ON-FARM CHARACTERIZATION OF BLACKHEAD SOMALI SHEEP BREED AND ITS PRODUCTION SYSTEM IN SHINILE AND ERER DISTRICTS OF SHINILE ZONE

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By

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DEDICATION

I dedicated this thesis manuscript to my father, Ferew Guadie and my mother, Etagegn Hunegnaw, and my family for their unreserved love, encouragement and their partnership in the success of my life.

STATEMENT OF AUTHOR

First, I declare that this thesis is my bonafide work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for an M Sc degree at the Haramaya University and is deposited at the University Library to be made available to borrowers under the rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author was born on December 13, 1979 in Deber Markos, Ethiopia. She attended her elementary and junior secondary school education at Endimata and T/Hayimanot schools from 1985 to1991. She pursued her secondary school education at Deber Markos Com. Sen. Sec. School in 1996 where she took the Ethiopian School Leaving Certificate Examination in 1996. She joined Awassa College of Agriculture (University of Hawassa) in 1997 and earned her B.Sc. degree in Agriculture (Animal Production and Rangeland Management) in July 2001. After graduation, she was employed by the Ministry of Agriculture and Rural Development of Ethiopia in August 2002 as a junior instructor in the Animal Science Department at Alage Agricultural Technical and Vocational Education Training (ATVET) until November 2003. She then transferred to Hollota ATVET College and worked there, until September 2006. In the same month and year, she joined the School of Graduate Studies at Haramaya University for Master of Science study in Animal Genetics and Breeding.

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LIST OF ABBREVIATIONS

BHS	Blackhead Somali
BL	Body Length
BW	Body Weight
CSA	Central Statistic Authority
CV	Coefficient of Variation
EL	Ear Length
EW	Ear Width
FAO	Food and Agriculture Organization of the United Nations
GLM	General Linear Model
HG	Heart Girth
HW	Height at Wither
ILCA	International Livestock Research Center for Africa
ILRI	International Livestock Research Institute
LI	Lambing Interval
LS	Litter Size
MOA	Ministry of Agriculture
PA	Peasant Association
r	Correlation Coefficient
R^2	Coefficient of Determination
SC	Scrotal Circumference
SD	Standard Deviation
SE	Standard Error
SNRS	Somali National Regional State
TC	Tail Circumference
TL	Tail Length
WOARD	Woreda Office of Agriculture and Rural Development

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ON-FARM CHARACTERIZATION OF BLACKHEAD SOMALI SHEEP BREED AND ITS PRODUCTION SYSTEM IN SHINILE AND ERER DISTRICTS OF SHINILE ZONE

ABSTRACT

The study was carried out in Shinile and Erer districts of Shinile Zone of the Somali National Regional State. The objectives of the study were: to characterize the production system and phenotypic characteristics of the Blackhead Somali; to evaluate on-farm survivability/ mortality of Blackhead Somali lambs during pre- weaning period and to determine the best fitted regression model for prediction of live weight of Blackhead Somali sheep breed based on body measurements under field conditions. Data were gathered through semi-structured questionnaire, focus group discussions, field observations and linear body measurements of sample populations. The overall least square mean reported Blackhead Somali sheep was 19.19. Generally, decreasing trends in Blackhead Somali sheep breed was reported. The major feed resource was natural pasture and source of water were from rivers, wells, natural ponds. Corral was used to house the sheep and goats together and they practiced partial controlled mating system. The reported production constraints were disease, feed and water shortage. According to farmers' report, the overall average age at puberty in females was 17.97 ± 3.97 and 13.65 ± 4.75 months in males. Age at first lambing, lambing interval , reproductive life span, and life time lamb production were 23.56 ±3.63 months, 10.46 ±2.58 months, 9.12 ±1.6 years and 8.18 ±2.27 lambs, res pectively. Per-weaning mortality rate was 47.8% and the major cause was disease (59.1%). The coat color patterns of Blackhead Somali sheep breed varies from patchy, pied and plain. The dominant color was black color of the head with white body color; body covered with short smooth hair, fat rumped tail and straight head profile; wattle was absent in female but present in male. The sheep flocks observed constituted higher proportions of females than males. Sex of animals had significant effect on body weight and linear body measurements except tail length, ear width and cannon bone circumference.

Males were heavier than females (29.50 kg vs. 25.80 kg) and had higher heart girth (72.72 cm vs. 71.29 cm), height at withers (61.30 cm vs. 59.97cm), and body length (65.82cm vs. 63.94 cm). The district effect was significant (p<0.05) for some measurements. Dentition classes of animals contributed significant differences to the body weight and some of linear body measurements. *Body weight was highly correlated (P < 0.01) with body dimensional traits with moderate to high positive correlation both in males (r=0.62- 0.81) and females (r=0.63-0.83). Based on fitted regressions models, heart girth was found to predict body weight with higher precision; height at wither with body length in combination with heart girth explained up to 75 % variation in body weight in both sexes. Best Fitted Regression equation based on* R^2 *Value are Y= 34.95 +0.15BL +0.52HG +0.19HW +0.06TC (*R^2*=76%) for females and Y=-29.4+0.2BL +0.4HG+0.17HW+ 0.11TC (*R^2*=77%) for male. Generally this breed showed their ability to thrive well and their potential for meat production under the prevailing harsh environmental conditions.*

1. INTRODUCTION

The sheep population in Ethiopia, estimated to be 24 million heads, is distributed and adapted across the diverse ecological zones of the country (FAO, 2003). Out of these, about 73 to 75% are kept on small scale mixed farms in the highland areas, while the remaining is found in the lowlands (FAO, 2003). There are many indigenous sheep breeds in Ethiopia including Menz, Horro, Arsi-Bale, Blackhead Somali, Adal, Tukur, Semen, Farta, Gumuz, Washera/ Dangila/ Agew, Wollo, Rutana, Sekota-Agew and Bunga (Sisay, 2002; Solomon and Gemeda, 2004; Workneh *et al*., 2004).

The Blackhead Somali is a widely distributed sheep breed through out the arid and semiarid areas in the south eastern parts of Ethiopia. It is the dominant sheep breed in the Somali region. The breed, locally known as *Wankie*, is also internationally recognized by names such as the Ogaden or Berbera Blackhead sheep. The breed has a distinguishing black color on the head and white on the rest of the body. The breed has small, short and sharply pointed ears with erect appearance. Generally, both sexes are polled with rudimentary horns occasionally seen in rams. It has a well pronounced fat rump at the base of the tail with heart shape in appearance (Technical Committee, 1975 cited by Beniam, 1992).

Although Blackhead Somali sheep can produce better under improved management conditions, the breed is generally managed under low input extensive production systems in their production environment, where scarcity of feed and water are the two major constraints. As such animals are forced to track long distances in search of feed and water particularly during the dry seasons and drought conditions. The long watering intervals, long walks, heat stress and little or no protection against disease affects the performance of this breed in their production environment. However, adaptation to the harsh climatic conditions and ability to produce from the limited and poor quality feed resources, makes this indigenous breed a good source of genetic material for future conservation and utilization.

Phenotypic characterization of livestock is complementary to the powerful biotechnological techniques for measurement of genetic diversity on the genome (Workneh *et al*., 2004). In short term and under the field to conserve and utilize indigenous breeds, however, phenotypic characterization can provide sufficient initial information for policy makers to obtain an overview of the national livestock pool (Rege and Lippner, 1992). The literature in this respect is either observational or recorded on sheep in experimental stations. These estimates may be closer to the potential rather than the actual production performance under the actual production environment.

At Werer Agricultural Research station, an attempt was made to assess the productive performances of Blackhead Somali sheep. However, there is no scientific information on the on farm performance of this breed. Since on-station production system, follow modern husbandry method (fencing, disease control, restricted breeding, housing, etc.), which would reduce feed selection possibilities, higher disease risks and restricted mating freedom, direct application of on-station results on breed comparison to field condition may not necessarily reflect the true situation on the range or free choice herding system in village (Peters, 1989; Habtemariam,1993). Therefore, this study was carried out with the following objectives:

Objectives

- To characterize the production system and phenotypic characteristics of the Blackhead Somali sheep in Shinile and Erer district of Shinile zone
- To evaluate on-farm survivability/ mortality of Blackhead Somali lambs during pre-weaning period.
- To determine the best fitted regression model for prediction of live weight of Blackhead Somali sheep breed based from body measurements under field conditions.

2. LITERATURE REVIEW

2.1. Origin and Domestication of Sheep

There are a number of different theories regarding the origin of domestic sheep. However, most sources agree that sheep originated from mouflon (Ensminger, 2002).There are two wild populations of mouflons still in existence (Ensminger, 2002): the Asiatic mouflon which is found in the mountains of Asia Minor and Southern Iran and the European mouflon of which the only existing members are found on the islands of Sardinia and Corsica. These two species are closely related with the only difference being the redder coloration and different horn configuration of the Asiatic mouflon. Some sources hypothesize that the European mouflon actually developed from the first domesticated sheep in Europe being allowed to become feral and that all sheep are actually descendants of the Asiatic mouflon.

Sheep and goat evolved about 2.5 million years ago in western Asia and south-eastern Europe (Ryder, 1983), and were the first ruminants to be domesticated by man, some time between 10,000 and 6,000 BC (Zeuner, 1963). Domestication took place first in South-western Asia. It appears that there were three prototypes of domestic sheep (*Ovis aries*) in southern and western Asia: the Muflon (O.*musimon*), the Argali (O.*ammon*) and the Urial (O.*orientals*). There are no indigenous domesticated sheep breeds in Central and South America. The so-called indigenous sheep in Africa are derived from Asia or Europe. No wild sheep were domesticated in Africa but both goats and sheep appeared in tomb and cave paintings in Egypt by about 7000 BP (before present). Sheep probably entered Sub Saharan Africa with cattle at some time in the period 6000-5000 BP possibly slightly later than goat. The thin tailed hairy sheep was the first taken to Africa. It is likely that they were introduced by the same Hamitic pastoralists migrating from the western Asia, who introduced the longhorn cattle. Fat-tailed course- woolen sheep in Africa were probably introduced to Africa about 3000 years after the thin tail breeds and probably by the Isthmus of Suez at the northern end of the Red sea and via the Babel Mandeb strides at its southern end (Payne and Wilson, 1999).

The origin of fat rumped breeds remains unknown but they occur in two disjunct and ecologically different regions (Payne and Wilson, 1999). Sheep belong to the suborder Ruminantia, the order Artiodactyla, the genus Ovis, and the family Bovidae. The domesticated sheep is classified as *Ovis aries*, the bighorn sheep as *Ovis canadensis*, and dall's sheep as *Ovis dalli*. The mouflon is classified as *Ovis musimon*, the Asian mouflon as *Ovis orientalis*, the Urial as *Ovis vignei*, and the argali as *Ovis ammon* (Encarta, 2007).

2.2. Small Ruminant Population of Africa

Indigenous small ruminant breeds constitute over 95% of the small ruminant population of Africa. The majority of small ruminants are owned by smallholder rural farmers for whom small ruminants serve as sources of nutrition and as important forms of investment. They provide a practical means of using vast area of natural grasslands in regions where crop production is impracticable. Indigenous small ruminant breed types are the result of many generations of natural selection dominantly for survival under the prevailing fluctuating feed scarcity, disease challenges, low level of management and a harsh climate rather than for high levels of production (Devendra and McLeroy, 1982; FAO, 2000; Markos *et al.*, 2004). The population of sheep and goats in sub-Saharan Africa is estimated to be about 124 and 147 million head, respectively (Winrock, 1992). Small ruminants represent an important component of the Ethiopian livestock production system, providing 12% of the value of livestock products consumed at the farm level and 48% of the cash income generated, but accounting for only 7% of the capital invested in the livestock sector by farmers (Kassahun *et al*., 1991; Tembley, 1998).

2.3. Sheep Breeds in Africa

There are many different types of sheep breeds in Africa. Apart from some breeds found close to the Mediterranean, all the breeds indigenous to Africa are hair type, i.e., they do not produce wool. In Africa, long-legged type sheep predominates around the Sahara.

This type is tall, has a thin tail and is well adapted to migratory existence. It includes the West Africa Long–legged breeds (Fulani, Maure, Tuareg), the Dongola, Northern Sudanese, Southern Sudanese and Zaghawa. In East Africa, fat-tailed type sheep predominates. Breeds of this type include the Abyssinian, East Africa Blackheaded and Masai. In South Africa, many of the sheep are derived from wool breeds imported from temperate countries. For instance a recognized breed Dorper was developed in South Africa in the 1930s by crossing the wool and hair sheep (Dorset Horn rams x Blackhead Persian ewes). This breed has a thick skin, which protects it from harsh conditions, and is the most sought after sheep skin in the world. The blackhead Persian in South Africa is a fat-rumped hair breed which has originated from the Somali. Some sheep breeds of Ethiopia are mentioned in Table 1. In Ethiopia according to the review work of Workneh *et al.* (2004) at least six sheep breeds are available in the country. This fall into three breed groups: the fat-tailed hair sheep, the fat-tailed coarse wool sheep and the fat-rumped hair sheep. DAGRIS (2004) mentions other breeds like Bonga that are not yet recognized at national level. The Bonga sheep type is from the southwest part of the country and it was sometimes associated with the Horro sheep.

Table 1. Some of the Ethiopian sheep breeds

Breed	Common name	Local name
Afar	Danaki, Adal	Danaki, Adal
Arsi-Bale	Ethiopian Highland, Abyssinian	Ethiopian Highland, Abyssinian
Blackhead Somali	Berber Blackhead, Blackhead Ogaden	Blackhead Ogaden, Boran, Adal, Afar Blackhead
Bonga	-	Bonga
Horro	Abyssinian, Ethiopian, Bonga, Wellega	
Menz	Ethiopian Highland, Abyssinian, Legagora	Ethiopian Highland, Abyssinian, Legagora
Tukur	Lasta, Ethiopian Highland, Abyssinian	Abyssinian

Source; DAGRIS (2004)

The distribution of sheep breeds in Ethiopia showed that: Horro breed is found in highland of western Ethiopia (west Shewa, Wellega, Kaffa and Illubabor); Afar/Adal breed is found in Afar Region and parts of Dire Dawa and South Wollo with the Afar pastoralists; Tukur breed also found in highlands of northern Ethiopia (parts of Tigray, Gondar and Wollo); Menz breed found in the highlands of north Shoa and some parts of south Wollo and Arsi-Bali breed found in highlands Arsi-Bale, Hararge, Sidamo, South Shoa; Blackhead Somali breed found in rangelands of eastern, south-eastern, southern and south-western Ethiopia; Gumuz found in north-western and western part of the country (Workneh *et al*., 2004; Solomon, 2007).

2.4. Sheep Population and Distribution in Ethiopia

Ethiopia is second in Africa and sixth in the world in terms of sheep population (FAO, 2003). In Ethiopia, sheep breeds have developed to live in a wide variety of environments, from desert to humid rainforests. Breeds which have to survive a long dry season often have a fat tail or rump which is a store of energy equivalent to the hump of camels or cattle. Breeds which walk long distances have long legs. Flock structure is a reflection of the system of management that explains to some extent the management objectives and strategies. The flock size in Ethiopia is smaller in the highlands compared with the lowlands (Wilson, 1982). Flock size is generally larger in the pastoral areas and is smaller in the humid agricultural regions (ILCA, 1979; Bayer, 1984). The mean flock size of Menz sheep at Debre Berhan area was 23.8 head and ranged from 2 to 83 (Agyemang *et al.*,1985).

2.5. Special Attributes of Sheep

Sheep is highly adaptable to a broad range of environments. They can utilize a wide variety of plant species and can be raised under mixed grazing condition complementary to goats, cattle and camels. They can efficiently utilize marginal and small plot of land as well. Due to their short gestation length and prolific reproductive rates, sheep has high production efficiency compared with large ruminants (Winrock International, 1976).

There is a faster turnover of capital because sheep sexually mature early and are young at slaughter. Smaller carcasses are also easier to market and consume in a short period. This is important as most rural areas lack proper storage facilities. Sheep produce lower absolute quantities of milk than cattle. However, when their body weight is taken in to account, their milk yield is higher than other species with the possible exception of camels (Wilson, 1991).

Under tropical environmental conditions, sheep is raised primarily for meat. Although milk is an important asset from sheep, it is rarely milked in Ethiopia. Pastoralists keep large flocks of sheep for subsistence, income, breeding, restoring wealth and social prestige. At a subsistence level, sheep is kept for occasional slaughter for meat. Sheep is sold regularly in exchange for small commodities and food items. Some male sheep are kept for reproduction purposes. At the age of four-five years, such male sheep are castrated for fattening. They have a high reproductive rate. In favourable conditions, a ewe can give birth every eight months, and the generation interval is less than two years. A high reproductive rate is important in an unfavorable environment where even now and then the numbers of animals are reduced by natural events, such as drought. After drought when the environment again becomes favourable, the numbers of sheep build up quickly (Gatenby *et al.,* 1991).

2.6. Reproductive Performance

Good reproductive performance is a prerequisite for any successful livestock production systems. In any small ruminant production system, high reproductive performance is a very important attribute and a major component of the overall production efficiency (Owen, 1976). It is the single most important factor influencing flock productivity (ILCA, 1990). Reproductive performance can be measured through age at puberty, age at first lambing, lambing interval and litter size of the breed. In addition to the animal genetic potential, environmental factors such as nutrition, management and climate impact reproduction performance of a breed.

2.6.1. Age at puberty

Puberty in the ewe lamb is the time at which estrous cycle starts. The age at puberty depends primarily on the growth of the lamb, which depends on the supply of sufficient and quality nutrition during the growth period. Well-fed lambs may reach puberty at nine months, but with inadequate nutrition, puberty may not be realized until twenty months (Gatenby *et al.,* 1991). Awassi lambs on a good diet first display oestrus at an average age of 274 days (Younis *et al*., 1978) but Rambouillte crossbred lambs in Rajasthan were about 615 days old at puberty (Kishore *et al*., 1982). Females, however, are somewhat slower than males in reaching sexual maturity. The age of puberty for females ranges from 5 to 20 months depending on breed, nutrition, and date of birth (Ensminger, 2002). Age at puberty in the ram is the time at which the ram lamb is able to successfully mate for the first time. As in the ewe, the age at puberty in the ram depends very much on management, particularly on the level of feeding. Rams may reach puberty at four months under intensive managements and it can take two years under extensive management conditions (Gatenby *et al*., 1991). Age of puberty influences both the production and reproductive life of the female through its effect on her life time lamb crops.

2.6.2. Age at first lambing

Average age at first lambing ranged from 11 to 24 months for west and central Africa ewes (Charray *et al*., 1980). West African Dwarf sheep tend to have their first offspring before they are two years old. Age at first lambing of some of Ethiopian sheep breeds are summarized in Table 2, and ranges from 13 to 24 months. The average age at first lambing of 17 months were reported for sheep in Adaa Leben and Menz sheep around Debre Berhan area, respectively (Niftalem, 1990; Samuel, 2005). Season of birth influences age at first lambing through its effect on feed supply and quality (Donney *et al.,* 1982). In some areas the effects appear to be related to the managements practices adopted (Wilson, 1986b)**.** Year and season in which the ewe lamb was born, influence the age at first lambing. In addition, it can be related to the management practices adopted rather than to any biological effects (Donney *et al*., 1982; Wilson and Murayi, 1988). The type of birth of the ewe significantly affects the age at which the ewe first lambed.

Lambs in multiple litter attained age at first lambing later than single born contemporaries (Wilson and Murayi, 1988). Maternal parity also significantly affects the age at first parturition. Offspring of young and old ewes mature later than those from dams in the intermediate age groups (Wilson, 1986a).

Table 2. Age at first lambing (AFL) of some sheep breeds of Ethiopia

Breed/type	AFL (days)	Source
*Menz	390-540	Agyemang *et al*.(1985)
Menz	495	Gautsch (1987)
*Menz	450-660	Abebe (1999)
Thin-tailed	411	Mukasa *et al*.(1986)
*Menz	477-547	Niftalem (1990)
Blackhead Somali	666.73	DAGRIS (2004)

*= On farm, AFL=Age at first lambing

2.6.3. Lambing interval (LI)

The mean lambing interval of ewes in the Maasai pastoral system in Kenya was 312 days (Peacock, 1996). Season of lambing significantly affected subsequent lambing interval, those ewes that lambed in the short dry season had the shortest interval than those lambed in the long dry season (Peacock, 1996). The average lambing interval of sheep around Debre Berhan area and Blackhead Somali sheep were 11.5 and 10.5 months, respectively (Agyemang *et al*., 1985; Beniam, 1992). The lambing interval of some Ethiopian sheep breeds is shown in Table 3. Values for the lambing interval of Ethiopian sheep breed ranges from 7.6 - 13.6 months. Through provision of satisfactory nutrition and proper management in the tropics, a lower lambing interval can be achieved. Three lambing from indigenous sheep in two years were reported by Aseidu *et al.* (1983). In West Africa, ewes lambing at even a six months interval, without provision of any supplementary feeding, were possible. Sex of the offspring has also impact lambing interval. In a Sahel type sheep lambing interval following male lamb crop was longer than the following female lamb (Wilson and Durkin, 1983).

2.6.4. Litter size

Litter size depends on the number of eggs shed by the ewe, i.e. her ovulation rate. Ovulation rate varies between breeds of sheep; increase with age of ewe up to six years, and is greater for seasonally breeding ewes in the first half of the breeding season (Hafez, 1974). Liter sizes of some Ethiopian sheep are given in Table 3. Biological and economic efficiency of sheep production is influenced by the number of lambs reared per ewe (Haresign, 1985).

Table 3. Lambing interval and litters size of some sheep breeds of Ethiopia

Breed/type	LI (days)	Litter size	Source
*Menz	350	-	Agyemang *et al*.(1985)
Menz	249	1.04	Gautsch (1987)
*Menz	229-273	1.03	Abebe (1999)
Thin-tailed	239	-	Mukasa *et al*.(1986)
Afar (Adal)	-	1.05	Wilson (1982)
*Menz	381-409	1.02	Niftalem (1990)
Blackhead Somali	315.97	-	DAGRIS (2004)
Blackhead Somali	-	1.00	Coppock (1994)
Menz	-	1.13	Mukasa *et al*.(2002)
Horro	-	1.14	Mukasa *et al*.(2002)
Local sheep around Dire Dawa	336-338	1.01	Aden (2003)
Washera	253	1.16	DBARC (2006)
Horro	-	1.53	Solomon (1996)
Horro	-	1.04	Galal (1983);Wilson (1991)

* = On farm results LI=Lambing interval

Horro sheep breed is the most prolific breed among the Ethiopian breeds with a litter size of up to 1.53 followed by Washera and Menz. Litter size of West Africa Dwarf sheep breed in south west Nigeria is 1.23 (Mack, 1983). Parity had a significant effect on litter size.

Litter size increases with increase age of the dam up to about five years or fourth parity, and decreases slightly thereafter (Wilson *et al.*, 1985; Wilson and Sayers, 1987). Level of nutrition influences litter size, with poor nutritional conditions during service period leading to reduced ovulation rate and increased embryo mortality and consequently decreased litter size (Gatenby, 1986; Gautsch, 1987).

2.6.5. Annual reproductive rate

Annual reproductive rate is defined as litter size times 365 days divided by lambing interval in days. Annual reproductive rate of sheep was 1.03 lambs /ewe/year for sheep around Debre Berhan area (Agyemang *et al*., 1985). Annual reproductive rate of Africa sheep varies from 1.10 to 1.36. It is affected by the year and season of lambing; being highest during the small rainy season and lowest when lambing occurred during the dry season. This may be due to the fact that ewes that lambed during the dry season had longer subsequent lambing interval than those that lambed during the rainy season (Gautsch, 1987; Niftalem, 1990).

2.7. Flock Offtake Rate

Offtake is generally meant to represent the proportion of animals leaving the total herd or flock annually. This could be in the form of deaths, slaughters, sales or other transactions such as exchanges, gifts, or loans. In sub Saharan Africa, measurement of small stock offtake is subject to a high degree of inaccuracy, partly because of lack of reliable data on small ruminant population, growth and production parameters, The unofficial small stock slaughter and marketing of animals also makes data collection for offtake estimation difficult. Offtake are mainly males since most females are reserved for breeding. Disposal percentage of sheep production around Debre Berhan area noted 6.5%, 7.8% and 25, 1% for deaths, slaughters, and sells, respectively (Agyemang *et al*., 1985). In Ada district of the Ethiopia highlands, annual sheep offtake rates for commercial purposes and home consumption were 18.4% and 7.3%, respectively (Mukasa *et al.*, 1986). Offtake was 28% for Sahel type sheep in the Sudan (Wilson, 1976) and 26.8% for West Africa long-legged sheep in Mali (Wilson, 1986a).

2.8. Mortality of Sheep

Ndamukong (1985) reported that lamb mortality accounts for serious losses in sheep production and is thus a major factor reducing profitability of sheep farming. In Ethiopia, disease alone accounts for mortalities of 30% in lambs and 20% in adults (Demelash *et al.*, 2006). Other predisposing factors affecting lamb mortality include breed type, age of lamb, litter size, season of birth, nutrition, birth weight, management, and parity of the ewe (Armbruster *et al.*, 1991; Mukasa-Mugerwa, 1996; Ibrahim, 1998). Mortality rate of some Africa sheep breeds are presented in Table 4. Animals born as twins have much higher death rates than those born as single mainly due to lower birth weights and lower milk availability per lamb. The majority of lamb mortality occurs within seven days of birth (Gatenby *et al.*, 1997). Lamb mortality is higher for lambs born from younger ewes than those born from older dams. Most sources on lamb mortality report that the average death loss of lambs at national level is somewhere in the range of 20 to 25% of the number of lambs born. Under most circumstances, it would be impractical to have a production goal of zero mortality. However, proper management of the flock at key times of the production cycle can reduce the amount of lamb mortality. A realistic goal of 10% lamb mortality is attainable by most producers. Gemeda *et al*. (2002) reported that survival rate was significantly ($P<0.001$) affected by birth weight of lambs. The lightest lambs generally had the highest mortality rate.

2.9. Pre-weaning Mortality

Lamb mortality is an important constraint limiting productivity. Studies indicate that up to 50% of the lambs born can die mainly due to diseases and other causes such as adaptation failure, dystocia, cold stress, starvation and mismothering (Hinch *et al.*, 1986**)**. The overall mortality rate of flock averaged 20% and mortality rate was influenced by many factors whose importance varied with lamb age. The per-weaning mortality rates were 25.3% and 8.8% for Horro and Menz sheep, respectively (Markos, 2006). Pre-weaning mortality of some Africa sheep breeds are presented in Table 4. Up to 40% pre-weaning lamb mortality rate was recorded in Nigeria (Ademosun, 1997).

In Uganda, the pre-weaning mortality rate of East African Blackhead sheep was 16% to 20% for singles and 28% for twins (Trail and Sacker, 1966 cited by Niftalem, 1990). Wilson, (1986b) reported that the mean mortality rate from birth to weaning at four months was 33% and the effects of year of birth, month of birth, single or twins, and parturition number of ewe were significant. The effect of sex was significant and females survived well than males, single born lambs had consistently higher survival than lambs born as multiples. Average pre-weaning mortality rates were 17% and 32% for Menz and Horro sheep, respectively (Markos, 2006). Lamb mortality rates vary from one flock to another depending mostly on management level. The major factors affecting lamb survival include age of lamb, litter size, birth weight, seasons of birth, nutrition and parity of the ewe (Gatenby *et al.*, 1997; Armbruster *et al.*, 1991). According to Gatenby (1986), prenatal lamb losses could be greatly reduced by good management, in some tropical commercial sheep flocks in Brazil and South Africa, 20% and 10% of the lambs are stillborn in traditional managed sheep production systems of the tropics, lamb mortality between birth and 150 days of age is estimated to be between 10-30% (Gatenby,1986).

According to Fithugh and Bradford (1983), improvement in ewe nutrition during pregnancy has reduced lamb mortality from 23% to 11%. The authors have also concluded that surviving the first week after birth does not ensure a lamb’s survival at perinatal stage because there are also other determining factors such as poor nutrition, diseases and parasite burden before and after weaning which influence the ultimate productivity of the animal. Average pre-weaning mortality rate in breed is 27.7% for single born lambs and 38.5% for twin born lambs. Similarly, Ibrahim (1998) stated that lambs born singly often have a higher survival rate than twin or triplet births; twins and triplets have a lower survival rate due to delivery mal position coupled with low weights at birth. Martinez (1983) reported that mortality percentages for Barbados Blackbelly of 19.1 and 43.0 percent at birth to 90 days and from 90 to 120 days, respectively.

Table 4. Pre-weaning lamb mortality rate of some Africa sheep breeds

Breed/type	Country	*MR	*PWM	Source
Africa long fat tailed	Rwanda	17.5	-	Wilson and Murayi(1988)
Maasai	Kenya	32.1	-	Wilson *et al.*(1985)
Menz	Ethiopia	39.5	-	Niftalem (1990)
Black headed	Ethiopia	21	-	Belete (1985)
Black headed	Ethiopia	46	-	Coppock (1994)
Menz	Ethiopia	29	-	Ibrahim (1998)
West Africa Dwarf	Ghana	32	-	Ngere and Aboagye (1981)
Sahel	Mali	30	-	Wilson and Traore (1988)
Nungua Black-head	Ghana	16	-	Ngere and Aboagye (1981)
Menz	Ethiopia	-	17	Mukasa (2002)
Horro	Ethiopia	-	32	Mukasa (2002)
Native sheep	Mali	-	30	Wilson (1982)
Yankasa	Nigeria	-	39	Otchere *et al.*(1985); Adu *et al.* (1985)
Djallonke	Senegal	-	33	Fall *et al.*(1982)
Menz	Ethiopia	16.8	17.71	Abebe (1999)

*MR=Mortality rate, PMR=Pre-mortality rate

2.10. Causes of Mortality

Major causes of lamb mortality are predators, diseases, losses and drought/malnutrition. For Menz sheep, 63% of the total death was due to diseases, predators, accidents and malnutrition (Niftalem, 1990).Type of birth, lambing seasons and level of managements also impact lamb mortality rate. Twins generally have a higher mortality rates than those born as singles. With regards to seasonality, mortality is greater born in the long dry season. There is a very large difference between the mortality rates observed between the best and the worst flocks in the Maasai pastoral system in Kenya (Peacock, 1996). In the Dire Dawa area of Ethiopia, the greatest cause of death to sheep was apparently disease, which was responsible for more than half of the mortality rate (57.32%).

This was followed by predators (14.63%), miss-mothering (12.20%) and accident (8.54%) reported by (Aden, 2003). In the Maasai pastoral system in Kenya, Peacock (1996) reported that 44% of the death was due to disease, predators and drought/malnutrition, and 15% due to losses and others causes comprising the rest.

2.11. Body Weight and Linear Body Measurements of Sheep

Body weights of male and female at different dentition classes vary greatly. Sheep at Debre Berhan area, the body weight of female and male Menz sheep were 22.7 kg and 27.2 kg for one dentition class, 24.7 kg and 30.4 kg for two dentition class, 25.6 kg and 33.8 kg for three dentition class and 27.7 kg and 28.7 kg for fourth dentition class, respectively (Agyemang *et al*., 1985). Body weight of the sheep at various ages was significantly affected by breed, birth type, and birth season (within year). The Horro sheep had large body weight than their Menz contemporaries by as much as 6% to 18% (Markos, 2006). In all age categories males were heavier than females in both breeds. The weight of Menz and Horro sheep were 16.2 kg and 16.1 kg at 12 months and 24.2 and 26.6 kg at 24 months of age, respectively (Markos, 2006). There is great deal of variation in body weight at different stage of growth within the breed and flock (Zewdu, 1991; Beniam, 1992).

Linear body measurements are significantly affected by sex of the animals, age of the animals, breed type and types of birth. Horro sheep are different in their body measurements from Menz, significantly at the age of 365 days. They are taller and longer but have a comparable heart girth, wither height at 180, 270 and 365 days of age were 50.93 cm, 55.13 cm, and 59.89 cm for male Menz lambs and 52.06 cm, 57.86 cm, and 61.91 cm for male Horro lambs, respectively (Kassahun, 2000). Similarly, Markos (2006) reported that the Horro sheep had significantly ($p<0.05$) larger body weight at 3, 12 and 24 months of age than the Menz by as much as 6 to 18%. For Menz and Horro breeds lambs born single were significantly ($p<0.05$) heaver than those born as twins or triplets all age categories, males were consistently heavier and larger in size than females (Markos, 2006).

Table 5. Body weight and body measurements of some sheep breeds

Breed/type	Location	Age (month)	HG (cm)	BL (cm)	HW (cm)	BW (kg)	Source
Menz (ewe)	Ethiopia	24	66.9	61.9	63.9		Markos (2006)
Blackhead Somali	Ethiopia	Mature	76.5	61.2	61.1	29.5	DAGRIS (2004)
Horro (ewe)	Ethiopia	24	67.2	65.4	67.3	-	Markos (2006)
Adal (ram)	Ethiopia	Mature	-	-	66	38	Galal (1983)
Sudan Desert (ram)	Sudan	Mature	-	-	80	60	Wilson (1991)
Red Masai (ram)	Kenya /Tanzania	Mature	-	-	70	41	Wilson (1991)

HG=Heart girth, BL=Body length, HW= Height at withers, BW=Body weight.

2.12. Estimation of Body Weight from Linear Body Measurements

Body measurements could be used to predict live weight fairly well in the situation where weighbridges are not available (Berge, 1977; Buvanendran *et al.*, 1980; Goonerwardene and Sahaayuraban, 1983). Knowing the body weight of animals is important for a number of management reasons, related to breeding for selection, marketing, feeding and health care. In addition, body weight determination is a major concern for the sheep buyers especially for rams selected for slaughter. Various linear body measurements are of valuable in judging the quantitative characteristics of meat and also important for developing suitable selection criteria (Islam *et al.*, 1991). Body measurements are considered as qualitative growth indicators which reflect the conformational changes occurring during the life span of animals (El-Feel *et al.*, 1990). Body weight can be reasonably estimated from some linear body measurements (Mayaka *et al.*, 1995).

As such some linear body measurements have been used to predict body weight by several authors in many breeds of sheep (Thys and Hardouin, 1991; Kasahun, 2000; Afolayan.*et al.*, 2006). Enevoldsen and Kristensen (1997) reported that different model may be needed to predict body weight in different environmental conditions and for different breeds. In Yankasa sheep breed in Nigeria; body weight was highly correlated with body dimensional traits (body length, heart girth and height at withers (r= 0.76 - 0.94). Of the body dimensional characters, heart girth was the most correlated trait to body weight and correlation between these two traits was r = 0.94. All variables such as height at wither, body length, heart girth, which are directly related to the size and weight of the animal, displayed moderate to high positive correlations with one another r = 0.79-0.87 (Afolayan *et al.*,2006). For Poulfouli sheep in north Cameroon; the heart girth explained 86.5 and 90.8 percent of the variation in the body weight of rams and ewes, respectively Thys and Hardouin (1991) suggesting that body weight can be reasonably estimated from heart girth measurements. Similarly, Kasahun (2000) reported that body weights of Menz and Horro sheep breeds at 6, 9 and 12 months of age could be fairly accurately estimated from heart girth measurements.

For Yankasa ewes in Nigeria kept under the semi-intensive system of management; Fasae *et al.,* (2005) developed a prediction equation of Y= -44.14 + 2.55X where Y = body weight (kg) and X = heart girth (cm). In Nilotic sheep both sexes, heart girth was highly correlated with body weight (r = 0.98 and 0.96) for males and females, respectively relative to wither height and scapuloischial length (r = 0.93 and 0.91) for males and (r = 0.91 and 0.92) for females, respectively (Atta, 2004). The prediction of body weight of Nilotic sheep can be based on y = 0.0001668 x2.867 for males and y = 0.0010674x2.407 for females, where y and x are body weight and heart girth (Atta, 2004). The method is more common for cattle (El Khidir, 1980), to a lesser extent for sheep, pigs and poultry (Lawrence and Fowler, 1997). According to Sulieman *et al.* (1990); Lawrence and Fowler (1997) added that the coefficient of determination of multiple regression of heart girth and any other linear measurements on body weight was slightly higher than that of the simple regression of heart girth on body weight. The authors concluded that live weight estimations based on two or more body measurements were not more accurate than the estimations based on heart girth alone (Thys and Hardouin, 1991; Ewnetu, 1999).

3. MATERIALS AND METHODS

3.1. Study Area

The study was conducted in Shinile and Erer districts of Shinile Zone of the Somali National Regional State (SNRS).

3.1.1. Location and area coverage

The Shinile zone is one of the nine zones of the SNRS. Shinile is named for its largest town, Shinile. Located at the northwestern point of the Somali Region, and stretching across the savanna north of the Amhar Mountains, Shinile Zone is bordered by Somalia (Somaliland) in the east, Djibouti in the north, Dire Dawa administrative council and Jijiga zone in the southeast, Oromia region in the southwest, and Afar region in the west. The zone is located at $9^0$30'-$10^0$45' N and $41^0$15'-$42^0$45' E (Corra, 2004).

Most of the areas fall within an altitude range from 950 to 1,350 m.a.s.l and the zone has a total area of about 85,000 km^2. According to the World Bank (2004), none of the inhabitants of Shinile district have access to electricity. This zone has a road density of 17.3 kilometers per 1000 square kilometers. The average rural household has 1.2 hectare of land compared to the national average of 1.01 hectare of land and an average of 2.25 for pastoral Regions. The Shinile Zone is structured into six districts, i.e., Shinile, Ayesha, Dembel, Erer, Afdem and Mieso. For this study, two districts, Shinile and Erer, representing predominant pastoral and agro-pastoral production systems, respectively (HCS, 2001; SUK, 2002), were selected. The location of the study districts in Shinile zone is presented in Figure 1. Shinile district is one of the 47 districts in the Somali Region of Ethiopia. It is bordered in the south by Dire Dawa, in the west by Erer, in the north and east by Ayesha, and in the southeast by Dembel. The track of the Addis Ababa - Djibouti Railway crosses this district, running in a direct course southwest from Adigale to Dire Dawa (CSA, 2005). It is the largest district in the zone covering a total area of 10,035 km^2 (Corra, 2004).

Erer is the other district selected for this study. It is bordered in the south by the Oromia Region, in the southwest by Afdem, in the west by the Afar Region, in the north by Djibouti, in the northeast by Ayesha, in the east by Shinile district, and in the southeast by Dire Dawa. The track of the Addis Ababa - Djibouti Railway crosses the southern part of this district along the lower slopes of the Amhar Mountains.

3.1.2. Climate, vegetation, soil and water resources

The Shinile zone falls under the hot to warm arid agro-ecological zone (MOA, 1998), comprising 60% arid, and 40% semi-arid agro-ecologies (IPS, 2000). The mean annual temperature varies between 35-40ºC. Furthermore, the zone is characterized by low and intermittent rainfall; having high annual and seasonal variability. The mean annual rainfall ranges from 300-600 mm (Baars and Said, 1998; IPS, 2000). The rainfall pattern in the Shinile zone, is characterized by main season rain (*Karan*) from July to September, and short season rain (*Gu*) from March to April (IPS, 2000; Bonnet *et al*., 2001).

The rangeland vegetation of the Shinile zone is generally described as open woodland, open bush lands and open grassland (Corra, 2004). Short to medium size grass species predominate this area. The major grass species include *Andropogon* and *Chrysopogon spp.* (Tezera, 1998; Baars and Said, 1999). The woody vegetation is dominated by shrubs mainly Acacia species (IPS, 2000).The dominant soil types are fluvisols, lithosols, and regosols (IPS, 2000). The predominant sources of water in Shinile zone are intermittent rivers and riverbeds (Tezera, 1998, UNDP, 2004). During the dry season, water is scarce through out the districts and the possible sources of water for human and livestock use are riverbed wells that are dug and protected in traditional ways. These wells are traditionally named as "*Elle*" or "*Lass*". The important intermittent rivers found in Shinile district are El-baye, Butigi, Kerkar and Heda. On the other hand, Erer district has three main permanent rivers known as Hurso, Gotta and Erer.

3.1.3. Human and livestock demography

Shinile zone has an estimated total human population of 452,112 of whom 237,067 are males and 215,045 are females. Urban dwellers account for 17.6% of the zone's population.The study district, Shinile has a human population of 113,630, of whom 53,000 are males and 60,630 are females; with 23.91% of its population residing in urban areas. Erer has an estimated total human population of 97,957, with 45,760 males and the rest females. The urban dwellers in Erer district are about 19.6% of the district's population. Thus the urban dwellers of both districts are above the Zone average (CSA, 2005). The *Issa* clans who are predominately pastoralists dominate the zone. The *Gurgura*, *Gadabursi* and *Hawiya* who are mainly agro-pastoralists are found in Erer district.

The total livestock population in Shinile zone is estimated to be about 2.75 million, including 0.9 million sheep, 0.8 million goats, 0.8 million cattle, 0.2 million camels and 46, 000 donkeys (IPS, 2000). In Erer district the livestock population is estimated to be 600,000. These include 200,000 cattle, 180,000 sheep, 150, 000 goats and 65,000 camels. In Shinile district, there are about 47,880 cattle, 191,730 sheep, 162,960 goats and 15,120 camels (LCNRDB, 2004).The kind of livestock the pastoralists prefer to keep is mainly governed by the structure and composition of the vegetation. Cattle prefer perennial grasses, while camels prefer bushy vegetation, and the small ruminants prefer heterogeneous landscape with varied grass and browse composition (Oba *et al*., 2000).

3.1.4. Farming systems

The agricultural production system in the Shinile zone is mainly characterized by livestock production with minimal involvement in crop production. The majority of the populations in the zone are pastoralists (Tezera, 1998). About 15-25% is agro-pastoralist, and a small proportion of the zone's populations (less than 5%) are engaged in commercial activities in urban (SUK, 2002). In Erer district, the majority are agro-pastoralists while in the Shinile district they are primarily pastoralists (SUK, 2002). The two most important crops grown by agro-pastoralists are sorghum and maize though sorghum dominates (HCS, 2001).

During the wet season, forage may be available throughout the districts minimizing movement of livestock in search of feed and water. However, the recurrent and prolonged drought occurring in this area usually force both pastoralist and agro- pastoralist to move frequently towards the mountainous areas in the south and east of the districts and to the Oromia region (HCS, 2001).

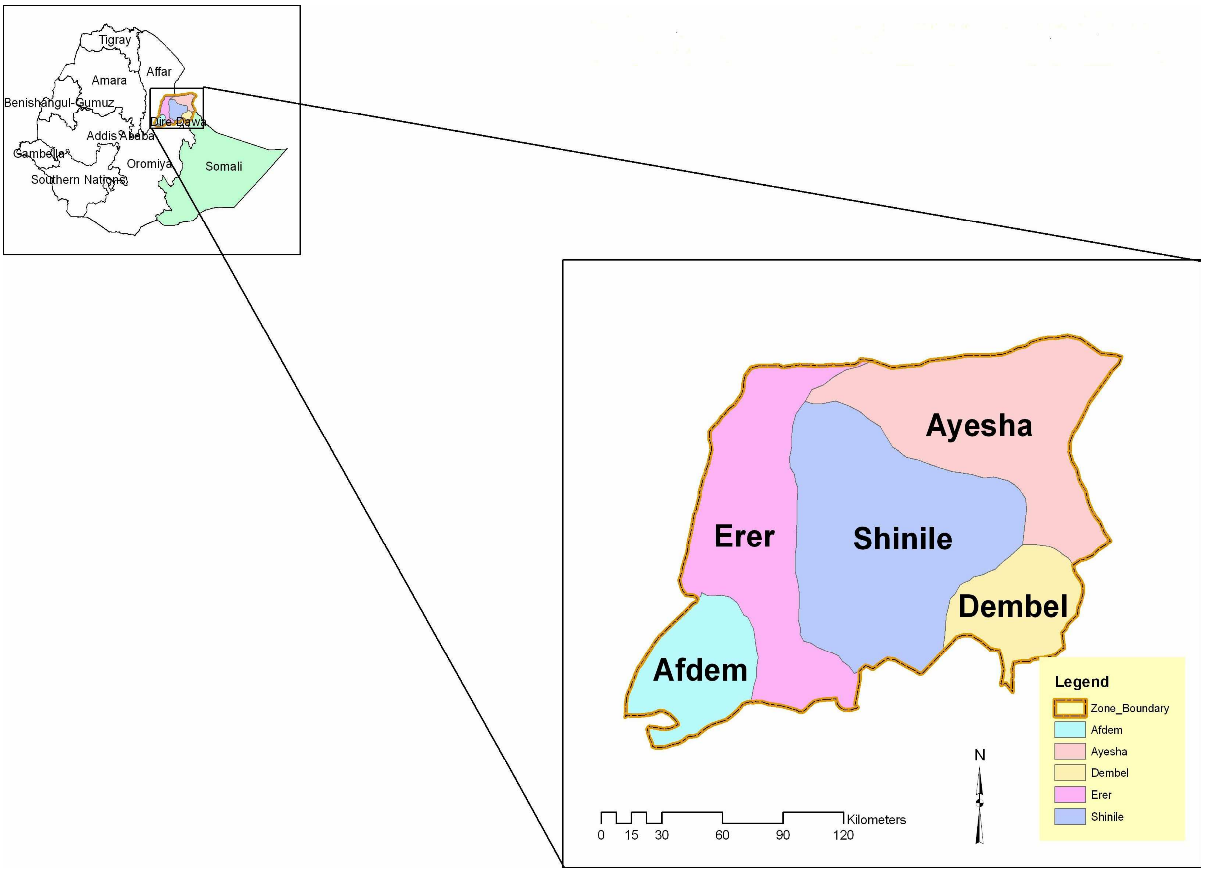

Figure 1. Location of the study districts in Shinile zone

3.2. Sampling Procedure

Study sites were selected based on the production system, concentration of sheep population, seasonal livestock movement patterns and security. A rapid field survey was done before the main survey to know the distribution and concentration of Blackhead Somali sheep breed and the production system of the area to establish sampling framework from which sampling of kebels were taken. Information was collected from Woreda Agricultural Office. Three kebels from each district (Dagah-Jebis, Tome and Lasdere from Shinile district while Gotta, Gode and Asbuli from Erer district) were selected randomly.

A total of 109 households, 55 from Shinile and 54 from Erer districts, were selected (Table 6). For each household survey, structured and pre-tested questionnaire was used. The structured questionnaires were adopted to collect all the pertinent information in a single visit formal survey method (ILCA, 1992). These questionnaire was designed to obtain information from respondents on household socio-economic situation including, history of origin, composition of livestock species, productivity, reproductive performance (age at puberty, age at first lambing, lambing interval, life time lamb crop and productive life), selection criteria for mating, management practices, feed resource utilization and availability, animal health condition, mortality and cause of mortality, trends in population and production constraint.

Group discussions were carried out with three groups per district. The discussion was held with village leaders, elders, women and socially respected individuals. Since it is believed that such individuals would have better information about the overall production potential of the breed as well as the production constraints, information regarding the origin of breed, trend in population, special character of the breed, cause of mortality, production system, husbandry practice, breeding methods and major constraints to maintain the breed, merits and demerits of keeping the breed was collected from group discussions.

Table 6. Summary of the total number of samples

Districts	Study sites	Linear body measurement		Monitoring of lambs	Survey	*GD
		Adult females	Adult males			
Shinile	3	157	73	133	55	3
Erer	3	149	86	97	54	3
Total	6	306	159	230	109	6

*GD=Group discussion

3.3. Data Collection

Both qualitative and quantitative data were collected. The qualitative data were collected using individual interview, group discussions, monitoring and observation of animals, whereas the quantitative data were gathered from field measurements.

3.3.1. Qualitative traits

Sex is an important factor of variation in many traits (Delage *et al.,* 1985). Thus, data on females and males were collected separately. Data on physical descriptions of the breed, i.e. coat color type, coat color pattern, head profile, hair type, ears size, wattle, and muzzle were observed and recorded. With regard to physical descriptions the standard breed descriptor list of FOA (1986a) was adopted. The attribute and code of physical descriptions are indicated in (Appendix Table 1).

3.3.2. Quantitative traits

Quantitative data were collected on a total of 230 Blackhead Somali sheep breed (157 females and 73 males) from Shinile district and 235 (149 females and 86 males) from Erer district. The male sample was less due to the low proportion of matured male animals in the area. The animals were managed under traditional systems.

To assess effect of age on the parameters measured, the animals were grouped by age as shown in Table 7. Measurements recorded were body weight, height at withers, body length, heart girth, tail length, tail circumference, scrotal circumference (male), cannon bone circumference, pelvic width, chest depth, ear length and ear width. Linear measurements were taken using a standard measuring tape, while body weight was measured using a spring weighing scale. List of body measurements is presented in (Appendix Table 2). The age of the animals was determined using the dentition method as described by (Gatenby and Humbert, 1991). Body measurements were taken from animals having one pair of permanent teeth and above by assuming that this is the age at which local sheep start to attain sexual maturity.

Table 7. Age of sheep by its dentition classes and number of sample

Pair of permanent incisor (PPI) teeth	Age range	N
1 PPI teeth	15 to 22 months	175
2 PPI teeth	22 to 28 months	87
3 PPI teeth	28 to 36 months	57
4 PPI teeth	> 36 months	146

N= Number of animals

3.3.3. Monitoring

For monitoring, a total of 230 lambs (133 from Shinile and 97 from Erer district) were used. All lambs were identified by marking with permanent marker on the body of lambs and the name of the owner of the lambs during the initial visit time since; identifying lambs by ear tag are not acceptable by the owners. Monitoring was done at 15 days interval for about five months from September 2007 to January 2008. Data collected were lambing date, sex, mortality, date of death, cause of death and disposal (sales, slaughters, purchase, gift, abortion).

3.4. Statistical Analysis

Data from the individual interview were described using the SPSS software. The physical description and monitoring data were described using SAS (SAS, 1999). The General Linear Model (GLM) procedure of SAS (1999) was used to analyze the linear body measurements. The Duncan multiple range test of Gomez and Gomez (1984) was used for mean separation. Within each group, body weight was regressed on body measurements using least square means by step wise regression analysis (Harvey, 1990) to determine the combination of body measurements for each sex and age that explains variation in the dependent variable (Sharaby and Suleiman, 1987). Separate prediction equations were developed for male and female Blackhead Somali sheep breed, and for different dentition classes. Pearson's correlation coefficients were used to estimate the correlation between body weight and body measurements. The criteria used to select the best fitted regression equation were coefficient of multiple determinations (R^2).

The model used for linear body measurements except scrotal circumferences

$Y_{ijk} = \mu + A_i + S_j + L_k + e_{ijk}$

Where:

Y_{ijk} = the observation of body measurements and body weight

μ = overall mean

A_i = the effect of i_{th} age group (I = 1, 2, 3, 4)

S_j = the effect of j_{th} sex (j = female and male)

L_k= the effect of K_{th} location (K = Shinile and Erer)

e_{ijk} = random residual error

The model used for scrotal circumference

$Y_{ij}=\mu + A_i + L_j + e_{ijk}$

Where:

Y_{ij} = the observation of linear body measurements (including scrotal circumference) and body weight

μ = overall mean

A_i = the effect of i_{th} age group (i=1, 2)

L_j = the effect of k_{th} location (k=Shinile and Erer)

e_{ijk} = random residual error

Pearson's correlation coefficients were estimated between body weight and all body measurements using SAS (1999). Further more, body weight was regressed on body measurements (body length, height at withers, heart girth, tail length, tail circumference and scrotal circumference) using stepwise multiple regression procedure of SAS (SAS, 1999) to determine the best fitted regression equations for the prediction of body weight from linear body measurements for adult animals. The following model was used for the multiple linear regression analysis within sex and dentition class.

For adult male animals:

$$Y_j= \alpha+ \beta X_1+ \beta X_2+ \beta X_3+ \beta X_4+ \beta X_5+ \beta X_6 + ej$$

Where:

Y_j = the dependent variable body weight

α = the intercept

X_1, X_2, X_3, X_4, X_5 and X_6 are independent variables, heart girth, height at withers, body length, tail circumference, tail length and scrotal circumference, respectively.

β_1, β_2, β_3, β_4, β_5 and β_6 is regression coefficient of the variables X_1, X_2, X_3, X_4 X_5 and X_6

e_j =the residual random error

For adult female animals:

$$Y_j = \alpha + \beta X_1 + \beta X_2 + \beta X_3 + \beta X_4 + \beta X_5 + e_j$$

Where:

Y_j = the dependent variable body weight

α = the intercept

X_1, X_2, X_3, X_4, and X_5 are independent variables; heart girth, height at withers, body length, tail circumference and tail length, respectively.

β_1, β_2, β_3, β_4 and β_5 is regression coefficient of the variables X_1, X_2, X_3, X_4 and X_5

e_j = the residual random error

4. RESULTS AND DISCUSSION

4.1. Household Information

4.1.1. Household age and size

Overall age of household heads ranged from 20 to 82 years with a mean of 45.8 ± 14.25years. Similar mean ages were observed form both districts (Shinile 47.4 ± 15.46 years and Erer 44.1± 12.85 years) (Appendix Table 4). Mean family size was 5.6, with male to female ratio of 3:2. More than 50 percent of the respondents' position in the household was household's head and 33 percent was spouse, the remaining were sons, daughters and relatives. In Shinile, 63.6 percent of the respondents' position in the household was household's head and 25.5 percent was spouse of head the remaining were sons, daughters and relatives. While in Erer 48 percent and 41 percent of the respondents' position in the household was household's head and spouse of head, respectively, the remaining were sons, daughters and relatives**.** The overall proportion of married and unmarried respondents was 92.7 percent and 7.3 percent, respectively (Appendix Table 3).

4.1.2. Gender and education levels

Among the household heads, 91 percent were male-headed while only 9 percent were female-headed. In Shinile, 87 percent of the households were headed by males and 13 percent by females, while in Erer 94 percent were headed by male and 6 percent by females. Mulugeta (2005) noticed in Ada Liben Woreda of Eastern Shoa zone that among the household heads, 80 percent were male- headed and 20 percent of the households were female –headed. The respondent's sex ratio was one to one. As far as educational status was concerned, 88 percent were illiterate, 10 percent had informal education (religious school), and only one percent attended elementary school (able to read and write). None of the respondents attended secondary schools (Appendix Table 3). Similarly, Shiferaw (2006) indicated in Fentalle district of East Shoa zone of Oromia region**,** 90 percent of the respondents were illiterate**.**

4.2. Mobility Pattern

Transhumance type of mobility pattern was practiced by 81.8 percent of the households in Shinile district, while in Erer district only 9.3 percent of the households used this practice. Mostly migration was practiced during sever dry seasons (January to April). In Erer districts, 90.7 percent of the respondents' were sedentary. During group discussion they reported that they mobilize their herd to the neighboring districts up to a distance of 100 km. All class of sheep is migrated regardless of their ages and sexes including lactating ewes.

Table 8. Reported migration patterns for Shinile and Erer districts

Mobility pattern	Shinile district		Erer district		Overall	
	*N (HH)	%	*N (HH)	%	*N (HH)	%
Sedentary	10	18.2	49	90.7	59	54.6
Transhumance	45	81.8	5	9.3	50	45.4

*N (HH) =number of households.

4.3. Origin and Distributions of Blackhead Somali Sheep

Neither the sample households interviewed through the questionnaire nor the owners of BHS sheep during group discussions had any specific information on the origin of the BHS sheep breed. A similar situation was reported by Solomon (2007) for Gumuz breed. The common view in the literature is that the breed's natural habitat covers a wide geographical area in East Africa. The Blackhead Persian, developed in South Africa, originated in the arid regions of East Africa. The breed is indigenous to the Ogaden in the Somali National Regional State, Southeastern Ethiopia and found in the lowland areas of Hararghe, Bale and Sidamo Administrative Regions (Girma, 1990). They are also indigenous to Somalia and Kenya where they are known as the Blackhead Somalia (Osman, 1985). The breed is found in neighboring Somali, South Sudan (Toposa breed) and Northwestern Kenya (Turkana, Gabbra or Boran Breed).

4.4. Composition of the Livestock Species

The major livestock species in the study area were cattle, sheep, goats, camels and donkeys. The percentage of livestock possession per household by district is summarized in Table 9. All the households had sheep in the two study areas. This is due to farmers who had sheep were only selected to get more information. Next to sheep, 98.2 percent of the households had goats followed by cattle (58.7%), donkeys (56%) and camels (50.5%). Even though purposive sampling of the respondent may not reflect the true picture of existing livestock ownership pattern in the study areas, according to IPS (2000), sheep and goats were the dominant livestock species in the study area. The higher proportion of sheep (Blackhead Somali) and goat as compared to cattle, might be due to the fact that sheep can thrive well under adverse conditions (feed shortages, and drought) while cattle are considered more sensitive to feed shortages.

In Shinile district, all respondents (100%) had sheep and goats. Donkeys and camels were the next important species owned by i.e. (92.7% and 67.3%) of the respondents, respectively. Donkeys were used for short to medium distance travel and to fetch water from rivers and wells to the village. The possession of cattle was least (43.6%). In Erer district also, sheep (100%) and goats (96.3%) were predominant. However, the next most important species was cattle (74.1%) followed by camels (35.2%) and donkeys (18.5%). This indicates that pastoralists (Shinile district) keep more browsers (goats and camels) and less grazer (cattle) than the agro-pastoralists (Erer district). This might be due to the fact that browsers (goats and camels) depend on a wider range of browse vegetation and can thrive during drought periods than the grazers (cattle and sheep).

Table 9. The percentage of livestock species possession per household with respondents owning Blackhead Somali sheep breed

Species	Shinile district (N=55)		Erer district (N=54)		Overall (N=109)	
	N	%	N	%	N	%
Sheep	55	100	54	100	109	100
Cattle	24	43.6	40	74.1	64	58.7
Goats	55	100	52	96.29	107	98.2
Donkeys	51	92.72	10	18.51	61	56
Camels	37	67.3	18	35.18	55	50.5

N= number of households

Pastoral (Shinile district) households rear various livestock species relatively in large number than the agro-pastoralists (Erer district). Mean number of various livestock species per household in the two districts are summarized in Table 10. The overall least square mean reported in the study areas were 3.78 ± 0.36 for cattle, 19.19 ± 1.2 for sheep, 37.39 ± 3.5 for goats, 3.96 ± 0.45 for camels and 2.39 ± 0.16 for donkeys. None of the respondents reported the existence of mules, horses and chicken in the study areas. However, few chicken were observed during the study period in Erer district.

Table 10. Least square means (±SE) of livestock holding per household in the study area

Species	Shinile district	Erer district	Overall
Cattle	3.45 ± 0.46	4.33 ± 0.59	3.78 ± 0.36
Sheep	25.20 ± 1.77^{b}	13.07 ± 1.78^{a}	19.19 ± 1.2
Goats	53.16 ± 4.93^{b}	20.71 ± 5.07^{a}	37.39 ± 3.5
Camels	5.27 ± 0.79^{b}	3.32 ± 0.55^{a}	3.96 ± 0.45
Donkeys	3.56 ± 0.17^{b}	1.50 ± 0.40^{a}	2.39 ± 0.16

$^{a, b}$ means with different superscripts within the same raw significantly different ***= P<0.001

The average holding of sheep (19.19 ±1.2) in the present study was higher than the average holding of Gumuz sheep (16.02 ± 14.1) at Metema (Solomon, 2007) and (6.97 ± 3.9) around Dire Dawa (Aden, 2003), but lower than the average holding of 24 animals in central highlands of Ethiopia (Abebe, 1999). There was significant difference ($P<0.001$) in herd size between the districts for sheep, goats, camels and donkeys, but there was no significant difference ($P>0.05$) in cattle herd size between in two the districts.

4.5. Current Status of Livestock Species

The perception of households on the population status of livestock species for the last ten years in the study area is summarized in Table 11. On the basis of proportion of respondents, the decline in number was highest for sheep (74.3 %), followed by cattle (73.4%), goats (57.8%) and camel (40%).

Table 11. Percentage of households that indicated population trends of major livestock species for the last ten years in the study area

Species	Shinile district	Erer district	Overall
Camels			
Increasing	18.9	44.4	27.3
Decreasing	32.5	55.6	40.0
Stable	48.6	-	32.7
*N(HH)	37	18	55
Goats			
Increasing	41.8	35.2	38.5
Decreasing	54.5	61.1	57.8
Stable	3.7	3.7	3.7
*N(HH)	55	52	107
Sheep			
Increasing	27.3	24.1	25.7
Decreasing	72.7	75.9	74.3
*N(HH)	55	54	109
Cattle			
Increasing	25.0	22.5	23.4
Decreasing	70.8	75.0	73.4
Stable	4.2	2.5	3.1
*N(HH)	24	40	64

*N (HH) = Number of households

The possible reasons reported by respondents for this trend were mainly rangeland degradation, frequent occurrence of disease, drought, shortage of feed and water. Similar reasons were reported by Belay *et al,* (2005). Contrary to this, Solomon (2007) indicated that the population livestock was increasing in Metema Woreda. It was related to the increasing human population due to resettlement, availability of extensive grazing land and attractive price for livestock due to cross-border market. According to the information generated during group discussions with the owner of BHS sheep in the study area, the drought in the area that occurs every two to three years this has resulted in the decline the number of livestock. The pastoralists are forced to move their sheep to the mountain area in search of feed and water during drought years.

4.6. Major Farming Activities

The overall major farming activities in the study area were livestock rearing (53.2%) followed by mixed livestock and crop farming (24.8%). The major farm activities used for home consumption and income generation are summarized in Table 12. In Shinile district, the majority of households (96.4%) were involved in livestock farming, while in Erer district, crop and livestock farming (48.1%) was the main farming activity. Livestock was a major source of cash income and home consumption in the pastoral area (Shinile district). However, a major source of cash income and household consumption was crop farming in agro-pastoral communities (Erer district). Livestock plays also a central role in determining the wealth and social status of pastoralists and agro-pastoralists. During the focus group discussion, sale of some horticultural crops such as tomato, onions, potatoes and cabbages were also reported to be used as additional source of income mainly in agro pastoral areas (Erer district). The important uses of sheep were mainly as source of cash income, meat, milk, breeding, manure, blood, skin and dowry (Appendix Table 5). According to the respondents sale of sheep to generate income ranked first. The cash obtained is used to buy food items, clothing and household supplies. The average family size of sample households was 5.68 ± 2.7 with the range of two to eighteen persons.

Sheep meat is a favorite food on special occasions such as the celebration of funeral rites, wedding ceremonies, Arafat and Mould. During group discussions, the owners of BHS, sheep are preferred for slaughter, valued and recognized as presents in honors of special guests. Milk of sheep was less common in Erer than Shinile district and ranked third. Functions like manure, skin and others received relatively low ranks among the reasons for keeping sheep (Appendix Table 5).

Table 12. Major farming activities used for home consumption and income generation in the study area

Activities	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Major farming activities						
Livestock only	53	96.4	5	9.3	58	53.2
Crop farming only	1	1.8	23	42.6	24	22.0
Livestock and crop farming	1	1.8	26	48.1	27	24.8
Overall	55	100	54	100	109	100
Major farming activities for home consumption						
Livestock only	46	83.6	6	11.1	52	47.7
Crop farming only	1	1.8	45	83.3	46	42.2
Livestock and crop farming	8	14.5	3	5.6	11	10.1
Overall	55	100	54	100	109	100
Major farming activities for income generation						
Livestock only	54	98.2	6	11.1	60	55.0
Crop farming only	-	-	44	81.5	5	10.4
Livestock and crop farming	1	1.8	4	7.4	44	44.6
Overall	55	100	54	100	109	100

*N = Number of households

Besides, BHS's sheep blood and fat from the tail is a delicacy in certain areas in preparing traditional medicines and is provided to pregnant women to prevent abortion during the last stages of pregnancy. According to the survey, the major crop was sorghum. In Shinile, the majority of households (83.6%) grow sorghum. Whereas, in Erer district combinations of maize and sorghum (46.8%) are the main crops grow. Horticultural fruits such as orange, banana, papaya, lemon and mango were common fruits in Erer district (Appendix Table 6).

4.7. Feed Resources and Availability

Based on interviews made with a total of 109 farmers from Erer and Shinile districts, the main feed resource for sheep is natural pasture during dry and wet seasons. The main feed resource available to sheep in the Shinile district is natural pasture. Bekele (1991) generalized that in Ethiopia the main feed resource are natural pasture, fallow land, stubble grazing and crop residues. The availability of feed for sheep in the study area shows seasonality. In Erer, crop residues from cereals (maize and sorghum) are more important feed sources especially during the dry season when grazing pasture is no more available.

Table 13. Major feed resources during the dry and wet seasons in Shinile and Erer districts

Type of Feed Resource	Shinile district				Erer district			
	Dry season		Wet season		Dry season		Wet season	
	*N	%	*N	%	*N	%	*N	%
Natural pasture	48	87.3	52	96.3	41	75.9	50	92.6
Soy bean and wheat bran	1	1.8	2	1.9	2	3.7	1	1.9
Crop residual and natural pasture	1	1.8	-	-	8	14.8	1	1.9
Leaves of trees and shrubs	5	9.1	1	1.8	3	5.6	2	3.7

*N=number of households

During the dry season the main feed sources that farmers use next to natural pasture were the combination of crop residuals (sorghum, maize stover) and natural pasture in Erer district but in Shinile collecting leaves of trees and shrubs were common. In addition, they move to mountain areas when severe feed shortage. In both areas, pastoralist stressed that lack of feed is the most important limiting factor for productivity of their sheep, and indicated the importance of improving their feeding regime as an essential step towards any improvement program. None of the respondents used concentrate feed. According to 80% the respondents, of seasonal shortage of feed in the area was severe for a period of four to five months every year (December to April). Over half of the number of households used grasses and leaves from shrubs and bushes to overcome seasonal feed shortage. However, 23% of the households were forced to purchase wheat bran and used crop-residues. The remaining pastoralist followed other measurements such as feed wheat bran and sorghum and selling animals (Appendix Table 7).

4.8. Water Sources and Availability

The main sources of water were rivers, wells, natural ponds and springs and their yields decline in the dry season**.** Sheep and goats were usually herded together for watering**.** According to respondents, the major source of water during the dry and wet seasons were rivers (52%) and (54%), respectively. Only small number of respondents used ponds and springs during both seasons (Appendix Table 8). The distances to watering points varied during the dry and wet seasons. The majority of the respondents went their animals up to 10 km in search water during the dry season, but during the wet season distance is reduced to five km. As shown in Table 15, during the wet season, 22 percent of the pastoralist watered ad libitum , 40.4 percent allowed only once a day, whereas 34.9 percent once in two days, and only 2.8 percent once in three days. However, during dry periods 50.5 percent of the respondents provided water once in three days, 27.5 percent once in two days and 16.5% once in a day, and the remaining allowed ad libitum.

Table 14.Watering point in the study areas in different seasons

Watering point	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Wet season						
Watered at home	36	65.5	1	1.9	37	33.9
Less than 1km	2	3.6	8	14.8	10	9.2
Between 1 and 5 km	16	29.1	35	64.8	51	46.8
Between 6 and10 km	1	1.8	10	18.5	11	10.1
Dry season						
Watered at home	1	1.8	1	1.9	2	1.8
Less than 1km	2	3.6	3	5.6	5	4.6
Between 1 and 5 km	35	63.6	32	59.3	67	61.5
Between 6 and10 km	17	30.9	18	33.3	35	32.1

*N=Number of households.

Table 15. Seasonal watering frequency and availability of water in the study area

Frequency of watering	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Wet season						
Freely available	28	50.9	16	29.6	24	22
Once a day	6	10.9	32	59.3	44	40.4
Once in two days	18	32.7	6	11.1	38	34.9
Once in three days	3	5.5	-	-	3	2.8
Dry season						
Freely available	-	-	6	11.1	6	5.5
Once a day	1	1.8	29	53.7	18	16.5
Once in two days	38	69.1	17	31.5	30	27.5
Once in three days	16	29.1	2	3.7	55	50.5

*N=Number of households.

The frequency of watering indicates the watering points are too far from villages. Watering is less frequent in this study compared to similar studies in other places. Watering once in two to three days was common in the lowlands of Dire Dawa area (Aden, 2003). The less frequent watering in the study area might be related to the hot climatic condition of the area.

4.9. Housing Sheep

Livestock housing may vary based on the production system. Good housing can determine productivity by reducing stress, disease hazards and making management easier. Tables 16 indicate that 98.2% and 92.6% of the respondents housed their sheep in corral in Shinile and Erer district, respectively. The pastoralists enclose their sheep and goats together at night. But where the number of animals is large, a separate pen is built for them. From the beginning of April to the end of October, males are kept in a separate pen for the purpose of controlling breeding. About 83.6% and 59.3% of the respondents housed sheep with other species (goats) in Shinile and Erer districts, respectively.

Table 16. Reported housing of sheep in the study area

Type of house	Shinile district		Erer district	
	*N	%	*N	%
Pen constructed				
Corral	54	98.2	50	92.6
In shed made of local materials (wood, stone)	1	1.8	4	7.5
Sheep housed together with other livestock				
Yes	46	83.6	32	59.3
No	9	16.4	22	40.7
Lambs housed with adults				
Yes	1	1.8	6	11.1
No	54	98.2	48	88.9

*N=Number of households

4.10. Herding Practices

Division of labor in sheep rearing activities is presented in Table 17. In this study it was found that the activities performed by adult females were herding, milking, preparation of feed and taking the animals to pasture for feeding and watering the animals and fetching water from distant places and cleaning the corral. There was no shortage of labor and it is not common to used hired labor in the study area. The role of adult males in case of sheep rearing is limited compared to adult females.

Table 17. Division of labor in sheep rearing among age and sex groups of the households

Activities	Age and sex group			
	Male > 15 yrs	Male< 15 yrs	Female >15yrs	Female < 15 yrs
Selling and purchasing	81.7	-	18.3	-
Herding	25.7	11.9	51.4	11
Feeding and watering	10.1	2.8	80.7	6.4
Milking	1.8	-	51.4	9.2
Care for sick animals	10.1	11.9	75.2	2.8

4.11. Breeding Management

In the study area, 78 percent of the respondents practiced partial controlled mating system. The ram run with ewes only during breeding season (December to January) and the remaining 22 percent used uncontrolled mating system. The primary reason for uncontrolled mating is the use of communal grazing area whereby animals from various households graze together. In the partial controlled mating method, the ram is not allowed to run throughout the year. Most farmers had one ram running with the flock throughout the year. About 15.6 percent (n=17) purchase in private.

The majorities (60%) of respondents do not practice special management of rams and the remaining provided supplementary feeds such as wheat bran. The purpose of keeping rams (70.6%) was for mating purpose, for fattening (13.8%) and for both fattening and mating purpose (15.6%). Selection of breeding animals was reported to be practiced in the study areas, and mainly focused on selection of breeding males. Selection of breeding females is not common. Selection criteria for breeding male animal were size, color and age in their order of importance (Table 19).

Table 18. Household's response on Blackhead Somali sheep breeding management

Breeding management	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Mating systems						
Partial controlled	52	94.5	33	61.1	85	78.0
Uncontrolled	3	5.5	21	38.9	24	22.0
Special management for breeding rams						
Yes	21	38.2	28	51.9	49	45.0
No	34	61.8	26	48.1	60	55.0
Purpose of keeping breeding rams						
Mating	33	60.0	44	81.5	77	70.6
Fattening	9	16.4	6	11.1	15	13.8
Mating and fattening	13	23.6	4	7.4	17	15.6
Source of breeding rams						
Born in the flock	49	89.1	43	79.6	92	84.4
Purchased in private	6	10.9	11	20.4	17	15.6
Selection of breeding rams						
Yes	54	98.2	53	98.1	107	98.2
No	1	1.8	1	1.9	2	1.8
Selection of breeding ewes						
Yes	2	3.6	21	38.9	23	21.1
No	53	96.4	33	61.1	86	78.9

Table 19. Ranking of selection criteria of breeding animals reported in Shinile and Erer districts as prioritized by the respondents (weighted average scores)

Selection criteria	Shinile district (N=55)	Erer district (N=54)
Size	1	1
Color	2	2
Age	3	3
Adaptability	7	5
Tail type	4	4
Growth	5	6
Character	6	7

N= number of households

In Shinile, the preferred colors for selecting breeding rams were black head with white body, brown, and pure white in order of importance. In Erer district, animals with brown head and white body followed by black head with white body and lastly pure white preferred. As reported by farmers in Erer district blackheads and white body are less resistant to diseases compared to dark brown head with white body.

Table 20. Summary of ages at marketing and culling of BHS sheep in the study area

	Shinile district (N=55)			Erer district(N=54)		
	Min	Max	Mean± S.D	Min	Max	Mean ±S.D
Market age for males (yr)	0.5	5	2.37±1.34	0.5	6	2.41±1.98
Market age for females (yr)	1	6	3.25±1.21	1	8	3.33±2.04
Culling age for males (yr)	2	6	4.21±1.12	3	4	3.50±0.70
Culling age for females (yr)	2	15	8.14±2.97	5	6	6.50±0.70

N= number of households

In Shinile district, however pastoralist indicated that blackhead with white body have ability to resistant drought than dark brown color. Unwanted color was pure black followed by pure white in Shinile district pure black color in Erer. The reason for this was lower market value (Appendix Table 9).

According to the respondents, pastoralist culled animals for sale at times of financial difficulties. Infertile and old ewes were usually culled first. If the magnitude of the financial problem is high, large numbers of ewes or other smaller animals are culled. Summary of reported market and culling age of BHS sheep in the study area are presented in Table 20. The average at marketing was age 2.37 ±1.34 and 3.25 ±1.21 years for males and females, respectively in Shinile district. In Erer district, the respective age was 2.41±1.98 and 3.33 ± 2.04 years. The marketing age was longer compared to Gumuz breed at Metema area that had 9.69 ± 2.01 and 11.31 ±1.92 months for males and females, respectively (Solomon, 2007). Culling age animals in Shinile district was 4.21±1.12 and 8.14±2.97 years for males and females, respectively, while in Erer district it was 3.50±0.70 and 6.50±0.70, respectively.

4.12. Major Constraints for Sheep Production

The major constraints of sheep production in the study area were scarcity of feed, shortage of water, disease problems (together with poor veterinary services), drought, predators, market problem and lack of extension services. Major constraints of sheep production reported in the study area are summarized in Table 21. Most respondents ranked animal diseases problem as the first constraint. Feed and water shortage have been reported by the respondent as common constraints and ranked second and third. Causes of feed shortage were shortage of grazing land, most lands covered by stone and frequent occurrence of drought. Predators like hyena and fox were the problems in the study area. Market facilities including access to main road and lack of extension services were identified as six and seven constraints, respectively. These constraints as explained by the respondents of Erer and Shinile districts are not different from those reported by others researches (Abebe, 1999; Aden, 2003; Mulugeta, 2005).

Table 21. Major constraints to sheep production in Shinile and Erer districts as prioritized by the respondents (weighted average scores) N=109

Variables	Ranks
Shortage of feed	2
Shortage of water	3
Disease incidence	1
Drought Occurrence	4
Predators	5
Market problem	6
Lack of extension services	7

4.13. Disease and Health Management

About half of the respondents (55 percent) depend on indigenous practices to treat sick animals and 15.6 percent rely on veterinary services to treat their sick animals, while 29.4 percent used both methods (Table 22). The most common external parasite was tick and respondents use; dichloro diphenyl trichloroethane (DDT), water and oil mixed together as an ointment to treat animals from infection. In case of bloat, the swollen part was burnt with a hot iron and pastoralist provide garlic and lemon. Most farmers were not willing to describe openly their traditional healing practices.

According to the respondents, 45 percent got drugs from government and private veterinarians, 43.1 percent from private veterinarians, 2.8 percent from shops and the remaining 9.2 percent from government veterinarians. About 63.3 percent of the respondents walk from six up to ten km and 36.7 percent from one to five km to reach the nearest veterinary services. Poor delivery of veterinary services was reported by most farmers.

Table 22. Percent of respondents who had access to veterinary services, distance to nearest veterinary services and method of treatments

	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Method of treatment						
Indigenous practice	22	40.0	38	70.4	60	55.0
Veterinary services	13	23.6	4	7.4	17	15.6
Both	20	36.4	12	22.2	32	29.4
Access to veterinary services						
Government veterinarian	7	12.7	42	77.8	10	9.2
Private veterinarian	38	69.1	9	16.7	47	43.1
Shop or market	-	-	3	5.6	3	2.8
Government and private	10	18.2	-	-	49	45.0
Distance to nearest veterinary services						
1 up 5 km	36	65.5	33	61.1	40	36.7
6 up 10 km	19	34.5	21	38.9	69	63.3

*N=Number of households.

4.14. Causes of Animal Death

According to the respondent's disease, predator and drought were the major reasons for reduction of number of sheep in the study area. The mean death of sheep during the previous year was 17±1.08 and 13±1.13 in Shinile and Erer districts, respectively. There was significant difference ($P < 0.01$) between districts except death caused by predators. The higher mortality occurred due to diseases in both districts; however, farmers do not know the type of diseases because of absence of veterinary service in the area. According to Shinile Zone Agricultural Office; FMD, Anthrax, Black Leg, Pastrolosis and Babiosis were the major causes of death in the study area.

This result is similar with the reports of Njau *et al.* (1988), Coppock (1994) for Menz sheep under station condition and BHS sheep under traditional management, respectively. Aden (2003) also reported that disease and predators were the major causes of animal loss around Dire Dawa area. The second causes of death in Erer district were predators mainly attacked by hyena and fox but in Shinile both drought and predators had the same effect. This is in agreement with that reported by Aden (2003) and Solomon (2007).

Table 23. Summary of reported sheep death during the 2006/07 year as recalled by the households

Description	No. of deaths	Shinile district	No. of deaths	Erer district	Overall
Predator	274	6.08 ± 0.44	219	6.25 ± 0.5	6.16 ± 0.33
Disease	479	9.97 ± 0.67^{b}	362	7.70 ± 0.68^{a}	8.85 ± 0.49
Drought	185	6.16 ± 0.48^{b}	108	5.14 ± 0.57^{a}	5.74 ± 0.37
Total death	940	17.00 ± 1.08^{b}	674	13.00 ± 1.13^{a}	15.37 ± 0.79

4.15. Characterization of Reproductive Performance

The reported reproductive performance of BHS sheep breed in the study area summarized in Table 24. The poor reproductive performance might be related to inappropriate management practices (poor nutrition, diseases, drought, etc.).

4.15.1. Age at Puberty

The age at puberty primarily depends on the nutrition supply during the growth period. Well-fed ewe lambs may reach puberty at nine months, but when nutrition is poor, puberty may occur as late as twenty months (Gatenby and Humbert, 1991).

Table 24. Summary of reported reproductive performance for BHS sheep breed in the study area (N=109)

Reproductive parameters	Shinile district (N=55)	Erer district (N=54)	Overall (N=109)
	Mean ± S.D	Mean ± S.D	Mean ± S.D
Age at puberty of females (months)	18.98 ± 4.28	16.94 ± 3.37	17.97 ± 3.97
Age at puberty of males (months)	14.05 ± 5.68	13.25 ± 3.81	13.65 ± 4.75
Age at first lambing (months)	24.9 ± 3.72	22.2 ± 2.99	23.56 ± 3.63
Lambing interval (months)	10.9 ± 2.33	10.01 ± 2.77	10.46 ± 2.58
Reproductive life span of ewe (years)	9.4 ± 1.76	8.84 ± 1.56	9.12 ± 1.6
Life time lamb crop (number)	8.4 ± 2.47	7.97 ± 2.03	8.18 ± 2.27

In this study according to the respondents the overall age at puberty in female Blackhead Somali sheep was 17.97 ± 3.97 months, while it was 18.98 ± 4.28 months and 16.94 ± 3.37 months in Shinile and Erer districts, respectively (Table 24).The age at puberty in males also depends very much on management, particularly level of feeding. Rams may reach puberty at four months under intensive management or two years under extensive management conditions (Gatenby and Humbert, 1991). According to respondents in the study area the overall age at puberty in male BHS sheep was 13.65 ± 4.75, while it was 14.05 ± 5.68 months and 13.25 ± 3.81 months in Shinile and Erer districts, respectively. This result may be due to poor management and feeding conditions practiced by pastoral and agro-pastoral farmers.

4.15.2. Age at first lambing

Based on the response of the farmers, the overall estimated mean age at first lambing of BHS sheep was 23.6 ± 3.63 months, while it was 24.9 ± 3.72 months in Shinile and 22.2 ± 2.99 months in Erer district.

This result is closer to the average age at first lambing of 713 days in Rwanda (Wilson and Murayi, 1988) but longer than 495 days and 512 days reported by Gautsch (1987) and Niftalem (1990), respectively for Menz breed at Debre Brehan. It is also longer than the thin tailed sheep and Gumuz sheep (411 days and 13.7 months) by (Mukasa Mugerwa, 1986) and (Solomon, 2007), respectively and longer than 666.73 days reported for the same breed (Beniam, 1992). Generally, this result is longer compared to the report of Wilson (1986c) who indicated that age at first lambing ranges from 15 to 18 months for most of traditionally managed ewes. But it ranges for west and central Africa ewes from 11 to 24 months (Charray *et al*., 1980). This wide range of age at first lambing is due to late maturity and poor management conditions in the study area. Early lambing, however, reduces replacement costs, increases animal and economic turnover rates and may lead to more rapid genetic improvement (Wilson and Durkin, 1983). Season of birth influences age at first lambing through its effect on feed supply and quality (Donney *et al.*, 1982).

4.15.3. Lambing interval

Lambing interval is affected by nutrition and management (Aseidu *et al.,* 1983), season (Wilson and Murayi, 1988; Peacock, 1996; Abebe, 1999), sex and breed (Wilson and Durkin, 1983), and year of lambing (Niftalem, 1990). The overall estimated mean lambing interval for BHS Sheep was 10.46 ± 2.58 months, while it was 10.9 ± 2.33 months in Shinile and 10.01 ± 2.77 months in Erer district. This value is closer to that reported for the same breed in Werer research station which was 315.97 days (Beniam, 1992) and 312 days reported by Peacock, (1996) in the Maasai pastoral system in Kenya, but it is rather shorter than that reported for Adal breed 365 days (Wilson, 1982), Menz breed 345 days (Agyemang *et al.*, 1985) and 395 days (Niftalem, 1990) for the same breed. This is due to some partial control method of mating performed specially in pastoral area (Shinile district).

4.15.4. Reproductive life span

According to the respondents the average overall reproductive life span of ewes was 9.12 ±1.6 years, while in Shinile it was 9.4 ± 1.7 years and in Erer it was 8.8 ± 1.5 years. This value is higher than that reported for Gumuz ewes which were 8.15 ±1.14 years by Solomon (2007).

4.15.5. Life time lamb crop

According to the respondents, on the average an ewe can produce 8.18 ± 2.27 lambs in her life time with the range of 4.5 to 15 lambs, while in Shinile it was 8.4 ± 2.47 and in Erer it was 7.97 ± 2.03 lambs. This number is lower than that reported for Gumuz breed (13.47 ± 1.76) lambs with a range of 10 to 18 lambs reported by Solomon (2007)**.** This could be due to the fact that single birth is common for this breed rather than short reproductive life span of the breed**.**

4.15.6 Weaning and castration of BHS sheep

Average weaning age of BHS sheep is summarized in Table 25. According to the respondents, the overall average weaning age was less than three months (41.3%) and the remaining 58.7 percent was greater than three months. The majority (65.5 percent) of pastoralist in Shinile district allow the lamb to suckle their ewes for less than three months. However, the remaining pastoralists wean the lambs after three months of age. About 16.7 percent in Erer district of the sample households' weaning takes place at less than three months. The remaining wean after three months. A traditional method (wood) of castration was most widely practiced in the study areas. Castration is performed for two reasons, namely, to control breeding and to fattening of rams for better price, but little importance is attached to the latter in some localities and high percentage occurred for combination of the two reasons (Appendix Table 10). According to the respondents, the average age of castration was 2.01 ± 1.16 years and castration at this age allows for a service period of one to three years. Some farmers (46.8%) provided extra feed for their animals after castration, for maximum of one week mainly wheat bran and *Enjera* (Appendix Table 10).

Table 25. Summary of reported weaning age of Blackhead Somali sheep in the study area

Average weaning age	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
<3 months	36	65.5	9	16.7	45	41.3
3-4 months	11	20.0	19	35.2	30	27.5
5-6 months	6	10.9	23	42.6	29	26.6
> 6 months	2	3.6	3	5.6	5	4.6
Total	55	100	54	100	109	100

*N=Number of households.

4.16. Pre-weaning Mortality Rate

A total of 110 deaths of lambs were recorded and pre-weaning mortality rate for the period from September 2007 to January 2008 was 47.8%. This is in agreement with earlier report, i.e. 10-50 percent was recorded to be common in young lambs up to weaning (Gatenby and Humbert, 1991; Ibrahim, 1998). However, it is very high as compared to traditional managed flocks in the tropics i.e. 10-30%, 40% in Nigeria and 33% reported by Gatenby, (1986), Ademosun (1997), Wilson (1986b), respectively. The overall average pre-weaning mortality rate of this study is higher than that reported for Horro and Menz sheep, 17 percent and 32 percent, respectively reported by Markos (2006). The pre-weaning mortality rate was high in Shinile compared to Erer district i.e. (49.6% and 45.4%, respectively).

The mortality rate recorded in this study was higher in females than in male lambs. This is in disagreement with Markos (2006) who indicated that the effect of sex was significant and females survived well than males. Pre-weaning mortality rate was influenced by many factors such as litter size (Gatenby *et al.*, 1997; Markos, 2006) and (Ibrahim, 1998), year of birth, month of birth (Gatenby *et al.*, 1997) and management level.

Table 26. Percentage of pre-weaning mortality rates of Blackhead Somali lambs

Variables	Number of lambs	Pre-weaning mortality rates	
		*N	%
Sex			
Male	95	41	43.2
Female	135	69	51.1
District			
Shinile	133	66	49.6
Erer	97	44	45.4
Overall mean	230	110	47.8

*N= number of death of lambs

According to Gatenby (1986) the major factors affecting lamb survival include age of lamb, litter size, birth weight, seasons of birth, nutrition and parity of the ewe (Gatenby *et al.*, 1997; Armbruster *et al.*, 1991; Notter *et al.*, 1991). Trail and Sucker (1969) reported that the average pre-weaning mortality rate in East African Blackhead sheep ranged from 16 to 20 percent for single born lambs and 28 percent for twin born lambs. Generally the result for this study indicates high level of pre-weaning mortally rate in the study area.

4.17. Causes of Pre-weaning Mortality

About 59.1% of the total deaths of lambs attributed to disease. Thus, the cause of death due to diseases could be predominantly tick infestation. About 15.5% of the total death occurred due to predators. Diseases were most important in lambs during the first three months of age. Generally, disease and predators caused more damage than other factors in both districts. Lamb mortality is one of the most important constraints limiting productivity of sheep in the area. Studies indicate that up to 50% of the lambs born can die mainly due to diseases and other causes such as adaptation failure, starvation and mismothering (Hinch *et al.,* 1986**)** which is similar to the present study.

Table 27. Causes of pre-weaning mortality of sheep in the study area

Causes of pre-weaning mortality	Shinile district		Erer district		Overall	
	N	%	N	%	N	%
Disease	38	57.6	27	61.4	65	59.1
Heat stress	4	6.1	7	15.9	11	10.0
Predators	11	16.7	6	13.6	17	15.5
Mismothering	3	4.5	1	2.3	4	3.6
Malnutrition	10	15.1	2	4.5	12	10.9
Accidents	-	-	1	2.3	1	0.9
Overall	66	100	44	100	110	100

The Blackhead Somali Sheep population in Shinile zone is about 0.9 million (IPS, 2000). Based on sex ratio in the present study, it may be predicted that the females (63%) and males (37%) are 570,600 and 329,400 heads, respectively. Assuming reported lambing rate i.e.1.0 lamb per year, these ewes will produce 570,600 lambs per year. Taking into consideration the male (50%) to female (50%) sex ratio, about 285,300 male lambs and 285,300 female lambs per year are produced. Based on the mortality rate (47.8%) reported in this study, the total and calculated loss are 272,747 lambs/year. Further considering the mortality rate sex wise i.e. males (43.2 %) to females (51.1%), the loss of male and female lambs will be around 123,250 and 145,788, respectively.

The average annual economic loss due to mortality of lambs on farms was 30,812,500 Birr depending on the price of sheep (250 Birr/lamb) from male lambs and according to these estimates the total money loss for the female sheep is thus approximately 29,157,600 Birr (200 Birr/ lamb). These figures do not include variables input costs that are difficult to measure. These figures represent the gross cost of sheep deaths. If the mortality rate can be reduced to 20%, we can save these 66,190 numbers of male lambs with a total amount 16,547,500 Birr (250 Birr/lamb) and 88,728 numbers of female lambs with a total amount 17,745,600 Birr (200 Birr/ lamb) per annum. By reducing mortality only, pastoralist in this area can gain around 34,293,100 Birr per annum.

4.18. Qualitative Traits of the Sample Population

The qualitative traits of Blackhead Somali sheep were observed separately for females and males in both districts. The major qualitative traits such as coat color patterns, coat color type, hair type, head profile, wattle, ear size and muzzle of physical traits of body parts as visualized in individual animals are summarized in Tables 28 and 29 for Shinile and Erer districts, respectively**.**

4.18.1. Qualitative traits of BHS sheep in Shinile district

The major qualitative traits in the female **BHS** sheep in Shinile district the observed percentages for coat color patterns were 72.5, 2.0 and 25.5 patchy, plain and pied, respectively. The most frequently observed predominant coat color was black head with white body (91.9%) and the same percentage of pure white color type and dark brown head with white body (4.0%). Out of the sampled females 30.9% had wattle. The head profile was flat/straight (100%) and their hair was short/smooth. Ear size was small (20.8%), medium (38.9%) and large (40.3%). The muzzle was non-pigmented in 78.9% of the ewes. Picture of a representative ewe is depicted in Figure 2.

In male **BHS** sheep the observed coat color pattern were patchy (65.1%), plain (3.5%) and pied (31.4%). The most dominant coat color was black head with white body color type (88.4%), pure white solid color (4.6%), and dark brown head with white body color (7.0%). In The majority of the male population, had wattle (97.7%). The head profile of most of the observed sample population was flat/straight and their hair type was short/smooth (100%). The ear size were small (19.7%), medium (43%) and large (37.2%). Muzzle was non-pigmented in 75.7% of the male animals. A representative picture of Blackhead male is displayed in Figure 3.

Figure 2. Blackhead Somali ewe

Table 28. Major qualitative traits of BHS sheep in Shinile district

Attributes	Female		Male	
	N	%	N	%
Coat color pattern				
Patchy	108	72.5	56	65.1
Plain	3	2.0	3	3.5
Pied	38	25.5	27	31.4
Coat color type				
Black head with white body	137	91.9	76	88.4
Pure white body	6	4.0	4	4.7
Dark brown head with white body	6	4.0	6	6.9
Hair type				
Short and smooth	149	100	86	100
Head profile				
Flat and straight	149	100	86	100
Wattle				
Present	46	30.9	84	97.7
Absent	103	69.1	2	2.3
Ear size				
Small	31	20.8	17	19.7
Medium	58	38.9	37	43.0
Large	60	40.3	32	37.2
Muzzle				
Pigmented	32	21.1	20	24.3
Non- pigmented	117	78.9	66	75.7

4.18.2. Qualitative traits of BHS sheep in Erer district

Details of some qualitative traits of **BHS** sheep population in Erer district are presented in Table 30. Blackhead Somali sheep breed is a fat rumped tailed type breed with different coat color patterns and coat color types. Observed coat color patterns of female were (60.5%) patchy, (25.5%) pied and (14%) were plain. Out of the total females on which observations were made (N =157), the majority (58%) of them had Black head with white body, about 26.8% percent had dark brown head with white body and some had pure white color (14%) (Appendix Figure 2). There was very little number of pure black colors (1.3%) which is not attractive in market. In all the females, the facial profile were flat/straight (100%) and hair type was (100%) short/smooth. The majority of females did not have wattle (77.7%). The ear size was small in (70.1%), medium in (19.7%) and large in size (10.2%). Most of them had no pigmented muzzle (65.9%) and all females were polled.

The major qualitative trait of male **BHS** sheep in Erer district is presented in Table 29. Out of (N=73) males, 19.2% were plain; pied (19.2%) and patchy (61.6 %) coat patterns. The major colors frequently observed in males were black head with white body (52.1%), pure white color (21.9%), and brown head with white body (24.7%) (Appendix Figure 1). Head profile was straight facial profile (100%) and short/smooth hair type (100%). Wattles were generally present in (89%). The ear size of male were small (80.8%), medium (13.7%) and large (5.5%).

Figure 3. Blackhead Somali ram

Table 29. Major qualitative traits of BHS sheep in Erer district

Attributes	Female		Male	
	N	%	N	%
Coat color pattern				
Patchy	95	60.5	45	61.6
Plain	22	14.0	14	19.2
Pied	40	25.5	14	19.2
Coat color type				
Black head with white body	91	58.0	38	52.0
Pure black body	2	1.2	1	1.4
Pure white body	22	14.0	16	21.9
Brown head with white body	42	26.8	18	24.7
Hair type				
Short and smooth	157	100	73	100
Head profile				
Flat and straight	157	100	73	100
Wattle				
Present	35	22.3	65	89
Absent	122	77.7	8	11.0
Ear size				
Small	110	70.1	59	80.8
Medium	31	19.7	10	13.7
Large	16	10.2	4	5.5
Muzzle				
Pigmented	53	34.1	18	24.7
Non- pigmented	103	65.9	55	75.3

4.19. Flock Composition

The distribution of sexes between the different dentition classes of sheep is summarized in Table 30. The number of males and females in the sample population and their ages were often used as an indicator of a particular traditional management system in Africa (Wilson, 1986a). Since data were not available, age of sheep was determined according to Gatenby *et al*, (1991).

Table 30. Classes and sexes composition of sheep flocks based on dentition under traditional management system in Shinile and Erer districts

Pair(s) of permanent incisor (PPI) teeth	Shinile district			Erer district		
	Total number of animals	Females		Total number of animals	Females	
		N	%		N	%
1 PPI teeth	78	35	44.9	97	42	43.3
2 PPI teeth	42	28	66.7	45	29	64.4
3 PPI teeth	28	18	64.3	29	24	82.8
4 PPI teeth	82	76	92.7	64	54	84.4
Overall	230	157	68.3	235	149	63.4

The sheep flocks observed under the traditional systems on average constituted higher proportions of females (68.3% in Shinile) and (63.4% in Erer) district. In Shinile district, breeding ewes with one and two pairs of permanent incisors teeth constituted about 40 % of the population, the rest being sheep older than two years of age, whereas in Erer district the composition of the two age groups were almost similar. Males with less than two pairs of permanent incisors were 78.0 % and 82.5% for Shinile and Erer district, respectively. Thus, the proportion of young males was higher than those of females. This is an indication of the prevailing management practice where more females than males are kept for extended periods for the purpose of breeding. Hence, the majority of males are culled for sale or consumption at an earlier age.

4.20. Body Weight and Linear Body Measurements

Body weight and body measurements of male and female Blackhead Somali sheep is shown in Table 31. Sex of animals had an effect on body weight and many of the body measurements. With the exception of tail length, ear width and canon bone circumference; significant differences between sexes were not observed (P>0.05), other parameters were different (P<0.05) between the sexes. Except for ear length which was larger (P<0.05) in females, other parameters were higher (P<0.05) in males.

Body weight values in males and female Blackhead Somali sheep measured in this study is greater than those noted for central highland sheep with 29.4 and 24.6 kg and Rift valley sheep with 27.4 and 24.7 kg for males and females, respectively (Sisay, 2002). On the other hand the values were lower than the North-western highland sheep with 31.4 and 29.5 kg, North-western lowland sheep with 33.1 and 30.7 kg (Sisay, 2002) and Gumuz sheep with 34.6 and 31.4 kg (Solomon, 2007) for males and females, respectively. Similar to the result of this study, in all age categories of Horro and Menz breeds, males were consistently heaver than females (Markos, 2004). The higher body weight in males than females noted in this study could be explained by the hormonal difference and different growth trends of the two sexes. Values for heart girth and height at withers for Blackhead Somali sheep observed in this study is lower than the ones reported for central highland, Rift Valley, North- western highland, North-western lowland sheep (Sisay , 2002) and Gumuz sheep (Solomon, 2007)**.** The body length values obtained in this study is higher than the values obtained for other breeds of the central highland and Rift Valley (Sisay, 2002). However, the small number of observations for North- western highland and North-western lowland sheep in the study of Sisay (2002) and Gumuz sheep in the work of Solomon (2007) might limit this comparison.

Table 31. Least square means (±SE) for body weight (kg) and body measurements (cm) of male and female Blackhead Somali sheep breed

Variables	Female (n=306)	Male (n=159)
Body weight	25.80 ± 0.20^{a}	29.50 ± 0.28^{b}
Body length	63.94 ± 0.24^{a}	65.82 ± 0.39^{b}
Heart girth	71.29 ± 0.22^{a}	72.72 ± 0.36^{b}
Height at wither	59.97 ± 0.21^{a}	61.30 ± 0.30^{b}
Chest depth	28.69 ± 0.17^{a}	30.23 ± 0.24^{b}
Pelvic width	20.89 ± 0.08^{a}	21.30 ± 0.11^{b}
Ear length	8.04 ± 0.14^{b}	7.49 ± 0.20^{a}
Tail circumference	22.92 ± 0.28^{a}	33.82 ± 0.39^{b}
Ear width	4.44 ± 0.07	4.49 ± 0.10
Tail length	20.21 ± 0.19	19.81± 0.27
Cannon bone circumference	7.48±0.03	7.58± 0.05

$^{a, b}$, means with different superscripts within the same row are significantly different *= P<0.05, n= number of animals

Results of the analyses of variance for body weight and body measurements in the two districts are summarized in Table 32. The district effect was significant (P < 0.05) for pelvic width, ear length, ear width, tail length and cannon bone circumference, but effect of district on body weight, height at withers, heart girth , body length, chest depth, tail circumference and scrotal circumference was not significant (P > 0.05). Accordingly, sheep in Shinile district had 2.6% wider pelvic width, 6.5% greater tail length, and 5.0% wider cannon bone circumference than those in Erer district. On the other hand, sheep in Erer district had 33.0% wider ear width and 33.9% greater ear length compared to Shinile district. Such district differences along with the insignificant greater body weight of animals in Shinile district could be attributed to differences in environment as well as management practices employed in the two districts.

Table 32. Least square means (±SE) for body weight (kg) and body measurements (cm) of Blackhead Somali sheep breed at the two districts

Variables	Shinile district (n=230)	Erer district (n=235)
Body weight	27.25± +0.26	26.82± 0.25
Body length	64.29 ± 0.27	64.51 ± 0.27
Heart girth	72.31 ± 0.26	72.26 ± 0.26
Height at wither	60.67 ± 0.25	60.17 ± 0.24
Chest depth	29.01± 0.20	29.42± 0.20
Pelvic width	21.31 0.09^{b}	20.76 0.09^{a}
Ear length	6.70±0.14^{a}	8.97±0.14^{b}
Ear width	3.82±0.08^{a}	5.08 ±0.08^{b}
Tail length	20.76 ±0.22^{b}	19.40± 0.22^{a}
Tail circumference	26.94 ±0.47	26.35 ±0.46
Cannon bone circumference	7.71± 0.04^{b}	7.32± 0.04^{a}
Scrotal circumference	24.00±1.00	25.94± 0.53

^{a,b} Least Square means with different superscripts within the same row are significantly different *=P<0.05, n= number of animals

Body weight and body measurements at different dentition classes of Blackhead Somali Sheep are presented in Table 33. Dentition classes significantly affected ($P < 0.05$) body weight and most of the linear body measurements**.** The trend in all body measurements and body weight increased with increase in dentition class, except for tail circumference which showed the opposite trend. In most variables that showed significant effect, values were similar between the first two and the last two dentition groups, but 3 and 4 pair dentition classes had greater value than the other two. This may be attributed to the faster growth rate of younger animals compared to the older ones. Similar finding was reported by Fasae (2006) who noted that body weight and body measurements increased with age of ewes for the first three years and then decreased slightly for ewes above four years. Searle *et al.* (1989) also reported that skeletal dimensions particularly tail length and height at withers increases greatly in the first year of life.

Table 33. Least square means ± body weight (kg) and body measurements (cm) of Blackhead Somali sheep breed at different dentition classes

Variables	Pair(s) permanent incisor (PPI) teeth			
	1pair (n=175)	2 pairs (n=87)	3 pairs (n=57)	≥ 4 pairs (n=146)
Body weight	26.46 ± 0.29[a]	26.86 ± 0.42[a]	28.30 ± 0.51[b]	28.34 ± 0.32[b]
Body length	62.64 ± 0.30[a]	62.95 ± 0.43[a]	65.14 ± 0.53[b]	65.49 ± 0.33[b]
Heart girth	70.77 ± 0.29[a]	71.34 ± 0.42[a]	73.59 ± 0.51[b]	73.84 ± 0.37[b]
Height at wither	59.60 ± 0.28[a]	59.93 ± 0.40[a]	62.29 ± 0.49[b]	62.55 ± 0.30[b]
Chest depth	28.65 ±0.23[a]	28.97± 0.33[ab]	29.64 ±0.41[b]	29.89 ±0.25[b]
Pelvic width	20.85 ±0.10	20.97 ± 0.15	21.07 ± 0.18	21.27± 0.11
Ear length	7.76 ±0.19	7.99 ± 0.27	8.01 ±0.33	8.06±0.21
Ear width	4.46 ± 0.10	4.46 ± 0.14	4.49 ± 0.18	4.55 ± 0.11
Tail length	19.60±0.25[a]	19.56±0.36[a]	19.57±0.45[a]	21.14±0.28[b]
*TC	28.32 ± 0.53[b]	27.01 ± 0.75[b]	27.21± 0.92[b]	24.21± 0.58[a]
*CBC	7.43±0.049	7.50 ±0.06	7.56 ±0.08	7.61± 0.05
*SC	24.69± 0.41[a]	30.57± 1.02[b]	-	-

[a, b], Means with different superscripts within the same row are significantly different; *=P<0.05, *TC= Tail circumference , *CBC=Cannon bone circumference , *SC =Scrotal circumference, n=number of animals

The fact that body weight of the third and fourth dentition classes are similar in this study suggest that keeping Blackhead Somali sheep beyond the third dentition class may not be advantageous in terms of meat production, unless the animals are kept for breeding purposes. Due to castration effect there was no record for scrotal circumference at three and above dentition classes. However, scrotal circumference increased by about 28% from the first to second dentition class. As there was no much difference in dentition class of the one pair and two pairs permanent incisor teeth on the one hand, and the three and four pairs permanent incisors on the other hand (Table 33), values were pooled to represent two groups of animals for the estimation of correlation and regression coefficients. The first and second dentition groups aged 15 to 28 months, and the third and fourth dentition groups aged above 28 months.

4.21. Correlation Coefficient between Body weight and Linear Body Measurements

The correlation coefficient among the body weight and body measurements of Blackhead Somali sheep within group one is presented in Table 34. Live weight was positively correlated ($P < 0.01$) with body dimensional traits (heart girth, body length, and height at withers) with moderate to high correlation coefficient both in males (r=0.60- 0.76) and females (r = 0.54 - 0.82). The high correlation coefficients between body weight and body measurements, suggest that either of these variables or their combination could provide a good estimate for predicting body weight of Blackhead Somali sheep. Of the body measurements, heart girth was the most related traits to weight and accounted for 82% and 76% of the variations in body weight for females and males, respectively. Variables such as girth, length and height, which are directly related to the size and weight of the animal, displayed medium to moderate positive correlations with one another both in males (r = 0.43 - 0.59) and females (r = 0.49 - 0.55) animals.

The correlation of body weight with chest depth, pelvic width, canon bone circumference and tail circumference were low to moderate for males (r = 0.27 - 0.55). Medium correlation (r = 0.32 - 0.43) was also noted in females except for canon bone circumference which was not significant. Scrotal circumference was related significantly with body weight, wither height, chest depth and pelvic width (r = 0.34 - 0.48). However, the correlation of body weight with ear length, ear width and tail length were generally non-significant except with ear width in males. Chest depth was correlated with wither height with moderate positive correlation both in males (r = 0.52) and females (r = 0.58). Ear length and ear width was highly correlated both in males (r = 0.67) and females (r = 0.75). These two ear traits positively correlate with chest depth both in males and females. The tail length displayed significant positive correlation with pelvic width and canon bone circumference only in females. The tail circumference and body dimensional traits showed significant positive correlations both in males and females, while the trend of correlation with other traits was different in the two sexes.

Table 34. Coefficient of correlations between body weight and linear body measurements in Blackhead Somali sheep at group one (above the diagonal for females and below the diagonal for males) N=262

	BW	BL	HG	HW	CD	PW	CBC	EL	EW	TL	TC
BW	1	0.54**	0.82**	0.61**	0.35**	0.35**	0.32**	-0.09	-0.01	-0.033	0.43**
BL	0.65**	1	0.49**	0.49**	0.11	0.33**	0.21*	-0.09	-0.03	0.036	0.24**
HG	0.76**	0.59**	1	0.55**	0.34**	0.42**	0.38**	-0.07	-0.02	0.032	0.39**
HW	0.60**	0.43**	0.49**	1	0.58**	0.10	0.20*	-0.15	-0.07	-0.025	0.25**
CD	0.41**	0.23**	0.30**	0.52**	1	-0.05	0.05	0.18*	0.22**	-0.081	0.09
PW	0.27**	0.25**	0.34**	0.14	0.07	1	0.50**	-0.00	0.00	0.23**	0.32**
CBC	0.14	0.21*	0.24**	0.17	0.14	0.21*	1	-0.07	-0.12	0.41**	0.35**
EL	0.10	0.07	0.12	-0.03	0.19*	0.02	-0.01	1	0.75**	0.00	-0.02
EW	0.20*	0.05	0.09	0.11	0.29**	0.00	-0.14	0.67**	1	-0.08	-0.00
TL	-0.06	0.03	-0.11	0.02	0.00	-0.09	0.11	0.10	-0.10	1	0.24**
TC	0.55**	0.28**	0.51**	0.31**	0.29**	0.14	0.13	0.25**	0.25**	0.00	1
SC	0.48**	0.25	0.25	0.43**	0.44**	0.34*	0.19	0.11	0.18	0.02	0.12

BW=Body weight, HG= Heart girth, BL=Body length, HW=Height at withers PW =Pelvic width, TL=Tail circumference, CD=chest depth, EL =Ear length, EW=Ear width, CBC= Canon Bone Circumference, SC= Scrotal circumference ** Correlation is significant at the 0.01,* Correlation is significant at the 0.05, N= number of animals

The correlation coefficient among the body weight and body measurements of Blackhead Somali sheep within group two is presented in Table 35. Correlations between body weight and body dimensional traits indicated a similar trend as observed in group one. Live weight was highly correlated ($P < 0.01$) with body dimensional traits (heart girth, body length, and height at withers) with moderate to high positive correlation both in males (r= 0.63 - 0.82) and females (r = 0.63 - 0.81). Of the body dimensional characters, heart girth was the most related traits to weight and accounted for 82% and 81% of variations in body weight for males and females, respectively. Variables such as girth, length and height, displayed medium to moderate positive correlations with one another both in males (r= 0.48 - 0.60) and females (r= 0.51- 0.58). The correlation of body weight with chest depth, pelvic width, and tail circumference followed a similar trend as that of group one and were less to moderately positive in males (r= 0.39 - 0.53) and less to positive in females (r = 0.21 - 0.49). However, the trend of correlation between body weight and canon bone circumference were inconsistent between the two sexes. The correlation of body weight with ear length, ear width and tail length, displayed non significant low or negative correlation (r=-0.29 to +0.23) both in males and females.

In females, chest depth was related to body dimensional traits with significant positive correlation (r= 0.15 - 0.37), while in males the chest depth was significantly correlated only with wither height. Similar to group one, ear length and ear width was highly correlated both in males (r = 0.90) and females (r = 0.78). These two ear traits did not display significant correlation with other variables in both sexes, except the positive correlation between ear widths and wither height in females. The tail length displayed significant positive correlation with pelvic width and canon bone circumference in females, while it was negatively correlated with heart girth in males. The tail circumference and body dimensional traits, displayed significant positive correlation in both sexes except the non significant correlation with body length in males, while the trend of correlation with other traits was different in the two sexes.

Table 35. Correlation coefficients among body weight and body measurements in Blackhead Somali sheep for group two (values above the diagonal are for females and below the diagonal are for males) N=203

	BW	BL	HG	HW	CD	PW	CBC	EL	EW	TL	TC
BW	1	0.63**	0.81**	0.63**	0.26**	0.21**	0.00	-0.06	-0.02	-0.03	0.49**
BL	0.71**	1	0.58**	0.51**	0.15*	0.20**	0.01	0.00	0.04	0.08	0.36**
HG	0.82**	0.48**	1	0.55**	0.18*	0.28**	0.04	-0.08	-0.06	0.06	0.49**
HW	0.63**	0.48**	0.60**	1	0.37**	0.16*	0.01	0.06	0.15*	0.06	0.39**
CD	0.39*	0.19	0.30	0.70**	1	0.09	-0.02	0.13	0.05	0.09	-0.00
PW	0.54**	0.54**	0.44*	0.26	0.06	1	0.13	-0.05	-0.01	0.20**	0.19*
CBC	0.40*	0.31	0.42*	0.21	0.19	0.51**	1	-0.07	-0.08	0.33**	0.12
EL	0.11	0.23	-0.06	0.03	0.19	-0.08	-0.24	1	0.78**	-0.00	-0.13
EW	0.23	0.26	-0.01	0.00	0.22	0.10	-0.04	0.90**	1	-0.09	-0.06
TL	-0.29	0.13	-0.43*	-0.10	-0.14	-0.08	0.00	-0.09	-0.11	1	-0.02
TC	0.53**	0.23	0.43*	0.39*	0.25	0.02	0.17	0.37*	0.35*	-0.25	1

BW =Body weight, HG= Heart Girth, BL=Body Length, HW=Height at Wither, PW=Pelvic Width, TL=Tail length, TC=Tail circumference, CD=chest depth, EL=Ear length, EW=Ear width, CBC= Canon Bone Circumference, ** Correlation is significant at the 0.01,* Correlation is significant at the 0.05, N=number of animals.

Overall correlations coefficient among the body weight and body linear measurements of Blackhead Somali sheep in two sexes are presented in Table 36. Body weight was highly correlated ($P < 0.01$) with body dimensional traits (heart girth, body length and height at withers) with moderate to high positive correlation both in males (r= 0.62- 0.81) and female (r= 0.63 - 0.83). Of the body dimensional traits, heart girth was the most related traits to weight and accounted for 81% and 83% of variations in body weight for males and females, respectively. This results, agrees with the work of (Fasae *et al.,* 2006) for Yankasa ewes in Nigeria. This indicates that it is possible to make prediction of body weight based on heart girth measurements. This observation agrees with that reported for some Nigerian cattle breeds (Umoh and Buvanendar, 1982). Similarly, Afolayan (2003) obtained a higher genetic correlation between body weight and heart girth as compared to the correlation between body weight and height across weaning and post weaning ages of some *Bos taurus* cattle breeds. Thus, in some practical management situations where the measuring scales cloud not be accessed, measurement of heart girth may be a better indicator of weight than height as suggested by Vargas *et al*. (2000) for Brahman cattle. Variables such as heart girth, body length and height at withers, displayed medium to moderate positive correlations with one another both in males (r= 0.49 - 0.62) and females (r= 0.47- 0.59). In general, the correlations among body weight and body dimensional traits followed a similar trend as observed in the two groups.

The correlation of body weight with chest depth, pelvic width, and tail circumference followed similar trend in the two groups and were less to moderately positive in males (r=0.37-0.58) and less positive in females (r= 0.33 - 0.43). Canon bone circumference with body weight, body dimensional traits and pelvic width, displayed low positive correlations both in males (r= 0.17 - 0.29) and females (r = 0.15 - 0.35). Canon bone circumference was related significantly with tail length and tail circumference but only in males. The body weight with ear width displayed low positive correlation only in males. The correlation of body weight with ear length, and tail length were non significant low or negative correlation (r= -0.07 to +0.07) both in males and females. The correlation among the body dimensional traits, chest depth, pelvic width and canon bone circumference were significantly positive with one another both in males (r = 0.17 - 0.57) and females (r = 0.15 - 0.51).

Table 36. Correlation coefficients among body weight and body measurements of females and males of all groups of Blackhead Somali sheep (values above the diagonal are for females and below the diagonal are for males) N=465

	BW	BL	HG	HW	CD	PW	CBC	EL	EW	TL	TC
BW	1	0.63**	0.83**	0.65**	0.36**	0.33**	0.21**	-0.07	-0.03	0.00	0.43**
BL	0.70**	1	0.59**	0.47**	0.21**	0.31**	0.16**	-0.04	-0.01	0.09	0.28**
HG	0.81**	0.62**	1	0.59**	0.31**	0.39**	0.24**	-0.08	-0.06	0.08	0.41**
HW	0.62**	0.49**	0.54**	1	0.51**	0.19**	0.15**	-0.03	0.02	0.05	0.30**
CD	0.47**	0.30**	0.37**	0.57**	1	0.08	0.06	0.14*	0.11*	0.04	0.06
PW	0.37**	0.32**	0.37**	0.18*	0.09	1	0.35**	-0.03	-0.01	0.23**	0.27**
CBC	0.19*	0.22**	0.27**	0.17*	0.15	0.29**	1	-0.07	-0.11*	0.38**	0.26**
EL	0.07	0.07	0.05	-0.04	0.16*	-0.01	-0.05	1	0.76**	-0.00	-0.07
EW	0.19*	0.08	0.06	0.09	0.26**	0.02	-0.12	0.71**	1	-0.09	-0.03
TL	-0.05	0.13	-0.11	0.05	0.02	-0.06	0.08	0.03	-0.10	1	0.12*
TC	0.58**	0.34**	0.54**	0.36**	0.33**	0.12	0.14	0.25**	0.26**	-0.01	1
SC	0.48**	0.25	0.25	0.43**	0.44**	0.34*	0.19	0.11	0.18	0.02	0.12

BW =Body weight, HG= Heart Girth, BL=Body Length, HW=Height at Wither, PW=Pelvic Width, TL=Tail length, TC=Tail circumference, CD=chest depth, EL=Ear length, EW=Ear width, CBC= Canon Bone Circumference, SC= Scrotal circumference, ** Correlation is significant at the 0.01,* Correlation is significant at the 0.05, N= number of animals.

Among these traits, the correlation of chest depth with wither height was highest both in males (r = 0.57) and females (r = 0.51). Ear length and ear width was highly correlated both in males (r = 0.71) and females (r = 0.76).While these two ear traits with other variables, displayed no significant correlation except with chest depth in both the sexes. Tail length displayed significant positive correlation with pelvic width and canon bone circumference in females, while the correlations with other variables were non significant in both sexes. Tail circumference and body dimensional traits, displayed significant positive correlation in both sexes, while the trend of correlation with other traits was inconsistent in two sexes.

4.22. Fitted Regression Models

The relationship between live weight and heart girth, body length or wither height were further looked at using linear regression (Table 37). Heart girth, among the three body dimensional traits, accounted for the highest variation in body weight in both males and females.

Table 37. Regression models for predicting body weight of female and male Blackhead Somali sheep from some linear body measurements

Dentition group	Females	R^2	Males	R^2
Group one	Y=-32.04+0.80HG	0.67	Y=-19.52+0.66HG	0.59
(15-28 months)	Y=-10.15+0.59HW	0.37	Y=-1.42+0.49HW	0.36
	Y=-7.63+0.51BL	0.29	Y=-1.25+0.47BL	0.42
Group two	Y=-24.05+0.70HG	0.65	Y=-32.02+0.84HG	0.68
(> 28 months)	Y=-9.18+0.55BL	0.40	Y=-24.37+0.84BL	0.50
	Y=-8.66+0.58HW	0.39	Y=-32.68+1.02HW	0.40
Overall	Y=-28.67+0.76HG	0.69	Y=-24.73+0.74HG	0.66
	Y=-11.66+0.62HW	0.43	Y=-7.33+0.57BL	0.49
	Y=-10.78+0.57BL	0.40	Y=-8.31+0.61HW	0.39

HW=height at withers, BL=Body length, HG=heart girth.

The second best relationship was observed between body weight and height at withers in group one, and body weight and body length in group two of both males and females. For the entire groups, heart girth accounted for 66% and 69% of the variations in body weight of males and females, respectively. The relationship of body weight with body length and height at withers was inconsistent between the two sexes.

A stepwise multiple regression analysis was carried by adding body measurements to heart girth one at a time. The essence was to determine effects of other body measurements on the precision of body weight prediction as compared to using heart girth alone. Equations for the estimation of body weight of animals in group one is shown in Table 38. Height at wither appeared to be important additional variable to heart girth to obtain up to 70% prediction of body weight for females. Further addition of body length improved the R^2 value to 73%. Further addition of tail circumference and tail length resulted in marginal increment in R^2 value. In males, scrotal circumference followed by height at withers appeared to be important additional variables to heart girth with the addition of both explained 78% of the variation in body weight.

The different regression equations for the estimation of body weight in group two for females and males are presented in Table 39. In females, addition of height at withers to heart girth gave increased R^2 by five percent to 70%. Further, addition of body length led R^2 value to 72%. The addition of more variables such as tail length and tail circumference did not improve the R^2 value. In males, there was no value for scrotal circumference since most males were castrated in this group. However, heart girth with body length explained 80% of the variation in body weight. Combination of heart girth, body length and tail circumference resulted in a maximum R^2 value of 84%.

Table 38. Multiple regression analysis of body weight on heart girth plus other variables of female and male Blackhead Somali sheep for group one (15-28 months)

Females (N= 134)	R^2	Males (N=128)	R^2
Y= -32.04 + 0.80HG	0.67	Y= -19.52 + 0.66HG	0.59
Y= -30.30 + 0.75HG + 0.08TC	0.68	Y= -16.71 + 0.57HG + 0.12TC	0.62
Y= -36.69 + 0.72HG + 0.17BL	0.69	Y= -25.22 + 0.54HG + 0.24HW	0.65
Y= -36.23 + 0.68HG + 0.22HW	0.70	Y= -22.24 + 0.51HG + 0.21BL	0.65
		Y= -24.59 + 0.63HG + 0.28SC	0.74
Y= -34.87 + 0.68HG + 0.16BL+ 0.07TC	0.70	Y= -19.38 + 0.41HG + 0.22BL + 0.12TC	0.68
Y= -34.5 + 0.64HG + 0.21HW + 0.07TC	0.72	Y= -22.43 + 0.46HG + 0.23HW + 0.11TC	0.68
Y= -40.57 + 0.60HG + 0.16BL + 0.21HW	0.73	Y= -26.58 + 0.43HG + 0.18BL + 0.20HW	0.69
		Y= -26.96 + 0.55HG + 0.13BL + 0.25SC	0.77
		Y= -30.02 + 0.52HG + 0.25HW + 0.20SC	0.78
Y= -8.79 + 0.15BL+ 0.2HW+ 0.56HG + 0.06TC	0.74	Y= -23.68 + 0.18BL + 0.19HW + 0.34HG + 0.11TC	0.73
Y= -36.68 + 0.15BL+ 0.20HW+ 0.56HG + 0.08 TC + -0.09TL	0.75	Y= -22.74 + 0.19BL+ 0.19HW+ 0.33HG + 0.11TC + -0.03TL	0.73

HW=height at withers, BL=Body length, HG=heart girth, TC=tail circumference, TL=tail length, N=number of animals

Table 39. Multiple regression analysis of body weight on heart girth plus other variables of female and male Blackhead Somali sheep for group two

Females (N=172)	R^2	Males (N=31)	R^2
Y= -24.05 + 0.70HG	0.65	Y= -32.02 + 0.84HG	0.68
Y= -22.92 + 0.65HG + 0.11TC	0.66	Y= -43.87 + 0.71HG + 0.34HW	0.71
Y= -29.07 + 0.57HG + 0.21BL	0.69	Y= -30.67+ 0.75HG+ 0.15TC	0.71
Y= -29.69 + 0.57HG + 0.24HW	0.70	Y= -49.19 + 0.64HG + 0.48BL	0.80
Y=-27.95+ 0.54HG + 0.20BL +0.08TC	0.70	Y= -40.60 + 0.65 HG + 0.28 HW + 0.13 TC	0.73
Y= -28.62 + 0.54HG + 0.22HW + 0.07 TC	0.70	Y= -53.52 + 0.59HG + 0.45BL + 0.15 HW	0.81
Y= -32.31+0.50HG+0.19HW +0.16BL	0.72	Y= -47.63 + 0.56HG + 0.47BL + 0.14 TC	0.84
Y= -30.73 + 0.50HG + 0.19HW + 0.17BL + -0.10TL	0.73	Y= -45.02 + 0.51BL + 0.50HG + -0.06 TL + 0.14 TC	0.84
Y=-29.92 + 0.48HG + 0.18HW + 0.16 BL + 0.05TC + -0.10TL	0.73		

HW=height at withers, BL=Body length, HG=heart girth, TC=tail circumference, TL=tail length, N=number of animals

Regression models for the estimation of body weight of Blackhead Somali sheep from data pooled over the two groups are presented in Table 40. The result of multiple regression analyses indicated that the addition of other body measurements to heart girth would result in greater accuracy of body weight prediction. The models revealed that height at withers and body length to be important additional variables to heart girth to predict body weight in both sexes reasonably well. The three variables accounted for 75% of the variation in body weight. Further addition of more variables to these combinations resulted in little improvement in R^2 value.

The finding of this result also showed that heart girth (HG) can best be used to predict body weight with the combination of three variables using the equation Y= 34.95 +0.15BL +0.52HG +0.19HW +0.06TC (R^2=76%) and Y= -29.4 + 0.2BL + 0.4HG + 0.17HW + 0.11TC (R^2=77) for Blackhead Somali sheep females and males, respectively. Despite better prediction of body weight from combinations of body measures, having these multiple variables to predict body weight posses a practical problem under field settings due to the higher labor and time needed for measurement. Thus, reduces the practical usefulness of using other measurements in conjunction with heart girth to predict body weight (Berge, 1977). Measuring heart girth with tape is easy, cheap and rapid. Besides, it explains most of the variations in body weight both in males and females. Generally, the higher association of body weight with heart girth was possibly due to the relatively larger contribution in body weight by heart girth (consisting of bones, muscles and viscera). Thus, body weight prediction from heart girth alone would be a practical option under field conditions with reasonable accuracy.

Table 40. Regression models for predicting body weight of female and male Blackhead Somali sheep from some linear body measurements of pooled values over the two groups

Females (N=306)	R^2	Males (N=159)	R^2
Y= -28.67 + 0.76HG	0.69	Y= -24.73 + 0.74HG	0.66
Y= -27.62 + 0.72HG + 0.08TC	0.70	Y= -21.93 + 0.64HG + 0.13TC	0.69
Y= -32.82 + 0.64HG + 0.19BL	0.72	Y= -30.83 + 0.61HG + 0.25HW	0.71
Y= -33.26 + 0.62HG + 0.23HW	0.73	Y= -28.1 + 0.56HG + 0.25BL	0.72
Y= -31.75 + 0.60HG + 0.19BL + 0.07 TC	0.73	Y= -27.93 + 0.53HG + 0.11TC+ 0.23 HW	0.73
Y= 32.21 + 0.59HG + 0.07TC + 0.23 HW	0.74	Y= -32.35 + 0.49HG + 0.19HW + 0.21BL	0.75
Y= -35.99 + 0.54HG + 0.20HW + 0.16 BL	0.75	Y= -25.31 + 0.25BL+ 0.46HG + 0.13TC	0.75
Y= 34.95 + 0.15BL + 0.52HG + 0.19HW + 0.06TC	0.76	Y=-29.4 + 0.2BL + 0.4HG + 0.17 HW + 0.11TC	0.77
Y= -33.47 + 0.16BL + 0.52HG + 0.19HW + 0.07T + -0.09TL	0.76	Y= -28.41+ 0.23BL+0.39HG + 0.18 HW + 0.12TC + -0.04TL	0.77

HG= Heart girth, BL=Body length, HW=Height at withers, TC=Tail circumference, TL=Tail length, N=number of animals

5. SUMMARY AND CONCLUSION

5.1. Summary

The present study was done to characterize the production system, phenotypic characteristics of the Blackhead Somali sheep, and survivability/ mortality of Blackhead Somali lambs during pre-weaning period and to determine the best fitted regression model for prediction of live weight of Blackhead Somali sheep breed on body measurements under field conditions. The study was conducted in Shinile and Erer districts of Shinile zone of the Somali National Regional State. The study on characterization of the production system was based on survey of 109 respondents and characterization of physical features by observation and measurement on adult animals (N = 465). Pre- weaning mortality rate was monitored on 277 lambs from September to January 2008.

The average flock size was 25.20 ± 1.77 in Shinile district, 13.07 ± 1.78 in Erer district with an overall mean of 19.19 ± 1.2. The breed is distinguished by the black color of the head and white color of the body. Dark brown color head was also observed specifically in Erer district. The body was covered with short smooth hair. Both rams and ewes are polled. The ear size varied from small to large. They have good mothering ability and ability to walk long distance in search of feed and water. Most of them have straight head profile. In Shinile district, the dominant coat color type was black head with white body; 91.9 percent in females and 88.4 percent in males. The coat pattern is dominated by patchy appearance 72.5 percent for females and 65.1 percent for males. The muzzle was pigmented only in 21.1% and 24.3% of females and male BHS sheep, respectively. The coat color pattern of in Erer district was patchy in 60.5 percent and 61.6 percent for females and males, respectively. The main type of coat color was blackhead with white body for females (58.0%) and males (52.1%). In males, 89% and in females, 32.3% had wattle. Muzzle was pigmented in 34.1% and 56 % in females and males, respectively. The population of the livestock species over the last ten years in the study area was declining as reported by the respondents. The major functions of sheep according to their importance were source of cash income, meat, and milk.

The major feed resources were natural pasture and crop residues, in Erer district while in Shinile district it was natural pasture. The main water sources were rivers, wells natural ponds and springs. Watering frequency was mostly once a day in the wet season and twice a day in the dry season. Seasonal shortage of feed in the area was severe for a period of four to five months (December to April). The overall major farming activities in two districts were livestock farming (53.2%). Livestock are major sources of income and home consumption in the pastoral areas (Shinile district). However, a major source of income and consumption was crop farming in agro-pastoral communities (Erer district). The farmers housed their sheep in corral in both districts. About 78 percent of the respondents practiced partially controlled mating system. Rams run with ewes only during the breeding season (December to January). Diseases were the major cause of death in both districts. The reported average weaning age of lambs was 3.95 ± 0.9 months. The reported main production constraints by the farmers were diseases and predators.

The estimated, age at puberty in female BHS sheep was 17.97 ± 3.97 months, it was 18.98 ± 4.28 months in Shinile and 16.94 ± 3.37 months in Erer district. Overall age at puberty in male BHS sheep was 13.65 ± 4.75; it was 14.05 ± 5.68 months in Shinile, and 13.25 ± 3.81 months Erer districts. The overall estimated mean age at first lambing was 23.56 ± 3.63 months; it was 24.9 ± 3.72 months in Shinile and 22.2 ± 2.99 months in Erer district. The overall estimated mean lambing interval was 10.46 ±2.58 months; it was 10.9 ± 2.33 months in Shinile and 10.01 ± 2.77 months in Erer district. The overall average reproductive life span of ewes was 9.12 ± 1.6 years; it was 9.4 ± 1.7 in Shinile and 8.8± 1.5 years in Erer district. On the average ewes produced 8.18 ± 2.27 lambs in her life time; it was 8.4 ± 2.47 in Shinile and 7.97 ± 2.03 lambs in Erer district. The overall average weaning age was less than 3 months (41.3%). Traditional method (wood) of castration was the most widely practiced method used to control breeding and fattening for better price. A total of 110 deaths of lambs were recorded and per-weaning mortality rate was 47.8%. The pre-weaning mortality rate was 49.6% in Shinile and 45.4% in Erer district. About 59.1% of the total death rate of lambs was attributed to diseases. Sex of animals had significant effect ($P < 0.05$) on body weight and linear body measurements except TL, EW and CBC. Males were observed to be significantly heavier than the females (29.5 kg vs. 25.8 kg).

The males in comparison to females had significantly higher HG (72.7 cm vs. 71.3 cm) and HW (61.3 cm vs. 59.9 cm). The least square mean of BL was higher for males (65.8 cm) as compared to females (63.9 cm). The males had 5.3% wider CD and 47.5% wider TC than females. The district effect was significant for PW, EL, EW, TL and CBC at (P<0.001). Sheep in Shinile district had 2.5% wider PW, 6.5% taller TL, and 5.0% wider CBC than Erer district sheep. However, in Erer district, sheep had 32.9% wider EW and 33.8% taller EL in comparison to Shinile district sheep. Dentition classes of animals contributed significant differences to the body weight and most of the linear body measurements**.**

Correlation coefficient of body weight was highly correlated with body dimensional traits (HG, HW and BL). Overall correlation of (pooled over the two groups) in the two sexes indicated similar trend for the two groups. Body weight was highly correlated (P < 0.01) with body dimensional traits with moderate to high positive correlation both in males (r = 0.62-0.81) and females (r = 0.63 - 0.83). HG was the most related traits to weight and accounted for 81% and 83% of the variation in BW for males and females, respectively. HG for accounted for 66% and 69% of the variations in BW of males and females, respectively for pooled estimates over the two age groups. HG was found to predicted body weight with higher precision, and also better than the other two measurements (BL and HW). It was observed that animal HW appeared to be important additional variable to HG to obtain up to 70% prediction of BW for females. Further, addition of BL to HW and HG improved the R^2 value to 75%. Best Fitted Regression equation based on R^2 Value are Y= 34.95 + 0.15BL + 0.52HG + 0.19HW + 0.06TC (R^2=76%) for females and Y= -29.4 + 0.2BL + 0.4HG + 0.17HW + 0.11TC (R^2=77%) for males.

5.2. Conclusions

Blackhead Somali sheep breed is one of the fat rumped tail types, patchy, pied and plain coat color, with black color of the head, white color of the body and limbs, flat and slightly concave head, some have wattle and both sexes are polled. Based on growth and reproductive performance, the present study demonstrate that blackhead Somali sheep breed has good potential for meat production under the prevailing harsh environmental condition of Shinile Zone and play an important role in the livelihood of people in these two areas. In the study area, there are less frequent watering points, acute shortage of feed resources especially during December to April and high mortality among the lambs during pre weaning period. Heart girth alone or in combination of other body measurement can be used to predict the body weight with reasonable accuracy.

5.3. Recommendations

- To improve the income of the farmers through sheep production and to conserve the breed, it is important to design and implement appropriate community- based health and breeding program for Blackhead Somali sheep breed.
- There is urgent need to establish the watering points in the study area so that flock should not move too far in search of water.
- To increase the productivity of sheep in the study area, there is need to develop alternative strategy to deal with the acute shortage of natural feed resources especially during the period of four to five months (December to April).
- Lamb mortality is one of the most important constraints limiting productivity of sheep in the area. If only mortality rate can be reduced to 20%, by improving housing, feeding and management practiced pastoralist in this area can additionally gain around 34,293,100 Birr per annum.
- The draught resistance of Black head with white body rams and the disease resistance of Brown head with white body rams further study is needed.

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7. APPENDIX

Appendix Table 1. Description of qualitative traits and respective codes

Traits respective	Codes
Sex of the animal	1= Female, 2= Male
Coat color pattern	1= Patchy, 2= Plain, 3= Pied
Coat color type	1= Blackhead with white body, 2 = Pure black, 3=Pure white, 4= Dark brown color.
Head profile	1= Convex, 2= Straight/Flat, 3= Concave
Hair type	1= Smooth/short , 2=Coarse
Ear size	1= Small, 2= Medium, 3= Large
Wattle	1= Present, 2= Absent
Muzzle	1= Pigments, 2= Non-pigmented
Dentition class	One pair permanent incisor teeth=1, Two pairs permanent incisor tooth=2, Three pairs permanent incisor tooth=3 and four pairs and above permanent incisor tooth=4.

Appendix Table 2. Definition of body weight and linear body measurements

Variables	Definition
Bodyweight (BW):	Taken on spring balance using to the nearest 50 kg.
Height at withers (HW)	From the bottom of fore leg to the point of shoulder using sliding measuring ruler (metal), to the nearest centimeter
Body length (BL)	from the tip of the scapular to the pine bone using tape meter
Chest depth (CD)	The depth of brisket; and distance between last rib and tuber coxae.
Ear length (EL)	From the base of the ear at the skull along dorsal to the tip of ear,
Tail length (TL)	From the point of attachment to the tip, to the nearest cm using tape meter.
Heart girth (HG)	Circumference of body immediately behind the shoulder blands in vertical plane, perpendicular to body length.
Scrotal circumference (SC)	Circumference measured at the widest part of the testis using a flexible plastic tape.
Pelvic width (PW)	The distance between the pelvic bones, across dorsum
Canon bone circumference (CBC)	A circumference measurement taken in centimeter at the narrowest part of the bone jointing fetlock and knee joint.

Appendix Table 3. Household structure of for different districts

	Shinile		Erer		Overall	
	N	%	N	%	N	%
Household sex						
Male	48	87.3	51	94.4	99	90.8
Female	7	12.7	3	5.6	10	9.2
Marital status						
Married	51	92.7	50	92.6	101	92.7
Widowed	4	7.3	4	7.4	8	7.3
Interviewee position in household						
Household head	35	63.6	26	48.1	61	56.0
Spouse of head	14	25.5	22	40.7	36	33.0
Relative	1	1.8	1	1.9	2	1.8
Son	4	7.3	2	3.7	6	5.5
Daughter	1	1.8	3	5.6	4	3.7
Education level						
Illiterate	49	89.1	47	87.0	96	88.1
Write and read	0	-	1	1.9	1	0.9
Grade	1	1.8	-	-	1	0.9
Religious school	5	9.1	6	11.1	11	10.1

N=number of households

Appendix Table 4. Household age in the study area

Household Age	N	Min	Max	Mean	S.D
Shinile district	55	20	82	47.38	15.46
Erer district	54	21	71	44.19	12.85
Overall	109	20	82	45.80	14.25

Appendix Table 5. Uses of Keeping Blackhead Somali sheep in the study area as prioritized by the respondents (weighted average scores) (N=109)

Variable	Total rank
Meat	2
Milk	3
Dowry	7
Wealth	4
Blood	10
Income	1
Tail fat	6
Skin	9
Manure	5
Breeding	8

Appendix Table 6. Major crops grown in Shinile and Erer districts

Major crops	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Maize	2	3.6	6	12.8	8	7.8
Sorghum	46	83.6	3	6.4	49	48
Sorghum and fruit	3	5.5	2	4.3	5	4.9
Maize and fruit	-	-	14	29.8	14	13.7
Maize and sorghum	4	7.3	22	46.8	26	25.5
Overall	55	100	47	100	102	100

*N=number of households

Appendix Table 7. Seasonal feed shortage conditions and coping mechanisms in the area

	Shinile		Erer		Overall	
	N*	%	N*	%	N*	%
Seasonal fluctuation in feed supply						
Yes	55	100	44	81.5	99	80
No	-	-	10	18.5	10	20
Coping mechanisms						
Sorghum	2	3.6	-	-	2	1.8
Furshca, leaves and crop-residual	22	40	4	7.4	26	23.9
Cutting grasses and leaves	8	14.5	43	79.6	51	46.8
Selling animals	16	29.1	7	13.0	23	21.1
Furshca and Wheat	7	12.7	-	-	7	6.4

*N=number of households

Appendix Table 8. Source of water according to respondents in the study areas

Water source	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Wet season						
Wells	21	38.2	3	5.6	24	22
Ponds	2	3.6	1	1.9	3	2.8
Rivers	18	32.7	41	75.9	59	54.1
Springs	14	25.5	9	16.7	23	21.1
Dry season						
Wells	39	70.9	5	9.3	44	40.4
Ponds	-	-	1	1.9	1	0.9
Rivers	11	20.0	46	85.2	57	52.3
Springs	5	9.1	2	3.7	7	6.4

*N=number of households

Appendix Table 9. Preferred color used to select breeding animals and unwanted color in Shinile and Erer districts as prioritized by the respondents (weighted average scores)

Color type	Shinile district (rank)	Erer district (rank)	Overall (rank)
Preferred color			
Brown head	2	1	2
Black head	1	2	1
Pure white	3	3	3
Unwanted color			
Brown head	3	4	4
Black head	4	2	3
Pure white	2	3	2
Pure black	1	1	1

Appendix Table 10. Reasons of castration and supplementary feed provide for castrated male as reported by respondents in the study area

	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Castration						
Yes	52	94.5	53	98.1	105	96.3
No	3	5.5	1	1.9	4	
Reasons for castration						
Control breeding	12	21.8	5	9.3	17	15.6
Better price	8	14.5	3	5.6	11	10.1
Both	35	63.6	46	85.2	81	74.3
Supplementary feed						
Yes	15	27.3	36	66.7	51	46.8
No	40	72.7	18	33.3	58	53.2

*N=Number of households

Appendix Table 11.Summerized herding practices reported of households in the study area

	Shinile district		Erer district		Overall	
	*N	%	*N	%	*N	%
Sheep flock herded during the day time						
Male and female separated	14	25.5	3	5.6%	17	15.6
Lambs are separated	14	25.5	18	33.3	32	29.4
All classes herded together	16	29.1	33	61.1	49	45
All classes herded separated	11	20.0	-	-	11	10.1
Way of herding						
A household run as a flock	44	80	20	37.0	64	58.7
More than one household run as a flock	11	20	34	63.0	45	41.3

*N=Number of households

Appendix Table 12. Mean square of body weight and body measurements for male and female BHS sheep

		Mean square of body weight and body measurements										
Source	d..f	BW	BL	HG	HW	TC	EL	EW	CBC	TL	PW	CD
Sex	1	1376	70.08	216.57	185.44	12436	598.97	183.62	1.018	16.83	35.33	248.03
P value		0.0001	0.7705	0.0002	0.0004	0.0001	0.0001	0.0001	0.122	0.24	0.0001	0.0001
Error	463	12.68	17.85	15.83	14.34	25.1	5.15	1.51	0.426	12.16	1.94	9.55
C.V(%)		13	6.61	5.54	6.26	10.57	6.69	31.15	18.8	30.17	17.37	8.68

Appendix Table 13. Mean square of body weight and body measurements of BHS sheep in Shinile and Erer districts

		Mean square of body weight and body measurements											
Source	d.f	BW	BL	HG	HW	TC	EL	EW	SC	CBC	TL	PW	CD
District	1	21.16	70.08	127.95	29	40.51	598.97	183.62	32.58	17.34	213.92	35.33	19.76
P value		0.244	0.047	0.004	0.160	0.377	0.0001	0.0001	0.0922	0.0001	0.0001	0.0001	0.161
Error	463	15.6	17.7	16.02	14.67	51.87	5.15	1.51	11.03	0.39	11.73	1.94	10.04
C.V (%)		14.61	6.58	5.57	6.34	10.84	6.63	28.91	27.55	17.06	27.02	8.31	13.01

Appendix Table 14. Mean square of body weight and body measurements for different dentition classes (DN)

		Mean square of body weight and body measurements at different dentition classes											
Source	d.f	SC	BW	BL	HG	HW	TC	EL	EW	CBC	TL	PW	CD
DN	3	207.69	55.4	270.47	156.22	127.49	461.63	1.2	1.19	0.922	81.02	4.86	45.55
P value		0.0001	0.0134	0.0001	0.0001	0.0001	0.0001	0.9	0.599	0.09	0.0001	0.064	0.0033
Error	461	7.39	15.36	16.17	15.35	13.97	49.18	6.47	1.9	0.424	11.72	2	9.83
C.V		10.65	14.4	6.29	5.45	6.1	10.73	6.72	32.38	30.36	17.05	26	8.66

Appendix Figure 1. Brown head ram

Appendix Figure 2. Pure white ewe

Questionnaire Format

On farm Characterization of Blackhead Somali Sheep Breed and its Production System in Shinile and Erer Districts of Shinile Zone

Enumerator Name _______ Code _____________________Zone _________

District _________________Kebele ____________________Altitude ______

Notes to the enumerator

1 Politely introduce yourself to farmers/pastoralists
2 Tell them briefly the objective of the study
3 Administer questionnaires politely
4 The respondents should be thanked for his/her time.
5 Record the response carefully

Fill the responses in the space provided or mark alternative response (s) where appropriate with an "**X**".

GENERAL INFORMATION AND SOCIO ECONOMIC ASPECTS

1. Interviewee ___________				
2. Household head		Sex	Age	
3. Position in household	a. Household head b. Spouse of head c. Relative d. Son e. Daughter		4. Age (yrs) a. <31 b. 31–40 c. 41–50 d. 51–60 e. 61–70 f. >70	

5. Sex	a. Male b. Female	6. Marital status a. Married b. Divorced
7. Education level	a. Illiterate b. Writing and reading	

8. Number of people living in the house by age and sex

	No.		No.
a. Males $\leq$ 15 yrs	________	a. Males >15	_______
b. Females $\leq$ 15yrs	________	b. Females >15	______

9. What is your major farming activity?

a. Livestock production

b. Crop production

c. Both

10. Numbers of livestock kept

	Number
a. Cattle	
b. Sheep	
c. Goats	
d. Camels	
e. Others (specify)	

11. Population trend in major livestock species

	Increasing	Decreasing	Stable	Reason
a. Sheep				
b. Cattle				
c. Goat				
d. Camel				

	Main season	Short rain		Main season	Short rain
a. Barley			e. Maize		
b. Wheat			f. Bean		
c. Teff			g. Pea		
d. Sorghum					

PRODUCTION AND MANAGEMENT SYSTEM

1. General

1.1. Production system

a. Crop–livestock system

b. Agro-pastoralists

c. Pastoralists

d. Others (specify)

1.2. Type of management *(Tick one box)*

a. Extensive b. Semi-intensive c. Intensive/backyard

1.3. Mobility

a. Sedentary

b. Transhumance

c. Nomadic

1.4. Purpose of keeping sheep

	Rank		Rank
a. Meat		h. Manure	
b. Milk		i. Blood	
c. Wool/hair		j. Skin	
d. Tail fat		k. Savings	
e. Breeding		l. Income	
f. Ceremonies		m. Dowry	
g. Wealth status			

1.5. Members of household who own sheep

a. Head d. Sons

b. Spouse e. Daughters

c. Head &spouse together f. The whole family

1.6. Members of household and hired labour responsible for sheep activities

(Tick one or more boxes in each column and row)

M = Male, F= Female

(>=15y) (>=15y)

	M	F	M	F
a. Purchasing sheep				
b. Selling sheep				
c. Herding				
d. Breeding				
e. Caring for sick animals				
f. Feeding				
g. Milking				

2. Feeding and Grazing

2.1. Feed source

	Wet season	Rank	Dry season	Rank
a. Natural pasture				
b. Established pasture				
c. Hay				
d. Crop residues				
e. Fallow land				

2.2. Grazing method

	Dry season	Wet season
a. Free grazing		
b. Herded		
c. Paddock		
d. Tethered		
e. Zero-grazing		

2.3. Length of grazing time during wet season (in hours):

Morning from _______________to __________ hours

Afternoon _________________to___________ hours

The whole day _____________hours

2.4. Length of grazing time during dry season (in hours):

Morning from_____________ to ___________ hours

Afternoon from____________ to____________ hours.

The whole day _____________hours.

2.5. Do you use communal grazing

a. Yes b. No

2.6. Trend in communal grazing areas?

a. Decreasing b. Increasing c. Stable

2.7. Reason

____

2.8. How is sheep flock herded during the day time?

a. Male and female are separated

b. Lambs are separated

c All classes herded sep together

2.9. Sheep flock is herded

a. Together with cattle

b. Together with goat

c. Together with camel

d. Together with calves

e. Together with equines

f. All herded together

g. Sheep herded separately

2.10. Way of herding

a. Sheep of a household run as a flock

b. Sheep of more than one household run as a flock

c. Others (specify) ____________________

2.11. If the answer is b, how many household mix their sheep together ___________

2.12. Crop residues used for sheep

	Wet season	Dry season
a. Wheat		
b. Barley		
c. Sorghum		
d. Maize		
e. Bean		
f. Pea		
g. Lentil		

2.13. Source of water	Dry season	Wet season	2.14. Distance to nearest watering point	Dry season	Wet season
a. Borehole/water well			a. Watered at home		
b. Dam/pond			b. <1km		
c. River			c. 1–5 km		
d. Spring			d. 6–10 km		
e. Pipe water			e. >10 km		

2.15. Are lambs watered with the adults?

a. Yes b. No

2.16. If no, describe watering distance and frequency for lambs?

____

2.17. Frequency of watering for adult animals	Dry season	Wet season	2.18. Water quality	Dry season	Wet season
a. Freely available			a. Clean		
b Once a day			b. Muddy		
c. Once in 2 days			c. Salty		
d. Once in 3 days			d. Smelly		

2.20. Housing/enclosure for adult sheep (*Tick one or more boxes)*
a. In family house
b. Separate house
c. Veranda
a. Kraal
b. Yard

2.21. Type of housing materials

(Tick one or more boxes in each column)

	Roof	Wall	Floor
a. Iron sheets			
c Wood			
d Stone/bricks			
e. Earth/mud			
f. Concrete			

2.22. Are lambs housed with adults?

a. Yes b. No

2.23. Are sheep housed together with

a. Yes b. No

2.24. Access to veterinary services

a. Government veterinarian

b. Private veterinarian

c. Shop or market

2.25. Distance to nearest veterinary services

a. < 1km

b. 1–5 km

c. 6–10 km

2.26. Mortality in the last 12 months

(Enter numbers)

a. Male

b. Female

2.27. Reasons for death

(Tick one or more boxes, then rank top 3)

c. Accident

d. Poisoning

f. Unknown

f. Drought

BREEDING

(Tick one or more boxes)

1. Do you have crossbred ram a. Yes b. No

2. If yes, how many? ________

3. Source of ram/s _____________

4. Do you have local ram? a. Yes b. No

5. If yes, how many? __

6. If more than one, why do you need to keep more than one ram?

7. Is there any special management for breeding ram? a. Yes b. No

8. If yes, specify type of management___________________________________

9. Purpose of keeping ram

a. Mating

b. Socio-cultural

c. For fattening

d. Others (specify)

10. Source of ram (s)

a. Born in the flock

b. Purchased, private

c. Purchased in partner

d. Rent

11. If you do not have breeding ram, how do you mate your Ewe?

a. Neighbouring ram

b. Unknown

c. Others (Specify) ____________

12. Do you practice selection for?

Breeding male a. Yes b. No

Breeding female a. Yes b. No

13. Age of selection

Breeding male _____ months Breeding female _____Months

14. Selection criteria for breeding ram?

a. Size

b. Colour

c. Horns

d. Character

e. Adaptability

f. Growth

g. Age

List the top 3 preferred colour

1.
2.
3.

Unwanted colour

1. ____
2. ____
3. ____

15. Selection criteria for breeding ewe

a. Size
b. Colour
c. Mothering character
d. Lamb survival
e. Lamb growth
f. Age at first sexual maturity
g. Lambing interval
h. Twining ability
i. Longevity
j. Adaptability

16. Breeding/mating

a. Controlled
b. Uncontrolled

17. If uncontrolled, what is the reason

a. Sheep graze together
b. Lack of awareness
c. Lack/insufficient number of ram
d. Others (specify) ____________

18. If adaptability is used as a criterion, What type of adaptability?

a. Disease tolerant
b. Drought tolerant
c. Feed shortage tolerant
d. Water shortage tolerant

CASTRATION AND CULLING

1. Do you castrate?

a. Yes
b. No

2. If yes, reasons for castration

a. Control breeding
b. Improve fattening

c. Better temperament

d. Better price

3. If no, give reason

4. At what age do you castrate?

a. < 3 months

b. 3–6 months

c. >6 months

Season of castration

Reason

5. Castration method

a. Modern

b. Traditional

Specify traditional method ______________________________

6. Numbers of animals added to the herd in the last 12 months

(Enter numbers)

	Males	Females
a. Born		
b. Bought		
c. Donated/gift		
d. Exchanged		
e. 'Rebi'		
f. Share from 'rebi'		

7. Numbers of animals reduced from the herd in the last 12 months

(Enter numbers)

	Males	Females
a. Sold		
b. Slaughtered		
c. Exchanged		
d. Died		
e. Predator		
f. Donated/gift		

8. Reasons for selling

a. Cash needed

b. Disposal/culling

9. If reason is for disposal what are the criteria for disposal?

	Males	Females
a. Size		
b. Unwanted colour		
c. Character		
d. Health		
e. Poor body condition		
f. Inferior production performance		

g. Old age

h. Delayed puberty

i. Sterile

j. Delayed lambing interval

k. Repeated abortion

l. Mechanical injury

10. Average market age in months Male_____ Female_______

11. Average culling age due to old age Male_____

a. Increased b. Decreased c. stable

PRODUCTION CHARACTERISTICS

1. Average age at sexual maturity			2. Age at first lambing			3. Lambing interval		
a. Male	___	Month	Average	____	Month	Average	____	Months
b. Female	___	Month	Maximum	____	Month	Maximum	____	Months
			Minimum	____	Month	Minimum	____	Months

4. Do you fix age at first mating for the females? a. Yes b. No

5. Do you fix age at first mating for the males? a. Yes b. No

6. Average reproductive lifetime of ewe (in years) _____________

7. Average number of lambing per ewes life time ___________________________

CONSTRAINTS FOR SHEEP PRODUCTION

1. What are the main constraints for sheep production? Rank them according to their significance.

Constraints Rank the top three

a. Genotype

b. Feed shortage

c. Water shortage

d. Disease

e. Drought

f. Market

g. Lack of superior genotypes

h. Predator

2. Do you have any access to sheep extension services?

a. Yes b. No

3. If yes, would you describe the services you have got so far?

a. Livestock credit scheme

b. Extension advisory service

c. Veterinary service

d. Others (specify)

4. If for livestock credit scheme, describe purpose of credit

a. Restocking

b. Establishing sheep husbandry

c. Fattening

d. Others (specify) ____________

5. If for extension advisory service

a. On feeding and grazing management

b. About sheep health

c. Breeding and management

d. Marketing

e. Others (specify) ______________

6. If for veterinary service

a. Advice on health management

b. Vaccination

c. Treatment

d. Others (specify)