Impact of sheep and goats ectoparasites on the tanning industry in Tigray Region, Ethiopia

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Abstract

A study was carried out to assess the effect of ectoparasites on the quality of processed skin and defects that cause downgrading and rejection of skins in pickled sheep and wet blue goat-skins at Wukro Sheba tannery in Tigray region. A total of 120 sheep and 120 goat pelts with known infestation by ectoparasites and ectoparasite free control pelts were purchased and processed in Sheba tannery and the corresponding skin defects were analyzed. Accordingly, three groups of 40 sheep pelts each (one group infested with *M. ovinus*, one group infested with *Damalina 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 with *Linognathus* spp. and a control group of ectoparasite free goat pelts) were used. Defects observed at pickled stage include cockle, scratch, scar, technical defects due to flaying and old age. A strong association ($P<0.001$) was observed between cockle lesion and infestation of sheep pelts with *D. ovis* and *Mellophagus ovinus* and infestation of goat pelts with sarcoptic mange. Further more, the severity of infestation of sheep pelts with *M. ovinus* and *D. ovis* and infestation of goat pelts with sarcoptic mange were found to correlate significantly ($P<0.001$) with severity of cockle defect. Further investigation on 1000 pickled sheep and 1000 wet blue goat skins revealed that scratch defect was the dominant (43.4 % and 53 %), followed by cockle (35 % and 21.5 %), scar (7 % and 6.8 %) and knife cut (3.4 % and 6.2 %) in pickled sheep and wet blue goat skins, respectively. There was a significant difference ($P<0.001$) in proportion of cockle between pickled sheep and wet blue goat skins. In addition, a strong association ($P<0.001$) was observed between cockle and scratch, and cockle and scars on both pickled skins. The economic loss due to quality deterioration of exported skin in the study tannery was estimated to be 778,199.41 USD for pickled sheep and 247,677.61 USD for wet blue goat skins per annum. The growing threat of ectoparasites to small ruminant production and to the tanning industry needs well coordinated and urgent control intervention.

Keywords: Ectoparasites, Goat, Sheep, Skin defects, Tigray Region, Ethiopia.
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Introduction

The small ruminant population of Ethiopia is about 24 million (CSA, 2012). 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. Furthermore, wool and manure are also important by-products of small ruminant productions (Kassa Bayou, 1998).

The small ruminant population of Tigray Region is estimated to be 1,022,779 sheep and 1,588,779 goats. A skin supply to central market from Tigray Region is estimated to be 1,066,144 sheep and goats skins per annum. The problem of parasitic skin diseases of small ruminants is still active and serious in some parts of Tigray Region 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 (TBoARD, 2006).

Therefore, the objectives of the current study were to assess the effect of ectoparasites on the quality of processed skin of sheep and goats, identify the magnitude and type of skin defects on pickled sheep and wet blue goat skins and to assess the financial impact of ectoparasites of sheep and goats to the Wukro Sheba tannery.

Materials and Methods

Study area and Study material

The study on pickled sheep skin and wet blue goat skin defects was conducted in Wukro Sheba tannery which is located in Wukro town of Tigray Region, about 823 km 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 exports pickled sheep and wet blue goat skins to different Asian and European countries (Wukro Sheba Tannery, 2005).

Pickled sheep skins and wet blue goat skins processed in Wukro Sheba tannery and fresh sheep and goat pelts purchased from the local markets of the study area were used as study subjects.

Study design

Pickled and wet blue skin examination

A 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 Wukro Sheba tannery. The sample size was determined from estimated prevalence of cockle defects 63 % (Kassa Bayu, 2005), accepted error 3 % and level of confidence 95 %. Based on this the minimum sample size for the study was 995 skins from each stage (Thrusfield, 2005).

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.

A total of 120 sheep and 120 goat pelts with known and registered ectoparasite infestations and non infested ectoparasite free control pelts were processed in Wukro Sheba tannery and the corresponding skin defects were analyzed. , Three study 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.

Skin size classification and grading

At the tannery, pelts were processed to pickled stages, sorted by size according to the criteria of quality standard authority of Ethiopia (QSAE, 2001a) and examined in natural light by four senior skin selectors and graded in to seven grade scales according to the criteria of quality standard authority of Ethiopia (QSAE 2001b). The extent and severity of cockle 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 cockle scoring methods (Pfeffer *et al*., Heath *et al*., 1996).

Furthermore, 1000 pickled sheep and 1000 wet blue goat skins that were collected from different areas and processed in the tannery were also further 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 quality standard authority of Ethiopia (QSAE, 2001b).

Data analysis

Descriptive statistics such as percentages and 95 % confidence interval were used to summarize the proportion of defects on pickled and wet blue skins. Chi-square test was computed by using SPSS 11.5 to test association between cockle and scratch, and cockle and scar on pickled sheep and wet blue goat skins. Correlation of the severity of ectoparasite infestation and severity of cockle on pickled skin were made by Pearson correlation using SPSS 11.5 for windows. $P < 0.05$ was considered to be statistically significant.

Results

The prevalence of cockle 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 lesion on sarcoptic mange infested goat pelts was 100 % while none of the *Linognathus* lice infested goat pelts were having cockle lesions at pickled stage. Beside this other defects such as scratches, scars, old age and technical defects due to flaying were observed in each group of pelts (Table 1).

Table 1: Defects observed at pickled stage in ectoparasites infested and apparently free sheep and goat pelts in Wukro Sheba tannery

Defect type	No. of defective sheep skins by group			No. of defective goat skins by group		
d	*M. ovinus*	*D. ovis*	Control	*Sarcoptes*	*Linognathus*	Control
Cockle	37 (92.5 %)	40 (100 %)	8 (20 %)	40 (100 %)	- (0.0)	- (0.0)
Scratch	20 (50 %)	28 (70 %)	8 (20 %)	25 (62.5 %)	37 (92.5 %)	17 (42.5 %)
Scars	23 (57.5 %)	25 (62.5 %)	11 (27.5 %)	18 (45 %)	23 (57.5 %)	16 (40 %)
Technical defects	6 (15 %)	7 (17.5%)	8 (20 %)	6 (15 %)	11 (27.5 %)	11 (27.5 %)
Old age	- (0.0)	2 (5 %)	4 (10 %)	4 (10 %)	2 (5 %)	1 (2.5 %)

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 2) for *M. ovinus* infested sheep pelts group (Pearson= 0.841, P=0.000); for *D. ovis* infested pelt group (Pearson=0.767, P=0.000) and sarcoptic mange infested goat pelt group (Pearson=0.559, P=0.000).

Table 2**:** Correlation of cockle status on pickled skins with type of ectoparasites and their severity in Wukro Sheba tannery.

Type of ectoparasites on raw pelts	Severity	Total No. of pelts	Cockle 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 that the majority number of pickled skins of apparently ectoparasite free sheep and goat pelt groups were graded as best grades (grade 1-3) when compared with those ectoparasite infested groups (Table 3).

Table 3. Grade distribution of ectoparasite affected and control sheep and goat pelts when processed to picked stage in Sheba tannery Tigray Region, North Ethiopia.

Ectoparasite affected and control groups	Grading distribution of pickled skins						
	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

Pickled sheep and wet blue goat skin defects

Analysis of 1000 sheep pelts processed in Sheba tannery to the pickled stage revealed that the presence of different types of skin defects namely scratch (43.4 %) followed by cockle (35 %), scar (7 %) and knife cut (3.4 %). Similarly, out of 1000 goats pelts processed to the wet blue stage in the same tannery showed that scratch accounted for 53 % followed by cockle 21.5 %, scar 6.8 % and knife cut 6.2 % (Table 4). 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.

Table 4: Percentage of defects on pickled sheep skins and wet blue goat skins in Sheba tannery

Defect types	Pickled sheep skin	Wet blue goat skin
Scratch	43.4 %	53.0 %
Cockle	35.0 %	21.5 %
Scar	7.0 %	6.8 %
Heat	3.8 %	0.0
Knife cut	3.4 %	6.2 %
Poor substance	2.3 %	0.0
Poor bleeding	1.3 %	0.0
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 %	0.0
Beetle damage	0.2 %	2.5 %
Crack	0.0	2.0 %
Demodectic mange	0.0	2.0 %

Statistically significant association was observed between cockle and scratch (P=0.000) on pickled sheep skin and between cockle and scratch (P=0.000) on wet blue goat pelts (Table 5).

Table 5: Association of scratch and scar with cockle on pickled sheep and wet blue goat skins in Sheba tannery.

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		

Effect of cockle on grades

Cockle was responsible for 35 % of the pickled sheep skin and 21.5 % of the wet blue goat skin downgrading and rejection in Sheba tannery Tigray Region, North Ethiopia. Grading of the 350 pickled sheep skin and 215 wet blue goat skin revealed that the proportion of skin with cockle was much higher in lower grades than in the top grades (Figure 1).

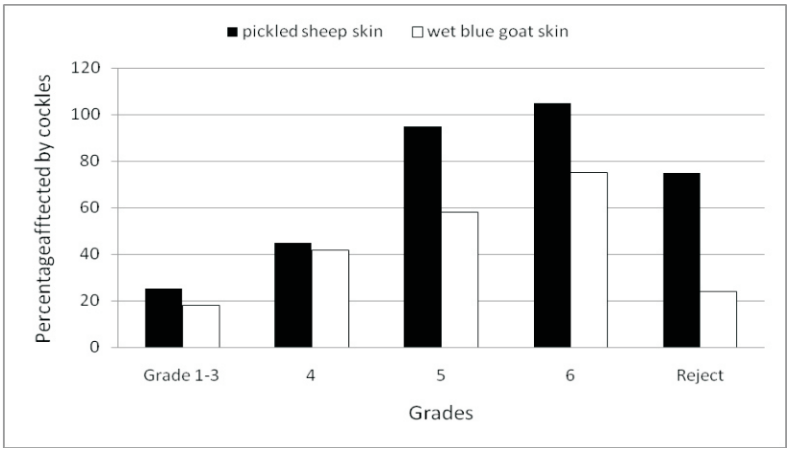

Figure 1: Grading of 350 pickled sheep and 215 wet blue goats' skins affected by cockle in Wukro Sheba tannery Tigray Region, North Ethiopia.

Financial impact of ectoparasites of sheep and goats on the Sheba tannery

In the international market, the price of exported skins is determined both by size and grade quality of the skins. One year (2006/2007) recorded data analysis indicated 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 Wukro Sheba tannery by size and grade and their value were given in Table 6 and Table 7.

Table 6: Financial losses due to cockle on pickled sheep skins in Wukro Sheba tannery

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 loss	-	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 loss	-	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 loss		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 loss		59,262	58,212	42,076.3	752.5	160,302.5
Total losses							778,199.41

Table 7: Financial losses due to cockle on wet blue goat skin in Wukro Sheba tannery Tigray Region, Ethiopia.

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 loss	-	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 loss	-	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 loss	-	10,695.3	11,667.89	8,691.37	5,728.32	31,599.41
Extra	% grades	14.2	18.3	24.3	37.3	5.9	
large	Quality/doz.	1,200	1,550	2,050	3,150	500	
	Value loss		15,135.75	17,400.81	26,446.77	2073.75	61057.08
Total losses							247677.61

The financial 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 (Table 3) 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 %, respectively. Based on the above points the annual financial loss due to cockle in Wukro Sheba tannery was 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 6 and 7). The calculated loss does not include processing and overhead costs in the tannery.

Discussion

The present study indicated that sheep pelts infested with *D. ovis*, *M. ovinus* and the control free groups showed cockle defect at pickled stage. The presence 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 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. This finding is in agreement with similar observations in New Zealand which indicated a positive relationship between *D. ovis* and the pickled defect cockle (Pfeffer *et al*., 1996; Heath *et al*., 1996). Association between sheep ked (*M. ovinus*) and cockle was already established. Similarly, association of cockle with the existence of *D. ovis* and *M. ovinus* infestations was established in sheep (Asp and Tauni, 1988; Kassa Bayu, 1998; Ermias Yisak, 2000; Tefera Sertse, 2004).

On the other hand the association of cockle with sarcoptic mange was demonstrated in goats (Numery Abdulhamid, 2001; Tefera Sertse, 2004). In control groups of sheep pelt in which no ectoparasite was found, cockle was detected at pickled stage on 20 % of the skins. Cockle can occur in response to a low number of lice and such light infestation can be missed during examination of the skin (Pfeffer *et al*., 1996). 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 on the animal. A relationship between the severity and extent of cockle on pickled skin and a number of ectoparasites present was suggested (Health *et al*., 1996).

Accordingly, the study on severity of ectoparasites in each group (light, moderate and severe) and severity of cockle (clean, light, moderate and severe) indicated that there was a strong correlation in *D. ovis* and *M. ovinus* infested ($P<0.001$) sheep pelt group and sarcoptic mange infested goat pelt group ($P<0.001$). This finding was in agreement with other authors in that positive correlation of cockle severity was observed with the count of lice and ked and size and number of affected lesions by mange, respectively (Heath *et al*., 1996; Tefera Sertse and Abebe Wossene, 2006). 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 were the major defects responsible for skin downgrading and rejections. In this study scratch was found 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 cause different level scratches on the skin (Kassa Bayu, 2006).

Cockle 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 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, 1998; Kassa Bayu, 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 prevalence 35 % in sheep and 21.5 % in goats was much closer to the observation where 30 % of pickled skin in Awash tannery were positive for cockle (Asp and Tauni, 1988).

However, the present cockle prevalence was relatively much lower than the previous reports at Sebeta tannery (88.5 %) in pickled sheep skin and at Dessie and Kombolcha tanneries 70.8 % in pickled sheep and 42.3 % in wet blue goat

skins (Ermias Yisak, 2000; Tefera Sertse and Abebe Wossene, 2007). 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 and scratch both on pickled sheep and wet blue goat skins. A similar observation was noted on pickled sheep and wet blue goat skins (Asp and Tauni, 1988; Ermias Yisak, 2000; Tefera Sertse, 2004). 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 causing scratches on their skin (Asp and Tauni, 1988; Urquhart *et al*., 1996; Wall and Shearer, 1997). Similarly, statistically significant association ($P<0.001$) was also found between cockle and scar on pickled sheep and wet blue goat skins. 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. 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.

This finding was in agreement with previous authors that association of *D. ovis* infestation of sheep with downgrading of skins and increase in intensity of cockle at lower grades was also demonstrated (Asp and Tauni, 1988; Heath *et al*., 1996; Ermias Yisak, 2000). The association of *D. ovis* and *M. ovinus* infestation of sheep and infestation of goats with sarcoptic mange causing downgrading of pickled skins was observed (Tefera Sertse and Abebe Wossene, 2007). In the current study, comparison of the grading of pickled skins from ectoparasite affected versus apparently ectoparasite free sheep and goat pelt groups demonstrated that the majority number of pickled skins were graded as best grades (grade 1-3) in the later group, which was in line with Quality and Standards Authority of Ethiopia (2001).

The impact of cockle on the tanning industry is a serious concern. 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 losses to the tanning industry is 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 they are not suitable for sale in export markets (FAO, 1998; Kassa Bayu, 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 financial impact of cockle in Wukro Sheba tannery 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.

In conclusion, the present study disclosed that sheep ked (*M. ovinus*) and lice (*D. ovis*) in sheep and sarcoptic mange in goats were found to be strongly associated with cockle defect in pickled sheep and goat skin. Lice of *Linognathus* spp were not observed to produce cockle on pickled skins, however, a strong association was observed between this parasite and scratches. Scratch along with cockle, scars and technical defects were the major causes of skin downgrading and rejection in Wukro Sheba tannery. Though, there are different grading system only the pickled skin type were observed to be used by Wukro Sheba tannery for both pickled and wet blue skins. Further more the raw skin grading system was not implemented for all types of skins. Effective extension system and programs that could raise public awareness on methods of flaying, preservation and handling of skins should be implemented. Moreover, training should be given to selectors on the grading system in order to implement pricing by grade system. 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.

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