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ASSESSMENT OF THE SHEEP PRODUCTION SYSTEM OF NORTHERN ETHIOPIA IN RELATION TO SUSTAINABLE PRODUCTIVITY AND SHEEP MEAT QUALITY

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ABSTRACT
A study was conducted in Northern Ethiopia to assess the sheep production system and factors affecting live sheep supply for quality meat. The survey was done in selected districts known for their high density of sheep population. The flock structure seems to be affected by the demand, requirement of breeding female, feed availability and the occurrence of disease and natural calamities. Farmers tend to keep more female sheep for longer (culling age of 5.9±0.4 and 1.9±0.5 for females and males respectively) for the reasons of feed shortage and requirement for breeding female. The ratio of male to overall female is small (1:6) and hence rams has maximum contact time with ewes that might contribute for inbreeding. The overall average age at puberty for female is 9-14 months. However, the presence of very young lamb rams and uncontrolled mating system led to early breeding of females which resulted in low conception rate, low birth weight, poor survival rates and in extreme cases causing inbreeding. The market structure for live animal in Tigrai region has four hierarchies with extremely poor infrastructure further affecting the provision of quality meat to the end consumer. Finally it was noted that five critical control points such as choice of breed (especially sire), age of animal, feed & feeding, animal disease & pests and the market infrastructures need to be given emphasis to ensure supply of live animal for better quality meat and profitability of the producers.

KEY WORDS: Sheep, production system, market supply, meat quality, Ethiopia.

INTRODUCTION

Shortage of food supply, quantity and quality of food are the major nutritional challenges in the world in general and developing countries in particular (Neumann *et al*., 2002). The inadequacy of the food supply due to the growth of population together with urbanization results in a significant demand for animal sources. As a result, recently, the demand for foods of animal origin is increasing (McDermott et al., 2010; Webb and Casey, 2010).

The farm animal genetic resource (livestock) in Ethiopia has higher value in the livelihood of the small farm households whether they are pastoralists or crop-livestock practitioners. Livestock provide high value food (meat and milk), labor force (tilling, oil mill service, and transportation), organic fertilization through their manure, biogas generation after fermentation of their waste, cash income through live animal & products sell, stored wealth to be dispense as required and prestige. Poorer people in major part of Ethiopia and other underdeveloped nations utilize livestock as sources of cash income (Thornton *et al*., 2002; Delgado et al., 1999). Therefore, utilizing the farm animal genetic resources efficiently and optimally is crucial for both food security and sustainable development.

The major production system of Ethiopia in general and Tigrai in particular is a mixed crop-livestock system with farmers keeping especially ruminants to different extents in small areas. Mostly animals are left to graze or browse in rangelands or in almost degraded grazing lands during the day time and supplemented, if at all, with hay or stover in backyards in the evening (Zelealem and Abreham, 2010). Animals in this type of production system are considered as low producing because of several factors such as insufficient feed availability confounded with the prevalence of disease and parasitic pests (Ademoson, 1993; Zinash and Seyum, 1991).

Small ruminants are widely distributed and are of great importance as major source of livelihood for smallholder farmers and the landless in rural communities in developing countries (Tembely, 1998). Sheep and goat are kept mainly as a secondary investment and require minimal input (Guido *et al*., 1983). Integration of sheep and goat with crop agriculture usually occurs under subsistence conditions on small-scale farmers. Small ruminants are an integral part of the system providing milk, meat, manure and cash to the farm family during time of need (Sandra, 1991). Small ruminants act as store of wealth and determine social status within the community. Due to these important functions small ruminants play an important role in improving food security and alleviating poverty. Because they are central to the nutrients cycling, small ruminants are important to the efficiency, stability and sustainability of faming system (ILRI, 2002).

Despite the economic importance of small ruminants to the farming household and overall economic development of a country, policy makers and development agents have not made enough efforts to improve the livestock production system in Ethiopia. Therefore, assessing the

potential and constraints for small ruminant production is mandatory. So far the efforts have been put forward in the region are not enough in this regard. As a result the area is suffering from poor extension system and lack of inputs in the livestock production sector.

Studying the socio- economic aspects of the household, small ruminant management and husbandry practices, constraints and their interaction with other farming activities is important to make development intervention.

Recently efforts have been made by the Tigrai Agricultural Research Institute (TARI), Ethiopia to phenotypically characterize the sheep breeds/types in Tigrai, Northern Ethiopia. Traditionally, it is believed that there are more than five breeds/types. However, four breeds are thought to be distinct and distributed in different agroecology of Tigrai. The breeds are Abergelle (Distributed in Districts such as Tanqua Tanqua-Abergelle, Tselemti, Kola tmeben and Alamata, lowlands of Ofla and Sokota), Begait (distributed entirely in Western and North Western Tigrai including districts such as Tahtay–Adyabo, Tsegede and Kafta humera), Ille (distributed in Raya-Azebo district and Afar region) and the common Tigrai highland sheep (distributed in all mid and highlands of Tigrai) (Zelealem and Abreham, 2010). All have distinct features which make them fit to their specific production system. Almost all sheep breeds are utilized for meat production except the Begait which is both milk and meat type.

The current study has been conducted to include the major small ruminant producing districts of Tigrai, Ethiopia giving more emphasis to sustainable sheep production system and enhance the quality of meat.

MATERIALS AND METHODS

Area Description and Available Sheep Breeds

The study was conducted in Tigrai National Regional State, Northern Ethiopia. (Figure1). Tigrai is one of the nine national regional states in Ethiopia located in Northern part of the country at15.02^0 N and 12.1^0 S latitude and 36.46^{0}W and 39.97^{0}E longitude. The region has shared borders with the state of Amhara in the South, Eritrea in the North, the state of Afar in the East and the republic of Sudan in the West. The total population is estimated to be 4.3 million with an annual population growth of 2.5 percent and majority of the population (76.2) living in rural areas (CSA, 2008).

Tigrai has six administrative zones namely Western, North Western, Central, Eastern and Southern, and Mekelle zones and 34 districts. The landform of Tigrai is highly complex with altitudinal ranges 500 to 3200 meters above sea level with an overall temperature ranging between 5^{0}c and 40^{0}c with respect to altitudinal ranges (Kumasi and Asenso-Okyere, 2011).

The region is composed of all agro-climatic zones especially "Kolla" (*Warm, semi-arid lowlands*) with altitudinal range of <1500 meters above sea level, "Weina dega" (temperate, cool sub-humid, highlands) with altitudinal range 1500 to 2500 meters above sea level and Dega (cool, humid highlands) with altitudinal range 2500 to 3000 meters above sea level. Agro-climatically Tigrai belongs to the African dry land, commonly referred to as Sudano-Sahelian region having a sub-tropical continental type of climate with a diverse agroecological zones and niches having distinct natural resources (Taffere, 2003). The climate in the region is characterized with a long dry season lasting 9 to 10 months and effective rain season of 50 to 60 days and total rainfall ranging between 400 and 800 millimeters which regards the region as moisture deficit region (Kumasi and Asenso-Okyere, 2011; Nyssen *et al*., 2005.

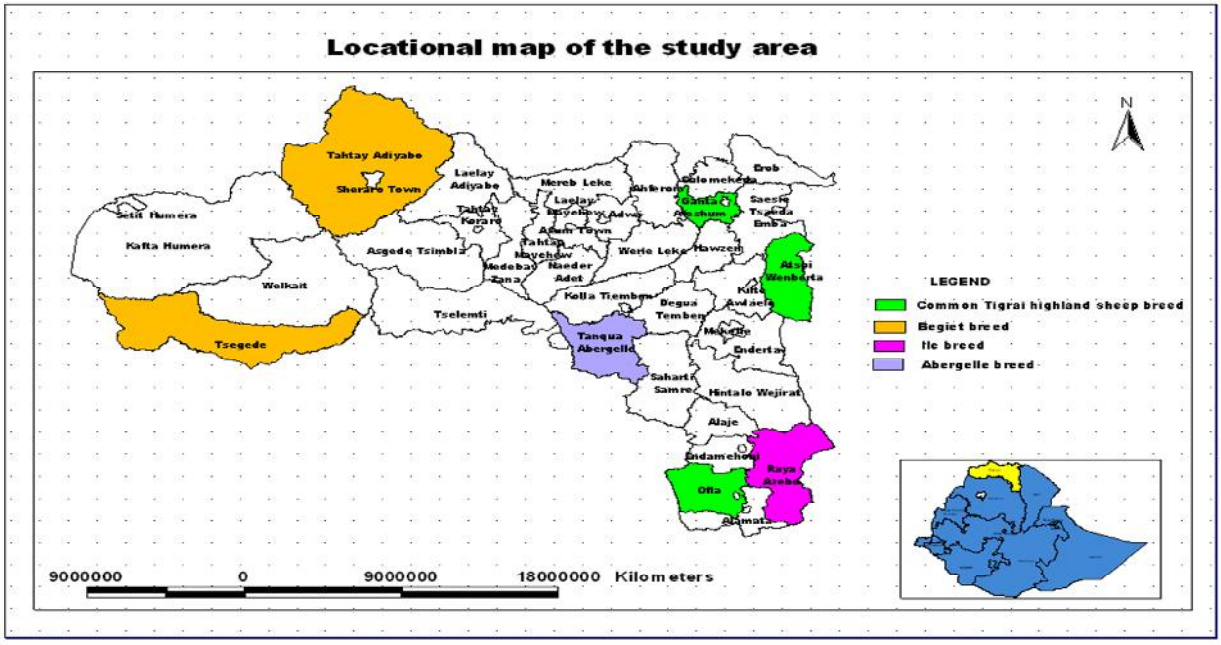

FIGURE 1. Map of Tigrai and surveyed districts

Sampling frame

The study was conducted within the time period of May-August 2011. The study sites were selected from areas that represent the major agro-ecologies of the region. From each agro-ecology, districts were taken as the largest unit for sampling and were selected on the basis of sheep population density. Then villages (the smallest units) were selected from each district for the survey. The districts were selected in such a way that all sheep breeds were represented, and included districts are Atsbi-Wenberta and Ganta-Afeshum (Eastern zone), Raya-Azebo and Ofla (Southern Zone), Tanqua-Abergelle, (Central zone), Tahtay-Adiyabo and Tsegede (Western zone) of Tigrai. These districts were selected from districts categorized previously as sheep producing areas because of their high sheep population density (Zelealem and Abreham, 2010). A questionnaire was designed to generate information related to the housing, watering, feeds and feeding, flock structure and composition, major reason for rearing sheep, disease prevalence and the treatment practice, production constraints and marketing. For reasons of keeping sheep farmers were asked to rank them based on importance/priority (five is given for the major important reason and one is given for the least important reason).

Focus group discussions were also conducted to generate additional information on markets and market actors, policy and regulatory issues. The focus group included livestock experts, veterinarians, local administrators, traders, market experts and researchers.

Data Analysis

Descriptive statistics and analysis of variance were done using JMP-9 statistical software. Data involving frequencies were analyzed using descriptive statistical procedure. For ranking descriptive analysis based on frequency was done using SPSS statistical software version 20. Comparisons of variables among districts were done using ANOVA procedure for univariate analysis by taking district as fixed effect. Significance difference between districts was analyzed using Tukey-Kramer HSD procedure at 1% probability level (α= 0.01). Information generated from focus group discussion was presented without further processing.

RESULT AND DISCUSSION

Flock Composition

The average sheep flock composition per household for the surveyed districts is presented in Table 1. The flock structure seems to be affected by production objective and demand, requirement of breeding female, feed availability and the occurrence of disease and natural calamities. In all areas the number of rams (intact matured male sheep) kept per flock (1.4 on average) is very small. Other male sheep are either lambs or castrated. The number of female and male sheep below six months of age looks equivalent. Farmers do not keep male animals for longer time and sell them at early age (usually before yearling age). The maximum age of male animals per household is around 2.2±0.1 years or less while that of female animals is 4.8±0.2 years and above. Most of the farmers generally sold their male animals at early stage because of feed shortage (as one of the major problems) and the need to maximize their breeding female animals in the flock. Therefore, the major meat in the market is lamb meat followed by hogget and mutton and hence is presumed the best quality meat. Generally the consumer in the region prefer to either slaughter lamb rams or purchase lamb meat or hogget. This fact is substantiated by the findings of Young and Lim (2001) where they found that New Zealand consumers' perceived that lamb has highest quality meat whereas hogget and mutton stand 23 and 36% lower than lamb meat, respectively. Studies elsewhere showed that meat becomes tougher as animals get older due to the increase cross linkage between intramuscular collagens rendering the meat more insoluble (Kopp and Bonnet, 1987).Farmers in all districts do not keep many aged ram in their flock, while they tend to keep aged ewe in their flock for breeding purpose (Tables 1 &2). As time goes on, the number of male animals assumes a decreasing trend and vice versa for female animals until the age of six or seven years. In all districts, the culling age of male animals is less than 2.5 years, however, for females it reaches 7.6 years. In most cases male animals are castrated at about 1 to 2 years of age for fattening purpose. Farmers sell fattened males at about 2.2 years of age (Table 1). The maximum number of rams in a flock ranges from 0.7 to 2.4 with an overall average of 1.4. The ratio of ram to ewe and ewe lamb combined is about 1.4:8.3 (or 1:6) which is larger compare to the normal range which is about 1:35 though it varies based on several factors including age and experience of the ram, nutritional condition and other environmental stressors (Susan, 2011). With this ratio rams will have maximum contacts with ewes and ewe lambs and breed them efficiently without missing any estrus. Hence, farmers pay their maximum attention in selecting male animals to keep them for breeding purpose. Farmers select male animals based on the performance of their ancestors and based on the body conformation and growth rate they manifest in their course of development. However, rather than keeping their local animals (breeds) they do not incorporate other breeds which are known for their reproduction and production.

Reproduction and production aspects

Mean age at first lambing of ewes is 16.4±0.3 (ranging 13.9-19.5 months) indicating age at puberty of 9-14 months (Table 2). This finding is comparable with previous works done on other breeds in different parts of Ethiopia. For example age at first lambing for Arsi-Bale sheep bred was reported within the range of 11.8-17 months (Getahun, 2008; Tsadkan, 2007; Samuel, 2005), while that of Menz Sheep breed ranges between 13 and 18.2 months (Dibissa, 2000; Niftalem, 1990; Mukasa-Mugerwa *et al*., 1986; Agyemang *et al*., 1985). The reported average ages of lambing for semi-arid and sub-humid sub-Saharan countries were 16.9 and 16.2 months, respectively (Otte and Chilonda, 2002). This implies that the sheep breeds in the study area have acceptable age range for breeding though it is late compared to temperate breeds that reach puberty at the age range of 5-12 months (Susan, 2011). However, this finding should be treated carefully since there are many other factors governing the age at puberty and the age at first lambing. In contrast to the age of lambing and number of lambs born per life time of a ewe the average mortality rate before weaning looks very high (>30%). Higher mortality rate is due either to lower mothering ability of ewes, high prevalence of infectious diseases and / or shortage of fed and nutrition.

TABLE 1. Average flock composition by age and sex (Means ± SE)

District	Ewe	Ewe lamb	Ram lamb	Castrated male	Ram	Overall female	Overall male	Max-age male	Max-age female
Tanqua-Abergelle	6.6±0.7^{abc}	2.2±0.3^{ab}	3.4±0.5^{bc}	0.1±0.1^{b}	2.6±0.2^{a}	8.9±0.8^{ab}	6.1±0.6^{a}	2.3±0.1^{abc}	5.2±0.3^{ab}
Atsbi-Wenberta	8.5±0.7^{a}	2.8±0.3^{a}	5.0±0.5^{ab}	0.1±0.1^{b}	1.3±0.2^{bc}	11.3±0.8^{a}	6.5±0.6^{a}	2.4±0.2^{abc}	5.0±0.3^{ab}
Ganta-Afeshum	4.7±0.2^{c}	0.9±0.2^{b}	2.5±0.2^{c}	0.0±0.0^{b}	1.2±0.1^{bc}	5.6±0.3^{b}	3.6±0.2^{c}	3.3±0.3^{a}	4.9±0.2^{ab}
Raya-Azebo	5.2±0.4^{bc}	2.2±0.3^{ab}	3.2±0.3^{bc}	1.2±0.2^{a}	0.7±0.2^{c}	7.3±0.5^{b}	5.1±0.3^{ab}	2.0±0.2^{bc}	4.1±0.2^{b}
Tahtay-Adiyabo*	5.1±0.5^{c}	3.2±0.4^{a}	5.3±0.4^{a}	0.1±0.0^{b}	1.5±0.2^{b}	8.3±0.6^{ab}	6.9±0.5^{a}	1.5±0.1^{c}	4.0±0.3^{b}
Tsegede*	4.9±0.4^{c}	1.2±0.2^{b}	2.2±0.2^{c}	0.1±0.0^{b}	0.8±0.1^{bc}	6.1±0.4^{b}	3.1±0.3^{c}	1.7±0.1^{c}	4.7±0.2^{b}
Ofla	7.5±0.5^{ab}	3.1±0.2^{a}	3.6±0.3^{bc}	0.1±0.0^{b}	1.5±0.2^{bc}	10.5±0.6^{a}	5.2±0.4^{ab}	2.7±0.2^{ab}	5.8±0.2^{a}
Overall	6.0±0.4	2.3±2.3	3.6±0.3	0.2±0.0	1.4±0.2	8.3±0.5	5.2±0.4	2.2±0.1	4.8±0.2

* The average number of sheep per household would be larger for this area. The reason for small values here is because the questionnaire was prepared only for small farm households.
Means within column with different letters vary at α =0.01

TABLE 2. Production and reproduction (Means ± SE) performance of sheep in different districts

District	Age at first lambing (months)	Five year's Births		Culling age (year)		Maximum birth per ewe before culling	Death before weaning (%)
		Female	Male	Female	Male		
Tanqua-Abergelle	19.5±0.3^{a}	14.4±0.5^{d}	12.4±0.5^{c}	5.7±0.8^{a}	1.9±0.8^{a}	9.5±0.3^{c}	31.8±1.3^{bc}
Atsbi-Wenberta	18.4±0.2^{ab}	15.8±0.5^{cd}	14.0±0.5^{c}	6.1±0.5^{a}	1.2±0.6^{c}	8.9±0.1^{c}	42.8±1.3^{a}
Ganta-Afeshum	18.0±0.4^{b}	16.5±0.5^{bcd}	15.8±0.5^{abc}	5.5±0.1^{b}	2.0±0.6^{a}	7.8±0.3^{e}	35.8±1.4^{b}
Raya-Azebo	15.2±0.2^{cd}	19.2±0.5^{a}	16.9±0.5^{ab}	6.2±0.3^{a}	1.8±0.0^{b}	10.2±0.1^{b}	30.4±1.2^{bc}
Tahtay-Adiyabo	15.5±0.2^{c}	18.8±0.5^{ab}	17.6±0.4^{a}	6.0±0.3^{a}	2.5±0.8^{a}	11.5±0.5^{a}	33.5±1.0^{bc}
Tsegede	14.1±0.3^{de}	18.7±0.4^{ab}	17.7±0.4^{a}	6.4±0.6^{a}	2.0±0.1^{a}	11.8±0.2^{a}	30.8±1.0^{bc}
Ofla	13.9±0.2^{e}	17.0±0.4abc	15.5±0.5^{bc}	5.1±0.1^{b}	1.6±0.4^{b}	8.7±0.6^{d}	29.4±1.0^{c}
Overall	16.4±0.3	17.2±0.5	17.7±0.5	5.9±0.4	1.9±0.5	9.8±0.3	33.5±1.2
R^2	0.84	0.88	0.87	0.92	0.92	0.77	0.82

Values within column with different letters vary at α =0.01

TABLE 3. Body conformation of animals by sex (Means ± St. Error)

District	Height at Wither (Cm)		Girth circumference (Cm)		Body length (Cm)		Compactness (Body length/Height)	
	Male	Female	Male	Female	Male	Female	Male	Female
Tanqua-Abergelle	59.7±0.5^{bc}	58.4±0.4^{bc}	73.3±0.7^{a}	70.3±1.3^{b}	47.9±0.5^{bc}	47.9±0.8^{c}	0.80±0.012^{bcd}	0.82±0.013^{cd}
Atsbi-Wenberta	57.9±0.8^{cd}	59.0±0.5^{bc}	71.2±1.2^{ab}	75.3±0.8^{a}	48.7±0.9^{bc}	50.0±0.6^{c}	0.84±0.012^{bcd}	0.84±0.013^{bcd}
Ganta-Afeshum	55.4±0.6^{cd}	58.8±0.5^{bc}	67.8±1.1^{ab}	73.8±0.5^{ab}	45.2±0.5^{c}	47.5±0.4^{c}	0.85±0.011^{bc}	0.86±0.011^{abc}
Raya-Azebo	53.9±0.8^{d}	56.2±0.6^{c}	70.2±0.8^{ab}	74.7±0.5^{ab}	49.7±0.7^{ab}	51.2±0.9^{bc}	0.93±0.012^{a}	0.91±0.013^{a}
Tahtay-Adiyabo	63.9±0.9^{a}	64.9±0.7^{a}	70.6±1.0^{ab}	74.5±0.7^{ab}	52.8±0.7^{a}	54.7±0.5^{a}	0.80±0.012^{d}	0.80±0.013^{d}
Tsegede	63.3±0.9^{ab}	64.6±0.6^{a}	68.4±1.1^{b}	72.7±1.1^{ab}	53.6±0.9^{a}	55.5±0.7^{a}	0.85±0.010^{bcd}	0.86±0.011^{abc}
Ofla	58.3±0.7^{c}	60.9±0.5^{b}	67.9±0.8^{b}	74.4±0.5^{b}	50.3±0.8^{ab}	53.9±0.6^{ab}	0.86±0.010^{b}	0.87±0.011^{ab}
Overall	59.5±0.8	61.0±5.8	69.8±1.0	73.7±0.8	50.3±0.8	52.2±0.8	0.85±0.011	0.85±0.012
R^2	0.87	0.91	0.85	0.85	0.88	0.86	0.72	0.69

Means within column with different letter vary at α =0.01

TABLE 4. Rank of reasons of keeping sheep as indicated by farmers in each district

Districts	Ranks				
	1st	2nd	3rd	4th	5th
Tanqua-Abergelle	Manure	Sell	Meat	Milk	----
Atsbi-Wenberta	Sell	Meat	Manure	Milk	Prestige
Ganta-Afeshum	Manure	Sell	Meat	Milk	----
Raya-Azebo	Sell	Meat	Manure	Milk	----
Tahtay-Adiyabo	Sell	Meat	Manure	Milk	Prestige
Tsegede	Sell	Meat	Manure	Milk	Prestige
Ofla	Sell	Meat	Manure	Milk	-----
Overall	Sell	Meat	Manure	Milk	Prestige

Reasons of rearing sheep and other small ruminant in the region

Small ruminants contribute to human welfare in a variety of ways. The major ones being that they are source of food (milk and meat), livelihood, and source of manure. Furthermore small ruminants can be raised with low feed requirement, are ease to handling and have quick return to reproduction (Berhanu, 1998). They are easily sold to raise the money to replace large ruminants, to pay loan, to purchase household equipment and other farm inputs, school fee for children and generally used to solve immediate problems.

This study generally showed that the main reason for rearing sheep by farmers is to sell the animals followed by their meat and manure (Tables 4). Milk and prestige are placed in fourth and fifth place respectively. Majority of the farmers indicated prestige as the major reason for keeping sheep are located in Atsbi-Wenberta (1.7%), Tahtay-Adiyabo (1.1%) and Tsegede (6.8%) districts (Table 4). Only two districts namely Tanqua-Abergelle and Ganta-Afeshum ranked manure first followed by sell and meat as the major reasons of rearing sheep.

The fact that Tigrai is characterized with vast land degradation and loss of fertility of soils with subsequent loss of productivity (World Bank Report 2008; Yesuf et al. 2008) the use of organic fertilizer especially animal manure is inevitable and has been practiced since times in history. In this respect research findings indicated increment of yield when manure was included with chemical fertilizer compared to chemical fertilizer only (Getachew and Taye, 2005; Wakene *et. al*., 2005). According to Joyce (1991), the effective use of small ruminant manure for small-scale low-income farmers can replace the need for and use of purchased inorganic fertilizer. Hence, the use of small ruminants in this regard can be said priceless.

Management and husbandry practice

The husbandry practices include housing, feeding, watering, lamb and kid rearing, mating management, grazing and disease control.

Housing

Farmers put their sheep in separate housing (pen) constructed in the homestead or around the homestead. Traditionally, the pens are constructed in two different ways. The first and most commonly used pen constructed is open ended without roof which is usually used to confine sheep during dry season at night and it is locally called “Dembe”. Except few respondents almost all households keep their flock separately from large ruminants. The second one is mostly used to confine sheep during rainy season to protect them from rain and cold. It is three or two-side wall constructed from local materials such as stone or wood and partially roofed which is locally called “Gebela”. Farmers with this sort of housing keep all types of animals together and sometimes humans spend the night with their animals to guard their animals. Animals get injured due to physical attack by dominant and larger animals. This is one of the various causes for abortion of pregnant ewes. This type of housing system also favors the growth of opportunistic and infectious microorganisms that cause serious illness in animals and humans (zoonosis diseases).

Farmers at Tahtay-Adiyabo and Tsegede construct pens on their farm land and occasionally change the sites of barns to distribute the manure. This type of manuring increases efficiency of manuring since animals stamp on the land and thoroughly mix the manure with the soil and the crop residues.

On the contrary, these sorts of barn construction do not take into consideration the optimal temperature requirement of sheep at night. In almost all cases animals are not protected from the cold draft coming at night times nor well protected from rain drafts at all the times. Hence, animals are to adjust themselves to the condition and mostly utilize much of the little energy they get from their feed to keep themselves wormer and consequently they are left with none or little energy for production and reproduction. In severe cases this stress and shortage of feed combined my cause abnormality in meat (Dark, Firm and Dry meat) from animals in this type of environment as depletion of glycogen reserve is the major cause for such meat abnormality (Gregor, 2007). Dark, Firm and Dry (DFD) meat occurs when animals are exposed to stress factors for longer period of time. This problem is more pronounced in the mid and highland areas where the night temperature falls dramatically. While in the lowland areas the problem probably be the effect of high temperature at day time and effect of rain at all times.

Sheep feeds and feeding system

A survey result by Alemayehu (2005) generalized that from the overall feed intake of animals in Ethiopia, natural pastures (including browse plants) and crop residues contributed 80-90 and 10-15 percent, respectively.

Feeding management of sheep is dependent on the nature of the livestock production system of the specific areas or districts. Generally there are two types of livestock production systems in the region. The first one is stationary or settled livestock production system where animals are taken to graze around the vicinity of their farm whereas sometimes taken little farther from the residential area. The other system is the transhumant system under which animals are trekked to much farther distance from their residential area during the dry season. This type of production system is practiced in addition to the former livestock production system in Western Tigrai (Tahtay-Adiyabo, Tsegede, Wolkait etc) where the Begait sheep breed is present. In the former system animals are a little bit being taken care of by feeding them crop residues and sometimes supplemented with mill byproducts (bran or oil seed cakes), whereas in the later type of production system animals are totally left to utilize only what their dams and Mother Nature can provide them.

Generally the main sources of feed are natural pasture which grows in communal grazing land, fallow land, around homestead and grasses and brows plants. Most of the farmers indicated natural pasture to be the main feed resource during all seasons. Some farmers mentioned crop residue and hay as a source of feed during dry season. There was no improved forage introduced in the small ruminant feeding system in the study area. Sheep generally graze the

whole day and water once a day, 3- 4 times a week. The major sources of water are rivers and streams to be reached by trekking.

The types of feed to be provided to animals are also dependent on the availability of feed types and the prevailing farming system. The major feed sources in Tanqua-Abergelle, Tahtay-Adiyabo, Tsegede and Raya-Azebo districts are predominantly stover (Maize and Sorghum), finger millet straw and browse plants especially dominated by *Acacia species, Ziziphus spinachristi, Phydorbia albida* and other thorny plants. While the major sources of feed in Atsbi-Wenberta, Ganta-Afeshum and Ofla districts are pasture lands which are usually communally owned and residues from cereal ['Teff' (Eragrostis abysinica), Wheat and Barley] farming. The animals of Raya-Azebo region are predominantly fed on *Acacia species, Ziziphus spinachristi* and other trees and crop residues such as Maize and Sorghum stover and straw from Teff. In all the areas, farmers give more attention to large ruminants and feed them preferably better feed compared to small ruminants.

Small ruminants usually obtain their feed from grazing and hence, they usually suffer from feed shortage and poor nutrition. Even the available feed has poor nutritive content, poor digestibility and unpalatable during major portion of a year. Moreover, sheep and goat are left to graze and browse alongside with large animals that even worsen the feed shortage since animals need to compete with each other. Almost all farmers in all the surveyed districts do not supplement their small ruminants. This finding substantiated the findings of Sandra (1991) who mentioned that most farmers in the region do not make effort to provide adequate feed for their animals. They often see small ruminants and poultry as equivalent to the wild foods in that they do not require much attention and will be there when needed. This is because the farmers do not understand the nutritional requirements of small ruminants.

The plantation of browse legumes at the back-yard and border lines of cultivated areas provides supplementary feeds for small ruminants during the wet season and serves as a hedge and source of fuel wood. The subsistence production systems are amenable to becoming intensive systems if farmers can receive information on how to produce good quality feed for their animals using locally available resources.

Mating Management

The average age of ewe lamb at first mating is 9-14 months. The respondents (71.4%) revealed that mating occurs all year round usually in the field while grazing. Uncontrolled breeding due to random mating, with the ram grazing together with the ewes, leads to early breeding of females resulting in low conception rate, low birth weight and poor survival rates. Mating within close relatives, especially Sire-daughter and ewe-offspring-could lead to inbreeding, which might have resulted in increased mortality.

Some farmers practice control mating to minimize weight losses and poor conformation in ewes. The probable life span of ewes is about 7 years and is expected to give birth four to five times. As the study indicated, autumn and winter (dry season) are the most common seasons of birth with autumn taking the majority of births. However, about 72.4% of the respondents also indicated that the season of reproduction (births) is not similar for all. Dry seasons are usually the seasons known for feed scarcity since natural pasture and some browse plants shed their leaves at these seasons. Therefore, lambs to be born in this season have lower birth weight and less body gain, hence, will have lower survival rate. The lambs born in autumn face the same problem at times though they are in better condition compared to that of lambs born in the dry season. Generally lambs born at the late rainy season have the advantage of season in which they get better feed that might help them to reach puberty at earlier age. Effect of season on lamb mortality in Ethiopian condition is illustrated by various researchers (Birhanu and Aynalem, 2011; Mengestie *et al*., 2011; Milan *et al*., 2011).

Diseases and disease control

Diseases and parasites especially *Ovine Pasturulosis, Ovine Pleuropneumonia, Fasciolosis* and Menge mites are mentioned as major contributers to high mortality before weaning. The most common diseases noted from the description of symptoms of diseases in all surveyed areas are *Ovine Pasturulosis, Ovine Pleuropneumonia*, and dysentery, skin diseases like scabies, internal parasites such as *Haemonchus, Hydatid cyst and Fasciola*. The most common external parasites were Menge mites, ticks, fleas and lice. Most of the respondents indicated that they spray anti external parasite chemicals on their sheep and goat. The animals are vaccinated against few of the diseases only. It was clear from this study that there is occasional use of veterinary drugs and traditional medicines prepared from local medicinal plants. The traditional medicines are generally used to cure the animal but sometimes they cause serious problems due to higher dose and adverse effects.

Live animal marketing

Generally the market hierarchy in all surveyed districts has more or less four levels. The first market level is trading at farmers' yard where all types of traders participate in buying and selling the animals. In most of the cases, traders and middle men (hired by larger traders and abattoir at Mekelle) travel long distances to reach the farmers and make the dealing and submit the animals to the terminal traders or abattoir at Mekelle (the capital city of the region). In some districts in the North West of Tigrai hired traders come from Sudan and make the deal and transfer the animals to illegal traders from Sudan (Trans boundary trading). In the North West the farmers get much greater price for their sheep compared to the other parts of the region because 1) their sheep are fast growing and have higher mature weight compare to the sheep from other parts of the region 2) illegal traders from Sudan pay higher price for the animals because of the high demand for sheep in Sudan. The second level of markets is the small village markets open once a week for one day. In this market; farmers, small traders, intermediate traders, and hired traders participate actively. The traders have the opportunity to compare the condition of the animals and compare and fix prices more strongly. The small traders

trek their animals on foot to the larger market at village towns. The small traders sell the animals they purchased from farmer's compound and village markets to intermediate and larger traders by adding some profits. Hired traders also actively participate in this market and hence, the prices of animals increase considerably. The last market is the market at larger towns and in Mekelle city. In this market end consumers, intermediate traders, hired traders and butcheries actively participate. Consumers with higher level of income will purchase live animals and slaughter them in their house. Some consumers also make a group and purchase animals to slaughter them at their house and share the meat equally. Other consumers purchase meat from butcheries who slaughter animals after inspection and approval by veterinary and municipality. The hired traders gather some animals and submit them to big fattening and slaughter houses. At Mekelle, the hired traders submit their animals either small or large animals to the Tanqua-Abergelle International Abattoir that exports meat outside of Ethiopia. Most castrated and fattened sheep are sold at the third level and at terminal market. Farmers bring their castrated and fattened rams to these markets seeking better prices and usually wait for national festivals or holidays. Sheep to be sold in market levels lower than third level are usually with live weight less than 25kg. This finding substantiates the report of Beyene and Lambourne (1985) that stated four-tire marketing system is the prevailing market hierarchy in Ethiopia. The only difference in this finding is the major actors in the market.

The market price of sheep depends mainly on body weight and condition which are dependent on availability of feed. During the dry season where feed is scarce animals dramatically lose weight and assume low body condition and hence will have lower price at markets. In some cases shortage of food in the farm household occurs in the late dry season (March to June) which forces them to bring their animals to market in large number in surplus of the demand and hence, the price will fall more. During the late rainy season and springs (September to February) animals are well fed and will have higher body weight and condition. In addition, these times are times for national festivals and commonly wedding seasons that force the demand for animals to increase, hence farmers and traders sell their animals with better price. Generally factors such as availability of feed, festivals, occurrence of disease and natural calamities, household requirements for expenditure such as purchase of grains and house consumables, consumer's income and preference affect the price of sheep. Though less significant, factors such as animal color, origin, age and temperament have effect on animal prices. Light colored sheep, young and active sheep will have relatively higher price. More or less the same factors were described to be the major factors affecting animal market price in previous studies (Ehui *et al*., 2000; Andargachew and Brokken, 1993).

FIGURE 2: Sheep and Goat trekking from Tanqua-Abergelle district to Mekelle market

Animals trek by their foot from the starting point at farmers' compound up to the terminal markets with less feed and water provision (Figure 2). While trekking animals are allowed to rest in the evening and roam around for grazing and drink water if encountered in their course of trekking. Only few intermediate traders and large merchants transport their animals by track from the tertiary market to the terminal market. This trekking and mix up of animals from different farm, villages and localities will have its own consequence on the health of the animals and subsequently on the quality of meat. The preference of consumers especially in terminal markets clearly discriminates animals which they believe trekked longer distance and come from specific localities.

Problems associated with the sheep production

Inadequate feed and nutrition, diseases prevalence, poor breeding stock, inadequate livestock production policies with respect to credit, extension and marketing have been

stated as the major constraints affecting livestock performance (ILRI, 2002).

All species of animals and all sexes except small ones graze and browse together in communal grazing lands and range lands. In this type of herding young animals usually are less competitive and get lesser amount of feed compared to the larger animals, and hence are more vulnerable to the effects of feed shortage and malnutrition. Sheep and goat are forced to graze on feeds with higher fiber and lesser digestibility. Supplementing small ruminants with industrial byproducts such as bran and oil seed cakes is not common. Mortalities due to feed shortage and malnutrition are common especially during the late dry seasons (March to June).

Another problem of production clearly observed from this study is that mortality rate before weaning reaches about 33.5%. Similar works on other breeds of Ethiopia in different locality under farmers' management condition also reported mortality rates greater than 20% for Horro and Menz sheep breeds (Tsedeke, 2007; Solomon and Gemeda, 2000; Markos, 2000; Solomon *et al*., 1995; Yohannes *et al*., 1995). There are many problems that exacerbate mortality rate before weaning. Diseases, effect of small birth weight and poor mothering ability especially in terms of milk production (ILRI, 1998) are some of them. Apart from the critical feed shortage diseases and parasites especially Ovine Pasturulosis, Ovine Pleuropneumonia, dysentery, Fasciolosis and Menge mites are mentioned as major causes of mortality before weaning. The other cause of mortality is bloating due to consumption of specific herb (*Medicago species*) which is known to have Tannin and Sapponin.

These problems added up with uncontrolled matting system causing low flock productivity expressed by late sexual maturity (age at first matting and age at first lambing), longer lambing interval, high pre-waning and post-weaning mortality, lower birth weight, negative post-weaning growth rate and lower mature body weight.

The other critical issue is the market and availability of credit schemes. Though there is a well developed micro financing system throughout the region that reaches each household in the rural, farmers are not utilizing the opportunity effectively. Farmers use the credit scheme mostly for purchase of improved seeds and fertilizer during the major rainy season. Only 6.3 % of the farmers utilized the credit scheme to purchase sheep and goat to generate income through trading fattened sheep and goat. Landless and jobless youth farmers rather prefer to involve in other businesses such as construction, metal and woodwork, etc and seek loan for these businesses.

The other issue related to the market is the infrastructure and the communication system. Farmers usually take their animals for sell to small local markets which are only active once a week. Information on market price, supply, grades and standards are lacking. The available information system favors consumers and is not favoring improvement on production in terms of quality and quantity. Farmers are extremely devoid of any market information of the major market outlets that makes them open to price fixing by intermediate traders and diminishing their bargain power. This in fact discourages them from using improved inputs for the quality of animal production since their cost of production (inputs and feeds) will be higher than their revenues. Currently the price of a single yearling sheep reaches about 1300 Ethiopian Birr (equivalent to 76 USD) at the terminal markets with farmers earning less than 60% of the price.

The market structure and infrastructure itself has considerable negative effect on sheep marketing and quality of production. Problems such as seasonality of market demand, rough roads, long distance trekking before slaughter and lack of feeding, watering and resting structures through the course of trekking contribute to the poor body condition and poor meat quality on animals. Pre-slaughter conditions are mentioned to affect the animal welfare and the overall meat quality. Animals are exposed to several factors during the transportation to the market. Congestion in limited space, frequent fluctuation of temperature, traveling for long distances, trekking, lirage facilities, road quality are among the various stressing factors. These factors apart from their stressing effect can cause death of animals in some instances (Fisher et. al., 2009). The stress factors through their increased effect on the physiology and physical activity of animals can causes depletion of glycogen reserve in the muscle rendering meat to have higher ultimate pH, darker color, firm and dry condition called DFD (Gregor, 2007). This type of meat can cause economic loss due to customers' preference against them (dark color and dry) and their liability to easy spoilage by bacteria (higher pH).

Conclusion and Future Perspectives

The Tigrai region has suitable agro-ecology for production of small ruminants. However, the flock size maintained by farmers is small due to those repeatedly mentioned problems especially feed shortage and widely distributed diseases. To alleviate feed shortage, there is a need to take feed inventory and introduce of improved forages and some tree legumes in the cropping system without leading to a serious competition with cultivated land.

The other problem is the prevalence of diseases and pests. Hence, controlled treatment and awareness of farmers is vital. There is also a need to provide adequate veterinary services and proper management practices. Government agencies are responsible to provide facilities for surveillance and diagnosis of diseases and should able to maintain adequate vaccine supply to prevent endemic and epidemic diseases. Therefore, government and development agencies should give due attention in all aspects of small ruminant production system to assist smallholder farmers to help themselves to extricate from chronic hunger and under line poverty.

As to the factors that would affect the meat and carcass quality, animal breed, animal age and nutrition & feeding practices were identified as critical points worth looking into. One of the major factors affecting growth rate and meat eating quality is breed. Farmers in the surveyed area do not keep male animals for long time and hence the sire effect on overall productivity of their flock is paramount. However, this is not fully perceived by farmers and choice of breed has

not been given due attention in the production system. Since choice of sire is a critical control point in sheep meat eating quality based on local market and international market requirements choice of sire requires at most attention in the sheep meat industry. Due attention should be given not to compromise growth rate with meat eating quality therefore, stakeholders should work to optimize profitability at the producers level and to run a balanced production between growth rate and meat eating quality. This can be achieved by encouraging producers and small scale sheep industries through different incentives and improving and developing an integrated supply chain.

The other aspect which requires due attention as a critical control point is the age of animal at slaughter. In these production system farmers sale their male animals at early stage and the available meat in the market in most cases is lamb meat which is tender. As different researchers reviled toughening of collagen is directly proportional with age of animals at slaughter, this finding has a positive outcome to the producers. However, it was also revealed that negative effect of age on meat tenderness is moderated by the increase of intramuscular fat content which increases with age and improves juiciness and flavor that impacts the overall liking of meat positively (Hopkins *et al*., 2005b). Therefore, an intensive work is required to optimize the overall liking of meat by consumers through balancing these quality attributes.

Feed shortage especially in the long dry season and considering small ruminant as secondary to large livestock hence not supplementing them with additional feed than grazing or browsing are critical problems in the production system. These factors extremely affect the growth rate and glycogen reserve of animals rendering them to have a low quality meat. Proper feeding with high energy diets increases the meat quality through increasing the muscle glycogen reserve, which acts as a buffer against pH surge, and intramuscular fat content (Bailey and Light, 1989; Rompala and Jones,1984). Therefore, this should be considered as a major critical point and requires intensive work. Glycogen depletion also causes due to pre-slaughter stress factors such as muster (confinement), transportation and lairage system. Trekking for long distance and congestion in a very small area while transportation are common practices at both the producers' level and marketing routs. Thought it is difficult to identify critical points in the market rout it is worth mentioning market infrastructures should be improved.

Improved production of sheep can be sustained if it is designed in such a way that it improves the income and livelihood of producers, processors and retailers and fulfills the consumers' demand of quality product. Optimal utilization of scares resources with due consideration of environmental conservation and reduction of green gas emission are also crucial for sustenance.

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