubs. Myiasis of sheep and goats is caused by screwworm flies from the genera *Lucilia, Calliphora*, *Phormia* and *Chrysomia*. *Chrysomia chlorophaga* and *C. albiceps* are sheep blowflies in Africa (Radostitis *et al*., 1994). Cutaneous myiasis of goats caused by species of *Lucilia*, or other *Calliphora* blowflies is less common than in sheep, probably because of the more open hair of goats (Wall and Shearer, 1997).

The life cycle of blowflies pass through complete metamorphosis, that is through four stages: egg, larvae, pupa and adults. Adult blowflies lay cluster of light to yellow eggs in wounds soiled wool, or carcasses, being attracted by the odor of decomposing matter. Larvae hatch from eggs in 8 to 72 hours and reaches full size in 10 to 20 days, depending on the temperature, moisture, amount and suitability of food and competition with other larvae. Full grown larvae are grayish white or pale yellow and hairy or smooth. Larvae pupate in the ground, in dry parts of a carcass, or even in the wool of live animals (Kimberling, 1988).

In sheep, screwworm myiasis occurs largely as a consequence of skin damage due to trauma; shearing, tail-docking or castration wounds. The main predisposing host factor for sheep myiasis by species of *Lucilia* is faecal and urine soiling, bacterial dermatitis, especially dermatophilosis and foot rot (Kimberling, 1988; Wall and Shearer, 1997).

The direct pathological effect of myiasis may vary considerably and depends on the species of ectoparasite, the number of larvae and the site of infection. In many cases infection 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). The infestation of the live animal with larvae (maggots) of blowflies is common in the soiled wool around the crutch area. 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 (Kimberling, 1988). The wound secretions then attract further flies. Open wounds produced cause severe scarring of the skin, which grossly affect the appearance of the final leather.

2.3. Diagnosis of ectoparasitic skin diseases

In making a diagnosis of ectoparasitic infestation or ectoparasite 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 (Wall and Shearer, 1997). 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).

2.3.1. 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 including feeding, de-worming, etc.

2.3.2. Clinical examination

According to Smith and Sherman (1994), simple observation allows identification of most external parasite infestations and clinical signs of skin diseases, thus many conditions can be diagnosed with reasonable certainty.

The entire skin surface of the patient should be examined for parasites and lesions and the elasticity of the skin, its temperature, thickness, color and consistency should be noted and response of the animal to palpation of affected area should be observed (Jackson, 1991; Kaufmann 1996). The appearance and location of lesions are the basis for diagnosis. According to Kaufmann (1996), the primary lesions include papules, vesicles, pustules and nodules. Secondary lesions such as scales, crusts and alopecia are the result of self trauma or super imposed bacterial infections.

During clinical examination unidentified external parasites or their eggs are collected, fixed and stored in 70 % alcohol or 10 % formalin and identification can be made with the help of identification keys (Soulsby, 1982). 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 picked up with the end of moistened paint brush. Unattached mites and ticks can be removed by combing or brushing of the host 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 (Kaufmann, 1996; Wall and Shearer, 1997).

According to Kaufmann (1996), 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 *Demodex.*

In case of alopecia it may be useful to examine the upper portion of the hair for evidence of fracture, which occurs with self-induced alopecia due to pruritus (Wall and Shearer, 1997).

In order to insure that the mouth parts of a tick 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 prevent respiration and, after about 30 minutes, the tick will drop off (Kaufmann, 1996).

2.3.3. Acetate strip examination

Short strip of acetate tape (e.g. Sellotape of Scotch 3M tape) can be applied repeatedly to either the hair coat or clipped skin surface. Materials and parasites in the coat or in the surface of the skin become attached to the tape which is then mounted on to the glass slides and examined microscopically. This is a useful technique for identifying mites (Kaufmann, 1996; Wall and Shearer, 1997).

2.3.4. Examination of skin scrapings

Examination of skin scrapings is very essential in the diagnosis of mange mites. But in longstanding cases mites are often very few in number and extremely difficult to find and their absence from the skin scraping does not negate a diagnosis (Jackson, 1991). Therefore, multiple sites should be scrapped to increase the likelihood of ectoparasite detection. According to Wall and Shearer (1997), superficial skin scraping (epidermal surface examination) after removing coat hair by gentle clipping can be used to identify surface mites, while deep skin scraping (deep epidermal examination) until capillary ooze occurs is useful in the diagnosis of burrowing and follicular mites such as *Sarcoptes scabiei* and *Demodex* species. According to Bowman *et al*., (2003) and Chauhan *et al*., (2006) there are three options for examination of skin scrapings:

- Direct smear: potassium hydroxide treated skin scrapings are placed on clean and dry glass slide with one drop of 10 % potassium hydroxide or sodium hydroxide. The

scrapings are macerated with scalpel or spatula and cover it with cover slip and examine under lower power of microscope.

- 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 proving a gentle heat to the sample. Then transfer to centrifuge tube and centrifuge at 3000 rpm for 10 minutes. The supernatant is discarded and one drop of sediment is placed on middle of clean slide; cover it with cover slip and examine under low power of microscope.
- Sugar flotation method: skin scrapings are kept in 10 % potassium hydroxide for 2-4 hours to digest the debris; transfer it to centrifuge tube and centrifuge at 3000 rpm for 10 minutes. The supernatant is discarded and distilled water is added in to the centrifuge tube to fill it half and mix the contents. The centrifuge tube is filled with saturated sugar solution, centrifuge for 10-15 minutes at 3000 rpm. By the gravitation force parasites of mange mites will come over the contents of the centrifuge tube. Then one drop of fluid is taken from top of the centrifuge tube and placed on middle of clean and dry glass slide. Cover it with a cover slip and examine under microscope.

A few drops of 10 % potassium hydroxide solution or liquid paraffin are added to the sample, a cover slip applied and cleansing of debris allowed proceeding for 15-30 minutes before microscopic examination. Large samples may be processed by boiling for 10 minutes in 10 % potassium hydroxide solution, centrifuging and performing sugar flotation on the sediment (Smith and Sherman, 1994).

2.3.5. Collection of free living ectoparasites

As described by Wall and Shearer (1997), mobile free-living mites, ticks and fleas can be extracted from bedding, nests and fecal material by careful search or by shaking the material through a tier of sieves of decreasing mesh-size. They may be swept from vegetation using a hand net. Most commonly used for collecting ticks, however, is a blanket drag. This is a woolen blanket or cotton towel, about 1meter square, attached to a bar at one side. The drag is pulled across low-lying vegetation and questing ticks attached to the cloth. Adult flies can be collected

using hand nets, usually consisting of a deep bag of fine mesh netting with a circular, wire stiffened, and opening on a pole.

Flies may be picked off as they visit their host or baits of rotting carrion or faeces, using either a hand net or more simply, by inverting a glass tube over them as they feed or rest (Wall and Shearer, 1997).

2.3.6. Biopsy and histopathology

According to Wall and Shearer (1997), biopsy and histopathology are not as useful as direct identification for the diagnosis of ectoparasitic dermatosis, but they may be valuable in some circumstances, such as insect and arthropod bite lesions. According to Jackson (1991) and Kaufmann (1996), small whole thickness strips of skin 25 mm x 5 mm are taken from normal and abnormal area and the skin strip should be fixed in formol saline before examining under microscope. According to Wall and Shearer (1997), histological changes often associated with ectoparasites include:

- an eosinophil-rich dermal infiltrate;
- collagen degeneration usually associated with dermal eosinophil infiltration;
- focal dermal necrosis, which occur in tick bite lesion;
- eosinophilic pustule formation, which occurs in cases of fleabite dermatitis and *Sarcoptes scabiei* infestations.

2.3.7. Serology

Enzyme Linked Immunosorbent Assay (ELISA) techniques have been developed to monitor *Psoroptes* infestations of sheep, cattle and non domesticated animals, but none is in routine use. Enzyme Linked Immunosorbent Assays (ELISAs) are used routinely by researchers for detection of *Sarcoptes scabiei* (OIE, 2002).

2.4. The status of small ruminant parasitic skin diseases in Ethiopia

Reports on skin diseases of small ruminants, especially parasitic skin diseases in Ethiopia are scanty and if present are also fragmented. Studies conducted at various localities of the country and tanneries report on magnitude of skin pelts damage due to skin disease, especially ectoparasites indicate that parasitic skin diseases of small ruminants are becoming growing threat for the production of small ruminants and export of skin in Ethiopia. The main parasitic skin diseases reported in Ethiopia include:

2.4.1. Mange

Mange of small ruminants was reported from different areas of the country with different magnitude ranging from 0 % to 7.85 % in sheep and 0.37 % to 11.8 % in goats. Higher prevalence rate up to 67.7 % in sheep and up to 31.8 % in goats were recorded, but these are prevalence on animals with visible skin lesions (Table 1).

Table1. Overall prevalence of mange in different areas of Ethiopia.

Location	Prevalence (%)		
	Sheep	Goats	Author/ year
Hararghe	7.85	11.8	Gashaw, 1986
Bale Robe	67.7*	**	Shenkutie, 1987
Addis Ababa	32.7*	**	Nigatu, 1992
Dire Dawa	0.73	6.8	Zelalem, 1994
Mekelle	1.5	**	Habte, 1994
Wolayta	0	8.5	Chalachew, 2001
Central Ethiopia	2.69	3.96	Haffeze, 2001
Sidama zone	2.07	4.27	Teshome, 2002
Selected zone of Tigray	30.2*	31.8*	Kedir, 2002
Southern range lands of Oromia	0.15	0.37	Molu, 2002
Selected sites of Amhara	0.4	6.1	Tefera, 2004
In and around Wolayta Sodo	0.0	0.98	Yallew, 2007

* Study conducted on animals with visible skin lesion, ** The study conducted does not include the species.

The variation in the prevalence of mange in different areas of the country is due to lack of consideration seasonal and altitude difference during sample collection. Hence, to avoid this problem consecutive serial sampling should be taken in different seasons of the year and geographical conditions of the country.

According to Amsalu *et al.*, (2000), the disease was reported to occur in lowlands and mid altitude of 59 districts of Amhara Regional State. It has become an important disease causing a loss of up to 93 % of the small ruminants in Yeku water shade development project area of Amhara Regional State (Mekonen *et al.*, 1999). For this reason, lack of small ruminant flock was identified as top ranking problem of the area. 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 Regional State bordering Afar, Tigray and Sudan (Amsalu *et al*., 2000).

Different species of mange mites were recorded from different parts of the country. Of the mange mite affecting sheep and goats, *Sarcoptes* is the most prevalent species in Ethiopia. *Sarcoptes* was reported to have prevalence of 2.37 % in goats and 0.44 % in sheep in Sidama zone (Teshome, 2002); 8.5 % in goats and nil in sheep from Wolayta (Chalachew, 2001); 0.4 % in sheep and 6.1 % in goats from selected sites of Amhara Regional State (Tefera, 2004). The prevalence of *Sarcoptes* from clinically diseased animals with visible skin lesion was 33.27 % in goats from Kombolcaha (Numery, 2001); 4.46 % in goats and 2.33 % in sheep from Hararghe (Gashaw, 1986); 30.3 % in sheep and 31.8 % in goats from Tigray (Kedir, 2002) and 52.2 % in goats and 0 % in sheep in Dire Dawa (Zelalem, 1994).

Records of Psoroptic mange were 0.95 % in sheep and 1.63 % in goats in Sidama zone (Teshome, 2002); 2.59 % in goats and 1.8 % in sheep in central Ethiopia (Haffeze, 2001). Relatively higher prevalence of 6.15 % in goats and 4.67 % in sheep from Harrarghe (Gashaw, 1986), 67.6 % in sheep from Bale Robe (Shenkutie, 1987), and 32.87 % from Addis Ababa (Nigatu, 1994) was recorded. However, these results are from clinically skin disease affected animals. Demodectic mange was reported to occur in Sidama at 0.95 % (Teshome, 2002) and in Wolayta at 0.74 % (Chalachew, 2001) in goats, in central Ethiopia 1.37 % in goats and 0.8 % in sheep (Haffeze, 2001), in the southern range land of Oromia 3.5 % in goats and 0.88 % in sheep (Molu, 2002), in Harrarghe 0.99 % in goats and 0.84 % in sheep (Gashaw, 1986) and in selected sites of Amhara Regional State 0 % in sheep and 0.5 % in goats (Tefera, 2004).

2.4.2. Lice

Lice infestations in small ruminants were reported with overall prevalence of 1.52 % in goats and 2 % in sheep (Haffeze, 2001) from central Ethiopia; 0.53 % in goats and 0 % in sheep (Molu, 2002) from southern range land; 14.25 % in goats from Komblocha (Numery, 2001); 2.4 % in sheep and 28.8 % in goats (Tefera, 2004) and 26.64 % in sheep and nil in goats from Wolayta Sodo (Yallew, 2007). The louse species identified were 0.8 % *D. ovis* and 1.2 % *Linognathus species* in sheep and 1.52 % *Linognathus species* in goats in central Ethiopia (Haffeze, 2001), 11.54 % *Linognathus stenopsis* and 2.71 % *B. capre* in goats from Kombolcha (Numery, 2001) and 31.8 % *D. ovis* and 18.6 % *D. caprae* in Wolayta Sodo (Yallew, 2007).

However, results obtained from examination of fresh sheep pelts showed a much higher infestation rate of 89.55 % (Ermias, 2000).

Both lice and keds are considered as cause of cockle ("ekek") in Ethiopian sheep pelts (Bayou, 1998). However, information on prevalence and distribution of keds are scarce but examination of fresh sheep pelts indicates 32.7 % infection rates (Ermias, 2000), and Cockle ("ekek") was responsible for 70.8 % of the pickled sheep pelt and 42.3 % of the wet blue goat pelt downgrading and rejection (Tefera, 2004).

2.4.3. Ticks

Reports from different areas of Ethiopia indicate that ticks are also among the skin parasites affecting small ruminants. The overall prevalence of ticks infestation reported was 0.96 % in sheep and 1.81 % in goats (Haffeze, 2001) from central Ethiopia; 5.27 % in sheep and 9.54 % in goats (Molu, 2002) from southern range lands; 23.8 % in sheep and 10 % in goats (Teshome, 2002) from Sidama zone; 66.5 % in sheep and 33.2 % in goats (Zelalem, 1994) from Dire-Dawa; 0.1 % in sheep and 10 % in goats (Tefera, 2004) from selected sites of Amhara Regional Stateal State; 31.78 % in sheep and18.63% in goats from Wolayta Sodo (Yallew, 2007).

The species identified were *Amblyomma spp*. (11.4 %), *Hyaloma spp*. (5.3 %), *Boophilus spp*. (7.1 %) from sheep and *Amblyomma spp*. (6.8 %) and *Boophilus spp.* (9.2 %) from goats in Sidama zone (Teshome, 2002); *Amblyomma spp.* (4.58 %) from goats in Kombolcha (Numery, 2001); and *Boophilus spp*. (0.1 %), *Amblyomma spp.* (2.1 %) and *Rhipiciphalus spp* (2.3 %) from sheep and *Boophilus spp*. (3.4 %), *Amblyomma spp*. (12.8 %) and *Rhipicephalus spp*. (8.6 %) from goats in selected sites of Amhara Regional State (Tefera, 2004); Amblyoma spp.10.28 %, *Boophilus spp.* 15.42 %, *Hyaloma spp*. 0.93 % and *Rhipiciphalus spp* 16.82 % in sheep and *Amblyomma spp* 4.9 % *Boophilus spp* 8.82 %, and *Rhipiciphalus spp* 8.82 % in goats in Wolayta Sodo (Yallew, 2007).

2.5. Skin defects and their nature

Skin is the outer covering of mature fully-grown animals of the smaller kinds such as sheep, goats, pigs, reptiles, birds and fishes, or of the immature animals of the larger species such as calves and colts (Thortensen, 1993). According to FAO (1995), skin is the outer covering of small animals such as sheep, goats and calf in raw and/or untanned form.

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 a number of surface and structural defects that hides and skins acquire during the life of the animal, slaughtering, storage and transportation stages. Top quality leathers, known as Aniline, are produced from hides and skin having few or no visible defects. Minor scratches and irregularities are not taken seriously and even considered to the contrary as a good proof for genuine aniline leather. Aniline leathers are generally soft, full in substance, and visibly display the attractive grain patterns of the natural skin and are produced by direct drum dyeing of leathers and/or skins without passing through grain correction process (Kidanu, 2001).

2.5.1. Types of skin defects

According to Kidanu (2001), skin defects are classified in to two main groups. First group being those created or acquired during the life of the animal (Pre-mortem defects) and second group being those that occur during and after slaughtering of animals (Post-mortem defects).

Pre-mortem (ante-mortem) defects

Pre-mortem defects include: Scratches, cockle (“ekek”), brand marks, scars, old age defects and poor substances (Kidanu, 2001).

Post-mortem defects

Post-mortem defects comprise: bruises, gouge marks, flay cut, bad bleeding, putrefaction, hair slip and beetle damages (Kidanu, 2001). Major defects seen on Ethiopian sheep and goats skin includes:

Putrefaction, parasitic damage, scratches and scars, heat damage, flay defects and poor substance. The major Ethiopian sheep and goats skin defects and their percentage proportion are shown in Table 2. Defects due to parasitic damage particularly cockle ("ekek") has increased dramatically in the past 10-15 years and is currently holding number one position as cause of skin down grading and rejection (Kidanu, 2001).

Table 2. Proportions of the major Ethiopian sheep and goat skin defects

Defect type	Percent on sheep skin	Percent on Goat skin
Parasitic	85	86
Scratch and scars	80	75
Flay	35	28
Putrefaction (heat)	22	19
Poor substance	20	4

Source: Kidanu (2001).

Studies conducted at Sebeta tannery on sheep skin and Kombolcha tannery on goats skin on routine production system indicate 89 % cockle ("ekek"), 51 % scratch, 49.5 % technical defects, 39.5 % disease scars and 24.1 % heat defects in pickled sheep pelts (Ermias, 2000); 17.16 % cockle ("ekek"), 56.3 % Scratch, 41.1 % technical defects, 33 % disease scar, 19.56 % crack and 10.25 % beetle damage in pickled goat pelts (Numery, 2001). Study conducted by Tefera (2004) indicate, the prevalence of cockle ("ekek") lesion on *D. ovis* and *M.ovinus* infested group of sheep pelts and sarcoptic mange infested goat pelts were 100 % and 95 % and 100 %, respectively, while none of the *Linognathus* lice infested goats were having cockle ("ekek") lesions at pickled stage. All the apparently ectoparasite free control goat skins were free from cockle ("ekek") lesion while 15 % of the control sheep pelts had cockle ('ekek') at the pickled stage.

Analysis of 1000 sheep skins processed in Dessie tannery to the pickled stage unveiled the presence of various skin defects of which cockle (70.8 %) was the dominant defect followed by scars (22 %), scratch (14 %), and knife damage (4.6 %). Similarly, out of 1000 goatskins processed to wet blue stage in Kombolcha tannery cockle ('ekek') accounted for 42.3 %, followed by scratch (29.5 %), scars (24.1 %) and knife damage (14.6 %) (Tefera, 2004).

Defect analysis of 1450 wet salted sheep skin and 1300 wet salted goats skin collected from randomly selected districts of Tigray Regional State and processed in Sheba tannery at Wukro to the pickled stage showed the presence of various skin defects of which mange (45 %) was the dominant defect followed by scratch (44 %). Details of the defects and their percentage proportion are shown in Table 3.

Table3. Proportions of the major sheep and goats skin defects in Tigray Regional State.

Defect type	% on sheep skin	% on goat skin
Heat	3.94	0.54
Scratch	44.00	30.77
Mange	45.00	12.54
Pox	0.80	18.46
Brand mark	1.17	3.77
Knife hole	6.83	16.77
Aged	3.10	2.85
Crack	0.00	6.31
Beetles	0.00	3.85
Others	1.10	1.54

Source: Sheba Tannery P.L.C, 2005 (Wukro, Tigray Regional State)

2.5.2. Causes of skin defects

Causes of pre-mortem (ante-mortem) defects

Pre-mortem defects may arise from natural or acquired causes. The various affecting factors and causes include:

Age, sex and breed of the animal: these have significant effect on quality of the leather. According to Kidanu (2001), the skin of sheep breed types of Ethiopian highlands and goats from some parts of low lands of Ethiopia, are considered to have fine grain with strong fiber structure. In domestic and international markets, Ethiopian skin qualities are identified as "Selale sheep skin type" and "Bati genuine goat skin" (Mahmud, 2000). According to Kidanu (2001), cross breeding Ethiopian sheep with European or Australian sheep to increase the carcass yield has generated inferior skin quality compared to those produced out of indigenous sheep. Skins from older animals have coarse grains and are thicker in substance. The younger the animal, the better the quality and the fine the grain. Thinner, finer and stronger leathers are likely made from female animal skins.

Climate and feeding: variations in climate and feeding of animals are major factors in determining quality of skins. Animals with poor nutrition yield skin of poor substance and lesser area than well fed healthy animals. Climate has also sizable impact on quality of the skin with respect to substance of skins and exposure to parasitic damage; highland skins are a bit thinner, less greasy and much stronger in fiber structure than skins from lowlanders (Kidanu, 2001).

Diseases: **t**he diseases that affect skin quality include: bacterial (Dermatophilosis); viral (pox, warts, foot and mouth disease); parasitic (lice, keds, mange, ticks) diseases. According to FAO (1995), demodectic mange lesions can be detected fairly easily by examining the flesh side of air dried skins, noting the round "Cheesy" yellow spots and the dried lesions in the hair. During early tanning process this cheesy mass is washed out leaving empty pockets, thus producing a pitted and scared grain surface. Other mange lesions (scabies) produce a coarse grain and scratch scars.

Ticks damage takes the form of small holes or small more or less healed scar but secondary infections leads to more extensive damage. Lice and keds causes scars and damage the grain surface by inflammatory setup (FAO, 1995).

Mechanical causes (damages): most noticeable defects on hide and skin like brand marks, scratches, scars and bruises are caused by mechanical means. Scratches are very common types of lesions caused mechanically by thorns, barbed wires and horns; where as branding is made by owners for animal identification and traditional healing purposes (FAO, 1995).

Causes of post-mortem defects

Post-mortem defects are classified in to three groups and these include:

Slaughter defects: these are defects due to flaying and poor bleeding during slaughtering. Flay defects are very common in Ethiopia because of lack of knowledge and experience of people who perform the job. Inadequate bleeding 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).

Preservation and storage defects: preservation methods such as salting or frame drying are not practical fully by farmers, collectors and traders of hides and skins, as a result of which hides and skins suffer from hair slips, mould and bacterial attacks. Delays in cleaning, drying or curing cause damage through putrefaction. Folding of flint dry skins leads to rupture of fibers and development of cracks (FAO, 1995). Rubbing, wetting, vermin damage and insect damage are also damages that occur due to incorrect storage of skins (Kidanu, 2001).

Transportation defects: inefficient transportation may cause delays in arrival to tanneries or preservation centers as a result of which green or salted hides and skins deteriorate in quality. Poor handling during loading and unloading may damage quality of hides and skins (Kidanu, 2001).

2.6. Impacts of parasitic skin diseases on the tanning and leather industry

The economic impact of skin diseases in Ethiopia is not well documented; however, this must be certainly high, judging from poor condition of affected animals, deaths, damage of the skin and cost of treatments. It also takes some time before disease affected treated animals could return to their normal body condition.

Nowadays, parasitic skin diseases are considered to be the most important factors responsible for deteriorating the quality of skin in tanning and leather industry implying huge economic loss to the country. The direct and indirect effect of the various skin diseases on the leather and tanning industry are summarized as follows:

2.6.1. Shortage of raw material

Currently there are 22 tanneries operating in the country with annual tanning capacity of 2.2 million hides, 25.9 million sheep skins and 13.7 million goat skins, but the annual potential of purchase is 1.7 million hides, 7.7 million sheep skins and 8 million goat skins (MoARD, 2008). This illustrate that the tanneries are utilizing only 77.3 %, 29.7 % and 58.4 % of their tanning potential, respectively, due to shortage of raw material. Skin diseases such as mange which damages the skin seriously can be observed on skins by farmers and skin and hide traders. Hence, such skin will not enter the market leading scarcity of supply to the tanneries (Kidanu, 2001).

2.6.2. Down grading or rejections of the skin

According to Health *et al.*, (1996) cockle is a nodular condition of the skin arising in response to infestation with *D. ovis* and is possibly a hypersensitivity reaction on the part of some sheep to antigen of louse origin. It is detectable after depletion of the hair or wool where they present as numerous small raised nodules on the grain surface of the pelt (Pfeffer *et al*., 1996).

A similar lesion known as “ekek” was associated with keds and lice infestations on Ethiopian sheep pelt (Bayou, 1998; Ermias, 2000) and in goat pelts with mange and louse infestations (Numery, 2001).

Cockle (“ekek”) in sheep and mange in goats are causes for downgrading and rejection of sheep and goat skins (Bayou, 1998; Tefera, 2004). In the past 10-15 years defects from the diseases and other causes have reached very significant level especially in sheep and goats’ skin dropping aniline leather (Grade 1-3) and increasing rejections. Tanneries reported that 35 % of sheep skin and 56 % of goats’ skin are rejected due to external parasites and out of the reject groups of the processed skin, about 80-90 % defects were believed to be due to external parasites. The estimated economic loss due to drop in quality of sheep and goat skin is around USD 25.8 million per year (Tefera, 2004).

According to Tefera (2004), one year (2002/2003) data analysis conducted in Dessie and Kombolcha tanneries indicate that 70 % of downgrading and rejection on pickled sheep pelts and 42 % of downgrading and rejection on wet blue goat pelts were due to cockle (‘ekek’). Accordingly the annual economic losses due to “ekek” in Kombolcha and Dessie tanneries excluding processing and overhead costs is calculated to be around USD 1.6 million for pickled sheep pelts and around USD 0.6million for wet blue goat pelts (Tefera, 2004). The economic loss due to cockle (‘ekek’) would have been much higher than this, if clinically mange affected skins which are selected by farmers, collectors and skin and hide traders had entered the tanneries (Kidanu, 2001; Tefera, 2004).

2.6.3. Increase in cost of labour and chemicals

According to Kidanu (2001), aniline leathers are produced by direct drum dyeing of leathers to increase resistance to stains, heat and mechanical damage without passing through grain correction process. Defects like “ekek” are detected only after removal of the hair/wool in tanneries, due to this raw skin selected as top grades may end up in to down grades and rejects.

Low quality finished leathers are produced from hides and skins suffering from different defects. Quantity of hides and skins available for this type of finish are as high as 50 % of total and are classified as rejects at crust stage in the tanning process. Most of them are finished by covering their defects with pigments or synthetic coating materials. Grain corrections require special skill and costs of chemicals used are much higher than those of aniline leathers. Paradoxically, their selling prices are three times cheaper than aniline leathers (Kidanu, 2001).

3. MATERIALS AND METHODS

3.1. Study area

The study on small ruminant ectoparasites was conducted in three districts of Tigray Regional State, namely Atsbi-womberta and Erob from eastern zone and Seharti-samre from southeastern zone of the region, north of Ethiopia located about 851, 968 and 833 kms away from Addis Ababa, respectively (Figure 1). Atsbiwomberta district has a common boundary with Afar Reginal State, Erob with Eritrea and Afar Regional State and Sehartisamre with Amhara Regional State. The livestock in the districts are indigenous breeds with small number of cross breed cattle kept around the town and exotic poultry breeds distributed through poultry improvement packages. The production system of the area is mixed crop livestock in which livestock are managed under extensive system in all of the three districts. Table 4 shows the detailed description of the study areas.

Table 4. Detail description of the study areas (selected agro climatic sites of Tigray Region).

Description	Districts		
	Atsbi- womberta	Erob	Seharti-samre
Altitude	1800 - 3100 masl	1400 - 2300 masl	1300 - 2100 masl
Rainfall	550 - 750 mm	350 -450 mm	362 - 833 mm
Temperature	15 - 25 ^{0}c	18 - 30^{0}c	18 - 32^{0}c
Agro-climate percentage:			
Highland	70 %	15 %	2 %
Midland	30 %	49 %	40 %
Lowland	-	36 %	58 %
* Livestock population:			
Cattle	58,264	19,690	98,016
Sheep	83,850	8,555	76,765
Goats	22,281	41,610	105,358
Equines	20,018	7,695	16,669
Camels	1,529	20	296
Poultry	100,457	19,677	182,975

*Source: TBoARD, 2006 Source of other information: DOARD

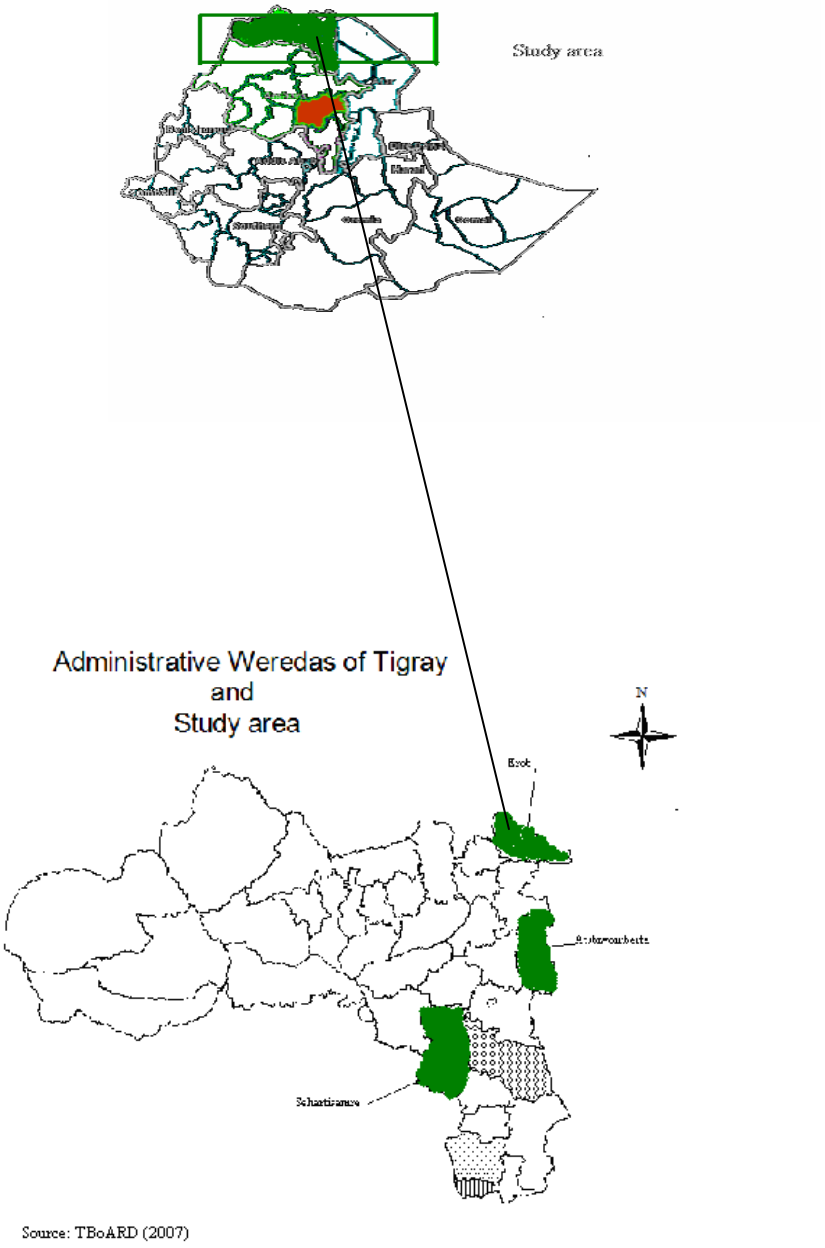


Figure 1: Map of the study area

The study on pickled sheep skin and wet blue goat skin defects was conducted in Sheba tannery which is located in Wukro town of Tigray Regional State about 823 kms north of Addis Ababa. The tannery has a soaking capacity of 6000 skins per day and process sheep skin to pickled and goatskin to wet blue stages. Recently the tannery has started to process the wet blue goat skin to crust stage. The tannery obtain raw sheep and goat skins from different parts of the country, however, North and South Gondar, North and South Wollo and Waghimra zone of the Amhara Regional State, Tigray Regional State and Addis Ababa town are the main suppliers. The tannery export pickled sheep and wet blue goat skins to different Asian and European countries.

3.2. Study Population

The study was conducted from November 2007 to April 2008. Indigenous sheep and goats owned by farmers and managed under extensive management system in different agro climatic zones (Table 4), pickled sheepskins and wet blue goatskins processed in Sheba tannery and fresh sheep and goat pelts purchased from the local markets of the study area were used as subjects of study.

3.3. Study design

3.3.1. Sample size determination and sampling methods

The study of ectoparasites on sheep and goats involved districts, peasant associations (PAs) and sheep and goats as a sampling unit. The districts were selected purposively based on their representation of different agro climatic zones; five PAs from each district having the corresponding agro climate were selected randomly. Sheep and goats in selected PAs were also selected randomly from animals grazing in communal pastures.

The sample size for the study was determined based on expected prevalence rate of the disease 20 % in each district (Sheba tannery, 2005), absolute desired precision of 5 % at confidence level of 95 %.

The sample size was calculated according to the following formula (Thursfield, 2005).

$$n = \frac{1.96^2 \, Pexp \, (1-Pexp)}{d^2}$$

Where:

n= required sample size,
Pexp = expected prevalence
d= desired absolute precision

Accordingly, the minimum sample size for the present study was found to be 246 sheep and 246 goats from each agro climatic zone.

For the cross-sectional study on pickled and wet blue skin defects; pickled and wet blue skins were selected randomly from sheep and goat pelts collected from different areas and processed in Sheba tannery. In Ethiopia it is estimated that 65 % of the defects observed in the skins are pre-slaughter defects developing in the live animals (FAO, 1998; Kassa, 2005). Of Pre-slaughter defects; defects due to cockle (‘ekek’) are the major one. Therefore, the sample size was determined from estimated prevalence of cockle (‘ekek’) defects 63 %, accepted error 3 % and level of confidence 95 %. Based on this the minimum sample size for the study was 995 skins from each stage. The sample size was calculated using the above formula.

A group of 40 pelts each affected by lice, ked and apparently parasite free pelts of sheep and another group of 40 pelts each affected by lice, mites and apparently parasite free pelts of goat were purchased from local markets of the study area for longitudinal study to assess the effect of each parasite on the quality of pickled skins.

3.3.2. Study type

The study consisted of a questionnaire survey, a cross-sectional clinical study on ectoparasites of small ruminants and examination of pickled sheep and wet blue goat skin defects and longitudinal study on effect of ectoparasites on quality of processed skin.

Questionnaire survey

A structured questionnaire format (Annex 2) was prepared to obtain general information on livestock ownership pattern, importance of keeping sheep and goats, awareness of ectoparasites that affect sheep and goats and their effect on small ruminant production and market value of the skin and the effect of ectoparasite control program in the area.

For the sake of convenience of data and time management a total of 75 individuals who owns sheep and goats were interviewed from different localities of the study area. For this purpose a total of 25 sheep and goat owners were selected from each agro-climate.

Clinical examination

A total of 1500 animals (750 sheep and 750 goats) randomly selected from the three agro climatic zones were clinically examined for the presence of ectoparasites or lesions. Before clinical examination, explanatory variables such as sex, age, body condition and hairiness of the selected animals were recorded. Body condition score of the animals considered as poor and good was recorded by modifying the system described in Gatenby (1991) for sheep and Steele (1996) for goats. Poor body condition score was given to sheep and goats which were extremely thin and those with smooth and less prominent spinous process, transverse process in which finger can be pushed and moderate depth loin muscle. Good body condition score was given for sheep and goats in which the spinous process only stick up very slightly; smooth, rounded and well covered transverse processes and those having full loin muscle and very fat.

Age categorization in to young (lamb/kid) and adult was performed as described by Gatenby (1991) for sheep and Steele (1996) for goats (Annex 3 and 4). Accordingly sheep and goats under one year were categorized as young and the rest as adult.

The clinical examination was performed by multiple fleeces parting in the opposite direction that in which hair or wool normally rests and visual inspection and palpation of the skin for parasites or lesions on all parts of the body of the animal including the ears and digits. Sheep and goats found infested by parasites were considered positive, the sites of infestation on the animal body were recorded and the parasites were identified based on their morphological structure as described in Wall and Shearer (1997).

Specimen collection and examination

Ectoparasites and their larvae unidentified during clinical examination, and scrapings of mange like lesions from clinically suspected animals were collected in a clean universal bottle, for detailed laboratory examination.

Samples of mange like lesions were collected by clipping the hair around affected area, scraping the edges of the lesion with scalpel as described by Chauhan *et al*., (2006) until capillary bleeding is seen in such away that the bled is being held at an angle that the material scraped falls on paper held underneath. The lesion was then dressed and the scrapped material transferred to a clean universal bottle containing glycerin and carried for laboratory examination. According to Coles, (1986) , a few drops of 10 % potassium hydroxide was added to the sample, allowed to stand for 30 minutes and the sediment was examined under different microscopic magnification for mites, their eggs and fragments. Ectoparasites such as ticks, lice and fleas were collected by hand from their attachment site and put into container and preserved with 70 % alcohol as described by Urquhart *et al*., (1996).

Collected ectoparasites were examined under stereomicroscope and identification was performed according to the identification key given by Okello-onen *et al*., (1999) for tick; and Wall and Shearer (1997) for mange mites, lice and flea.

Study on effects of ectoparasites on quality of skin and defects in the tannery

A total of 120 sheep and 120 goat pelts with known and registered ectoparasite infestations including non infested ectoparasite free control pelts were processed in Sheba tannery and the corresponding skin defects were analyzed. For the study, three groups of 40 sheep pelts each (one group infested by *M. ovinus*, one group infested by *D. ovis* and a control group of ectoparasite free sheep pelts) and three groups of 40 goat pelts each (one group infested with sarcoptic mange, one group infested by *Linognathus spp*. and a control group of ectoparasite free goat pelts) were used.

Each pelt was examined for the presence of ectoparasites or lesions by multiple fleeces parting at six sites (neck, shoulder, belly, flank, back and rump) on each side as described by Health *et al*., (1995a) before purchase. Due to the mobile nature of sheep ked, pelts affected by ked were purchased only from sheep that were positive on clinical examination prior to slaughter. On each group of pelts infected by ectoparasites a subjective assessment scores were made on the basis of count of ectoparasite and distribution of lesion. Accordingly a sub grouped of light, moderate and severe score was assigned to each pelt in each group and all the pelts were individually identified using punch marks and polythene tubes and salted until processed.

At the tannery, pelts were processed to pickled stages, sorted by size according to the criteria of QSAE (2001) (Annex 8) and examined in natural light by four senior skin selectors and graded in to seven grades according to the criteria of QSAE (2001) (Annexes 7 and 9). The extent and severity of cockle (‘ekek’) and other lesions were recorded and given a subjective grading of clean, light, moderate and severe based on the distribution and density of lesions per unit area adopting Health *et al*., (1996) and Pfeffer *et al*., (1996) cockle scoring method. A score of clean was given when no cockle (‘ekek’) is detected, light represented low number of scattered lesions in localized area, while severe represented a high density of lesion over two third of the skin or more. The goat skins were further processed to wet blue stage and examined again by the selectors under the same conditions.

Furthermore, 1000 pickled sheep and 1000 wet blue goat skins that were collected from different areas and processed in the tannery were randomly examined to identify the type and magnitude of skin damage in the tannery. During examination each selected skin was sorted by size and examined for defects in natural light by skin selectors and defects on each skin were recorded and the skins were graded in to seven grades as per the criteria given in QSAE (2001).

3.3.3. Data management and analysis

Microsoft Excel was used for data entry and statistical software SPSS 11.5 for data analysis. Descriptive statistics such as percentages and 95 % confidence interval were used to summarize the proportion of infected and non-infected animals and proportion of defects on pickled and wet blue skins. The effects of different epidemiological risk factors such as climate, age and body condition on prevalence of ectoparasites in sheep and goats were analyzed by logistic regression using SPSS 11.5 for windows. Chi-square test was computed by using SPSS 11.5 to test association between cockle (‘ekek’) and scratch, and cockle (‘ekek’) and scar on pickled sheep and wet blue goat skins. Correlation of the severity of ectoparasite infestation and severity of cockle (‘ekek’) on pickled skin were made by Pearson correlation and Kendall’s tau-b test, computed using SPSS 11.5 for windows and $P < 0.05$ was considered to be statistically significant.

4. RESULTS

4.1. Questionnaire survey

The responses of the questionnaire survey forwarded to small ruminant owners were summarized by districts (agro climate) (Annex 11). The questionnaire survey indicated that sheep and goats to be the dominant species owned by farmers for different reasons. The major reasons for keeping sheep and goats were for income generation and insurance 73/75 (97.3 %) followed by home milk consumption 72/73 (96 %) and meat consumption 55/75 (73.3 %). All the respondents from highland, midland and lowland knew one or more skin diseases on small ruminants. The major ectoparasites mentioned by respondents were keds, lice and ticks in the highlands and mange mites, lice and ticks in the midlands and lowlands. All respondents from the three agro climatic zones noted that mange has effect both on sale of live sheep and goats and affected skins (Table 5). While the majority of respondents did not indicated that ticks, keds and lice to have effect either on the sale of the affected animal or its skin.

Table 5. Respondents' response on various focal points considered in the questionnaire survey in selected agro climatic sites of Tigray Regional State.

Focal points	Response proportion in % (n = 75)			
	Mange	Lice	Keds	Ticks
Age groups				
▪ Adults	77.3	74.7	63.3	48.0
▪ Youngs	2.7	4.0	6.7	30.7
▪ All age groups	20.0	21.3	30.0	21.3
Seasonality				
▪ Yes	57.3	70.7	62.0	56.0
▪ No	42.7	29.3	38.0	44.0
Effects on				
▪ Sale of live animals	100	2.67	6.67	0
▪ Skin sale	85.33	0	0	0

Keds and mange were observed to affect mainly sheep and goats, respectively. Different age groups of sheep and goats were observed to be affected by mange, ked, lice and ticks (Table 5). Seasonality of occurrence of these diseases was also reported by the respondents. The season of occurrence was reported as dry and cold seasons for ked, lice, mange and dry seasons for ticks.

Response on participation in the treatment campaign program launched by the government for sheep and goats against ectoparasites indicated that only 65/75 (86.6 %) of sheep and goat owners have participated and used to treat their animals. According to the program each animal should have been treated 4 times at 10-14 days interval and after this 3 times at 1 month interval, but 82 % of the respondents who have participated in the program have treated their animals less than 4 times. Beyond that the interval between treatments was not regularly practiced.

4.2. Results of clinical and laboratory examination of small ruminants for ectoparasites

A total of 750 sheep and 750 goats were examined for ectoparasites and out of these 414 (55.2 %) sheep and 435 (58 %) goats were found to be infested with one or more ectoparasites. The ectoparasites identified on sheep were *M. ovinus*, tick infestations, *D. ovis, Linognathus species* and *Ctenocephalides species* infestations at prevalence of 19.1 %, 16 %, 15.3 %, 11.5% and 9 %, respectively (Table 6). The major ectoparasites identified on goats include tick infestations, *Linognathus species*, sarcoptic mange and *Ctenocepahlides species* on 223 goats (29.7 %), 209 goats (27.9 %), 94 goats (12.5 %) and 83 goats (11.1 %), respectively. The tick species identified on sheep were 7.5 % *A. variegatum*, 4.1 % *R. pulchellus*, 2.9 % *B. decolaratus*, 2 % *A. gemma* and 1.7 % *R. evertsi evertsi*. The tick species identified on goats were *A. variegatum*, *R. pulchellus*, *B. decoloratus*, *A. gemma* and *R. evertsi evertsi* at prevalence of 10.8 %, 9.1 %, 7.2 %, 4 % and 2.9 %, respectively.

Table 6. Prevalence of ectoparasites on sheep and goats in selected agro climatic sites of Tigray Regional State.

Ectoparasites	Sheep (n = 750)		Goats (n = 750)	
	Prevalence (%)	95 % C.I	Prevalence (%)	95 % C.I
M. ovinus	19.1	0.16-0.22	-	-
D. ovis	15.3	0.13-0.18	-	-
D. caprae	-	-	2.7	0.02-0.04
Linognathus spp	11.5	0.09 -0.14	27.9	0.25-0.31
Ctenocephaldies spp	9.0	0.07-0.16	11.1	0.09-0.13
Sacroptic mange	1.3	0.01-0.02	12.5	0.10-0.15
Demodectic mange	-	-	6.8	0.05-0.09
Tick infestations:	16.0	0.13-0.19	29.7	0.31-0.38
A. variegatum	7.5	0.06-0.09	10.8	0.09-0.13
A. gemma	2.0	0.01-0.03	4.0	0.03-0.05
B. decoloratus	2.9	0.02-0.04	7.2	0.05-0.09
R.. pulchellus	4.1	0.03-0.06	9.1	0.07-0.11
R. evertsi evertsi	1.7	0.01-0.03	2.9	0.02-0.04
Overall	55.2	0.512	58.0	0.592

The common sites of *M. ovinus* infestation on 143 sheep positive for ked were the rump, the neck, the shoulder and the sides with proportion of 65.7 %, 55.3 %, 45.6 % and 36.2 %, respectively. The major tick attachment sites on sheep were the head more dominantly the ear (52.5 %) and the tail (16.5 %) while the rest are found attached at other sites of the body such as the digits and ventral part of the abdomen.

Sacroptic and demodectic mange infestations were recorded as generalized forms in 64.8 % and 35.2 % of the cases in goats. The main infestation sites for *Linognathus spp*. in goats were the shoulder (60.5 %), the neck (58.7 %) and the sides (49.8 %). The major attachment sites for ticks were the head, especially the ear, under the tail (anal region), the leg/digits, the neck and the belly with proportion of 82.5 %, 13.0 %, 7.9 %, 6.5 % and 3.6 %, respectively.

4.2.1. Prevalence of ectoparasites of sheep and goats based on age, body condition and agro climate.

The overall prevalence of ectoparasites was (48.9 %, 59.2 %) and (44.8 %, 66.4 %) in young and adult sheep and goats, respectively (Table 7 and 8). However, there was no statistically significant difference (P>0.05) in prevalence of *D. ovis*, *M. ovinus* and sarcoptic mange infestations between young and adult sheep (Table 9). Statistically significant difference (OR=3.15, P<0.001) in prevalence of *Linognathus spp*., *Ctenocephalides spp*. (OR=0.22, P<0.001) and tick infestation (OR=2.06, P<0.01) was observed between adults and young age groups of sheep.

In goats there was a statistically significant difference between the prevalence of *Linognathus spp*. (OR=2.85, P<0.001), demodectic mange (OR=35.66, P<0.001), sarcoptic mange (OR=4.61, P<0.001) and tick infestations (OR=2.20, P<0.001) between young and adult goats, respectively. However, there was no statistically significant difference (P>0.05) in the prevalence of *Ctenocephalides spp*. and *D. caprae* infestations between the two age groups of goats (Table 10).

The overall prevalence of ectoparasites in animals with good and poor body condition was 44.7 % and 85.1 % in sheep, and 44.5 % and 87.6 % in goats, respectively. Body condition specific prevalence of ectoparasites in sheep and goats are shown in Table 7and 8. In sheep, logistic regression analysis indicated statistically significant differences in the prevalence of *D. ovis* (OR =1.986, P<0.01), *Linognothus spp*. (OR= 17.33, P<0.001), *M .ovinus* (OR= 2.085, P< 0.001) and tick infestations (OR = 2.007, P< 0.01) between poor and good body condition animals, while no statistically significant difference (P> 0.05) was noted in the prevalence of *Ctenocephalides spp*. and sarcoptic mange infestations between poor and good body conditioned animals. There was a statistically significant difference in the prevalence of *D. caprae* (OR= 13.31, P<0.001), *Linognathus spp*. (OR= 7.783, P<0.001), sarcoptic mange (OR= 336.63, P<0.001) between poor and good body condition goats. However, no statistically significant difference (P> 0.05) was observed in the prevalence of *Ctenocephalides spp.* infestations between poor and good body condition goats (Table 10).

The overall prevalence of ectoparasites in highland, midland and lowland were 67.6 %, 49.2 % and 48.8 % and 41.6 %, 66.4 % and 66 % in sheep and goats, respectively (Table 7 and 8). The effect of agro climate on the prevalence of ectoparasites identified on sheep was analyzed using logistic regressions (Table 9). The prevalence of *M. ovinus* among the agro climates showed statistically significant difference between midland and highland (OR=0.046, P<0.001) but there was no statistically significant difference (P>0.05) between midland and lowland agro climates. A similar logistic regression analysis performed on the prevalence of *D. ovis* among the three agro climates indicated statistically significant difference (OR =0.250, P<0.001) between highland and midland while no significant difference (P>0.05) was recorded between highland and lowland and midland and lowland. A significant difference in the prevalence of *Linognathus spp*. (OR=46.024, P<0.001) was found between midland and highland and also between lowland and highland (OR=56.15, P<0.001). The prevalence of ticks indicated statistically significant difference between midland and highland (OR=14.76, P<0.001) and between lowland and highland (OR=38.04, P<0.001). The prevalence of sarcoptic mange and *Ctenocephalides spp*. infestations in sheep was not statistically significant (P>0.05) among the different agro climates.

In goats, logistic regression analysis indicated statistically significant difference in prevalence of sarcoptic mange infestations between midland and highland (OR=17.22, P<0.001) and between midland and lowland (OR=3.31, P<00.001). The prevalence difference of *Linognathus spp* between highland and midland was statistically significant (P<0.05) while no significant difference (P>0.05) was indicated between highland and lowland and midland and lowland. The prevalence of *Ctenocephalides spp*. showed no statistically significant difference between all agro climates.

Table 7. Prevalence of ectoparasites of sheep based on age, body condition and agro climate in selected sites of Tigray Regional State.

Ectoparasites type	Age		Body condition		Agro climate		
	Adult (n=456)	Young (n=294)	Good (n=555)	Poor (n=195)	Highland (n=250)	Midland (n=250)	Lowland (n=250)
M. ovinus	20.4	17.0	15.9	28.2	52.4	4.8	-
D. ovis	16.8	12.9	12.8	22.6	34.4	11.6	-
Linognathus spp	15.4	5.4	3.1	35.4	0.4	15.6	18.4
Ctenocephalides spp	4.2	16.7	8.1	11.8	-	13.2	14.0
Sarcoptic mange	2.0	0.3	-	5.1	-	3.2	0.8
Ticks	19.5	10.5	13.3	23.6	1.2	15.2	31.6
Overall	59.2	48.9	44.7	85.1	67.6	49.2	48.8

Table 8. Prevalence of ectoparasites of goats based on age, body condition and agro climate in selected sites of Tigray Regional State.

Ectoparasites type	Age		Body condition		Agro climate		
	Adult (n=458)	Young (n=292)	Good (n=515)	Poor (n=235)	High land (n=250)	Mid land (n=250)	Lowland (n=250)
D. caprae	4.1	0.3	0.6	7.2	4.0	4.0	-
Linognathus spp	35.4	16.1	14.6	57.0	23.2	32.4	28.0
Ctenocephalides spp	4.8	20.8	11.8	9.4	10.8	10.0	12.4
Sarcoptic mange	17.7	4.4	0.2	18.3	2.0	26.0	9.6
Demodectic mange	10.9	0.3	1.7	17.9	3.2	7.6	9.6
Ticks	35.8	20.2	26.6	36.6	7.2	36.4	45.6
Overall	66.4	44.8	44.5	87.6	41.6	66.4	66.0

4.2.2. Prevalence of *M. ovinus* infestation by hair type

The prevalence of *M. ovinus* on hairy, less wooly and wooly sheep was 0.4 %, 6.3 % and 49.6 %, respectively. There was a statistically significant variation in the prevalence of *M. ovinus* (χ^2=150.01, P= 0.000) between wooly 125/252 (49.6 %) and hairy 1/229 (0.4 %) sheep. Similarly a statistically significant difference was observed (χ^2=122.9, P=0.001) in the prevalence of *M. ovinus* in wooly 125/252 (49.6 %) and less wooly 17/269 (6.3 %) sheep.

Table 9. Logistic regression of agro climate, age and body condition for ectoparasites of sheep in selected sites of Tigray Regional State.

Risk factors	*D. ovis*		*M. ovinus*		Sarcoptic mange		*Linognathus spp.*		*Ctenocephalides*		Ticks	
	P-value	OR	P-value	OR	P-value	OR	P-value	OR	P-value	OR	P-value	OR
Agro climate												
Highland	1	1	1	1	1	1	1	1	1	1	1	1
**Midland	0.000	0.250	0.000	0.046	0.994	5.3E+07	0.000	46.02	0.994	2.5E+08	0.000	14.76
**Lowland	0.994	-	0.993	-	0.995	1.3E+07	0.000	56.14	0.994	2.6E+08	0.000	38.04
*Midland	0.994	2.1E+08	0.994	8.1E+07	0.07	4.09	0.405	0.82	0.794	0.934	0.0000	0.388
Age group												
Young	1	1	1	1	1	1	1	1	1	1	1	1
Adult	0.143	1.37	0.25	0.80	0.09	5.9	0.000	3.15	0.000	0.22	0.001	2.06
BSC												
Good	1	1	1	1	1	1	1	1	1	1	1	1
Poor	0.001	1.98	0.000	2.08	0.99	8.7E+07	0.000	17.33	0.125	1.52	0.001	2.007

**Reference category highland

*Reference category lowland

BSC= Body Score Condition

Table10. Logistic Regression of agro climate, age and body condition for ectoparasites of goats in selected agro climatic sites of Tigray Regional State.

Risk factors	*D. caprae*		*Linognathus spp.*		*Ctenocephalides spp.*		Sarcoptic mange		Demodectic mange		Ticks	
	P-value	OR	P-value	OR	P-value	OR	P-value	OR	P-value	OR	P-value	OR
Agro climate												
Highland	1	1	1	1	1	1	1	1	1	1	1	1
**Midland	1.00	1.00	0.022	1.59	0.77	0.92	0.000	17.22	0.035	2.49	0.000	0.09
**Lowland	0.99	-	0.21	1.29	0.57	1.17	0.001	5.2	0.005	3.2	0.037	0.68
*Midland	0.99	6.7E+07	0.28	1.23	0.39	0.78	0.000	3.31	0.43	0.77	0.000	10.8
Age group												
Young	1	1	1	1	1	1	1	1	1	1	1	1
Adult	0.014	12.59	0.000	2.85	0.000	0.19	0.000	4.61	0.000	35.66	0.000	2.2
BSC												
Good	1	1	1	1	1	1	1	1	1	1	1	1
Poor	0.000	13.31	0.000	7.78	0.32	0.77	0.000	336.63	0.000	12.23	0.006	1.59

**Reference category highland

*Reference category lowland

BSC= Body Score Condition

4.3. Effects of ectoparasites of sheep and goats on skin quality

The prevalence of cockle (‘ekek’) lesion on *D. ovis* and *M. ovinus* infested group of sheep pelts was 100 % and 92.5 %, respectively. On the other hand the prevalence of cockle (‘ekek’) lesion on sarcoptic mange infested goat pelts was 100 % while non of the *Linognathus* lice infested goat pelts were having cockle (‘ekek’) lesions at pickled stage. From the control groups 20 % (8/40) of the control sheep pelts were having cockle (‘ekek’) at the pickled stage while all the apparently ectoparasite free control goat pelts were free from cockle (‘ekek’) lesion. Beside this other defects such as scratches, scars, old age and technical defects due to flaying were observed in each group of pelts (Table 11). There was a significant difference in the prevalence of cockle (‘ekek’) between *D. ovis* infested and control sheep pelt group (χ^2= 75.590, P=0.000), *M. ovinus* infested and control sheep skin (χ^2 =72.680, P=0.000) and sarcoptic mange infested goatskin and control goatskin group (χ^2= 120.0, P=0.000) indicating a strong association between these parasites and the pickled skin defect cockle (‘ekek’).

Table11. Defects observed at pickled stage in different groups of ectoparasite infested and apparently free sheep and goat pelts in Sheba tannery Tigray Regional State.

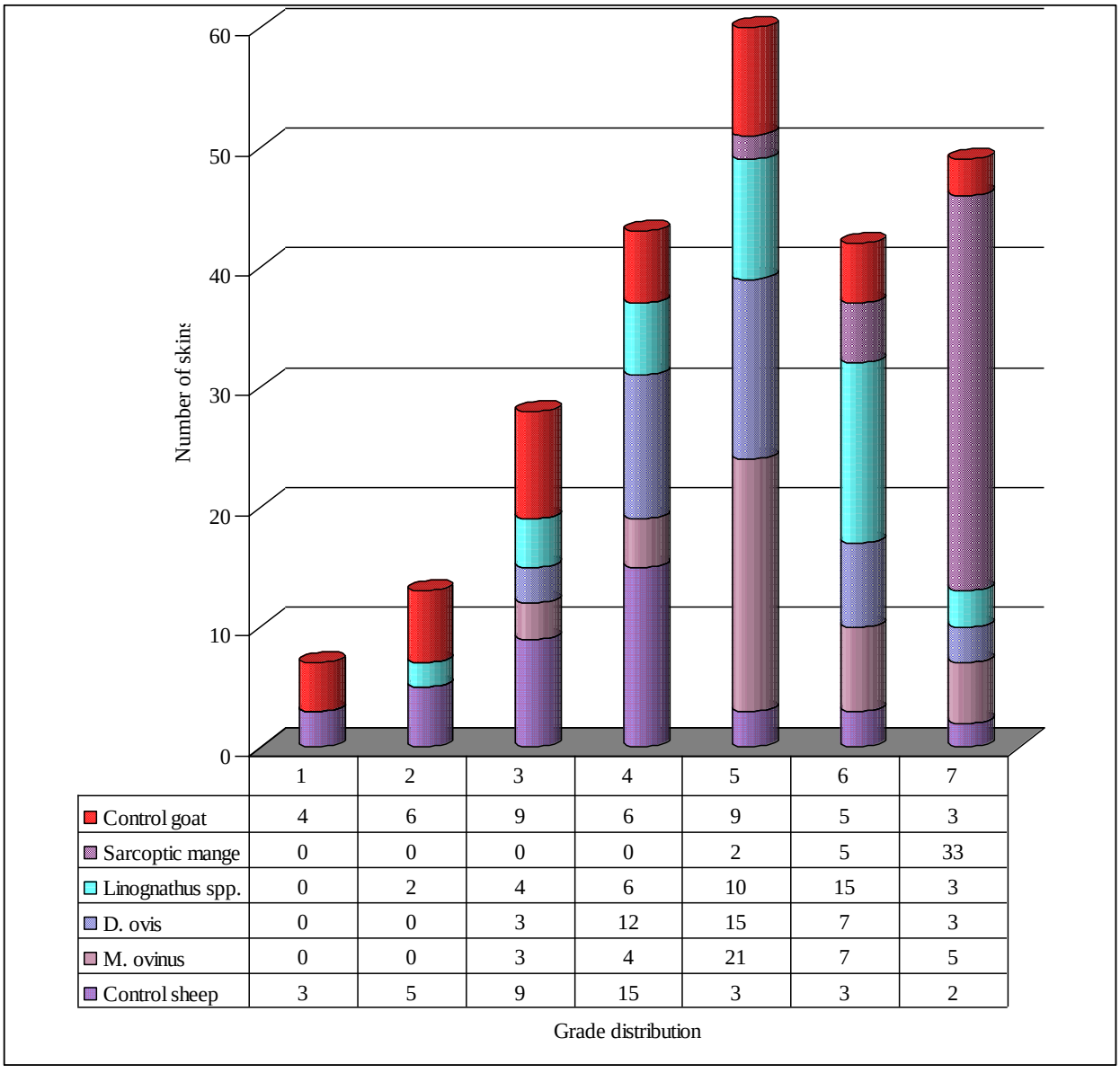
Defect type	No. of defective sheep skins by group			No. of defective goat skins by group		
	M. ovinus	*D. ovis*	Control	*Sarcoptes*	*Linognathus*	Control
Cockle	37	40	8	40	0	0
Scratch	20	28	8	25	37	17
Scars	23	25	11	18	23	16
Technical defect	6	7	8	6	11	11
Old age	-	2	4	4	2	1

There was a strong positive correlation between the severity of ectoparasite infestations (light, moderate and severe) on raw pelts and the severity of cockle (clean, light, moderate and severe) on pickled skins (Table 12) for *M. ovinus* infested sheep pelts group (Pearson= 0.841, P=0.000; Kendall's tau-b= 0.836, P=0.000); for *D. ovis* infested pelt group (Pearon=0.767, P=0.000; Kendall's tau-b= 0.679, P=0.000) and sarcoptic mange infested goat pelt group (Pearson=0.559, P=0.000; Kendall's tau-b 0.534, P=0.000).

Table12. Correlation of cockle status on pickled skins with type of ectoparasites and their severity in Sheba tannery Tigray Regional State.

Type of ectoparasites on raw pelts	Severity	Total No. of pelts	Cockle ('ekek') status on pickled skins			
			Clean	Light	Moderate	Severe
M. ovinus infested sheep	Light	8	3	4	1	0
	Moderate	20	0	0	20	0
	Severe	12	0	0	4	8
D. ovis infested sheep	Light	19	0	14	5	0
	Moderate	14	0	4	10	0
	Severe	7	0	0	1	6
Control (free) sheep	-	40	32	8	0	0
Sarcoptes infested goat	Light	16	0	6	3	7
	Moderate	10	0	0	1	9
	Severe	14	0	0	0	14
Linognathus infested goat	Light	20	20	0	0	0
	Moderate	12	12	0	0	0
	Severe	8	8	0	0	0
Control (free) goat	-	40	40	0	0	0

Grading of pickled skins from each ectoparasite affected and control groups according to QSAE (2001) indicated more number of pickled skins in apparently ectoparasite free sheep and goat pelt groups were graded as best grades (grade 1-3) when compared with those ectoparasite infested groups (Figure 2 and Annex 12).



	1	2	3	4	5	6	7
Control goat	4	6	9	6	9	5	3
Sarcoptic mange	0	0	0	0	2	5	33
Linognathus spp.	0	2	4	6	10	15	3
D. ovis	0	0	3	12	15	7	3
M. ovinus	0	0	3	4	21	7	5
Control sheep	3	5	9	15	3	3	2

Figure2**.** Grade distribution of ectoparasite affected and control sheep and goat pelts when processed to picked stage in Sheba tannery Tigray Regional State.

4.4. Results of pickled sheep and wet blue goat skin defects

Analysis of 1000 sheep pelts processed in Sheba tannery to the pickled stage revealed the presence of different types of skin defects namely scratch (43.4 %) followed by cockle (35 %), scar (7 %) and knife cut (3.4 %) (Figure 3 and Annex 13). Similarly, out of 1000 goats pelts processed to the wet blue stage in the same tannery scratch accounted for 53 % followed by cockle 21.5%, scar 6.8% and knife cut 6.2%. (Figure 3 and Annex 13). Defects such as knife cut, poor bleeding, machine defects, putrefaction, beetles damage, crack and heat were technical defects due to faulty flaying, preservation, handling and processing of skin. Though cockle was the second dominant defect next to scratch in both pickled sheep and wet blue goat skins, there was a statistically significant difference (P=0.000, χ^2 =44.957) in proportion of cockle between pickled sheep skins and wet blue goat skins.

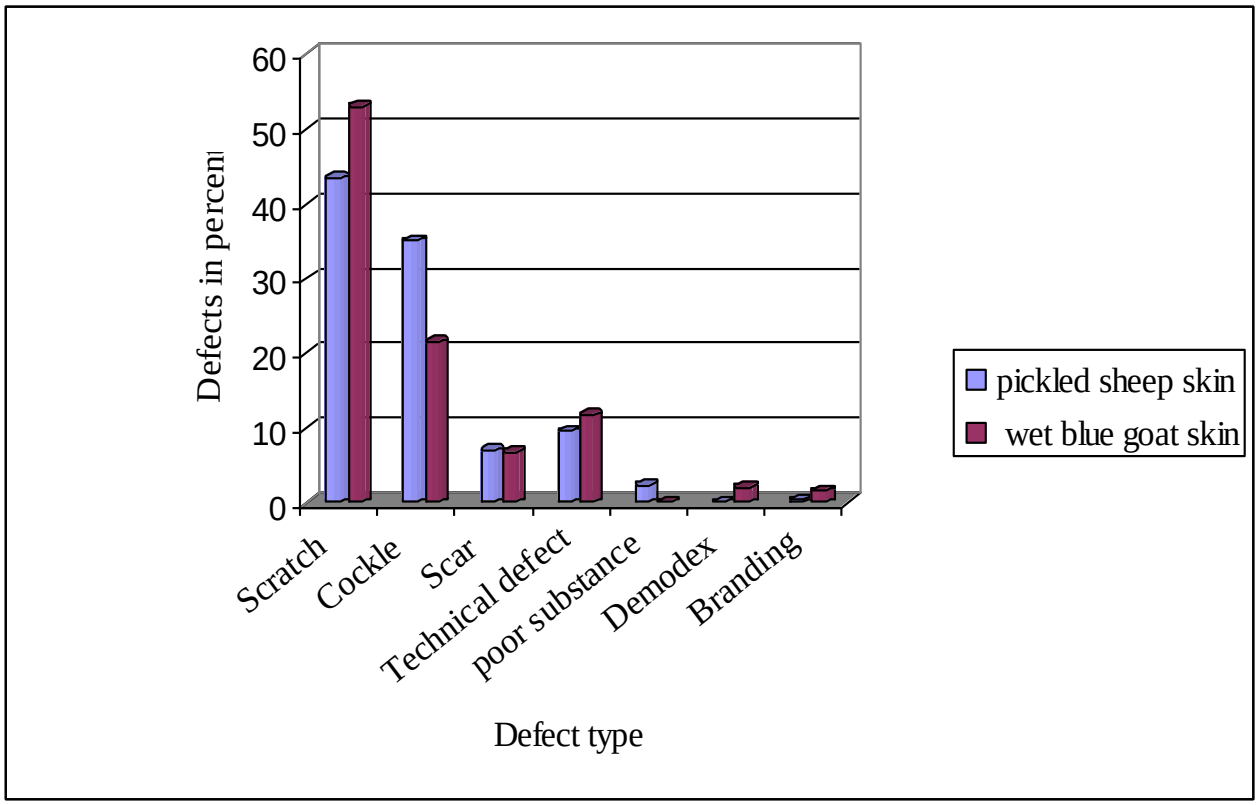


Figure 3. Percentage of defects on pickled sheep and wet blue goat skins in Sheba tannery Tigray Regional State

4.4.1. Association of cockle with scratch and scars

Significant association was observed between cockle (‘ekek’) and scratch (P=0.000, χ^2 = 18.438) on pickled sheep skin and between cockle and scratch (P=0.000, χ^2 =54.688) on wet blue goat pelts (Table 13).

Table13. Association of scratch and scar with cockle on pickled sheep and wet blue goat skins in Sheba tannery Tigray Regional State.

Type of skin	Defect type	Defect status	Cockle status		Pearson’s χ^2	P- value
			Negative	Positive		
Pickled sheep	Scratch	Negative	400	166	18.438	P=0.000
		Positive	250	184		
	Scar	Negative	622	308	20.678	P=0.000
		Positive	28	42		
Wet blue goat	Scratch	Negative	321	149	54.688	P=0.000
		Positive	464	66		
	Scar	Negative	752	180	38.831	P=0.000
		Positive	33	35		

4.4.2. Effect of cockle (‘ekek’) on grades

Cockle was responsible for 35 % of the pickled sheep skin and 21.5 % of the wet blue goat skin responsible for downgrading and rejection in Sheba tannery Tigray Regional State. Grading of the 350 pickled sheep skin and 215 wet blue goat skin revealed that the proportion of skin with cockle (‘ekek’) was much higher in lower grades than in the top grades (Figure 4).

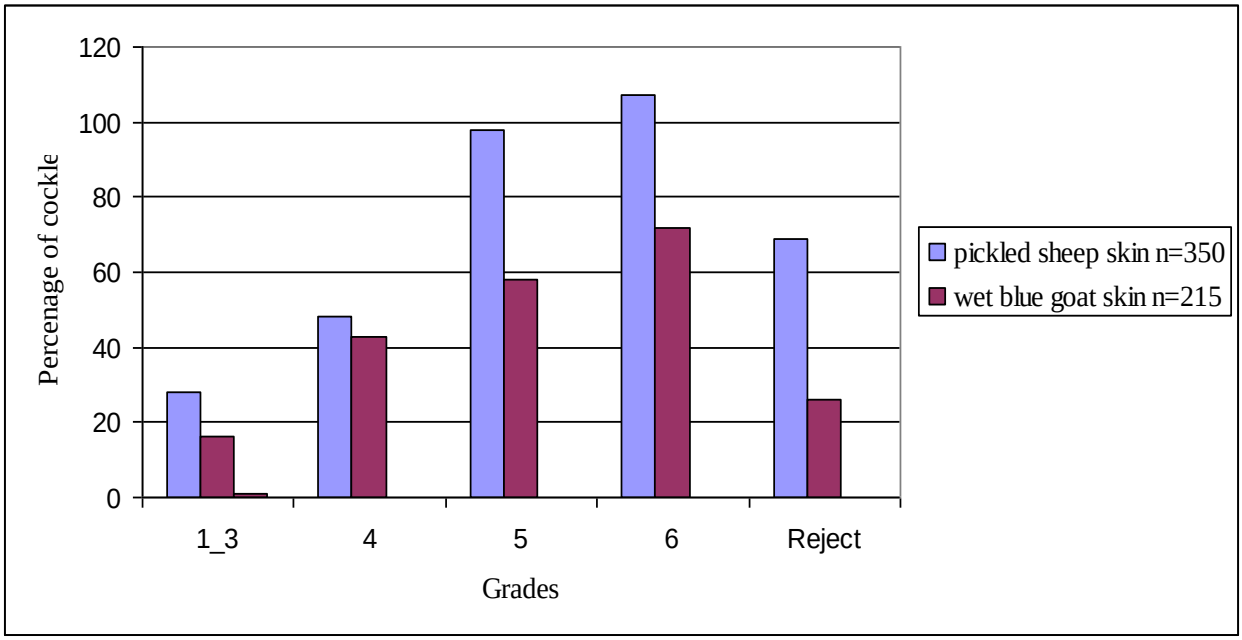


Figure 4. Grading of 350 pickled sheep and 215 wet blue goats' skins affected by cockle in Sheba tannery Tigray Regional State.

4.5. Economic impact of ectoparasites of sheep and goats to the tanning industry in Tigray Regional State

In the international market, the price of exported skins is determined both by size and grade quality of the skins. One year (2006/2007) record data analysis indicate that 23.3 % , 18.2 %, 42.2 % and 16.3 % of the 659,400 pickled sheep skins and 36 %, 29 %, 14 % and 21 % of the 484,680 wet blue skins processed in Sheba tannery belong to small, medium, large and extra large sizes, respectively.

Considering the proportion of skin in each size group, the quality of pickled sheep skins and wet blue goat skins presented for international market from Sheba tannery by size and grade and their value were given in Table 14 and Table 15.

The economic losses due to cockle was calculated on the assumption that 35% of downgraded and reject on pickled sheep pelts and 21 % of downgrading and rejection on wet blue goat pelts

(Annex 12) were due to cockle and controlling of cockle causing ectoparasites will improve the proportion of downgrading and rejection of skins to the best skin grades (1-3) by 35 % and 21 %, respectably. Based on the above points the annual economic losses due to cockle in Sheba tannery is calculated at about 778,199.41 USD for pickled sheep skins and about 247,677.61 USD for wet blue goat skins which makes a sum of 1,025,877.02 USD for both skins (Table 14 and 15). The calculated loss does not include processing and over head costs in the tannery.

Table14. Economic losses due to cockle on pickled sheep skins in Sheba tannery Tigray Regional State.

Size	Description	Grades					Total cost (USD)
		1-3	4	5	6	Reject	
Small	% grades	25.0	28.8	32.5	13.7	-	
	Quality/doz.	3650	4200	4750	2000	-	
	Value obtained	257,325	192,948	146,775	39,320	-	636,368.00
	Value expected	257,325	260,479.8	198,146.25	53,082	-	769,033.05
	Difference	-	67,531.8	51,371.25	13,762	-	132,665.05
Medium	% grades	31.0	32.0	37.0	-	-	
	Quality/doz.	3,100	3,200	3,700	-	-	
	Value obtained	262,260	195,520	143,412	-	-	601,192.00
	Value expected	262,260	263,952	193,606.2	-	-	719,812.2
	Difference	-	68,432	50,194.2	-	-	118,620.2
Large	% grades	10.8	21.9	32.9	34.0	0.4	
	Quality/doz.	2,500	5,050	7,650	7,900	100	
	Value obtained	266,400	468,438	375,997.5	201,055	2,000	1,313,890.5
	Value expected	266,400	632,391.3	507,596.61	271,424.25	2,700	1,680,512.16
	difference		163,953.3	131,599.11	70,369.25	700	366,621.66
Extra	% grades	4.5	28.5	31.3	34.6	1.1	
large	Quality/doz.	400	2,550	2,800	3,100	100	
	Value obtained	39,560	169,320	166,320	120,218	2150	497,568
	Value expected	39,560	228,582	224,532	162,294.3	2902.5	65,7870.5
	Difference		59,262	58,212	42,076.3	752.5	160,302.5
Total losses							778,199.41

Table15. Economic losses due to cockle on wet blue goat skin in Sheba tannery Tigray Regional State.

Size	Description	Grades					Total cost (USD)
		1-3	4	5	6	Reject	
Small	% grades	14.4	21.6	29.6	33.7	0.7	
	Quality/doz.	2,100	3,150	4,300	4,900	100	
	Value obtained	100,485	119,637	157,810	153,860	1,400	533,192
	Value expected	100,485	144,760.77	190,950.1	186,170.1	1,694	624,059.97
	Difference		25,123.77	33,140.10	32,310.1	294	90,867.97
Medium	% grades	20.0	21.5	25.15	32.5	0.85	
	Quality/doz	2,350	2,520	2,950	3,820	100	
	Value obtained	123,657	110,098.8	86,022	107,800.4	1,570	429,148.2
	Value expected	123,657	133,219.55	104,086.62	130,438.48	1,899.7	493,301.35
	difference		23,128.75	18,064.62	22,638.08	329.7	64,153.15
Large	% grades	13.6	19.6	25.9	38.0	2.9	
	Quality/doz.	772	1,100	1,466	2,150	162	
	Value obtained	37,750.8	50,930	55,561.4	41,387.5	2,592	188,221.17
	Value expected	37,750.8	61,625.3	67,229.29	50,078.87	3,136.32	219,820.58
	Difference		10,695.3	11,667.89	8,691.37	5,728.32	31,599.41
Extra large	% grades	14.2	18.3	24.3	37.3	5.9	
	Quality/doz.	1,200	1,550	2,050	3,150	500	
	Value obtained	74,340	72,075	82,861	125,937	9,875	365,088
	Value expected	74,340	87,210.75	100,261.81	152,383.77	11948.75	426145.08
	Difference		15,135.75	17,400.81	26,446.77	2073.75	61057.08
Total losses							247677.61

5. DISCUSSION

The high overall prevalence of ectoparasites in selected agro climatic sites of Tigray Regional State recorded in sheep (55.2 %) and goats (58 %) is indicative of the importance of these disease problems in small ruminants in the study area. Poor management and poor level of awareness of small ruminant owners on the effect of ectoparasites are strongly believed to have contributed to the widespread occurrence of the diseases. This fact has been noted during the questionnaire survey where only few respondents were observed to appreciate the effect of ectoparasites other than mange as causing health problem, debilitating effect and reducing the quality of skin.

Lice infestations were the most prevalent ectoparasites recorded in both species with a prevalence of 30.6 % in goats and 26.8 % in sheep (Table 6). Out of the 229 goats positive for lice, 27.4 % were infested with *Linognathus species*, 2.4 % were infected with *D. capri* and 0.8 % were having mixed infestation. Out of the 201 sheep positive for lice, 14.9 % were infested with *D. ovis*, 11.1 % with *Linognathus spp*. and 0.8 % were having mixed infection.

The overall prevalence of lice infestation obtained in the study was relatively higher than observations made in central Ethiopia, 2 % in sheep and 1.5 % in goats (Haffeze, 2001), around Kombolcha 14.2 % (Numery, 2001), in Southern range land nil in sheep and 0.5 % in goats (Molu, 2001) and 26.64 % in sheep (Yallew, 2007) in Wolayta Sodo. On the other hand the present prevalence of lice infestation was relatively lower than 39.8 % in sheep and 29.2 % prevalence in goats in Amhara Regional State (Tefera, 2004). Such differences in prevalence may arise from differences in agro climate, in 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 on flock basis has 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 includes: poor feeding and management, poor sanitation and inadequate utilization of veterinary service. These conditions were observed during the study period where small ruminants were allowed to graze on devastated areas with little vegetation cover, managed mixed with other species of animals and kept under dirty barns. Although, most of the owners (86.6 % of the respondents) use veterinary service to treat their animals and have participated in the treatment campaign launched by the regional government, the intervals between treatments was observed to have a gap of one month. This is due to poor awareness of the farmers on the biology of the disease. Lice infestations were also associated with damage to the skin, loss in production, irritation and possibly vector in disease transmission (Kaufmann, 1996; Wall and Shearer, 1997). The irritation caused by even modest population of lice leads to scratching and rubbing, causing damage to the skin and sever infestation with *Linognathus species* may cause anemia (Wall and Shearer, 1997; Foryet, 2001). *D. ovis* is responsible for the development of nodular hypersensitivity reaction lesion (cockle) in pickled skins (Health *et al*., 1995a; Wall and Shearer, 1997; Sertse *et al*., 2006a). A similar observation was noted in Sheba tannery from the present study where *D. ovis* was strongly associated with cockle. Considering the high prevalence of *D. ovis* in the study area and mobile nature of the parasite, the economic importance of the lice both for the farming community and for the tanning industry could be immensely very high.

Damalinia ovis requires suitable temperature and fiber of appropriate diameter to which eggs can be attached during its oviposition (Kettle, 1984). *D. ovis* eggs develop and hatch over the range of 33- 39^{O} C and are virtually independent of relative humidity over the range of 7- 75 %. The temperature at skin surface of sheep is 37.5 ^{O}C and this is the temperature at which maximum oviposition of *D. ovis* occurs. In this study statistically significant difference ($P < 0.001$) in prevalence of *D. ovis* was recorded in highland (34.4 %) than in midland (11.6 %). High prevalence of the parasite on highland agro climate can be explained by requirement of *D. ovis* for its oviposition.

Linognathus species infestation was found to be more prevalent in sheep and goats with poor body condition (35.4 % and 57 %) than those with good body condition (31.1% and 14.6 %), respectively. Poor body condition goats were 7.7 times more at risk for *Linognathus spp.* infestations than good body condition. Animals in poor body condition which are fed improperly and exposed to debilitating diseases carry heaviest infestations of lice since debilitated animals do not groom themselves and live the lice undisturbed causing anemia (Urquhart *et al*.,1996).

Mellophagus ovinus was the second most important ectoparasite observed in sheep accounting for 19.1 % over all prevalence. Infestation with *M. ovinus* leads to irritation and staining of the wool by the feces of the ked. The irritation results in animal biting and rubbing with resultant damage to the fleece and development of a vertical ridging of the skin called cockle (Kettle, 1984; Kaufmann, 1996; Urquhart *et al*., 1996; Wall and Shearer, 1997; Kassa, 2006). The prevalence of *M. ovinus* was 52.4 % in highland and 4.8 % in midland. However, no case of *M. ovinus* was recorded in the lowlands. Similar result was obtained by questionnaire survey where all respondents from highland and a few respondents from midland considered ked as a problem in their respective area, but no respondents from lowland mentioned the existence of ked in their area and/or flock. In hot and humid tropics the parasite is restricted to cooler highlands and infestations may be lost when sheep are moved to hot dry areas (Radostitis *et al*., 1994). Temperature may play an important role in the dynamics of the ked (Kettle, 1984). The present finding of higher prevalence of *M. ovinus* 55.9 % in wooly sheep and 0.4 % in hairy sheep was suggestive of the fact that wooly breeds are susceptible to ked infestation (Wall and Shearer, 1997).

Ticks of three genera (*Boophilus, Amblyomma* and *Rhipicephalus*) were identified both in sheep and goats. The species identified were *B. decoloratus, A. variegatum, A. gemma, R. pulchellus* and *R. evertsi evertsi*; with over all prevalence of 16 % and 29.7 % in sheep and goats, respectively. Infestation of *A. gemma* and *A. variegatum* were reported by Morel (1980) in sheep, Gulilat (1987) and Wallaga (1997) in sheep and goats.

Similarly, Belete (1987) reported *A. variegatum* both in sheep and goats in Nekemte Awraja, *R. evertisi evertisi* (Morel, 1980; Gulilat, 1987; Belete, 1987; Wallaga, 1997), *R. pulchellus* (Morel 1980; Gulilat, 1987; Wallaga, 1997), *B. decoleratus*, *A.variegatum*, *A.gemma*, *R. pulchellus* and *R. evertsisi evertsi* (Tefera, 2004) were reported to exist in sheep and goats in different areas of Ethiopia.

The prevalence of tick infestation in sheep and goats was found to be higher in lowland and midland with prevalence of (31.6 %, 45.6 %) and (15.2 %, 36.4 %), respectively. The higher prevalence of tick infestations in goats in lowland areas may be attributed to higher temperature, humidity and prolonged sunlight that favors the survival and reproduction of ticks in these areas (Pangui, 1994). A similar observation was observed during the questionnaire survey where sheep and goat owners noted seasonality in occurrence of ticks which is related to the dry season of the year. Relatively higher prevalence of tick infestation was observed in animals with poor condition (23.6 % in sheep and 36.6 % in goats) than good body condition (13.3 % in sheep and 26.6 % in goats).Young and undernourished animals are known to be susceptible to many diseases including ectoparasites (Urquhart *et al*., 1996).

Tick infestations in sheep and goats have both cutaneous and systemic effects. The cutaneous effect of ticks feeding on sheep and goats includes development of papules, pustules and ulceration, while the systemic effect includes introduction of surface bacteria in to the skin, causing abscess or systematically leading to bacteremia and septicemia, tick paralysis due to neurotoxin or transmission of microorganisms (Wall and Shearer, 1997). Despite such effects of ticks in sheep and goats their effect as cause of downgrading and rejection of skins in the tannery was minimal. This is because the major tick attachment sites were the ear, legs and belly regions which are less valuable parts of the skin for tanning and are usefully trimmed off before tanning. Clinical mange due to *Sarcoptes scabiei var. caprae*, *Sarcotes scabiei var. ovis* and *Demodex caprae* were among the ectoparasitic diseases diagnosed in sheep and goats. The overall prevalence of clinical mange in sheep and goats were found to be 1.3 % and 19.3 %, respectively. The prevalence of mange obtained in the present study was higher than the observations made in other parts of Ethiopia.

Previous studies by Gashaw (1986) reported mange in 7.8 % of sheep and 11.8 % of goats in Hararghe, Zelalem (1994) 0.73 % in sheep and 6.8 % in goats in Dire Dawa, Chalachew (2001) nil in sheep and 6.9 % in goats in Wolayta, Teshome (2002) 2.1 % in sheep and 4.3 % in goats in Sidama zone, Tefera (2004) 0.4 % in sheep and 6.6 % in goats in Amhara Regional State State and Yallew (2007) nil in sheep and 0.98 % in goats Wolayta Sodo. Similar observation was obtained during the questionnaire survey where farmers have noted that mange infestations are more prevalent in goats than in sheep. Accordingly, mange was more prevalent during the wetter and cooler months of the year. A similar observation was reported by Olubumni (1995) in Nigeria.

There was statistically significant difference ($p<0.01$) in the prevalence of goat sarcoptic mange among highland (2 %), midland (26 %) and lowland (9.6 %) agro-climates. Goats in midland and lowland were 17.2 and 5.2 times at risk for sarcoptic mange infestations than those in the highland, respectively. Interviewed sheep and goat owners also noted that mange is more of a problem of midland and lowland goats. High temperature, humidity and sunlight favor mange infestation (Pangui, 1994). Mites have been shown to be capable of surviving off the host for short periods, but the length of time that *Sarcoptes* scabiei can survive off the host depends on environmental conditions but may be between 2 and 3 weeks (Wall and Shearer, 1997). In the midland and lowland of the study area natural caves are abundant where goats prefer them to be inside during rainy and cold seasons. The higher temperature, humidity, sunlight and abundance of natural caves which prevail in midland and lowland may have accounted for the differences in prevalence. The prevalence of mange was also much higher in poor condition (18.3 %) than good condition (0.2 %) goats. The susceptibility of poor condition animals to mange may be responsible for such differences (Radostitis *et al.*, 1994). The burrowing and feeding activities of *Sarcoptes scabiei* cause intense itching, inflammation, hair loss and formation of crusts of exudates, loss of condition and death (Olubunmi, 1995). Therefore, the economic impact of mange must be definitely high judging from poor condition of affected animals, loss of affected skin, deaths due to the disease and cost of treatments.

Infestation by fleas of *Ctenocephalides species* was one of the ectoparasite problems encountered in sheep and goats in the study area. Generally ruminants including sheep and goats, horses and pig do not have their own species of fleas (Urquhart *et al*., 1996). However, most species of flea are not host specific and feed on any available animals, but in many cases full fertility is achieved after feeding on specific host. *Ctenocephalides spp*. occasionally infests sheep and goats and the clinical signs include; papules, crusts, pruritus and excoriation (Wall and Shearer, 1997).

The present study indicated that sheep pelts infested with *D. ovis*, *M. ovinus* and free control groups showed cockle at pickled stage at prevalence of 100 %, 92.5 % and 20 %, respectively. The prevalence of cockle at pickled stage on sarcoptic mange infested goat pelts group was 100 %. However, *Linognathus species* infested and free control groups of goat pelts did not show any kind of cockle lesion at pickled stage. Statistical analysis of these figures showed a strong association between the presence of *D. ovis* and *M. ovinus* in sheep and sarcoptic mange in goats and occurrence of cockle at pickled stages. In support of this finding, observations of Health *et al*., (1995), Pfeffer *et al*., (1996) and Health *et al*., (1996) indicated a positive relationship between *D. ovis* and the pickled defect cockle in New Zealand. Evert *et al*. (1969) cited by Health *et al*. (1995) was the first to demonstrate association between sheep ked (*M. ovinus*) and cockle. Asp and Tauni (1988), Bayou *et al*., (1998), Ermias (2000) and Tefera (2004) reported association of cockle with the existence of *D. ovis* and *M. ovinus* infestations in sheep. Bayou *et al*., (1998), Numery (2001) and Tefera (2004) also demonstrated the association of cockle with sarcoptic mange in goats. In control groups of sheep pelt in which no ectoparasite was found, cockle was detected at pickled stage on 20 % of the skins. Pfeffer *et al.* (1996) explained this fact as cockle can occur in response to a low number of lice and such light infestation can be missed during examination of the skin. In addition if the animals were treated before slaughter it is possible that the lice could disappear before the cockle lesion had recovered which is expected to persist up to 20 weeks after removal of the lice (Health *et al*., 1996).

Failure of development of cockle in three of the pelts infested with *M. ovinus* may be attributed to the duration of infestation and number of *M. ovinus* required to initiate development of cockle (‘ekek’) on the animal. A relationship between the severity and extent of cockle on pickled skin and a number of ectoparasites present was suggested by Health *et al*., (1995b).

Accordingly, the study on severity of ectoparasites in each group (light, moderate and severe) and severity of cockle (clean, light, moderate and severe) (Table 12) indicated a strong correlation in *D. ovis* and *M. ovinus* infested ($P<0.001$) sheep pelt group and sarcoptic mange infested goat pelt group ($P<0.001$). In support of this finding Health *et al*., (1996), Sertse *et al*., (2006b) observed positive correlation of cockle severity with the count of lice and ked and size and number of affected lesions by mange, respectively.

Examination of pickled sheep and wet blue goat skins showed scratches, cockle, scars and technical defects due to flaying, preservation, handling and processing of skins to be the major defects responsible for skin downgrading and rejections (Annex 13). In this study scratch was found to be the most prevalent defect followed by cockle on pickled sheep and wet blue goat skins. Scratches are caused mostly as a result of poor management of the animals since most of them are kept under extensive management system where thorny bushes and/or weeds abound (Kassa, 2006). Similar observation was obtained during the questionnaire survey where all respondents reported that small ruminants are managed mixed with other species of animals on whatever available area for grazing.

Cockle (‘ekek’) as a single defect and together with other defects, was responsible for 35 % of the pickled sheep and 21.5 % of the wet blue goat skins downgrading and rejection. In Sheba tannery, selectors do not include larger round nodular lesions which were actually due to demodectic mange observed in goat pelts as cockle (‘ekek’) defect. The main reason for this was the fact that selectors were considering lesions of demodectic mange as pox defects. After tanning demodectic mange lesions appear as round nodular cheesy mass which on further processing disappear leaving empty pockets that produce pit and scar on grain surface (FAO, 1995; Kassa, 2006). In cockle affected skins, the most commonly affected parts were the rump, neck, shoulder, sides and belly. The present finding with regard to cockle (‘ekek’) prevalence 35 % in sheep and 21.5 % in goats was much closer to the observation of Asp and Tauni (1988) in which 30 % of pickled skin in Awash tannery were positive for cockle.

However, the present cockle (‘ekek’) prevalence was much lower than recent reports by (Ermias, 2000) at Sebeta tannery (88.5 %) in pickled sheep skin and (Sertse *et al*., 2006b) at Dessie and Komolcha tanneries 70.8 % in pickled sheep and 42.3 % in wet blue goat skins. This difference in prevalence of cockle in pickled skins in the study area may be due to the treatment intervention conducted in the region for the past three years.

Statistical analysis of 1000 pickled sheep and 1000 wet blue goat skins indicated that there was a statistically significant association ($P<0.001$) between cockle (‘ekek’) and scratch both on pickled sheep and wet blue goat skins (Table 14). Asp and Tauni (1980) and Ermias (2000) had also a similar observation on pickled sheep and Tefera (2004) on both pickled sheep and wet blue goat skins, respectively.

This association could be attributed to the itching and rubbing of sheep and goats infested by lice, ked and mange mites against bushes, thorns, posts and barbed wires (Asp and Tauni, 1988; Urquhart *et al*.,1996; Wall and Shearer, 1997) causing scratches on their skin. Similarly, statistically significant association ($P<0.001$) was also found between cockle (‘ekek’) and scar on pickled sheep and wet blue goat skins (Table 14). This could be probably due to the development of secondary bacterial complication at sites where ectoparasites feed, causing lesions which up on healing leaves scars (Asp and Tauni, 1988; Radostitis *et al*., 1994). In this study it was observed that the proportion of pickled skins with cockle defect were much higher in lower grades (grade 4, grade 5, grade 6 and rejects) compared with the first three best grades (Table 13). Infestation of sheep with *D. ovis* and *M. ovinus* and goats with sarcoptic mange leads to development of cockle responsible to cause higher proportion of skins to fall in to lower grades (Table 13). In agreement with this finding Health *et al*., (1996) has also demonstrated association of *D. ovis* infestation of sheep with downgrading of skins, Asp and Tauni (1988) and Ermias (2000) have also reported increase in intensity of cockle (‘ekek’) at lower grades. Further more, Sertse *et al*., (2006b) have demonstrated association of *D. ovis* and *M. ovinus* infestation of sheep and infestation of goats with sarcoptic mange with downgrading of pickled skins.

The impact of cockle (‘ekek’) on the tanning industry is thoughtful. This is mainly due to the fact that ‘cockle’ lesion can not be detected at the raw skin and selection can not be made prior to processing. The defect appears only after processing the skin into pickled stage. Therefore, the tanning industry loses three times with regard to each cockle affected skins; first through the purchase of raw skins 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 not suitable for sale in the more profitable price of export markets (FAO, 1998; Kassa, 2006).

The different tanning costs in European tanneries are estimated to be 50-65 % for raw materials, 20 % for overhead, 12-15 % for labor, 10 % for chemicals and 3 % for energy costs (Hadly, 2001). In Ethiopia, since labor cost is cheaper than the European industries; the proportion of raw material cost, overhead cost, energy and chemical costs are estimated to exceed the above figures. The economic impact of cockle (‘ekek’) in Sheba tannery (Wukro) due to exported pickled sheep and wet blue goat skins quality deterioration and rejection excluding the chemical, labor, overhead and energy costs was estimated to be 778,199.41 USD for pickled sheep and 247,677.61 USD for wet blue goat skins.

6. CONCULUSION AND RECOMMENDATIONS

Ethiopia has a large small ruminant population characterized by different sheep and goat types that are adapted to different agro climate and environmental conditions. However, the contribution of these animals to the national export income and food production is far below the existing potential. Ectoparasites are among the major causes of sheep and goat production constraints and quality deteriorations of exported skin in the country. Even though difference in distribution of different ectoparasites among agro climates was observed, the overall prevalence is generally high resulting in high economic losses through decreased production and productivity, deaths and damages of the skin.

To combat the problem of ectoparasitic diseases of small ruminants a control campaign program have been designed by MoARD in 2005 to be implemented in Tigray, Amhara and Afar regions. But the program was not implemented coordinately by the three regions at the same time. Tigray Regional State started implementing the program alone in 2006 and Amhara and Afar regions started after a year in 2007. In addition to that there was no a coordinated work among these regions especially in bordering areas and districts where livestock movement for different reasons (grazing, watering and marketing) is high. Furthermore, during the treatment program the designed ten days interval between treatments was not fully practical in the study areas which may have favored the parasites to be persistent and endemic. The frequency of treatment was also observed to be minimal than the planned treatment frequency.

The present study disclosed that lice, ked, mites, ticks and fleas to be the major ectoparasites of sheep and goats in selected agro climatic sites of Tigray Regional State. Sheep ked (*M. ovinus*) and lice (*D. ovis*) in sheep and sarcoptic mange in goats were found to be strongly associated with pickled sheep and goat skin defect called cockle (‘ekek’). Ticks mainly infest sites which are trimmed before the tanning process; therefore their importance on skin quality deterioration is minimal. Lice of *Linognathus spp*. were not observed to produce cockle (‘ekek’) on pickled skins, however, a strong association was observed between this parasite and scratches. However, scratches are believed to be dominantly results of poor management of animals.

Scratch along with cockle, scars and technical defects were the major causes of skin downgrading and rejection in Sheba tannery. Cockle was found to be responsible for downgrading and rejection of 35 % of sheep and 21.5 % of the goat pickled skins in Sheba tannery causing high economic loss. Except in clinically mange induced skin lesions, cockle is not observed in the raw skin. Because of this the economic loss due to cockle is not only due to downgrading and rejection but also due to costs of processing affected skins. There are different grading system standards for raw, pickled, and wet blue skins, however, only the pickled skin grading system standards were observed to be used by Sheba tannery for both pickled and wet blue skins. Further more the raw skin grading system was not implemented for all types of skins.

Therefore, based on the above points the following recommendations are forwarded:

- Effective extension system and programs that could raise public awareness on management of animals, effect of ectoparasites and control methods and methods of flaying, preservation and handling of skins should be implemented.
- Treatment guidelines should be developed in accordance with the agro climatic situation of an area, where in the midlands and lowlands mange is a serious problem and natural caves are abundant, effective acaricides should be used and animals should be kept away from the caves to avoid reinfestation by mites.
- There should be adaptation of standard grading system for raw skins by all tanneries. Moreover, training should be given to selectors on the grading system in order to implement pricing by grade system. This will enable to reduce costs of processing of inferior materials and in turn encourages farmers to improve the management and health of their animals and thereby produce quality product.
- Further detailed study on causes of scratches should be conducted in the region, since scratches are the dominant defect problems causing downgrading and rejection of skins.
- Control programs should be designed and implemented with the participation of all stakeholders (farmers, tanners, government and other concerned bodies) and there should be strong coordination between neighboring regions and/or districts with strict follow up and control from MoARD during implementation time.

7. REFERENCES

AAPBMDA (1999): Market Problems and Measures to be Taken, Addis Ababa, Ethiopia, Pp. 19.

Amsalu, D.; Bewket, S.; Kassa, T.; Tefera, S.; Gezahgne, M.; Dagne, M. and Shihun, S. (2000): Mange: A disease of growing threat for the production of small ruminants in Amhara Regional State. In: Proceedings of the Opportunities and Challenges of Goat Production in East Africa, November 10-12, 2000 at Debub University, Awassa, Ethiopia, Pp. 80-91.

Asegedech, S. (1999): Pathology of sheep and goat skins affected by ectoparasites and control of sheep and goat skin diseases for improved quality of hides and skins (phase II). In: Proceedings of an In-service Training Exercise on Hides and Skins Improvement, February 9-12, 1999, Addis Ababa, Ethiopia, Pp. 28.

Asp, J. and Tauni, M. (1988): Skin Diseases on Ethiopian Sheep and their Effect on the Pickled Skin, A Minor Field Study, Sweden University of Agricultural Sciences, Uppsala, Pp. 27.

Ayele, S.; Assegid, W.; Jabbar, M. A.; Ahmed, M. M. and Belachew, H. (2003): Livestock Marketing in Ethiopia, A Review of Structure, Performance and Development Initiatives, Working Paper No. **52**, Addis Ababa, Ethiopia, Pp. 1-14.

Bayou, K. (1998): Control of sheep and goat skin diseases. By Ian, B.C. and Kassa B. (eds.). In: Proceedings of Control of Sheep and Goat Skin Diseases for Improved Quality of Hides and Skins, February13-14, 1998, FAO, Addis Ababa, Ethiopia, Pp. 13-15.

Blood, D. C.; Radostitis, D. M. and Henderson, J. A. (1983): Veterinary Medicine, A Text Book of the Disease of Cattle, Sheep, Pigs, Goats and Horses, Sixth Edition, Bailleire Tindall, London, Pp. 963-963.

Bowman, D. D.; Lynn, C. R.; Eberhard, L. M. and Alcaraz, A. (2003): Georgis' Parasitology for Veterinarians, Eighth Edition, W.B. Saunders Company, USA, Pp. 1-78.

Chalachew, N. (2001): Study on Skin Diseases of Cattle, Sheep and Goats in and Around Wolayta Sodo, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Chauhan, R. S. and Agarwal, D. K. (2006): Text Book of Veterinary Clinical And Laboratory Diagnosis, Second Edition, Jaypee Brothers Medical Publishers Ltd., New Delhi, India, Pp. 189-192.

Coles, H. E. (1996): Veterinary Clinical Pathology, Fourth Edition, W. B. Saunders Company, Philadelphia, Pp. 391-403.

CSA (2006): Ethiopian Agricultural Sample Enumeration, 2004/2005, Statistical Report on Livestock Population, Part 4, Addis Ababa, Ethiopia.

EARO (2000): A Kid Looking after a Kid -Our loved ones, Next Generations! What do they need! EARO, Addis Ababa, Ethiopia, Pp. 63.

Ermias, Y. (2000): A Study on Ectoparasites of Fresh Sheep Pelts and Assessment of Pickled Skin Defects Processed at Sebeta Tannery, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Everet, A. L.; Robert, I. H.; Willard, H. J.; Apodaca, S. A.; Bitcover, E. H. and Naghski, J. (1969): The cause of cockle , a second sheep skin defect identified by infesting a test flock with ked (*M. ovinus*), *J. Am. Leath. Chem. Assoc*., **64**: 460-476.

FAO (1995): Flaying and Curing of Hide and Skins as a Rural Industry, FAO, Agricultural Development Paper No. **49**, Rome, Italy, Pp. 134.

FAO (1998): Control of sheep and goat skin diseases for improved hide and skins (phase II). In: Proceedings on Hide and Skin Improvement, Ian, B. C. and Kassa B. (eds.), Febroary13-14, 1998, FAO, Addis Ababa, Ethiopia, Pp.12-15.

Foreyt, W. J. (2001): Veterinary Parasitology, Reference Manual, Fifth Edition, Iowa State University Press, Blackwell Publishing, USA, Pp. 69-71.

Gashaw, T. (1986): Preliminary Survey of Mange Mites in Black Ogaden Sheep, Goats and Pigs in Harrarghe Administrative Region, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Gatenby, M. R. (1991): Sheep. Coste, R. and Smith, J. A. (eds.), the Tropical Agriculturalist, Macmillan (London) and CTA (Wageningen), Pp. 6-11.

Getachew, T. (1995): Parasites of small ruminants. In: Gray, G.D. and Vilenberg, G. (eds.), *Parasitological Research in Africa*, **52**: 198-232.

Gryseels, G. and Anderson, F. M. (1983): Studies on Traditional Agricultural Systems, Initial Result, 1977-1980. Research on Farm and Livestock Productivity in Central Ethiopian Highlands, ILCA, Addis Ababa, Ethiopia, Pp. 7-22.

Gulilat, A. (1087): Survey of Ticks on Domestic Animals in Hararghe Administrative Region, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Habte, G. (1994): The Prevalence of Mange Mite Infestations in Camel, Cattle and Sheep in and around Mekelle, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Hadly, P. (2001): Improved hide and skin quality through ectoparasites control. In: Proceedings of Technical Workshop on Good Practice for Ethiopian Hides and Skin Industry, December 4-7, 2001, Addis Ababa, Ethiopia, Pp. 5-7.

Haffeze, M. (2001): Study on Skin Diseases of Small Ruminants in Central Ethiopia, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Health, A. C. G.; Cole, D. J. W.; Bishop, D. M.; Pfeffer, A.; Cooper, S. M. and Risdon, P. (1995a): Preliminary investigations in to the etiology and treatment of cockle, a sheep pelt defect, *Veterinary Parasitology*, **56**: 239-254.

Health, A. C. G.; Cooper, S. M.; Cole, D. J. W. and Bishop, D. M. (1995b): Evidence for the role of sheep biting lice (*Damalinia ovis*) in producing cockle, a sheep pelt defect, *Veterinary Parasitology*, **59**: 53-58.

Health, A. C. G.; Bishop, D. M.; Cole, D. J. and Pfeffer, A. (1996): The development of cockle, a sheep pelt defect in relation to *Damalinia ovis*, the sheep biting louse, *Veterinary Parasitology*, **67**: 259-267.

Hopla, C. E.; Dureden, L. A. and Keirans, J. K. (1994): Ectoparasites and Classification, *Rev. Sci. Tech. Off. Int. Epiz*., **13:** 985-1012.

Jackson, P. (1991): Skin Diseases in Goats. In: Boden, E. (ed.) Sheep and Goats Practice, Bailliere Tindall, Pp. 34-67.

Jubb, K. Y.; Kennedy, P. C. and Palmer, N. (1993): Pathology of Domestic Animals, Fourth Edition, Academic Press Inc., Pp.112-198.

Kassa, B. (2005): Pre-slaughter defects of hides/skins and intervention options in East Africa: Harnessing the leather industry to benefit the poor. In: Proceedings of the Regional Workshop, April 18-20, 2005, Addis Ababa, Ethiopia, Pp. 71-82.

Kassa, B. (2006): Cockle, mange and pox: Major threats to the leather industry in Ethiopia. Ethiopian leather industry: Perseverance towards value addition. In: Proceedings of the National Workshop, December 14-15, 2006, Addis Ababa, Ethiopia, Pp. 71-92.

Kassa, B. (2007): Skin Diseases of Ruminant Livestock, Training Manual for the Control of Skin Diseases of Ruminant Livestock in Ethiopia, Addis Ababa, Pp. 1-22.

Kaufmann, J. (1996): Parasitic Infections of Domestic Animals, a Diagnostic Manual, Birkhauser, Germany, Pp. 188-201.

Kedir, M. (2002): Study on Mange Mite Infestations in Small Ruminants and Camel in two Selected agro climatic sites of Tigray, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Kettle, D. S. (1984): Medical and Veterinary Entomology, Mackeys of Chatham Ltd., UK. Pp. 132-135.

Kidanu, C. (2001): Hide and skin defects, nature and effect on the industry. In: Proceedings of the Technical Workshop on Good Practices for the Ethiopian Hides and Skins Industry, December 4-7, 2001, Addis Ababa, Ethiopia, Pp. 1-7.

Kimberling, C. V. (1998): Jensen and Swifts Disease of sheep, Third Edition Lea and Febiger, Philadelphia, Pp. 285-315.

Lehman, T. (1993): Ectoparasites, direct impact on host fitness, *Parasitology Today*, **9**: 8-13.

Mahmud, M. (2000): Raw hides and skin improvement in Ethiopia status and challenges. In: Proceedings of the Opportunities and Challenges of Goat Production in East Africa, a Conference Held November 10-12, 2000 at Debub University, Awassa, Ethiopia.

MEDaC (1998): Survey of Livestock and Fisheries Development, MEDaC Agricultural Development Department, Livestock Team, Addis Ababa, Ethiopia Pp. 64-65.

Mekonen, K.; Gizaw, S. and Desta, L. (1999): Yeku Integrated Water Shade Development Project Feasibility Study Report, Bureau of Agriculture, Amhara Regional State.

MoARD (2005): Mange, Lice and Sheep Ked control project in Amhara, Tigray and Afar regions, MoARD Animal Health Department, Addis Ababa.

MoARD (2008): The Effect of Hide and Skin Quality on Domestic and Export Markets and Evaluation of the Campaign against Ectoparasites of Sheep and Goats in Amhara, Tigray and Afar Regions, Official Report to Regions and other Sectors, Addis Ababa, Ethiopia.

Molu, N. (2001): Epidemiological Study on Skin Diseases of Small Ruminants in the Southern Range Land of Oromia, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Morcombe, P. W.; Young, G. E.; Ball, M. D. and Dunlop, R. H. (1996): The detection of lice (*Damalinia ovis*) in mobs of sheep: A comparison of fleece parting, the lamp test and table lock tests. *Aust. Vet. J*., **73**: 170-173.

Nigatu, K. (1992): Preliminary Survey of Mange of Sheep and Cattle in and Around Addis Ababa, DVM thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Noble, R. E. and Noble, A. G. (1982): Parasitology, the Biology of Animal Parasites, Fifth Edition, Lea and Febiger, USA, Pp. 323-370.

Numery, A. (2001): Prevalence and Effects of Ectoparasites in Goats and Fresh Pelts and Assessment of Wet Blue Skin Defects at Komoblcha Tannery, South Wollo, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

OIE (2002): Mange. In: Manual of Standards Diagnsotic Test and Vaccines, Oie @oie. Int.

Okello-onen, J.; Hassan, S. M. and Essuman, S. (1999): Taxonomy of African Ticks, An Identification Manual, ICIPE Science Press, Nirobi, Pp. 124-125.

Okoh, A. E. J. and Gandame, J. N. (1992): Sarcoptic mange of sheep in Plateu State, Nigeria, *Bull, Anim. Hlth. Prod. Afri*., **30**: 61-63.

Olubunmi, P. A. (1995): The prevalence of mange due to *Sarcoptes scabiei Var Capri* in Ile-Ife area of Nigeria, its control and management, *Bull. Anim. Hlth. Prod. Afr*., **43**: 115-119.

Pangui, L. J. (1994): Mange in domestic animals and methods of control, *Rev. Sci. Tech. Off. Int. Epiz*, **13:** 1227-1243.

Pearse, H. G. B. and Gardner, J. A. (1994): Probability of correctly identifying a lice affected flock of sheep using visual inspection (fleece parting), *Wool tech. sheep Breed*, **42**: 144-149.

Peter, G. (1995): Parasites and Skin Diseases, J. A. Allen and Company Limited, London, Pp. 212-256.

Pfeffer, A.; Cole, D. J. W.; Bishop, D. M.; Health, A. C. G. and Phagan, M. D. (1996): Detection of *Dermatophilus* and lice (*D. ovis*) on flayed pelts and cockle on the skin of live lambs, *New Zealand Veterinary Journal*, **44**: 121-125.

QSAE (2001): Leather: Wet Blue Chrome Tanned Skin General Requirements (ES 206: 2001).

QSAE (2001): Raw Hides and Skins: Grading of Sheep and Goatskins by Appearance and Mass (ES 39:2001).

QSAE (2001): Raw Hides and Skins: Terminology Relating to Defects (ES 32: 2001).

Radostitis, O. M.; Blood, D. C. and Gay, C. C. (1994): Veterinary Medicine, Text Book of Cattle, Sheep, Pigs, Goats and Horses, Eighth Edition, Bailliere Tindall, UK, Pp. 1280-1308.

Roberts, I. H.; Blachut, K. and Meleney, W. P. (1971): Over summering location of scab mite, *Psoroptes ovis*, on Sheep in New Mexico, *Annals of Entomological Society of America*, **6**: 105-108.

Sewell, M. M. H. and Brockesby, D. W. (1990): Hand Book on Animal Disease in the Tropics, Fourth Edition, Bailliere Tindall, Pp. 2-28.

Sheba Tannery (2005): A Report to Tigray Regional State Government Regarding Quality Deterioration of Hides and Skins in the Region due to External Parasites, 25 March, 2005.

Sertse, T. and Wossene, A. (2006a): A Study on ectoparasites of sheep and goats in eastern part of Amhara Regional State, north east Ethiopia, *Small ruminant Research, Elsevier B.V., Rumin*, **3042**: 1-6.

Sertse, T. and Wossene, A. (2006b): Effect of ectoparasites on quality of pickled skins and their impact on the tanning industries in Amhara Regional State, Ethiopia, *Small ruminant Research, Elsevier B.V., Rumin*, **3041**: 1-7.

Shenkutie, A. (1987): Survey and Treatment Trial of Mange Mites in Sheep and Cattle of Robe Area, Bale Administrative Region, DVM Thesis, FVM, Addis Ababa University.

Smith, M. C. and Sherman, D. M. (1994): Goat Medicine, Williams and Wilkins, Maryland, Pp. 17-47.

Soulsby, E. J. L. (1982): Helminthes, Arthropods and Protozoa of Domesticated Animals, Seventh Editon, Lea and Febiger, Philadelphia, Pp. 375-502.

Steele, M. (1996): Goats. Coste, R. and Smith, J. A. (eds.), the Tropical Agriculturalist, Macmillan (London) and CTA (Wageningen), Pp. 79-80.

TBoARD (2006): Livestock Development Project of Tigray Regional State, Mekelle, Ethiopia.

TBoARD (2007): Map of Tigray Regional State in Relation to Agricultural Development Strategies.

Tefera, S. (2004): Investigation on Ectoparasites of Small Ruminants in Selected Sites of Amhara Regional State and their Impact on the Tanning Industry, MSc Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Teshome, W. (2002): Study on Small Ruminants Skin Disease in Sidama Zone, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Thortensen, J.C. (1993): Practical Leather Technology, Kreiger Publishing Company, Malabar (Florida), USA, Pp. 84-115.

Thrusfield, M. (2005): Veterinary Epidemiology, Third Edition, Blackwell Science Ltd., UK, Pp. 229-245.

Urquhart, G.M.; Armour, J.; Duncan, J. L.; Dunn, A. M. and Jennings, F. W. (1996): Veterinary Parasitology, Second Edition, Blackwell Science Ltd., UK, Pp. 141-205.

Wall, R. and Shearer, D. (1997): Veterinary Entomology, First Edition, Chapman and Hall, UK, Pp. 1-438.

Wallaga, D. (1997): Survey of Ticks and Tick-borne Diseases in eight Domestic animals in and around Debre Zeit, Eastern Shoa, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Wondwossen, A. (1997): Country repot: Ethiopia. In: Proceedings of a Seminar on Livestock Development Policies in Eastern and Southern Africa, July 28 – August 1, 1997, Mbabany, Organized by CTA, OAU/IBR and the Ministry of Agriculture and Cooperative, Swaziland.

Yallew, T. (2007): Study on Prevalence of Ectoparasites of small ruminants in and around Wolayta Sodo, Southern Ethiopia, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

Zelalem, T. (1994): Survey on Mange Mite and Ticks of Camel and Small Ruminants in Dire Dawa Region, DVM Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

8. ANNEXES

Annex 1: Definitions and synonyms (QSAE, 2001)

Alopecia: spontaneous hair loss occurs more often in crossbreeds, mainly at the end of winter. Shearing at inappropriate time is thought to increase the risk of hair loss. Nutritional deficiencies or imbalances (such as high calcium with low zinc) have also been incriminated. Partial alopecia (hypotrichosis) is a non specific secondary lesion.

Bad bleeding: is a defect due to small cutaneous vessels that appear as slightly depressed lines on the grain side of the skin because of improper bleeding.

Brand marks: are man made marks on animals' skin or hide, generally used for ownership identification, and made by means of hot iron.

Butt: is that part of the skin or hide covering the rump or hind part of animal (it is that part of a skin or hide left after the bellies and shoulders have been removed)

Cockle/ "Ekek": is allergic dermatitis which causes itching, observable only after removal of the hair or wool and is characterized by multiple small circular lesions on the grain side of the skin.

Flaying (Syn. Skinning): is the removal of the skin from the animal

Flay damages: are defects caused by flaying knife.

Fleece: is sheep's wooly coat

Erythema (Reddening): it occurs in many acute disease conditions and is not diagnostic.

Grain: is the surface of the unhaired pelt or leather

Grain damage: is any damage to the grain side of a skin or hide, whatever its origin may be.

Heat defect: is a defect that occurs due to a high temperature during curing on the grain side of processed skins

Hide: is the raw skin of a mature or fully grown animal of the larger kinds, e.g. Cattle, horse and whale.

Leather: is the skin or hide of animal prepared by tanning, which still retains its original fibrous structure more or less intact, but from which hair or wool may or may not have been removed and has been treated so as to be imputrescible even after treatment.

Liming: is the soaking of skins and hides in milk or lime for a few days in order to loosen hair, and to plump and swell the skin.

Old age defects: is a grain defect which appears as a dark discoloration along the back bone.

Papule: are a circumscribed solid mass less than 1cm in diameter that is usually elevated and erythematous. Follicular papules suggest bacterial, fungal or parasitic infections, whereas papules without a hair follicle at the center are typical of allergy and ectoparasites.

Pelt: is the skin of slaughtered animal the hair or fur still on it.

Pickling: is the treatment of scudded and bated skins or hides with a solution of salt and acid, such as sulfuric, formic hydrochloric, etc. to preserve them or as preservation for tanning operation.

Pruritus (itching): frequently leads to excoriations and other secondary lesions. If pruritus is severe, special consideration is given to the possibility of sarcoptic or chorioptic mange. Other conditions that may be pruritic include lice, zinc deficiency and photosensitization.

Putrefaction (rottenness): is the fermentation of comparatively big quantities of skin or hide proteins, usually by anaerobic bacteria producing foul smelling gases.

Scales and crusts: scales (squames, flakes) are loose fragment of stratum corneaum. Admixture with sebaceous and apocrine secretions makes the scales yellowish, greasy and adherent. Crusts are solid adherent combinations of materials such as serum, blood, pus, keratin, micro organisms and medications. They indicate that exudation has occurred and thus are nonspecific.

Scars (Disease scars): are circumscribed white spots, slightly ticker than the surrounding leather. They are often in a group and impossible to tell the origin of these scars as the healing phase of many lesions look similar.

Scratches: are elongated scars of different sizes. They are the results of the healing of any wound in the skin with that elongated shape.

Skin: is the outer covering of mature fully grown animals of the smaller kinds such as sheep, goats, pigs, reptiles, birds and fishes, or of the immature animals of the larger species such as calves and colts in raw and/or untanned form.

Tanning: is the treatment of putrescible hides and skins with tanning agents (tannins) so as to convert the former into imputrescible leather.

Tick marks: are defects on the grain of a skin or hide caused by the ectoparasite ticks (in some cases the marks become so deep that it shows on the flesh side).

Vesicles and pustules: a vesicle is a papule shaped fluctuant elevation containing serum. They are transient and suggest autoimmune irritant or viral etiologies. A pustule is pus filled vesicle and indicate infection, if follicular in orientation but may be autoimmune if non follicular. Demodecosis is a common follicular lesion in goat.

Annex 2. Questionnaire used to evaluate the impact of ectoparasites on small ruminants.

Date _____ Zone _____District _____

PA/Tabia _____ Village/Kushet_____

Owner name _____

1. Family income source (Rank)

Crop sale ☐ Animal product sale ☐

Animal sale ☐ others ☐

2. Livestock ownership pattern (number of animals owned)

Sheep_____ Camel _____

Goats_____ Equines_____

Cattle_____ Poultry_____

Beehives_____

3. Why do you keep sheep and goats? (Rank)

For income generational and insurance ☐

Meat for home ☐ Milk for consumption ☐

Wool production ☐ Skin production ☐

Others ☐

4. Management type

Mixed farming ☐ Livestock production ☐

Semi-pastoral ☐

5. Which species are more important for this area?

Sheep ☐ Goats ☐ Equally ☐

6. How do you manage sheep and goats?

Mixed with other species of animals ☐ separately ☐

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

Yes ☐ No ☐

8. If yes, can you mention them?

_____

_____

9. Which species are more commonly affected?

Disease	Sheep	Goats	Equally
Lice	☐	☐	☐
Ticks	☐	☐	☐
Keds	☐	☐	☐
Mange mite	☐	☐	☐
Dermatophilosis	☐	☐	☐
Others	☐	☐	☐

10. Which age groups are more affected?

	Sheep			Goats		
Disease	Lamb	Young	Adult	Kid	Young	Adult
Lice	☐	☐	☐	☐	☐	☐
Ticks	☐	☐	☐	☐	☐	☐
Keds	☐	☐	☐	☐	☐	☐
Mange mites	☐	☐	☐	☐	☐	☐
Dermatophilosis	☐	☐	☐	☐	☐	☐
Others	☐	☐	☐	☐	☐	☐

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

Diseases	Sheep	Goats	I do not know
Lice	☐	☐	☐
Ticks	☐	☐	☐
Keds	☐	☐	☐
Mange mite	☐	☐	☐
Dermatophilosis	☐	☐	☐
Others	☐	☐	☐

12. If yes in what season the disease is mostly encountered:

Lice _____

Ticks _____

Keds _____

Mange mite _____

Dermatophilosis _____

13. Which skin diseases have effect on sell of sheep and goats?

Disease	Yes	No
Lice	☐	☐
Ticks	☐	☐
Keds	☐	☐
Mange mite	☐	☐
Dermatophilosis	☐	☐
Others	☐	☐

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

Disease	Yes	No
Lice	☐	☐
Ticks	☐	☐
Keds	☐	☐
Mange mite	☐	☐
Dermatophilosis	☐	☐
Others	☐	☐

15. How do you treat skin diseases animals? Modern treatment ☐ Traditional treatment ☐

16. Which skin diseases are treated traditionally?

Disease	Yes	No
Lice	☐	☐
Ticks	☐	☐
Keds	☐	☐
Mange mite	☐	☐
Dermatophilosis	☐	☐

17. What is the name of traditional remedy used?

And its effect (recovery/partial recovery)

_____

_____

18. Are there other control methods other than treatment? If yes please mention it

_____

_____

19. Have you treated your animals (Sheep and Goat) during the campaign launched by the government against ectoparasites

Yes ☐ No ☐

20. If yes, how many times have you treated your animals and why?

_____

_____

21. Which option of treatment was applied?

Spraying ☐

Dipping ☐

22. How do you evaluate the result of the treatment?

Very good ☐

Good ☐

No change ☐

I don't know ☐

23. Is there any problem of skin diseases on your animals after treatment?

Yes ☐ No ☐

24. If yes, which disease and why?

_____

_____

_____

Thank you for co-operation

Annex 3: Goats' age determination depending on teeth.

Category	Age	Teeth
Kid	Under 1 year	Eight sharp incisors
Yearling	1-2 years	Central part of baby teeth replaced by permanent ones
Young adult	2-3 years	4 permanent teeth
Adult	3-4 years	6 permanent teeth
Adult	4-5 years	8 permanent teeth
Older adult	Over 5 years	Worn teeth and some missing

Source: Steele (1996).

Annex 4: Age determination of sheep depending on teeth.

Permanent incisors	Age of sheep
None	Less than 1 year and three months
One pair	1 year three months to one year 10 months
Two pairs	1 year 10 months to 2 years 4 months
Four pairs	More than three years

Source: Gatenby, M. R. (1991).

Annex 5. Frequency distribution of ectoparasites on sheep and goats by sex.

Type of ectoparasite	sheep		Goat	
	Male n=211	Female n=539	Male n=190	Female n=560
M. ovinus	49	94	0	0
D. ovis	38	77	0	0
D. caprae	0	0	8	12
Linognathus spp	23	63	51	158
Ctenocephalides spp	20	48	28	55
Sarcoptic mange	3	7	29	65
Demodectic mange	0	0	16	35
Tick infestation	26	94	54	169
Overall	124	290	122	313

Annex 6. 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 7: 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 8: Grading of pickled skins by size.

Skin origin	Size	Size in dm^2	Code
Lamb		Up to 20	00
		20 to 40	01
Sheep, Goats	Small	20 to 40	00
	Medium	40 to 65	01
	Large	65 to 90	02

Source: QSAE (2001) ES 39: 2001

Annex 9: 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
Grades 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 10: 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: Sheba tannery P.L.C. (2008) Personal communication.

Annex 11: Summary of questionnaire survey

Questions forwarded to respondents on various focal points	Number of respondents by agro climate		
	Highland	Midland	Lowland
1. Source of income rank			
Crop sale			
1	13	0	12
2	12	5	13
3	0	20	0
Animal sale			
1	12	20	13
2	13	5	12
3	0	0	0
Animal product sale			
1	0	0	0
2	0	0	0
3	24	2	23
Others			
1	0	5	1
2	0	15	0
3	1	5	1
4	0	0	0
2. Livestock owner ship pattern			
Sheep and goat			
No	0	0	0
1-5	3	10	4
5-10	7	13	10
>10	15	2	11
Cattle			
No	0	15	0
1-5	16	10	17
5-10	4	0	6
>10	5	0	2
Equine			
No	3	6	3
1-5	22	19	22
5-10	0	0	0
>10	0	0	0
poultry			
No	0	0	0
1-5	8	9	10
5-10	7	11	7
>10	10	5	8

Questions forwarded to respondents on various focal points	Number of respondents by agro climate		
	Highland	Midland	Lowland
camel			
No	25	25	25
1-5	0	0	0
5-10	0	0	0
>10	0	0	0
3. Reason for keeping sheep and goat			
Income and insurance			
No	0	0	0
1	25	25	23
2	0	0	2
3	0	0	0
Meat for home			
No consumption	0	0	0
1	0	2	3
2	5	8	2
3	20	15	20
Milk for home			
No	0	0	0
1	0	0	0
2	24	25	23
3	1	0	2
Skin production			
No	0	0	0
1	7	0	0
2	8	0	0
3	0	0	0
4	10	15	15
Others (manure)			
No	0	0	0
1	0	0	0
2	5	0	7
3	20	15	18
4. More important species in the area			
Sheep	23	5	6
Goat	0	16	10
Equal	2	4	9

Questions forwarded to respondents on various focal points	Number of respondents by agro climate		
	Highland	Midland	Lowland
5. Small ruminant management system			
Mixed with other species	25	25	25
separately	0	0	0
6. Knowledge of skin disease on small ruminants			
Yes	25	25	25
No	0	0	0
7. Type of skin diseases known			
Mange	15	25	25
Sheep ked	25	5	0
Lice	25	25	25
Tick	25	25	25
Others	6	8	7
8. More commonly affected species			
lice			
Sheep	10	9	8
Goat	11	11	10
Equally	4	5	7
Sheep ked			
Sheep	25	5	4
Goat	0	0	19
Equally	0	0	2
mange			
Sheep	0	5	4
Goat	25	20	19
Equally	0	0	2
Ticks			
Sheep	3	7	10
Goat	16	10	8
Equally	6	8	7
9. More commonly affected age groups			
Mange			
Lamb / kid	0	0	0
Young	0	2	0
Adult	18	17	23
All	7	6	2

Questions forwarded to respondents on various focal points	Number of respondents by agro climate		
	Highland	Midland	Lowland
Lice			
Dry	15	16	10
Rainy	0	0	0
Cold	7	5	0
Ticks			
Dry	23	0	19
Rainy	0	0	0
Cold	0	0	0
12. Effect of skin disease on sell of sheep and goats			
Mange			
Yes	25	25	25
No	0	0	0
Keds			
Yes	5	0	0
No	20	0	0
Lice			
Yes	2	0	3
No	23	25	22
Ticks			
Yes	0	0	0
No	25	25	25
13. Effect of skin disease on sell of skin			
Mange			
Yes	21	23	20
No	4	2	5
Keds			
Yes	0	0	0
No	25	0	0
Lice			
Yes	0	0	0
No	25	25	25
Ticks			
Yes	0	0	0
No	25	25	25
14. Methods used to treat ectoparasite			
Modern	20	19	21
Traditional	0	3	2
None	5	3	2

.

Questions forwarded to respondents on various focal points	Number of respondents by agro climate		
	Highland	Midland	Lowland
15. Control methods other than treatment			
Flock segregation	0	0	0
Culling	0	2	0
Changing of palaces	0	0	0
None	25	23	22
16. Participation in treatment of sheep and goats			
Yes	20	22	23
No	5	3	2
17. Options used to treat sheep and goat			
Dipping	11	8	13
Spraying	9	14	10
None	5	3	2
18. Result of the treatment			
Very good	0	0	0
Good	12	10	15
No change	8	12	23
19. Problem of skin disease after treatment			
Yes	20	22	18
No	0	0	5
20. How many times were treated			
2 times	5	0	0
3 times	10	18	17
4 times	5	4	4
5 times	0	0	2

Annex 12: Grade distribution of ectoparasite affected and control sheep and goat pelts when processed to picked stage in Sheba tannery Tigray Regional State.

Parasite type on raw pelts	Grade distribution of skins at picked stage (no. of skins)						
	1	2	3	4	5	6	rejects
M. ovinus infested sheep pelts	0	0	3	4	21	7	5
D. ovis infested sheep pelts	0	0	3	12	15	7	3
Control sheep pelts	3	5	9	15	3	3	2
Sarcoptic mange infested goats	0	0	0	0	2	5	33
Linognathus infested goats	0	2	4	6	10	15	3
Control goats' pelts	4	6	9	6	9	5	3

Annex 13: Percentage of defects on pickled sheep skins and wet blue goat skins

Defect type	% Pickled sheep skin	% Wet blue goat skin
Scratch	43.4	53.0
Cockled(‘ekek’)	35.0	21.5
Scar	7.0	6.8
Heat	3.8	0
Knife cut	3.4	6.2
Poor substance	2.3	0
Poor bleeding	1.3	0
Machine defect	1.2	1.5
Old age	1.0	2.0
Putrefaction	0.8	1.0
Branding	0.3	1.5
Wart	0.3	0
Beetle damage	0.2	2.5
Crack	0	2.0
Demodectic mange	0	2.0

Annex 14: Severity classification for study on effect of ectoparasites on the quality of skin.

Group	Mean count/lesion distribution	Severity score
D. ovis, Linognathus spp.	0	Free
	1-50	Light
	50-150	Moderate
		Severe (heavy)
M. ovinus	0	Free
	1-10	Light
	10-25	Medium
	>25	Severe(heavy)
Sarcoptic mange	No lesion	free
	Lesion localized at one site	Light
	Lesions localized at two sites	Moderate
	Lesions localized at more than two sites	Severe

Annex 15: Average export price of pickled sheep and wet blue goat skins by size and grade.

Item	Size	Price in USD by grade									
		Grade 1-3		Grade 4		Grade 5		Grade 6		Reject	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Wet	40/50	46	50	36	40	33	41	28	35	12	17
Blue	50/55	49	57	41	48	27	34	24	32	14	20
Goat	60/70	50	62	43	52	30	38	25	34	16	23
skin	70+	59	65	46	54	38	44	37	40	17	25
Pickled	40/50	67	75	43	49	27	35	17	23	12	17
Sheep	50/60	81	89	59	65	36	42	25	36	13	20
skin	60/70	102	112	89	95	46	54	22	30	14	22
	70+	103	105	90	94	55	64	35	42	16	25

Source: Sheba tannery (2007) Personal communication.

CURRICULUM VITAE

Personal Data:

- Name - Mulugeta Yebegaeshet.
- Date of birth – January 20, 1964.
- Place of birth - Adwa, Central Zone, Tigray Regional State.
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- Nationality - Ethiopian.
- Profession - Veterinarian.
- Occupation - Regional Senior Expert in Tigray Regional State.
- Contact Adress- Simonmulu@yahoo.com. Tel. 251-0914730293

Educational background:

Period	Institution	Award
• 1973-1976	Queen Sheba Elementary Adwa	
• 1976-1982	Queen Sheba Secondary school	Certificate
• 1983-1988	Kharkov Zoo-veterinary Institute, Ukraine (former U.S.S.R)	D.V.M. Degree

Work Experience:

Period	Institution
• 1989-1991	MoA, Wadladelanta Awraja, Amhara Regional State, Veterinarian.
• 1991-1994	MoA,Tehuledre District, Amhara Regional State, Field Veterinarian.
• 1994-1997	Southern Zone, Tigray Regional State, Zonal Veterinarian.
• 1997-1999	Southern Zone, Tigray Regional State, Regulatory Team Leader.
• 1999-2008	Tigray Bureau of Agriculture and Rural Development, Regional Veterinarian (Senior Expert).

Project Designing output:

- Raya Valley Development Project, Livestock and Animal health component (1998), Southern Zone, Tigray Regional State.

Special skills:

- Computer skills in MS DOS, MS Words, MS Excel, MS Access And MS power point

Languages:

- Tigrigna: speaking and writing.
- Amharic: speaking and writing.
- English: speaking and writing.
- Russian: speaking and writing.

Research output:

- Mulugeta Yebegaeshet (1988): Prevalence of Bovine Fasciolosis, Treatment and Control Options in and around Adwa, DVM thesis, Zoo-veterinary institute, Kharkov, Ukraine.
- Mulugeta Yebegaeshet (2008): Study on Ectoparasites of Small Ruminants in three Selected agro ecologiccal Sites of Tigray Region and their Impact on the Tanning Industry, MSc Thesis, Faculty of Veterinary Medicine, Addis Ababa University.

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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: _____

Signature: _____

Date of submission: _____

This thesis has been submitted for examination with our approval as academic advisors.

Academic Advisors:

Dr. Yacob Hailu (DVM, MVSc, PhD, Assistant Professor) _____

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