ON-FARM PHENOTYPIC CHARACTERIZATION AND PERFORMANCE EVALUATION OF ABERGELLE AND CENTRAL HIGHLAND GOAT BREEDS AS AN INPUT FOR DESIGNING COMMUNITY-BASED BREEDING PROGRAM

MSc Thesis

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Haramaya University

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By
Alubel Alemu

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SCHOOL OF GRADUATE STUDIES

HARAMAYA UNIVERSITY

As Thesis Research advisors, we hereby certify that we have read and evaluated this thesis prepared under our guidance by **Alubele Alemu** entitled **On-Farm Phenotypic Characterization and Performance Evaluation of Abergelle and Central Highland Goat Breeds as an Input for Designing Community-Based Breeding Program.** We recommend that it be submitted as fulfilling the Thesis requirement.

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DEDICATION

I dedicate this Thesis manuscript to **all** of my family members especially to my grandmother Emahoy **YALGANESH TAFETE (R.I.P.),** my elder sister W/ro **MISANESH ALEMU,** my elder brother Ato **MESAFINT ALEMU** and my lovely wife W/ro **ELSA AMARE (Elsi).**

STATEMENT OF AUTHOR

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BIOGRAPHICAL SKETCH

The author of this thesis, Mr. Alubel Alemu, was born on September 22, 1986 at Libo Kemkem District, South Gondar Zone, Amhara Regional State, Ethiopia from his father Ato Alemu Habesha and his mother W/ro Wubalem Kassie.

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ACRONYMS AND ABBERVIATIONS

AARC	Abergelle Agricultural Research Centre
ADWG	Average Daily Weight Gain
AIC	Akaike Information Criteria
AnGR	Animal Genetic Resources
ANRS	Amhara National Regional State
ARARI	Amhara Regional Agricultural Research Institute
BIC	Bayesian Information Criteria
BL	Body Length
BW	Body Weight
CG	Chest Girth
CSA	Central Statistical Authority
DNA	Deoxyribonucleic Acid
EL	Ear Length
FAnGR	Farm Animal Genetic Resource
FAO	Food and Agriculture Organization of the United Nation
FMD	Foot and Mouth Disease
GARC	Gondar Agricultural Research Center
GLM	General Linear Model
GPS	Global Positioning System
HL	Horn Length
HW	Height at Withers
IBC	Institute of Biodiversity Conservation
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
Lk	Livestock
masl	meter above sea level
NA	Not available
NGO	Non Governmental organization
NRC	National Research Council

ACRONYMS AND ABBERVIATIONS (*Continued)*

PA	Peasant Association
PPI	Pair of Permanent Incisor
PPR	Pest des Petit, Ruminants
PW	Pelvic Width
R^2	Coefficient of Determination
RL	Rump Length
RMSE	Root Mean Square Error
SAS	Statistical Analysis System
SC	Scrotum Circumference
SDARC	Sekota Dry Land Agricultural Research Center
SE	Standard Error
SERA	Strengthening Emergency Response Abilities
SNNPR	Southern Nations Nationalities and Peoples Region
SPSS	Statistical Package for Social Science
X^2	Chi Square

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ON-FARM PHENOTYPIC CHARACTERIZATION AND PERFORMANCE EVALUATION OF ABERGELLE AND CENTRAL HIGHLAND GOAT BREEDS AS AN INPUT FOR DESIGNING COMMUNITY-BASED BREEDING PROGRAM

By

Alubel Alemu: BSc in Animal Production and health, Jimma University

Major Advisor: Tadelle Dessie (PhD)

Co-Advisors: Yoseph Mekasha (PhD)

ABSTRACT

The objectives of this study were to describe the production environment and production systems, characterize (phenotypic) and evaluate on-farm performances of Abergelle and Central Highland goat breeds. A total of 256 farmers in Ziquala (68), Tanqua Abergelle (70) and Lay-Armachiho (118) districts were interviewed for the household survey. Data for qualitative and quantitative characters were collected from a total of 640 4PPI age category goats (143 from Ziquala and 183 from Tanqua Abergelle districts on Abergelle goat breed and 314 from Lay Armachiho district on Central Highland goat breed). Base flock, flock dynamics, birth and growth weight, milk yield data recordings were taken from mid July 2013 up to mid August 2014 for on-farm performance evaluation. Data collected through questionnaire (survey) were described by descriptive statistics using SPSS. Observations on qualitative traits were analyzed for male and female goats separately using frequency procedure of SAS. Whereas, quantitative traits were analyzed using the GLM procedures of SAS. Individual interviews and group discussions made in all of the three districts indicated that all of the farmers practiced both crop and livestock production. The first objective of keeping goat in all districts was to get cash income. Unlike Lay Armachiho district, all goat keepers in Ziquala and Tanqua Abergelle districts reported that they milk their goats. From the current survey result milk yield (mean±SD)/doe/day (liter) in the rainy and in the dry seasons in Ziquala district were 0.43±0.24 and 0.15±0.14 respectively. The corresponding values for Tanqua Abergelle district were 0.48±0.24 and 0.19±0.29 respectively. The actual on-farm milk yield (mean±SE) monitoring result in Ziquala district in wet and dry seasons were 285.42±5.64 and 243.12±9.92 milliliter/doe/day respectively. The corresponding values for Tanqua Abergelle district were 452.68±6.15 and 362.03±9.19 milliliter/doe/day respectively. Communal natural pasture and river water were the major sources of goat feeding and watering respectively both in dry and wet seasons in each of the three districts. Among the interviewed goat keepers in the study districts 97.1% in Ziquala, 98.7% in Tanqua Abergelle and 66.8% in Lay Armachiho had their own indigenous breeding male goat. Coat color, body conformation and growth rate were the first,

second and third selection criteria for breeding buck respectively in Ziquala and Tanqua Abergelle districts. The corresponding values for Lay Armachiho district were body conformation, growth rate and coat color. The first preferred trait for does was milk yield in Ziquala and Tanqua Abergelle districts and body conformation in Lay Armachiho district. Drought, disease and feed shortage were the first, second and third major constraints respectively for goat production in Ziquala and Tanqua Abergelle districts. The corresponding values for Lay Armachiho district were disease, theft and predator. Majority of Abergelle goat coat color was brown/red (30.40%) and its combination with other coat colors (50.61%), whereas relatively high proportion of Central Highland goat had white coat color (21.66) and its combination with other coat colors (55.09 %). There were very high significant differences (at least $P<0.01$) across breeds in all body measurements except ($p>0.05$) rump length and pelvic width. From all the measurements compared, Central Highland goat had higher values except rump length, pelvic width and horn length. In general, males showed higher measurements than females and the interaction between sex and breed significantly (at least $p<0.05$) affected all the parameters measured. Least square means (±SE) of body weight (kg) for Abergelle males and females at 4PPI were 30.75±0.60 and 24.30±0.32 respectively. The corresponding values for Central Highland goats were 34.79±0.73 and 33.11±0.31 respectively. The average flock size per monitored households in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 27.33±1.88, 19.18±1.32 and 13.79± 9.41 goats respectively. The overall least square means (±SE) for birth, three, six and nine month weights (kg) of Abergelle goat kids at Ziquala district monitoring site were 1.98± 0.06, 7.30± 0.21, 9.25±0.31 and 11.21±0.53 respectively. For the same breed at Tanqua Abergelle district monitoring site for the above age categories (in kg) were 1.97± 0.06, 7.43± 0.23, 11.08±0.33 and 13.24±0.55 respectively. The corresponding values for Central Highland goats in Lay Armachiho district monitoring site were 2.31±0.04, 10.67± 0.17, 17.53±0.24 and 22.66±0.44 respectively. As recommendation, further cluster studies should be conducted on Central Highland goat breed for the uniformity or dissimilarity of goats for the areas delineated by FARM Africa (1996). Abergelle goat keepers traditionally believe that 'liybia' goat is prolific and productive due to especial gene it has. This traditional knowledge should be scientifically proved or disproved whether this goat genetic makeup is significantly different or similar with other ordinary goats in the same goat breed.

Key words: Phenotypic characterization, Production environment, goat production, On-farm goat performance evaluation, Abergelle and Central Highland goat breeds

1. INTRODUCTION

Ethiopia is endowed with abundant livestock resources of varied and diversified genetic pools with specific adaptations to a wide range of agro-ecologies. Farm animals as a whole are an integral part of the country's agricultural system and are raised both in the Highland and lowland areas. Similarly, the habitats of the indigenous goat breeds extend from the arid lowlands (the pastoral and agro-pastoral production system) to the humid Highlands (mixed farming systems) covering even the extreme tsetse-infested areas of the country (Workneh, 1992).

The country is home for diverse indigenous goat populations, numbering 24.06 million heads (CSA, 2013) parallel to its diverse ecology, production systems and ethnic communities. Goat in Ethiopia is a among neglected farm animals in agricultural research and development programs. Apart from limited experiences of FARM Africa (1996) in crossbreeding of local goats with exotic dairy goats for improved milk production in the Hararghe Highlands and the SNNPR, there has been no organized goat improvement program in the country (Azage *et al*, 2010). These goat populations are phenotypically classified into 13 distinct major breed types or populations (DAGRIS, 2007). However, genetic/molecular characterization revealed only the presence of eight distinctively different breed types or populations in the country (Tesfaye, 2004). According to this author, the eight distinct genetic entities include Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergelle, Afar, Highland goats (previously separated as Central and North-West Highland) and the goats from the previously known as Hararghe Highland, Short-eared Somali and Long-eared Somali.

In developing regions, populations of livestock of the same species, especially if they are geographically isolated and recognized by ethnic owners as being distinct from others around them, are traditionally recognized/considered as distinct eco-types or breeds (Solomon *et al*, 2011). Abergelle goat types are widely distributed along the Tekeze River in Southern Tigray (Tembien and Inderta), Waghimra, Raya Azebo, and North Gondar (Simien). These goats are kept by the Agew and Tigray ethnic groups. Central Highland goats are mainly found in the Central Highlands, west of the Rift Valley, Wollo, Gondar and Shoa (FARM Africa, 1996).

Breed characterization has a paramount importance for efficient utilization and conservation of farm animal genetic resources. Absence of adequate information on the characteristics of breeds potentially leads to miss decision and genetic erosion through cross breeding, replacement and dilution (Zewdu, 2008).

Characterization of Farm Animal Genetic Resources (FAGR) encompasses all activities associated with the identification, quantitative and qualitative description, and documentation of breed populations and the natural habitats and production systems to which they are or are not adapted. The aim is to obtain better knowledge of FAGR, of their present and potential future uses for food and agriculture in defined environments, and their current state as distinct breed populations (FAO, 1984; Rege, 1992)

There are two types of breed characterization: phenotypic and genotypic characterization. The genetic relationship between breeds can be quantified by estimating allelic frequencies from biochemical or DNA analysis (NRC, 1993). The classical description of breeds (coat color, horns, tail type, etc.) is based upon phenotype. Phenotypic characterization can be complementary to the powerful biotechnological tools for measuring genetic diversity at the level of the genome. Characterization tools range from simple descriptions of traditional livestock populations to a highly sophisticated molecular genetics tools (Solomon *et al*, 2011).

Characterization activities should contribute to objective and reliable prediction of animal performance in defined environments, so as to allow a comparison of potential performance within the various major production systems found in a country or region. It is, therefore, more than the mere accumulation of existing reports (FAO, 2007).

Performance recording is an important tool to suggest the breeding policy for a given area. However, recording in general is hardly practiced in any livestock species in the country, to identify the performance and management gaps (Awigichew, 2000; Tibbo, 2006). Thorough monitoring of the productive, reproductive and economic performance of small ruminants and their existing level of integration with crop production and other livestock keeping is required to capture a full picture of their contribution and thereby verifying possible intervention areas (Getahun, 2008).

Very often, the results obtained from on-station research are of little relevance to traditional production systems and may not contribute much towards understanding of the specific adaptation of animals to farmer's conditions (Rey *et al*., 1992). One further attraction of on-farm performance study is that it provides information in location specific production conditions that could lead to breed improvement options that are appropriate to the system (ILCA, 1987; Rey *et al*., 1992). However, unlike on-station experiments, on-farm study is influenced by many factors which could not be controlled.

Despite its significance in terms of milk, meat, cash income and skin production, research on Abergelle goat breed has been scant (Belay, 2008). Moreover information on the central Highland goat is very limited. Thus characterizing these goat genetic resource and evaluation of their performance in their existing production environment is very useful to plan different developmental strategies like community-based genetic improvement program and others.

Therefore, the objectives of this study were:

1. To characterize (phenotypic) Abergelle and Central Highland goat breeds in their existing production environments.
2. To describe the production environment and their production systems as an input for designing community-based goat genetic improvement program.
3. To evaluate and document on-farm performances of Abergelle and Central Highland goat breeds to plan appropriate breeding strategy and other developmental issues in the future.

2. LITERATURE REVIEW

2.1. Origin and Domestication of Goats

Taxonomically the domestic goats (Capra hircus) belong to the order Artiodactyla, suborder Ruminantia, family Bovidae and tribe Caprini. Goats are divided into two genera: Capra and Hemitragus. As cited by Tesfaye (2004), the genus Capra is divided into eight species (Ansell in Meester and Setzer, 1977; Corbet, 1978; Alados, 1985b): C. aegagrus, C. hircus, C. ibex, C. walie, C. caucasica, C. cylindricornis, C. pyrenaica, C. falconeri. (http: //www. press. jhu. edu /books/walkers mammals_of_the_world/artiodactyla/artiodactyla.bovidae.capra.html)

Domestication of goats is considered to have occurred in the mountainous area of western Asia between the 7th and 9th millennium B.C. (Epstein, 1971; Devendra and Burns, 1983). The origin of domestic goats remain uncertain and controversial, however, archaeological evidence suggests that were probably first domesticated in the Fertile Crescent region of the Near East possibly first in the Zagros Mountains area 10,000 years ago (Zeder and Hesse, 2000). The Bezoar (Capra aegagrus) is thought to be the progenitor of the domestic goat.

It is believed that by the 5th millennium B.C. goats had reached Egypt and by about 3500 BC goats with spiral or corkscrew horns entered Egypt from the Middle East. From Egypt the goats moved to the South and West part of the African continent.

Goats in Africa have traditionally been divided into three main families the Dwarf goats of West and Central Africa, the Savannah goats of sub-Saharan Africa and the Nubian type goat of Northern Africa (Epstein, 1971; Wilson, 1991). Generally, goats of sub-Saharan Africa are divided into three major types following their morphology; the long lop-eared type in north east and southern Africa, the small short-eared type dominant in eastern Africa and the dwarf short-eared type of West Africa. Most tropical goats were not well characterized both by genotype and phenotype and can be called nondescript. However, there have been several attempts to assign goats to breed/types based on such variables as origin, utility, body size, ear shape and ear length (FARM Africa, 1996).

It is assumed that the first wave of goats entered Ethiopia from the north between 2000 and 3000 B.C. The ancestors of Ethiopian goats are closely associated with goat types which migrated from the Middle East and North Africa.

2.2. Goat Breeds in Ethiopia

2.2.1. Indigenous goat breeds (populations)

Table 1. Distribution of documented indigenous goat breeds/types in Ethiopia

Breed group name	Breed name	Synonym	Distribution
Long eared goats	Barka	Bellenay, Beni Amer	Northern and northwestern Ethiopia near the border with Eritrea and the Sudan
	Long eared Somali	Digodi, Melebo, Boran Somali, Benadir, Gigwain	Rangeland of the southern Ogaden,Bale,Borana and Southern Sidamo with the Somali and Borana Pastoralists
Short eared Small-horned	Short eared Somali	Ogaden, Mudugh, Dighier,Abgal, Issa-Somali, Bimal	Northern and Eastern Ogaden and around Dire Dawa
	Western Highland	Agew	Highlands of Western Ethiopia (Gondar, Gojjam, Wollega and Shoa)
	Western Low land	Gumuz	Lowlands of Western Ethiopia (Metekel, Assosa, and Gambella)
	Woyto-Guji	Woyto, Guji, Konso	North Omo, South Omo, Sidamo, Borana
	Abergelle	NA	Southern Tigray, North Wollo, and North Gondar
	Afar	Adal, Assaorta, Denakil	Afar region and parts of Eritrea and Djibouti with the Afar Pastoralists
	Arsi-Bale	Arsi, Gishe, Sidama, Manta, Awarch	Arsi, Bale, Sidamo and western Hararghe Zones
	Central Highland	Brown Goat, Kaye	Highland of Central Ethiopia from Tigray through Wollo, Gondar to Shoa
	Hararghe Highland	Kotu-Oromo	Highlands of eastern and western Hararghe
	Keffa	NA	Keffa and adjoining parts of Kembata and Hadiya

Source: Asfaw and Tamrat, (2004), NA=not available

Information compiled on physical description and management system revealed that there are 14 goat types in Ethiopia and Eritrea (Farm-Africa, 1996). Almost all indigenous goat types in Ethiopia (Table 1) fall under the general group of Short eared Small-horned goats found throughout eastern, central and southern Africa. They inhabit all agro-climatic zones and production systems in the areas. There is only one breed (the Barka) from a different breed group, and it comes mainly from Eritrea (Asfaw and Tamrat, 2004). However, a recent genetic characterization of Ethiopian goats by Tesfaye (2004) was inconsistent with this classification of FARM Africa. Following the analysis of 15 microsatellite loci, the results indicate eight separate genetic entities: the Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergalle, Afar, Highland Goats (previously separated as Central and North West Highland) and the goats from the previously known Hararghe, Southeastern Bale and Southern Sidamo provinces (Hararghe Highland, Short-eared Somali and Long-eared Somali goats).

2.2.2. Exotic goat breeds in Ethiopia

Most of the goat breeds introduced to date have been dairy goats with the main purpose of crossing with local goats to improve milk production in areas where goat milk is known to be consumed (Alemu and Merkel, 2008). However, Very recently, Boer goat semen has been imported from the United States of America for crossbreeding studies at the two Universities (Haramaya and Hawassa) to improve meat production of local goats (IBC, 2004). Anglo-Nubian, Boer, Saanen and Toggenburg goats are some of the important breeds that have been introduced to Ethiopia (Alemu and Merkel, 2008).

2.3. Goat Flock Demography

Flock structure is the proportion in the flock of the different age and sex classes of goats. The number of males and females in flocks and their ages are often used as an indicator of a particular traditional management system in Africa (Wilson, 1986). Flock structure is also a basis for calculating or forecasting flock productivity (ILCA, 1990). For instance, a relatively low proportion of young stock in a flock would suggest that adult mortality is low or pre weaning mortality is high, or the kidding percentage is low. Alternatively, it may mean that more kids were sold during the year (Ibrahim, 1998). When the primary objective is to produce milk,

the proportion of females retained is usually higher than when the objective is to produce meat (FARM Africa, 1996). A high proportion of castrates suggest that the system is likely to be related to meat production objectives. For example, in low land goats of Ethiopia, the primary objective is to produce milk and castrates with four pairs of incisors account for 0.5% of the total flock, whereas for the Central Highland goats whose primary purpose is meat production and sale in times of need the proportion of castrated male with four pairs of incisors is 2.2% (Nigatu, 1994).

2.4. Goat Production Systems

In Africa, it is possible to distinguish two major types of production systems. These are the traditional systems and the modern ones. The two groups differ essentially in their use of the main factors of production, with traditional systems using mainly land and labour while modern systems also have large capital requirements and generally a lesser requirement for one or other of the remaining factors (FAO, 1991).According to FAO (1991) Two principal criteria serve to define traditional systems. The first is the degree of dependence of the household or the production unit on livestock or livestock products either for household income or for food supply. The second is the type of agriculture practiced in association with livestock production.

Table 2. Classification of small ruminant production types and systems in tropical Africa

Type	System	Macro-management	Main production factors	Nutrient source
Traditional	Pastoral	Nomadic/Semisedentary	Land	Range
	Agro-pastoral	Transhumant/Sedentary	Land/Labour	Range/Crop byproducts
	Agricultural	Sedentary	Labour/Land	Crop byproducts/ Household waste/Forage
	Urban	Sedentary	Labour	Household waste/Feed
Modern	Ranching	Sedentary	Land/Capital	Range/Forage
	Feedlot	Sedentary	Capital/Labour	Feed/Forage
	Dairy farm	Sedentary	Capital/Labour/Land	Feed/Forage
	Station	Sedentary	Land/Labour/Capital	Range/Forage/Feed

Source: FAO, 1991

Sheep and goats are distributed in all agro-ecological zones of the country although the majority of the sheep population is concentrated in the Highlands. The majority of the goat population is found in large flocks in the arid and semi-arid lowlands. In pastoral and agro–pastoral production systems, found in arid and semi-arid agro–ecological zones, goats are kept by nearly all pastoralists, often in mixed flocks with sheep, freely grazing or browsing in the rangelands (Yoseph, 2007).

2.5. Socio-Economic Importance of Goat Production

Goats are important for diversifying production, creating employment, increasing income, building capital, contributing to human nutrition and reducing risk, in addition to their quantifiable outputs of several products (Banerjee *et al*., 2000). The short generation interval of sheep and goats coupled with high frequency of multiple births allow for rapid increases in animal numbers. This builds financial capital and allows the sale of surplus animals for cash that can be used for other agricultural enterprises, school fees, medical bills, etc (Alemu and Merkel, 2008). In the context of smallholder subsistence agriculture, the objectives of keeping goats go beyond the products of meat, milk, fiber, manure and offspring, and include benefits in resource use, socio-economic and socio-cultural functions (Jahnke, 1982).

Very often, there are no banking facilities in rural areas and an easy way to store cash for future needs is through the purchase of sheep and goats. In fact, in some areas, small ruminants have been described as the 'village bank'. It has to be noted that this is beyond the cash value of the animal (Alemu and Merkel, 2008).

Unlike market-oriented commercial farmers, subsistence livestock producers follow broad production objectives that are driven more by their immediate subsistence needs rather than demands of a market (Workneh et al., 2003). As subsistence goats are a low-cost and inflation-proof alternative of saving, their value provides asset (financing) and security (insurance) benefits at times of difficulty. Being small animal, compared to the big animals as cows its value is not very high (Winrock International, 1992). This means keeping goats is not too risky and restoration of the herd size is also quickly done. Little capital investment in buildings or other

materials is required for their upkeep, and space and maintenance requirements are low (Jahnke, 1982).

Sheep and goats contribute a quarter of the domestic meat consumption; about half of the domestic wool requirements; about 40% of fresh skins and 92% of the value of semi-processed skin and hide export trade. At optimum off take rates, Ethiopia can export 700,000 sheep and 2 million goats annually, and at the same time supply 1,078,000 sheep and 1,128,000 goats for the domestic market. The current annual off take rate of sheep and goats is, however, only 33 and 35%, respectively (Alemu and Merkel, 2008).

2.6. Characterization of Farm Animal Genetic Resources (AnGR)

Characterization of indigenous breeds is a base for any breed or productivity improvement programs. Characterization should include physical description, reproduction and adaptations, uses, prevalent breeding system, population trends, predominant production system, description of environments in which it is predominantly found and an indication of performance levels (Workneh *et al.,* 2004). There are two types of breed characterization: phenotypic and genotypic characterization.

2.6.1. Phenotypic characterization

Phenotypic characterization of animal genetic resources for food and agriculture (AnGR) is the practice of systematically documenting the observed characteristics, geographical distribution, production environments and uses of these resources. The information provided by characterization studies is essential for planning the management of AnGR at local, national, regional and global levels (FAO, 2011).

In the developed world, livestock recording schemes provide a continuous source of data for monitoring trends in the industry, including improved understanding of breeds and the production system. Unfortunately, such structures are not available in most developing countries. Here, designed, rapid, on-farm surveys can be useful for collecting basic (macro level) information on production systems, population statistics of breeds, physical (or descriptive)

characteristics and performance levels-milk production, fertility, mortality, longevity, growth, meat production etc.(Philipsson et al, 2011)

FAO (1986) published a comprehensive list of variables for describing the phenotypic and genetic characteristics (descriptor lists) of FAnGRs as the basis for systematic phenotypic characterization and to facilitate global valid comparison and classification of breeds within a species. However, the organization had come to recognize that these descriptors were far too complex for universal application (FAO, 2007).

2.6.2. Genetic characterization

Outcomes of morphological characterization need to be complemented by genetic characterization (FAO 2007). Genetic characterization involves the description of breeds in terms of the relative allelic frequencies, degree of polymorphism using a set of neutral reference markers and classifying livestock breeds using genetic distances between populations/breeds (Cavalli-Sforza and Edwards 1967; Nei 1972; Nei *et al*. 1983).

Genetic characterization tools included biochemical (protein) polymorphisms and molecular polymorphisms. However, biochemical markers lack the power to resolve differences between closely related populations because of low polymorphism (Meghen *et al*. 1994)

2.7. Productivity of Indigenous Goat Breeds

In sub-Saharan Africa the majority of sheep and goats are raised by smallholder farmers on a small scale; profitability is low due to low market weight, overall low reproductive efficiency and high mortality (Ibrahim, 1998).

2.7.1. Reproductive performance

Reproduction is a series of events (gamete production, fertilization, gestation, reproductive behavior, kidding, etc.) that terminates when a young is born. Reproductive performance is a prerequisite for any successful livestock production programme. Where farm resources are

severely limited as it is often the case in sub-Saharan Africa, reproduction failure is the first sign of decreased productivity (Mukasa-Mugerwa et al*.,* 2002).

Measures of reproduction commonly used in sheep and goats include age at puberty, age at first lambing/kidding, post-partum interval, parturition interval and fertility indices (Alemu and Merkel, 2008). On the other hand Ibrahim (1998) added some other reproductive efficiency measuring parameters: fertility, prolificacy (litter size), fecundity (fertility x prolificacy) and survival.

According to Alemu and Merkel (2008) the cause of reproductive failures in sheep and goat is varied and often poorly understood. This depression of reproductive performance can be broadly classified into:

- Failure to mate;
- Failure of fertilization in mated animals;
- Loss during any stage of gestation (embryonic, fetal losses);
- Neonatal mortality and subsequent loss occurring until the time of weaning

Flock reproductive rate also affects selection intensity and consequently the rate of genetic improvement in all traits under selection. Poor reproductive performances of Ethiopian sheep and goats can be associated with genetic factors, poor management, seasonal fluctuations in feed resources and diseases (Mukasa-Mugerwa *et al*., 2002).

2.7.2. Productive performance

Growth performance

Growth is a very important characteristic of animals for meat production and it depends on factors such as breed, sex, nutrition and other environmental conditions. Most of Ethiopian goats' adult body weight range from 25-40 kg (Peacock, 1996). Mukassa-Mugerwa *et al*. (1989) stated that growth rate of goats in Ethiopia declined from 104 g/day at 3 months to 87 g/day, 65 g/day and 44 g/day at 6 , 12 and 24 months, respectively. The results of preliminary classification by FARM Africa (1996) have shown that variation exits between indigenous goat breeds for body weight traits. Table 3 shows some linear body measurements in matured adult females of the indigenous goat breeds in Ethiopia.

Several studies in the tropics have shown that body weight in goats could be estimated from chest girth measurement with fair accuracy (Badi *et al*., 2002; Slippers *et al.,* 2000). These findings are in line with the study conducted on the morphological characteristics of indigenous goats in representative zones and districts of Amhara Region (Halima *et al.,* 2012) that correlation coefficients (r) between live weight and other body measurement traits were found positive with the presence of highly significant (P<0.01) associations of body weight with heart girth (r= 0.899) and body weight with body length (r=0.729) for west Amhara Region goat populations' (Gumuz, Begia-Medir and Agew goat ecotypes). The same author showed that correlation coefficients (r) between live weight with heart girth (r= 0.823) and live weight with body length (r=0.538) for the east Amhara Region goat populations (Bati, Abergelle and Central Abregelle goats).

Table 3. Linear body measurements in adult females of indigenous goat breeds

Breed	Parameters (Mean ± SD)		
	WH (cm)	BW (kg)	CG (cm)
Nubian	70.1 ± 3.4	34.1 ± 5.4	74.3 ± 3.8
Barka (Begayit)	67.9 ± 4.3	33.8 ± 5.3	73.9 ± 4.8
Afar	60.9 ± 3.3	23.7 ± 3.4	67.4 ± 3.8
Abergelle	65.0 ± 2.8	28.4 ± 3.5	71.2 ± 3.8
Arsi-Bale	66.1 ± 3.5	30.4 ± 4.5	74.9 ± 4.0
Woyto-Guji	66.4 ± 3.5	28.8 ± 5.0	72.5 ± 4.2
Hararghe Highland	62.5 ± 3.5	29.1 ± 4.5	72.8 ± 4.5
Short-eared Somali	61.8 ± 4.1	27.8 ± 6.0	70.4 ± 4.7
Long-eared Somali	69.4 ± 3.3	31.8 ± 5.4	74.4 ± 4.0
Central Highland	67.9 ± 3.2	30.1 ± 5.4	74.1 ± 4.4
Western Highland	70.8 ± 4.7	33.0 ± 6.0	75.8 ± 4.5
Western Lowland	63.5 ± 3.8	33.9 ± 6.9	75.9 ± 5.2
Keffa	66.7 ± 4.0	28.2 ± 5.2	72.2 ± 4.5

BW = Body weight; WH = Wither height; CG = Chest girth; SD = Standard Deviation

Source: FARM Africa (1996)

Milk yield performance

Compared to cow milk, goat milk is richer in vitamins and minerals, so particularly appropriate for the diet of the elderly, the sick and children (Devendra and Burns, 1983; Getahun, 2008). In central rift valley, in eastern, south-eastern and north-eastern part of Ethiopia, goat milk is

consumed by farming community (Abule, 1998; Workneh *et al.,* 2004). According to Workneh Ayalew and Rowlands (2004), goats are more frequently milked in the *kolla* agro-ecological zones, low livestock density areas and in the pastoral production systems (Table 4). The reported average daily milk off-take is 0.5 liter per doe for an average lactation length of about 3.4 months.

Table 4. Average milk off-take (liters per day) of goat by agro-ecological zones, livestock densities and production systems

Categories	No. of household olds	Average milk yield (litres)				
		Mean	sd	Min	Max	Range
AEZ						
Dega	103	0.6	0.4	0.2	2	1.8
Weinadega	211	0.5	0.3	0.13	2	1.88
Kolla	351	0.5	0.3	0.1	1.5	1.4
Overall	665	0.5	0.3	0.1	2	1.9
Livestock densities						
Low	139	0.6	0.3	0.2	1.5	1.3
Medium	152	0.5	0.3	0.1	2	1.9
High	190	0.5	0.3	0.12	2	1.88
Very High	184	0.5	0.3	0.2	2	1.8
Overall	665	0.5	0.3	0.1	2	1.9
Production systems						
Crop–livestock	470	0.5	0.3	0.1	2	1.9
Agro-pastoral	135	0.5	0.3	0.13	1.5	1.38
Pastoral	60	0.5	0.3	0.25	1	0.75
Overall	665	0.5	0.3	0.1	2	1.9

Source: Workneh Ayalew and Rowlands (2004), AEZ =**Agro-ecological zones**

2.8. Community-Based Goat Genetic Improvement Strategy in Ethiopia

Apart from limited experiences of FARM Africa in crossbreeding of local goats with exotic dairy goats for improved milk production in the Hararghe Highlands and the SNNPR, there has been no organized goat improvement program in the country (Azage *et al, 2010*). However there are on-going works on village (community) based goat genetic resource improvement projects by Amhara Regional Agricultural Research Institute (ARARI) at Sekota Dry Land Agricultural Research Center (SDARC), Gondar Agricultural Research Center (GARC) and Debre Birhan

Agricultral Ressearch Center (DBARC) on Abergelle, western low land and central Highland goats respectively.

2.9. Research Gap in the Study Area

Characterization of AnGR aims to obtain better knowledge of AnGR, of their present and potential future uses for food and agriculture in defined environments, and their current state as distinct breed populations (FAO, 1984; Rege, 1992). According to FAO (2007) changes in population size and structure need to be documented regularly for all breeds. Monitoring should be conducted at least once per generation of the species, particularly for breeds classified as at risk or potentially at risk. This requires surveys at intervals of about eight years for horses and donkeys, five years for cattle, buffalo, sheep and goats, three years for pigs and two years for poultry species.

Abergelle and central Highland goat breeds were phenotipically characterized more than 18 years back by FARM Africa (1996) during Ethiopian and Eritrean goat types characterization. Even though FARM Africa (1996) was able to provide information on physical description and other related issues of Ethiopian goat breeds, this work was not aimed to characterize these goat breeds to the direction of village or community based genetic improvement strategy. Goat on-farm performance evaluation and monitoring work in Ethiopia is scant. Furthermore, updating of the previous results is vital since genetic resources and production systems are not static, routine inventories and on-going monitoring is needed (Sölkner *et al.,* 1998).

3. MATERIALS AND METHODS

3.1. Study Areas

The study was conducted in two National Regional States of Ethiopia: Amhara National Regional State (in Ziquala and Lay Armachiho districts) and Tigray National Regional State (in Tanqua Abergelle district) to study Abergelle and Central Highland goat breeds (Fig 1).

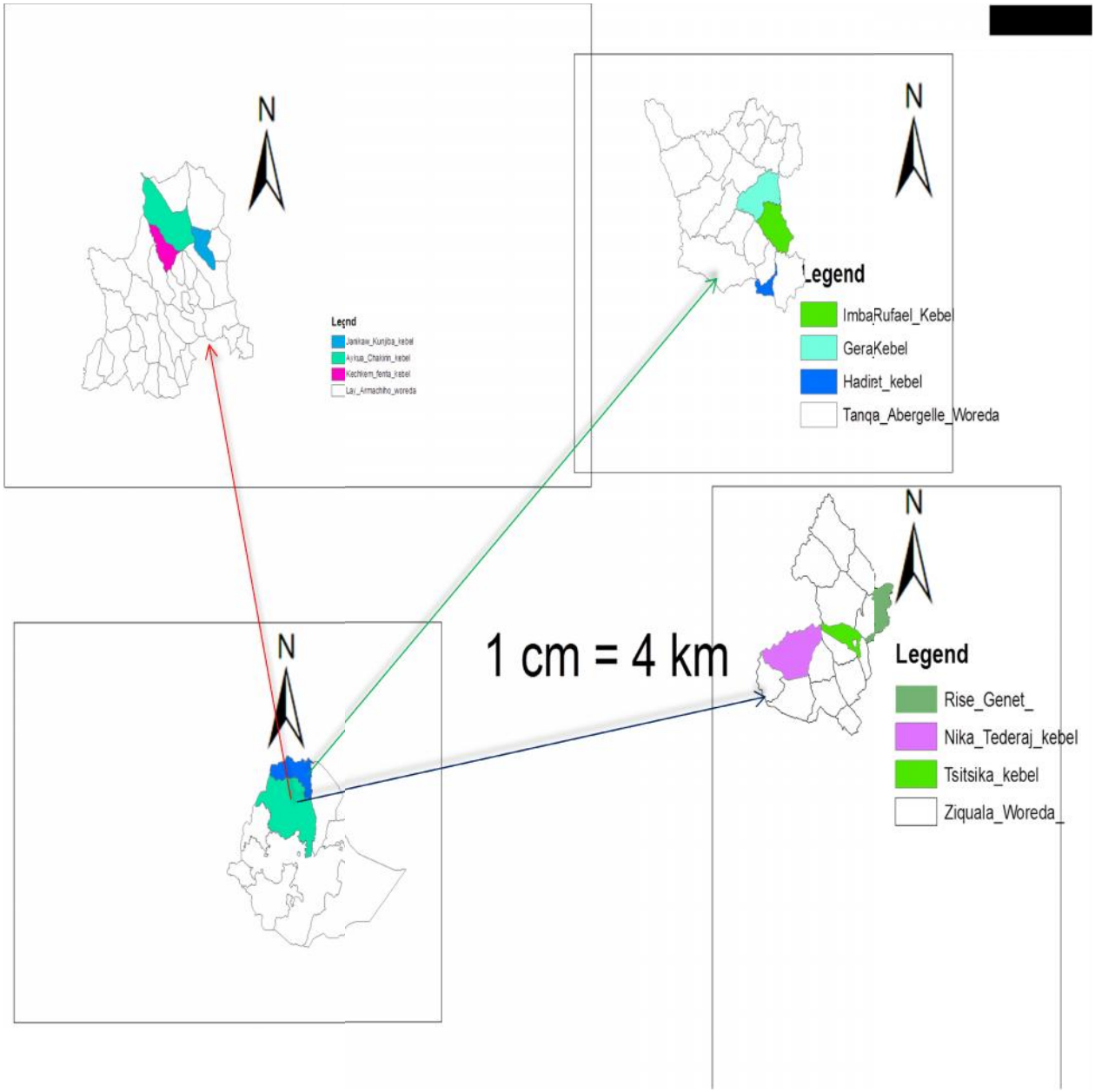


Figure 1. Map of the study areas

Ziquala district

Ziquala district is one of the seven districts in Wag Hmira zone, Amhara National Regional State (ANRS). It is located 65 km from the Zone town (Sekota) and 784 km from Addis Ababa, Ethiopia. Its latitude, longitude and altitude at the district town (Tsitsika) are 12^{o} 48'N, 38^{o} 47' E and 1462 masl respectively. The sampled PAs in Ziquala district extended from 12^{o} 76' to 12^{o} 81'N by latitude and 38^{o} 66' E to 38^{o} 89' E by longitude (from Nika Tederaj to Rise Genet) in the range of 1237 to 1684 masl altitudes (actual GPS records during data collection with ± 3.5 meter tolerable error). In Ziquala district the rainfall is unimodal, short and erratic that extends not more than two months per year, usually from end of June to the end of August. The annual average rainfall and temperature in Ziquala district was 255mm and 22^{o}c respectively (Dereje, 2004). The erratic seasonal rainfall coupled with the steep slopes topography with low vegetation cover have led to low retention of ground water and high run-off, which in turn led to extensive soil erosion in the district. Crop production usually fails due to low soil fertility and high moisture stress, almost every year. As result majority the population is dependent on food aided organizations (NGOs and Governmental organizations).

Services (e.g. health services both for human and livestock, school, hotel) and infrastructures (e.g. road) are generally very poor in Ziquala district. Abergelle goat breed in Wag Hmira zone is mainly found in three districts (Sihala, Ziquala and Abergelle) which are neighboring to central Tigray zone in the North. This goat breed is also found in some parts of Sekota and Dihana districts of the zone in the Northern part.

.**Tanqua Abergelle district**

Tanqua Abergelle district is found in Central Tigray Zone which is located 110 km from Mekelle (the capital city of Tigray National Regional State) and 893 km from Addis Ababa. The latitude, longitude and altitude at the district town (Yechila) are 13^{o} 22 N, 38^{o} 99 E and 1574 masl respectively. The PAs sampled in Tanqua Abergelle district located from 13^{o} 21' to 13^{o} 44'N by latitude (from Hadinet to Gera) and 38^{o} 95' E to 39^{o} 00' E by longitude in the range of 1432 to 1825 masl altitudes (actual GPS records). The mean annual rainfall of Tanqua Abergelle district was 539 mm and the temperature ranges from 20-28^{0}c (SERA, 2000). Higher value of average

annual temperature of Tanqua Abergelle district was recently reported by Gebremedhin *et al* (2013) that range between 27 and 30°C.

Relatively, infrastructures (e.g. all weather road) and services (e.g. health services for human, school, and hotel) in Tanqua Abergelle district is better than Ziquala district but less than Lay Armachiho district. Abergelle goat breed is found mainly in Tanqua Abergelle and Tenbien districts in the zone (FARM Africa, 1996) which are nearby for Sihala, Ziquala and Abergelle districts in the South.

Lay Armachiho district

Lay Armachiho district is one of the twenty three districts found in North Gondar Zone which is located 20 km in North of the Zone town (Gondar) and 758 km from the capital city of Ethiopia (Addis Ababa). At the district town (Tikil Dingai) latitude, longitude and altitudes are 12^{o} 58'N, 37^{o} 04' E and 2052 masl respectively. Sampled PAs in Lay Armachiho district situated from 12^{o} 80' to 12^{o} 93'N by latitude and 37^{o} 34' E to 37^{o} 53' E by longitude (from Camfenta to Janikaw) in the range of 1178 to 1281 masl altitudes (actual GPS records). Lay Armachiho district gets flatter and lowland as one travels from the South to the North where goat population is relatively high in number and economically important. In Lay Armachiho district annual temperature and annual rainfall ranges between 17-24C^{0} and 840-1200 mm per year respectively. However, the northern lowland areas of Lay Armachiho have the highest annual temperature of between 22-24C^{o}.Generally the district's altitude ranges from 1000 to 3000 masl. More specifically, fifty percent of the land mass in the northern part of lies between 1000 and 2300 masl, while the remaining lies between 2000 and 3000 masl (Kahsay, 2013). In Lay Armachiho district the rain fall is unimodal and usually starts from May to September. Relatively, the amount and duration of rain per year is better than Ziqual and Tanqua Abergelle districts. As result the vegetation cover in Lay Armachiho district is relatively better.

Relatively, infrastructures (e.g. all weather road) and services (e.g. health services for human, school, and hotel) in Lay Armachiho district is better than both Ziquala and Tanqua Abergelle districts.

Total number of livestock populations, PAs, households and human populations in each district are presented in Table 5 and 6.

Table 5. Total number of livestock populations in each district

District	Cattle	Goat	Sheep	Donkey	Mule	Horse	chickin	Beehives
Z. (2014)	64629	101122	25872	7340	349	1	26272	16151
T A(2014)	75728	247540	100027	19541	349	42	104390	12560
L.A(2012)	198755	74636	39135	21762	379	334	164650	19819

Z =Ziquala,T.A=Tanaqua Abergelle, L.A=Lay Armachiho
Source: Respective district agricultural and rural development offices

Table 6. Total number of PAs, households and human populations in each district

District	Total PA	MHH	FHH	THH	Male	Female	Total
Ziquala†	15	9061	2822	11865	24093	24937	48515
Ziquala*	-	-	-	-	22464	21500	43964
T.Abergelle†	21	18540	5105	23645	54021	51935	105956
T.Abergelle*	-	-	-	-	47126	45718	92844
L. rmachiho†	34	29733	5907	35640	92537	94567	187101
L.Armachiho*			-	-	79513	78284	157797

†=2014 respective district agricultural and rural development offices (Unpublished), MHH =Male Household, FHH= Female Household, THH=Total Household *= CSA 2007census,

3.2. Study Site Selection

The study areas were selected purposively based on the populations of two goat breeds: Abergelle goat breed in Waghimra and Central Tigray zones and Central Highland goat breed in North Gondar zone. Before selection of districts and peasant associations (PAs), a series of steps were followed. First, discussions were made with the zonal livestock experts and researchers to select one district at each of the three zones. Thus Ziquala district in Waghimra zone, Tanqua Abergelle district in Central Tigray zone and Lay Armachiho district in North Gondar zone were selected. Within the selected districts a rapid field survey and discussions were made with a team of researchers and the respective district animal science experts to locate appropriate PAs for the baseline data collection (characterization) and for on-farm performance monitoring purpose.

Three PAs in each district (Rise Genet, Tsitsika and Nika Tederaj, from Ziquala district, Hadinet, Imbarufael and Gera from Tanqua Abergelle district and Kechkemfenta, Aykuwachakirin and Janikaw kunjiba from Lay Armachiho district) were selected. Within the selected nine PAs, survey (individual household interviews and group discussions) and goat linear body measurements were made. From these nine selected PAs one PA was selected from each district (Tsitsika, Hadinet and Kechkemfenta) for on-farm performance monitoring purpose. Within the selected PAs for on-farm performance monitoring purpose one village in each of Ziquala (Bilaku village with 33 selected participant households) and Tanqua Abergelle (Dingur village with 44 selected participant households) districts and three villages in Lay Armachiho district (Wikaw, Mizaw and Zentay villages with 38 selected participant households) were selected and on-farm performance data were collected. Due to low number of goat population per household and scattered settlement of farmers in Lay Armachiho district, three villages were included to increase the population size of monitored animals and goat keepers.

Throughout all the steps (from the zone to PA) the criteria used to select study sites were goat population, economic importance of goat in the area and willingness of farmers to participate in this study program.

3.3. Data Types and Methods of Data Collection

Data were collected from secondary data sources, stakeholders meeting including farmers, pretested semi- structured questionnaire, employing field measurements (on qualitative and quantitative traits), organizing group discussions (farmers and Development agents) and on-farm performance recorded data.

Enumerators for data collection both for survey and linear body measurements were from the staffs of the respective research centers: four researchers from Sekota Dry Land Agricultural Research Center for Ziquala district, four researchers from Abergelle Agricultural Research Center for Tanqua Abergelle district and three researchers from Gondar Agricultural Research Center for Lay Armachiho district and one district animal expert in each district except in Tanqua Abergelle district.

3.3.1. Stakeholders meeting

Different stakeholders (including farmers) meeting was organized at each district before the commencement of the actual field work. The research team was accompanied by the respective district animal production experts and DAs (PA development agents) to conduct the meeting. The meeting was focusing on clarifying and sensitizing farmers and different stakeholders on the objectives of the research, gathering information about challenges and opportunities of goat production in the respective study districts. Moreover, the meeting was helpful to avoid unrealistic expectations by the communities and different stakeholders.

Different stakeholders invited for the meeting were a minimum of 15 farmers, one livestock development agent (DA) working in the selected peasant association, one animal production expert at district level, one animal breeding researcher and two livestock traders (excluding Lay-Armachiho district) working in the area at each selected districts.

The different stakeholder's participation was helpful to understand the challenges and opportunities in the areas and to map out possible intervention issues along the value chain.

3.3.2. Questionnaire and group discussion

Modified questionnaire was prepared by adopting a questionnaire prepared by ILRI (International Livestock Research Institute)-OADB (Oromiya Agricultural Development Bureau) for survey of livestock breeds in Oromiya region (Workneh and Rowlands, 2004) and standard description list developed by FAO (1986). The questionnaire was pre-tested before administration and some re-arrangements were made based on the study objectives (appendix1). A total of 256 farmers in Ziquala (68), Tanqua Abergelle (70) and Lay-Armachiho (118) districts were interviewed for the household survey.

Climatic data on temperature and rainfall, geographical location, human and livestock demography data were collected from the Zone administrative office, the district office of Agriculture and Rural Development and other written documents.

3.3.3. Body measurements and observations

It is customary to describe breeds in terms of mature females if the researcher has no special intention to see the size of flock owned and flock structure (FARM Africa, 1996). This is because they usually exist in larger numbers and it is easier to determine their stage of maturity than for males. Data for qualitative and quantitative characters were collected from a total of 640 4PPI (4 pair of permanent incisors) age category of goats (143 from ziquala and 183 from Tanqua Abergelle districts on Abergelle goat breed and 314 from Lay Armachiho district on Central Highland goat breed). Data were recorded on the prepared format adopted from the standard description list developed by FAO (1986) and ILRI-OADB breed descriptor list (Workneh and Rowlands, 2004). Data for quantitative characters were collected using 100cm long textile measuring tape and suspending balance having 50 kg capacity with 0.2 kg precision. Data were collected early in the morning to avoid the effect of feeding and watering on the animal's body size (FAO, 2012). Pregnant does and sick goats were excluded from sampling. Each experimental animal was identified by sex, site (location), breed and flock number (farmer) (Appendix Table 2).

3.3.4. On-farm performance evaluation and monitoring

After farmer's trait preferences data were collected and analyzed using ranking index method and group discussions were made, on-farm data recording formats were developed based on the preferred traits in the respective districts (Appendix 3). Enumerators in each district were recruited and trained how to record the on farm performance data. Enumerator's educational level was from grade eight to diploma level. Animals were identified by ear tags. Close supervision and guidance for enumerators' were given by the respective agricultural research centers (Sekota Dry Land Agricultural Research Center for Ziquala district, Abergelle Agricultural Research Center for Tanqua Abergelle district and Gondar Agricultural Research Center for Lay Armachiho district by nominating one animal breeding researcher as a focal person). On-farm data recording formats were developed on different sheets. Accordingly, number and types of goats owned by farmers at the beginning of flock inventory (base flock), flock dynamics (in-flows and out-flows), milk yield data per week (excluding Lay Armachiho

district), birth data within 24 hours (birth type, birth weight and birth date i.e. season of birth), and body weight data (for three, six and nine months) were recorded.

3.4 Data Management and Analysis

After data were coded and entered into the computer for analysis, preliminary data analysis like homogeneity test, normality test and screening of outliers were employed before conducting the main data analysis. Household survey (questionnaire) data was analyzed using districts as fixed factor.

After significance test was made between sampled goat types in Ziquala and Tanqua Abergelle districts both for qualitative and quantitative data, these sampled goat populations were merged as one breed (Abergelle goat breed) because of they are homogenous in all the parameters except for toggles presence and absence. Therefore, based on the analysis made between these districts (Ziquala and Tanqua Abergelle) and the earlier work report (FARM Africa, 1996) throughout this paper Abergelle goat breed stands for goats sampled in Ziquala and Tanqua Abergelle districts. Using FARM Africa's (1996) report goats sampled in Lay Armachiho district is named as Central Highland goat.

3.4.1. Questionnaire and group discussion

Data collected through questionnaire (survey) were described by descriptive statistics using Statistical Package for Social Sciences (SPSS 14.0 for windows, release 14.0, 2005). Chi-square was employed when required to test ($p \leq 0.05$) the independence of categories. F-test was applied when required to test the statistical significance ($p \leq 0.05$). Indices were calculated for ranked data to provide ranking of the reasons of keeping goat, goat breeding objective, buck and doe selection criteria, contribution of different farming activities to the family food and income and major goat production constraints etc. Index (e.g. having five rank level) was calculated as Index = Sum of (5 X number of household ranked first + 4 X number of household ranked second + 3 X number of household ranked third + 2 X number of household ranked forth + 1 X number of household ranked fifth) given for an individual reason, criteria or preference divided by the sum of (5 X number of household ranked first + 4 X number of household ranked second + 3 X

number of household ranked third + 2 X number of household ranked forth+ 1 X number of household ranked fifth) for overall reasons, criteria or preferences.

3.4.2. Body measurement and observation

Observations on qualitative traits were analyzed separately for male and female goats using frequency procedure of Statistical Analysis System (SAS, release 9.1, 2003) within breed. Chi-square was employed when required to test the independence of categories or to assess the statistical significance ($p \leq 0.05$) within breed. Chi-square was also calculated across/between breeds to test the existence of significance differences between breeds.

Multiple Correspondence analyses were employed to see the associations of the qualitative traits by breed. Quantitative traits (Body weight and other body measurements: Body Length (BL), Wither Height (WH), Chest Girth (CG), Chest width (CW), Rump length (RL), Pelvic Width (PW), Horn Length (HL), Ear Length (EL) and Scrotum Circumference (SC)) were analyzed using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS, release 9.1, 2003). Sex (excluding scrotal circumference) and breed of the experimental goat were fitted as fixed independent variables while body weight and other linear body measurements were fitted as dependent variables. When analysis of variance declares significance, least square means were separated using adjusted Tukey-Kramer test.

Model used to analyze body weight and other linear body measurements was:

$Y_{ijk} = \mu + Si + Bj + (SB)ij + e_{ijk}$

Where: Y_{ijk} = the observed k (body weight or other linear body measurements) in the i^{th} sex and j^{th} breed of the experimental goats

μ = overall mean

Si – the effect of i^{th} sex (male and female)

Bj = the effect of j^{th} breed group (Abergelle goat and Central Highland goat)

(SB)ij = the effect of interaction of i^{th} of sex group with j^{th} of breed group

e_{ijk} = random residual error

The relationship (using Pearson's correlation coefficient) between body weight and other linear body measurements was calculated for each breed and sex separately. The stepwise multiple linear regression analysis was done to obtain models for estimation of live body weight from other linear body measurements for each breed and sex separately. Initially, selection of variables at $p \leq 0.05$ was employed by incorporating all variables at the same time to see the order of selected variables, and then stepwise regression analysis was made. The smaller values of Conceptual predictive (*Cp*), Akaike Information Criteria (AIC), Schwarz Bayesian Criteria (SBC) and RMSE and the higher value of R^2 were used to determine those traits that contribute much to the response variable (Kaps and Lamberson, 2004). Best fitted model was selected based on (R^2), R^2 change, RMSE and simplicity of measurement under field conditions. The following models were used for the analysis of multiple linear regressions.

For male:

$Y_j = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e_j$

Where:

Y_j = the response variable; body weight

a = the intercept

X1, X2, X3, X4 and X5 are the explanatory variables of body length; height at wither, chest girth, pelvic width and scrotum circumference respectively.

$\beta_1, \beta_2 \ldots \beta_5$ is regression coefficient of the variables *X1, X2,..X5*

e_j = the residual random error

For female:

$Y_j = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e_j$

Where:

Y_j = the response variable; body weight

a = the intercept

X1, X2, X3, X4, X5, X6 are the explanatory variables of body length, wither height, chest girth, chest width, rump length and pelvic width respectively.

$\beta_1, \beta_2 \ldots \beta_6$ is regression coefficient of the variables *X1, X2... X* 6

e_j = the residual random error

3.4.3. On-farm performance evaluation and monitoring

Basic statistics (mean, least square mean, standard deviation, standard error, range, maximum, minimum, frequency and percentage) were used for base flock, final flock, flock dynamics, flock structure, milk yield, birth data and growth performance studies. Model used to analyze growth performance of monitored goat (birth to nine months) was:

$Yijbf= \mu + Si + Pj + Tb + eijbf$

Where: Yijbf = Observed live body weight (birth, three, six and nine months) and weight gain per day (from birth to three months , from three to six months and from six to nine months) at i^{th} sex, j^{th} parity and b^{th} type of birth

μ = Overall mean

Si= the effect of i^{th} sex (i = male and female)

Pj = the effect of j^{th} parity (j = 1, 2, 3, 4, ≥5)

Tb= the effect of b^{th} type of birth (b = single, twin, triple)

eijbf = random residual error

Based on Dereje's study result (Dereje, 2004) in Ziquala district, natural grasses and shrubs can only support the animals during the wet season from July to December. The survey part of this study result also confirmed that feed situation in Ziquala and Tanqua Abergelle districts where critical from December up to June and conversely feed is relatively better from July to December. Therefore based on the above mentioned evidences, model used to analyze milk yield for Abergelle goat breed in Tanqua Abergelle and Ziquala districts was:

$Yijltf= \mu + Si + Pj + Dl + Mt + (SB)il + eijltf$

Where: Yijltf = Observed milk yield at i^{th} season, j^{th} parity, l^{th} location and t^{th} milking time

μ = Overall mean

Si= the effect of i^{th} season (i = relatively feed available season (July up to December), relatively feed scarce season (January up to June))

Pj = the effect of j^{th} parity (j = 1, 2, 3, 4, 5≥6)

Dl= the effect of l^{th} loction or site (l=Ziquala and Tanqua Abergelle districts)

Mt= the effect of t^{th} milking time (Evening and morning)

(SB)il = the effect of interaction of i^{th} season with l^{th} loction or monitoring site

eijltf = random residual error

4. RESULTS AND DISCUSSIONS

4.1. General Household Information

General Socioeconomic characteristics, family size, land and livestock holding, crop and livestock farming system in the Ziquala, Tanqua Abergelle and Lay-Armachiho districts is presented bellow.

4.1.1. General socioeconomic characteristics

A total of two hundred fifty six farmers were interviewed for the household survey. Sex, position in the household, educational background, age and marital status of the respondents is presented in Table 7.

Table7. Number (N) and percentage (%) of households per Sex, position in the household, educational background, age and marital status of the respondents in the study districts

Descriptors	Ziquala		Tanqua Abergelle		Lay Armachiho		Overall		Test	
	N	%	N	%	N	%	N	%	X2 – value	p-value
Sex of the respondents									na	
male	62	91.2	67	95.7	114	96.6	243	94.9		
female	6	8.8	3	4.3	4	3.4	13	5.1		
Respondents position in the HH									na	
owner	68	100	70	100	112	94.9	250	97.7		
shepherd	0	0	0	0	1	0.8	1	0.4		
relative	0	0	0	0	5	4.2	5	2		
Ability to read and write									11.3	0.003
yes	14	20.6	30	57.1	52	55.9	96	62.5		
no	54	79.4	40	42.9	66	44.1	160	37.5		
Educational background									19.3	0.013
Read and	2	2.9	10	14.3	27	22.9	39	15.2		

write*										
primary	10	14.7	17	24.3	22	18.6	49	19.1		
secondary	1	1.5	2	2.9	3	2.5	6	2.3		
high school	1	1.5	1	1.4	-	-	2	0.8		
Age									11	0.354
<20	-	-	-	-	3	2.5	3	1.2		
21-30	16	23.5	14	20	19	16.1	49	19.1		
31-40	27	39.7	21	30	34	28.8	82	32		
41-50	12	17.6	20	28.6	35	29.7	67	26.2		
51-60	10	14.7	8	11.4	16	13.6	34	13.3		
>60	3	4.4	7	10	11	9.3	21	8.2		
Marital status									na	
single	1	1.5	-	-	9	7.6	10	3.9		
married	63	92.6	70	100	104	88.1	237	92.6		
divorced	2	2.9	-	-	2	1.7	4	1.6		
widow	2	2.9	-	-	3	2.5	5	2		

*na = not applicable for X^2-square test i.e some of the observation(s) within the category are less than 5 counts *=informal learning to read and write like adult school or religious school HH = household*

In this particular study male respondents accounted the largest proportion in all the study areas: 91.2%, 95.7% and 96.6% in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively. The remaining lower proportion of women respondents in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively were 8.8%, 4.3% and 3.4%. The occurrence of less percentage of women respondents in the study areas may be due to work load inside the house and as a result the probability of getting them outside of the house is less. Moreover, when someone knocks the door of somebody's house, male usually comes out first and respond specially if the household head is male. The comparisons of male to female ratio in the above sentences do not necessarily mean household head but sex of the respondent's proportion.

4.1.2. Family size, land and livestock holding

Family size in terms of total and both sexes were not significantly ($P<0.05$) different across all the three districts. Average family size in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 6.4, 6.5 and 7.1 respectively. The National, Tigray Regional State and Amhara Regional State rural average family size in 2007 census were 4.9, 4.6 and 4.5 respectively (CSA, 2007). The current study results regarding on family size in all the three districts were higher

than both the national and their respective regional states rural average household size. In agreement with the current study result, Zewdu (2008) reported higher family size than the national family size in Horro (7.3) and in Adiyo Kaka (8.6). Higher figure than the national average family size were also reported by Grum (2010) around Dire Dawa, Ahmed (2013) in Horro Guduru Wollega Zone and Biruh (2013) in low land areas of South Omo Zone.

Average total land holding including own grazing land in hectare in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 2.5, 2.5 and 3.3 respectively. There is highly significant ($p<0.005$) differences between Abergelle goat keepers (Ziquala and Tanqua Abergelle districts) and Central Highland goat keepers (Lay Armachiho district) in terms of total land holding and land with a title deed.

Almost all respondents (100% in Ziquala, 99.8% in Tanqua Abergelle and 95.7 % in Lay Armachiho districts) indicated that the trend of land holding per household is decreasing over time. Human population growth rate, expansion of the existing town and newly established town, delineation of huge land for forestry (area closure), establishment of governmental institutes (school, clinic, farmer training center), land degradation and soil erosion are some of the mentioned factors for declining of landholding per house hold across all the districts.

In all the study districts same livestock species are kept with different average numbers per household; which may indicate the importance of those particular animals in these particular areas. Average number of cattle, goat and sheep holding per household in the study districts were significantly ($p<0.0001$) different. In Ziquala and Tanqua Abergelle districts average number of all livestock species per household did not show significant ($p>0.05$) differences (Table 8.). Relatively, higher average number of cattle (9.6) per household was observed in Lay Armachiho district than in Ziquala (5.1) and Tanqua Abergelle (5.0) districts. In contrast higher average number of goat and sheep per household were observed in Ziquala and Tanqua Abergelle districts than Lay Armachiho district (Table 8.). Goat population per household (mean ± SD) in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 36.1±61.9, 38.2±63.9 and 10.5±7.5 respectively. The current study result on Abergelle goat population per household was higher than the report of FARM Africa (1996), which was 20, and lower than Solomon (2013) report (48.5) on the same goat breed. The disagreement may be due to goat population

differences across districts (since study districts are different) or random sampling error i.e by chance farmers having higher number of goat population were interviewed in the previous study and the reverse is true in the current study.

Table 8. Mean ±SD family size (n), land holding (ha) and livestock holding (n) per household by districts

Descriptors	**Ziquala (N=68)**	**Tanqua Abergelle (N=70)**	**Lay Armachiho (N=118)**	**Overall (N=256)**	**Test**	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	F-value	p-alue
Family size						
Male	3.3(1.5)^{a}	3.4(1.2)^{a}	3.8(1.8)^{a}	3.5(1.6)	2.152	0.118
female	3.1(1.6)^{a}	3.1(1.5)^{a}	3.3(1.8)^{a}	3.2(1.7)	0.443	0.643
Total	6.4(2.1)^{a}	6.5(1.9)^{a}	7.1(2.9)^{a}	6.8(2.4)	2.079	0.127
Land						
Total land†	2.5(1.2)^{a}	2.5(1.4)^{a}	3.3(2.5)^{b}	2.9(2.0)	5.42	0.005
Total land with a title deed*	1.8(0.9)^{a}	1.5(0.9)^{a}	2.9(2.4)^{b}	2.2(1.8)	14.94	0.000
Total land used in rainy season	2.3(1.1)^{a}	2.1(1.1)^{a}	3.0(7.2)^{a}	2.6(5.0)	0.892	0.411
Total land used in dry season	0.2(0.3)^{a}	0.2(0.3)^{a}	0.3(0.8)^{a}	0.2(0.5)	0.034	0.967
Livestock						
Cattle	5.1(4.0)^{a}	5.0(3.8)^{a}	9.6(7.2)^{b}	7.1 (6.1)	20.45	0.000
Goats	36.1(61.9)^{a}	38.2(63.9)^{a}	10.5(7.5)^{b}	24.9(48.1)	10.52	0.000
Sheep	8.2(10.0)^{a}	7.1(9.5)^{a}	1.3(2.5)^{b}	4.7 (8.0)	24.56	0.000
Donkey	1.1(0.9)^{a}	1.3(1.0)^{a}	1.0(0.9)^{a}	1.1(1.0)	2.17	0.117
Chicken (indigenous)	7.7(6.2)^{a}	7.9(6.4)^{a}	9.5(8.8)^{a}	8.6(7.6)	1.56	0.211
Chicken (Exotic)	0.2 (0.7)^{a}	0.8(4.9)^{a}	0.62(2.3)^{a}	0.5 (3.0)	0.69	0.505
Bee colony (hive)	3.0(5.7)^{a}	2.0(5.0)^{a}	1.6(3.8)^{a}	2.1(4.7)	2.01	0.136

a, b, c: different superscripts denote significant differences at $P<0.05$ between means within rows, SD= standard devation, N=number of sampled household,Land with a title deed* =excluding rented land, †=including own grazing land

4.1.3. Crop and livestock farming system

Individual interviews and group discussions made in all of the three districts indicated that all of the farmers practiced both crop and livestock productions with a varied degree of attention (interest of intensification/maximization).

Major food crops produced in 2012 production year in each of the study districts as recalled by respondents is presented in fig. 2. Almost all (95.59, 97.14 and 97.46 percent in Ziqual, Tanqua Abergelle and Lay Armachiho districts respectively) respondents in all of the study districts produced sorghum for household food consumption. Relatively equivalent percents of respondents were observed in Ziquala and Tanqua Abergelle districts in each of the given food crops (Fig. 2.) production activity. Higher respondent's percentages in Lay Armachiho district were observed in maize, millet and noug production. Since lowland peasant associations of Lay Armachiho district were sampled (where goat population was relatively higher) this food crop types do not necessarily represent Highland parts of the district.

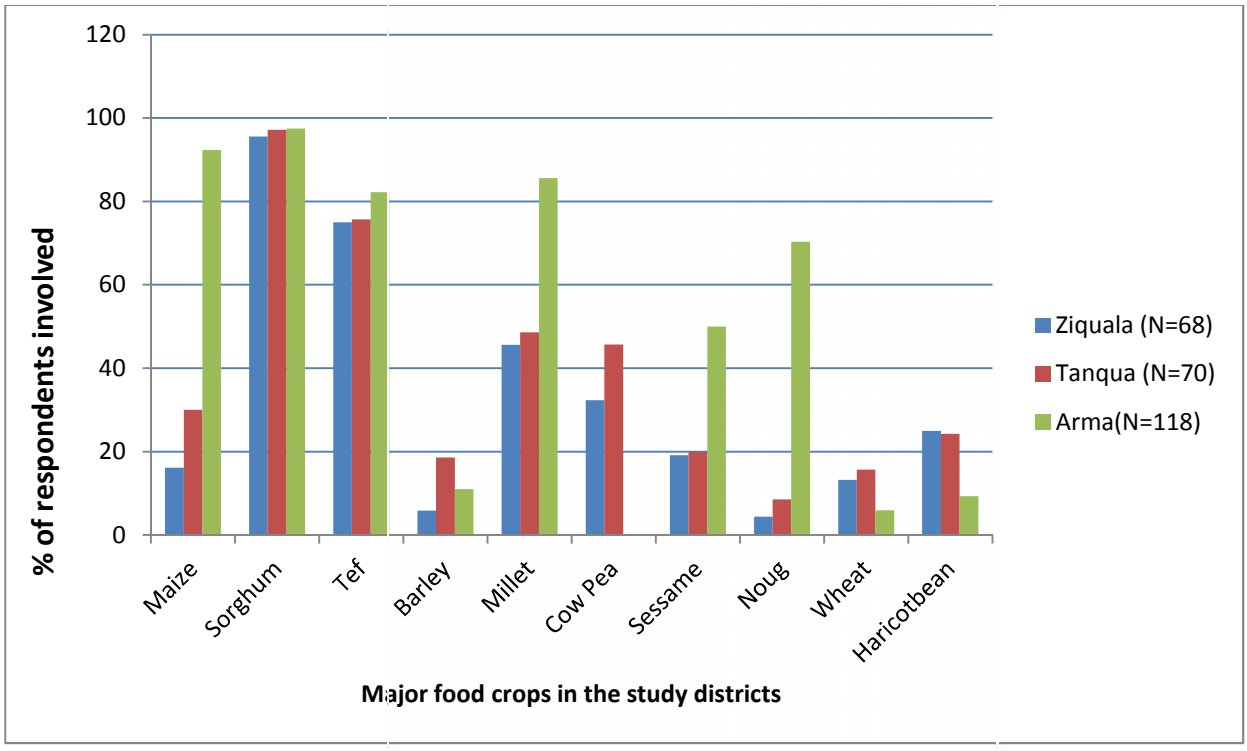


Figure 2. Major food crops in the study districts by percent of respondents involved in the production

Based on the calculated indices (Table 9.) regarding for household food source for ziquala and Tanqua Abergelle were livestock, crop, daily labor and trading in order of ranks. As household food source crop, livestock, trading and daily labor in Lay Armachiho district has an index value of 0.56, 0.41, 0.02 and 0.01 respectively and in ranking order.

Table 9. Food, cash income sources and livestock contribution for food and cash income

Descriptors	Ziquala				Tanqua Abergelle				Lay Armachiho			
	1st rank	2nd rank	3rd rank	Index	1st rank	2nd rank	3rd rank	Index	1st rank	2nd rank	3rd rank	**Index**
FS												
Livestock	49	49	2	0.71	59	10	2	0.55	9	109	0	0.41
Crop	15	17	5	0.24	9	59	5	0.42	109	1	1	0.56
Trading	1	0	1	0.01	0	1	1	0.01	0	6	0	0.02
Daily labor	3	2	1	0.04	2	0	1	0.02	0	2	1	0.01
CIS												
Livestock	53	13	1	0.53	60	10	0	0.54	74	27	3	0.49
Crop	6	46	14	0.35	8	55	7	0.38	31	72	1	0.42
Trading	1	1	2	0.02	1	3	8	0.05	8	1	5	0.05
Daily labor	7	6	0	0.09	1	1	1	0.02	2	1	1	0.02
Handicraft	1	0	0	0.01	0	1	1	0.01	2	2	2	0.02
LKCF												
cattle	18	39	10	0.35	21	33	13	0.34	92	20	1	0.46
goat	46	16	4	0.43	43	20	5	0.42	24	78	15	0.35
sheep	2	8	26	0.12	4	10	24	0.13	0	5	7	0.02
donkey	0	3	18	0.06	0	4	22	0.07	1	10	56	0.11
chicken	0	0	5	0.01	0	2	4	0.02	1	2	21	0.04
beehives	2	2	2	0.03	2	1	1	0.02	0	0	7	0.01

FS=for food source, CIS=for cash income source, LKCF=livestock for cash income and food source

4.2. Goat Flock Structure and Management

Goat flock structure by age and sex in Ziquala, Tanqua Abergelle and Lay Armachiho districts is presented in Table 10. There were significant ($p<0.05$) differences on the average goat populations in each of all age and sex categories across districts. Using mean separation techniques we can clearly see that goat flock structure in Ziquala and Tanqua Abergelle districts in all age and sex categories were not significantly ($p>0.05$) different.

From Table 10 we can learn that within a given household goat flock in Ziquala district one can find 16.02% male kids less than six months, 16.57% female kids less than six months, 11.31% males between six month to one year, 14.73% females between six month to one year, 7.92% males greater than one year (intact), 30.92% females greater than one year and 2.53% castrated. The corresponding values for Tanqua Abergelle district were 14.48%, 15.80%, 9.60%, 14.97%, 7.71%, 35.05% and 2.38% respectively. In the same way, 17.80%, 16.64%, 7.78%, 12.67%, 9.60%, 33.44% and 2.07% respectively were the observed corresponding values for Lay Armachiho district.

The ratio of male to female in all of the three districts at the age of less than six months was proportional. However, above six months female proportions were high especially at age of greater than one year. This is because of male goat greater than one year is frequently sold whenever cash is needed in the household (group discussion and see Table 29). Here intervention is needed to control negative selection to improve the reproductive and productivity of goats particularly for males because of farmers usually sell good body condition (which may have good genetic makeup) to get high price. The ratio between males (intact) greater than one year of age and their female counterparts in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 1:4, 1:5 and 1:4 respectively. These particular study results were in agreement with that of Wilson (1988) who reported ratios of between1:4 and 1:6 for small ruminants in traditional livestock production systems of Africa.

Within a given flock in the study areas the first and second highest proportions were females greater than one year and kids (both sex) less than six months respectively, which is in agreement of the report made by Biruh (2013) on Woyto Guji goats in low land areas of south Omo zone. High proportion of kids within a flock might be an opportunity to increase the selection intensity which in turn increases production and productivity within a short period of time.

Table 10. Number and Mean (±SD) of each of goat classes by district

Goat classes by age and sexes	Ziquala (n=68)		Tanqua Abergelle (n=70)		Lay Armachiho (n=118)		Overall (n=256)		Test	
	N	Mean ± SD	N	Mean ±SD	N	Mean ±SD	N	Mean ±SD	F-value	p-value
Male kids < 6 months	374	5.50± 8.74 [a]	383	5.47±8.87 [a]	215	1.87±1.91 [b]	972	3.84±6.84	9.36	0.000
Female kids < 6 months	387	5.69 ± 8.44 [a]	418	5.97±9.19 [a]	201	1.75±1.70 [b]	1006	3.98±6.89	12.01	0.000
Male 6 months to 1 year	264	3.88± 9.32 [a]	254	3.63±9.47 [a]	94	0.81±1.29 [b]	612	2.41±7.10	5.64	0.004
Female 6 months to 1 year	344	5.06± 10.06 [a]	396	5.66±11.09 [a]	153	1.32±1.66 [b]	893	3.52±8.11	8.40	0.000
Male > 1 year (Intact)	185	2.72± 4.90 [a]	204	2.91±5.30 [a]	116	1.01±1.51 [b]	505	2.00±3.99	6.79	0.001
Female > 1 year	722	10.62±12.89 [a]	927	13.24±16.00 [a]	404	3.58±3.22 [b]	2053	8.18±11.75	19.03	0.000
Castrate	59	0.87.±2.46 [a]	63	0.90±2.62 [a]	25	0.22±0.59 [b]	147	0.58±1.93	3.87	0.022
Total	2335	34.34±49.99	2645	37.79±53.83	1208	10.24±7.27	6188	24.17±40.40	-	-

The average goat farming experiences (in years) of the respondents in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 14.10±9.35, 15.70±10.97 and 11.08±11.63 respectively. The average numbers of goats used to start goat farming (as recalled by the owners) were 13.72±11.68, 13.11±12.60 and 3.34±6.25 in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively. More than 79% of source of this first goat to start goat farming in the study areas were as a gift from the family (from mother or father or both) and purchased from neighboring farms or markets. The remaining percents of source of the first goat were from development projects as gift, development project as loan and as a gift from relatives or friends.

Even though farmers in the study areas do not keep any kind of record for their goat farming activities they can trace back and remember some of the major activities they did. The overall goat flock dynamics (out flow and in flow) for one year (April 1, 2012-March 30, 2013) considering respondents percentage who said "yes" for selling and buying were 60.5 % and 42.6 % respectively. Most of the respondents bought female goat greater or equal to one year old for production purpose and they sold all goat classes with different priority (see Table 29) whenever cash is needed. Percentages of respondents who said "yes" for buying of goat for the last twelve months in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 32.4%, 32.9% and 54.2% respectively. In the same way Percentages of respondents who said "yes" for selling of their goat for the last twelve months in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 70.6%, 60.0% and 55.1% respectively.

Individual goat identification by the owner (household) using different techniques like using coat color, specific name, ear tag, parentage (pedigree) or using any other techniques has an advantage even after the animal died, lost or sold. For instance, if veterinary technician gets shortage of vaccine while he/she was giving vaccine for the household flock, he /she can register the specific name of goat(s) that do not have been given vaccine so that he/she can give them vaccine for the other day accordingly. The other advantage of individual goat identification by the owner (household) for the breeders is to trace back the pedigree of the animal at least by the dam side. In general, majority of farmers in all of the three districts identify their goat by coat color (98.4%), name (58.2%), and parentage (100%). Here parentage identification generally stands for dam side but it is not to mean that farmers do not know the sire of the kid. Individual goat identification (respondent percentage) by coat color, name and parentage in Ziquala district

were 100%, 76.5% and 77.9% respectively. The corresponding values for Tanqua Abergelle district were 97.1%, 87.1% and 70.0% respectively. Similarly, farmers in Lay Armachiho district identified their goat by coat color (98.3%), name (30.5%) and parentage (40.7%).

Farmers in Ziquala district reported that goat mobility around the Tekezie basin in peak dry season is common to search areas where feed and water is easily available. Even though the degree of mobility (which class of goat to move, duration of stay far from permanent house and the distance to move) is less than Ziquala district, goat keepers in Tanqua Abergelle district also exercised goat movement from place to place in search of feed and water. In contrast farmers in Lay Armachiho districts do not move their goat anywhere because of feed and water is not a problem especially in dry season. Goat keepers (42.5% of the respondents) in Ziquala district move their whole goat flock around the Tekezie basin at peak dry season (usually from February to June). Similarly, Goat keepers (22.8% of the respondents) in Tanqua Abergelle district move their goat flock (usually very young kids, very old and sick goats are left in and around the permanent residence of the household) from April to June for a few days or for a few weeks.

4.3. Goat Production Objective

The purpose of keeping goat in the study areas is presented in Table 11. According to Jaitner *et al*. (2001) knowledge of reasons for keeping animals is a prerequisite for deriving operational breeding goals. Rank of purposes of keeping goat in Ziquala and Tanqua Abergelle districts was the same even though the index value for each of the objectives are different. In contrast goat production objectives in Lay Armachiho district was different from Ziquala and Tanqua Abergelle districts except goat rearing was the means of cash income in the first rank for all of the three districts.

Different studies in Ethiopia concerning goat production objectives indicated that cash income is the primary goat production objective by the respective goat keepers. For instance Mahilet (2012) on Hararghe Highland goat, Ahmed (2013) on Ethiopian indigenous goats in Horro Guduru Wollega zone and Solomon (2013) on Abergelle and Western Lowland goat breeds, reported that cash income was the first rank among different goat production objectives.

Table 11. Ranking of goat production objectives by districts

Production Objectives	Ziquala			Tanqua Abergelle			Lay Armachiho		
	1st Rank	2nd Rank	Index	1st Rank	2nd Rank	Index	1st Rank	2nd Rank	**Index**
Sale/Cash Income	58	6	0.60	43	14	0.48	108	10	0.64
Manure	6	37	0.24	21	19	0.29	0	0	0.00
Meat	2	11	0.07	0	12	0.06	8	88	0.29
Milk	2	14	0.09	6	25	0.18	0	0	0.00
Saving	0	0	0.00	0	0	0.00	2	20	0.07

The current study result index values of goat production objectives as source of cash income, manure, meat, milk and as means of saving were 0.60, 0.24, 0.07, 0.09 and 0.00 respectively in Ziquala district. The corresponding values for Tanqua Abergelle district were 0.48, 0.29, 0.06, 0.18 and 0.00 respectively. In Lay Armachiho district goat production objectives as source of cash income, manure, meat, milk and as means of saving were 0.64, 0.00, 0.29, 0.00 and 0.07 respectively. Goat keepers in Ziquala and Tanqua Abergelle districts use goat milk in their daily diet as row milk or products of milk (cheese, butter, and yogurt). However, goat milk consumption in Lay Armachiho district is strictly a cultural taboo.

4.4. Milk Production

Unlike Lay Armachiho district goat keepers, all goat keepers (100%) in Ziquala and Tanqua Abergelle districts reported that they milk their goats. Frequency of milking and milk yield per day per doe were different in the rainy and in the dry seasons due to feed and water scarcity in the dry season for both districts. Percent of respondents who said “yes” for goat milking twice per day (morning and evening) in the rainy and in the dry season in Ziquala district were 96.8% and 36.8% respectively. The corresponding values for Tanqua Abergelle district were 87.7% and 39.1% respectively. The remaining percentage for each season was goat milking once per day.

Majority of the respondents (>82%) in each district use goat milk after processing it traditionally (making butter out of milk by agitating it in hand). The remaining percentage of the respondents reported that they use goat milk as raw milk and by boiling. It is cultural taboo that ladies (mostly > 15 years old) are not allowed to use raw milk but processed i.e. products of milk

(cheese, butter, and yogurt). This is because of mainly for two reasons. The first reason was if she is adapted to use raw milk, other members of the household will not get milk and milk products specially butter for selling. The second reason was, they believe that it is too difficult for her husband to make the first sexual intercourse (disvirgining process) when she gets married. Traditionally, goat keepers in both districts believe that goat milk has some medicinal values and improves the health status of human being than cow milk as goat eats so many plant species. Fortunately, in agreement with the farmer's indigenous knowledge about goat milk verses cow milk, it is scientifically proved that goat milk is better than cow milk in many ways. (http://www.mtcapra.com/benefits-of-goat-milk-vs-cow-milk/) (Accessed on November. 6 2014). All respondents in both districts (100%) reported that milk and milk products are consumed in their household, whereas 29.4% in Ziquala district and 39.7% in Tanqua Abergelle district marketed milk products (butter) to generate cash income.

Milk yield, lactation length and weaning age of kids across Ziquala and Tanqua Abergelle districts were not significantly ($p>0.05$) different in both seasons. From the current survey result milk yield per doe per day (in liter) in the rainy season and in the dry season in Ziquala district were 0.43±0.24 and 0.15±0.14 respectively. The corresponding values for Tanqua Abergelle district were 0.48±0.24 and 0.19±0.29 respectively. Biruh (2013) reported average volume of milk yield per day per doe (liter) in Benatsemay, Hamer and Dasenech districts without classifying the season were 0.176, 0.184 and 0.208 respectively. This is lower than the current survey results in the rainy season and higher than in the dry season in Ziquala district.

Table 12. Mean ±SD of milk yield (liter), lactation length (months) and weaning age (months) by district

Milk yield, lactation length and Weaning age	**Ziquala (N=68)**	**Tanqua (N=70)**	**Overall (N=138)**	**Test**	
				F-value	**P-value**
Milk /doe/day in the rainy season	0.43±0.24 [a]	0.48±0.24 [a]	0.46±0.24	1.96	0.164
Milk /doe/day in the dry season	0.15±0.14 [a]	0.19±0.29 [a]	0.17±0.23	1.21	0.273
Lactation length in the rainy season	4.21±2.02 [a]	3.59±2.11 [a]	3.90±2.09	3.10	0.081
Lactation length in the dry season	4.32±1.40 [a]	4.46±2.00 [a]	4.39± 1.73	0.23	0.634
Weaning age of kids	4.85±1.81 [a]	4.84±1.73 [a]	4.85± 1.77	0.00	0.973

SD=Standard deviation N=number of respondents, means were compared within rows

Generally, lactation length in the rainy season is shorter than dry season because of the feed and water availability that will in turn create conducive environment for doe to conceive and kids to wean shortly. Average lactation lengths (in months) in Ziquala district in the rainy and dry seasons were 4.21±2.02 and 4.32±1.40 respectively. Similarly, the corresponding values for Tanqua Abergelle district were 3.59±2.11 and 4.46±2.00 respectively. Average weaning age of kids (in months) in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 4.85±1.81, 4.84±1.73 and 4.5 respectively. As indicated in Fig 3 some farmers in Ziquala and Tanqua Abergelle districts use artificial weaning techniques by prohibiting suckling of kids to its dam by putting liquid cow-dung on teat and udder and by tying the teat using a thread like substance. However, this practice was also used if kids were kept together with does during the day time so that goat keepers can get milk at night.

a) b)

Figure 3. Traditional suckling control methods in Ziquala (a) and Tanqua Abergelle (b) districts

4.5. Labor division for the routine goat Husbandry activities by the household

Although all the family members involved in the routine goat Husbandry activities, the extent (the size of percentage) and coverage (number of activities shared by a given household members) were different because of age and gender categories in the household. Detail profiles of each of the housed members in the routine goat Husbandry activities in Ziquala, Tanqua Abergelle and Lay Armachiho districts are presented in Table 13, 14 and 15 respectively.

In all the study districts purchasing and selling activities were left for males greater than fifteen years old specially for the household head. This is because he is believed to be knowledgeable to select the best breeding doe and buck when he purchase and he can sell animals at best price by negotiation. Even though the percentage of females (greater than fifteen years old) activities in purchasing and selling were low relatively higher percentages were observed in Selling. As a summary, males greater than fifteen years old in the family involved in purchasing and selling activities greater than 94.1% and 89.7 % respectively in all the districts. Whereas females greater than fifteen years old involved in purchasing and selling activities less than 14.4 % and 39.1 % respectively in all the districts. These data clearly shows us that males, specially household head, were exclusively decision maker in economical issues in the family.

Relatively higher percentage of involvements by males less than fifteen years old and males greater than fifteen years old in the family and in hired labourers were observed in herding, breeding, caring sick animals, feeding and milking activities in all the districts. In contrast making and selling dairy products were almost exclusively done by females specially females greater than fifteen years old in Ziquala and Tanqua Abergelle districts. In all the study areas all age categories of females do not allowed slaughtering animals including chicken because of religious and culture of the communities. Slaughtering activity was done by males greater than fifteen years old in the family (>97.01 %) and to some extent (<22.0%) by males greater than fifteen years old in hired labourers in all the study districts.

Table 13. Labor division for the routine goat husbandry activities by the household in Ziquala district

Activities	Family member				Hired labour			
	female		male		female		male	
	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)
Purchasing	-	7(10.3)	-	64(94.1)	-	-	-	-
Selling	-	25(39.1)	-	61(89.7)	-	-	-	-
Herding	10(14.7)	4(5.9)	34(50.0)	9(13.2)	4(5.9)	0(0.0)	5(7.4)	2(2.9)
Breeding	2(2.9)	4(5.9)	29(42.6)	33(48.5)	4(5.9)	4(5.9)	14(20.6)	2(2.9)
Caring sick animals	6(8.8)	17(25.0)	40(58.8)	43(63.2)	2(2.9)	-	12(17.6)	-
Feeding	6(8.8)	3(4.4)	26(38.2)	35(51.5)	7(10.3)	-	8(11.8)	14(20.6)
Milking	3(4.4)	8(11.8)	28(41.2)	38(55.9)	6(8.8)	1(1.5)	3(4.4)	2(2.9)
Making dairy products	9(13.2)	66(97.1)	-	-	-	-	-	-
Selling dairy products	8(11.8	63(92.6)	2(2.9)	2(2.9)	-	-	-	-
Barn cleaning	27(39.7)	32(47.1)	28(41.2)	45(66.2)	4(5.9)	1(1.5)	2(2.9)	-
Slaughtering	-	-	-	68(100)				1(1.5)

NB A given activity is possible to be performed by more than one household member and a given household member is responsible for different husbandry activies

*T*able 14. Labor division for the routine goat husbandry activities by the household in Tanqua Abergelle district

Activities	Family				Hired labour			
	female		male		female		male	
	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)
Purchasing	-	2(2.9)	-	68(97.1)	-	-	-	-
Selling	-	4(5.7)	-	67(98.5)	-	-	-	2(2.9)
Herding	4(5.7)	7(10.0)	46(65.7)	3(4.3)	-	-	1(1.4)	2(2.9)
Breeding	2(2.9)	2(2.9)	31(44.3)	27(38.6)	4(5.7)	-	5(7.1)	-
Caring sick animals	1(1.4)	9(12.9)	10(14.3)	55(78.6)	-	2(2.9)	3(4.3)	-
Feeding	1(1.4)	2(2.9)	40(57.1)	32(45.7)	2(2.9)	-	4(5.7)	3(4.3)
Milking	3(4.3)	15(21.4)	40(57.1)	29(41.4)	2(2.9)	1(1.4)	4(5.7)	1(1.4)
Making dairy products	8(11.4)	62(88.6)	-	-	-	-	-	-
Selling dairy products	4(5.7)	59(84.3)	4(5.7)	1(1.4)	-	-	-	-
Barn cleaning	19(27.1)	22(31.4)	41(58.6)	33(47.1)	-	1(1.4)	5(7.1)	-
Slaughtering	-	-	-	68(97.1)	-	-	-	(3(4.3)

NB A given activity is possible to be performed by more than one household member and a given household member is responsible for different husbandry activities

*T*able 15. Labor Labor division for the routine goat husbandry activities by the household in Lay-Armachiho district

Activities	Family				Hired labour			
	female		male		female		male	
	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)	≤15years N (%)	>15years N (%)
Purchasing	-	17(14.4)	-	111(94.1)	-	-	-	7(5.9)
Selling	-	37(31.6)	-	113(95.8)	-	-	-	19(16.1)
Herding	16(13.6)	13(11.0)	79(66.9)	38(32.2)	-	1(0.8)	9(7.6)	1(0.8)
Breeding	5(4.2)	12(10.2)	23(19.5)	63(53.4)	15(12.7)	-	21(17.8)	6(5.1)
Caring sick animals	9(7.6)	51(43.2)	31(26.3)	58(49.2)	-	-	7(5.9)	1(0.8)
Feeding	31(31.6)	38(32.2)	62(52.5)	47(39.8)	-	6(5.1)	9(7.6)	1(0.8)
Barn cleaning	60(50.8)	71(60.2)	67(56.8)	-	-	3(2.5)	5(4.2)	-
Slaughtering	-	-	-	117(99.2)	-	-	-	26(22.0)

NB A given activity is possible to be performed by more than one household member and a given household member is responsible for different husbandry activities.

4.6. Feed and Feeding Management

4.6.1. Major goat feed sources and browsing/grazing management

Index values of major goat feed sources in Ziquala, Tanqua Abergelle and Lay Armachiho districts during dry and wet season is presented in Table 16. Communal natural pasture was the major source of goat feed both in dry and wet seasons in each of the three districts. The current survey result is in agreement with Tesfaye (2009), Grum (2010), Amelmal (2011) and Biruh (2013) reported in Metema district, around Dire Dawa, Dawuro Zone and Konta Special Woreda of SNNPR and Low Land areas of South Omo Zone respectively.

The index value of communal natural pasture in wet (rainy) season in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 0.68, 0.69 and 0.58 respectively. The corresponding values of fallow land in wet season were 0.32, 0.31 and 0.42 respectively. In dry season crop residues (0.21), Crop aftermath (0.08) and Hay (0.05) were ranked second, third and fourth next to communal natural pasture (0.66) for goat feed in Ziquala district. The same ranking order was observed in Tanqua Abergelle district with corresponding values of 0.30, 0.12 and 0.08 respectively next to communal natural pasture (0.50). In Lay Armachiho district goat feed supplementation was not common. This might be because of goat feed in the area is not critical specially in dry season after food crop is harvested and relatively good vegetation cover. Natural pasture (0.83) and crop aftermath (0.17) were the major goat feed sources in Lay Armachiho district.

Here, it is not to mean that the above mentioned goat feed sources were the only goat feed sources in the study areas. There were other feed sources like locally made beverage byproducts from '*tela*' and '*areki*', food left over from household, backyard forages, private browsing and grazing land which is locally called '*hidarya'* in Tigrigna '*kilkil' in Amharic* and mineral soil. Since index values were calculated up to third rank and the above mentioned feed sources were not appeared up to third rank, consequently index value for each of feed sources were zero.

Table 16. Ranking of goat feed sources by district in wet and dry seasons

feed source and season	Ziquala				Tanqua Abergelle				Lay Armachiho			
	1st rank	2nd rank	3rd rank	Index	1st rank	2nd rank	3rd rank	Index	1st rank	2nd rank	3rd rank	Index
Wet season												
Natural pasture	64	1	1	0.68	63	4	1	0.69	113	7	2	0.58
Fallow land	4	24	33	0.32	7	35	0	0.31	5	73	97	0.42
Dry season												
Natural pasture	63	12	36	0.66	53	12	22	0.50	107	93	31	0.83
Hay	0	3	13	0.05	3	6	13	0.08	0	0	0	0.00
Crop residues	5	29	7	0.21	14	41	1	0.30	0	0	0	0.00
Crop aftermath	0	12	6	0.08	0	15	20	0.12	11	15	47	0.17

4.6.2. Major crop residues

Goat feed supplementation was not practiced in Lay Armachiho district both in dry and rainy seasons. According to the respondents in Ziquala and Tanqua Abergelle districts, feed supplementation for goats was prioritized based on the reproductive status, body condition, health condition, age, candidate goat to be slaughtered or sold in the near future and season of the year. Accordingly, newly kidding does (to initiate milk production for the kids and household consumption), emaciated goats, sick goats, kids and goat to be slaughtered or sold in the near future were given highest priority to be supplemented, mostly from February to early June.

Cowpea and sorghum residues (locally called '*goyla'* and '*mawa'* respectively) were most common goat feed supplements in both Ziquala and Tanqua Abergelle districts in dry season, mostly from February to early June. Concerning the number of varieties (types of supplement feed sources) used for goat feed supplementation in dry season, Tanqua Abergelle district had more alternatives (around six supplement feed sources) than Ziquala district (having three supplement feed sources). The ranking order (based on the calculated index value) of goat feed supplements in dry season in Ziquala district were Sorghum (0.43), Cowpea (0.40) and Sesame (0.17).

Table 17. Major crop residues used for goat feed supplementation in Ziquala and Tanqua Abergelle districts

Crop residues	Ziquala					Tanqua Abergelle				
	1st rank	2nd rank	3rd rank	4th rank	Index	1st rank	2nd rank	3rd rank	4th ran	Index
Cowpea	42	13	3	1	0.40	43	4	2	2	0.33
Sorghum	21	39	11	3	0.43	22	27	7	0	0.32
Maize	0	0	0	0	0.00	5	15	0	4	0.12
Barley	0	0	0	0	0.00	0	6	0	21	0.07
Sesame	5	13	6	18	0.17	0	6	2	8	0.05
Groundnut	0	0	0	0	0.00	0	12	4	17	0.11

Whereas in Tanqua Abergelle district Cowpea, Sorghum, Maize, Ground nut, Barley and Sesame residues were used for goat supplements in dry season in order of importance with index value of 0.33, 0.32, 0.12, 0.11, 0.07 and 0.05 respectively.

4.6.3. Major forage plant species

Major forage plant species in Ziquala, Tanqua Abergelle and Lay Armachiho districts are presented in Table 18, 19 and 20 respectively. Data for major forage plant species index values calculation were collected based on not the palatability or the special important nature of the plant (e.g. medicinal value or milk quality and quantity effects etc.) but based on availability and duration (i.e. by the concept of intake proportion throughout the year). For instance '*mata', Grewia kakothamnos* was reported in Ziquala and Tanqua Abergelle districts as the most palatable goat feed but currently it is too hard to find a single tree in the areas. For scientific name of each plant species Azene (2007) and Dagnachew (2011) reference materials were used.

Table 18. Major forage plant species for goats in Ziquala district

plant name		1st	2nd	3rd	4th	5th	Index	Mostly available
Local	Scientific	rank	rank	rank	rank	rank		
Goza	*Balanites aegyptica*	15	21	19	9	6	0.26	year round
Abika	*Acacia tortilis*	8	15	15	13	7	0.19	Jun.-Mar.
Tsalwa	*Acacia asak*	16	7	10	9	1	0.17	Jun-Mar.
Ekima	*Terminalia glaucescens*	13	8	9	8	10	0.16	Jun-Mar.
Giba	*Ziziphus spinachristi*	6	6	3	3	3	0.08	Sep.-Jun
Mata	*Grewia kakothamnos*	2	6	6	5	6	0.07	year round
Arina	Na	6	2	0	4	4	0.05	year round
Loza	Na	0	0	0	4	5	0.01	year round

na = scientific name not available on the above reference materials

Table 19. Major forage plant species for goats in Tanqua Abergelle district

Plant name		1st	2nd	3rd	4th	5th		Mostly available
Local	Scientific	rank	rank	rank	rank	rank	Index	
guawaza	*Balanites aegyptica*	17	12	7	5	5	0.21	year round
giba	*Ziziphus spinachristi*	20	13	9	8	6	0.25	Sep.-Jun
woyba	*Terminalia glaucescens*	16	8	9	7	4	0.19	Jun-Mar
siraw	*Acacia spp*	8	11	9	9	6	0.16	Jun-Mar
tsalwa	*Acacia asak*	0	3	8	15	18	0.1	Jun-Mar.
arena	na	6	2	0	1	2	0.05	year round
kebkeb	na	1	1	6	1	3	0.04	Oct.-Jun

na =scientific name not available on the above reference materials

Table 20. Major forage plant species for goats in Lay Armachiho district

Plant name		1st	2nd	3rd	4th	5th		Mostly available
Local	Scientific	rank	rank	rank	rank	rank	Index	
kirkira	Na	26	33	22	10	3	0.22	Year round
shola	Ficus sur	25	22	24	19	8	0.20	Year round
atat	Maytenus arbutifolia	25	13	13	11	12	0.15	Year round
girar	Acacia spp	23	8	11	11	10	0.13	June -February
agam	Carissa edulis	9	18	10	10	10	0.11	Year round
gumero	Capparis tomentosa	7	10	16	19	16	0.11	Year round
warka	Ficus vasta	2	6	9	3	9	0.05	Year round
Bamba	Ficus sycomorus	1	7	2	1	5	0.03	Year round

na = scientific name not available on the above reference materials

4.7. Herding and Herd Management

4.7.1. Herding

As stated by Sölkner-Rollefson (2003), a good understanding of the community's herding practices is crucial to bring sustainable improvement in the smallholders flock through community-based strategies. All (100%) goat keepers in Ziquala and Tanqua Abergelle districts herded their goat both in dry and rainy seasons. But in Lay Armachio district 92.7 % and 7.3 % of the respondents herded and tethered respectively during rainy (cropping) season and 25.8% and 18.3% of the respondents herded and tethered their goat respectively during dry season. The remaining 55.9% of the respondents' goat were roaming during dry season. Here it should be noticed that goat keepers in Lay Armachio district were keeping their goat mainly to protect crop damage (during cropping season) even though goat theft in the area was reported as one of the biggest problem in goat production. After all crops harvested in Lay Armachio district from cropping areas, goat keepers usually visited (checked) their goat during watering time (11:30 am-1:30 pm) and when goats are coming back to around the homestead (around 4:30pm-6:30pm).

Goats in all of the study areas spend by grazing and or browsing all the day time (from 6:30am-7:00pm). In the study areas goat keeping practice is presented in Table 21. Majority (>92.6%) of goat keepers in Ziquala and Tanqua Abergelle districts herded their goats separately from kids. This is because of goat keepers need to milk their goats two times per day and newly born kids need close attention. In the above mentioned two districts most of goat keepers herded their goats together with sheep. According to the respondents, goats in Lay Armachiho district were herded separately with kids (49.2 %) and all classes of goats together (50.8%). In all the study areas all the respondents reported that communal grazing land is decreasing over time due to the same reasons mentioned above for the reasons of decreasing landholding size per household in the study areas. Some farmers in Ziquala (17.2%) and Tanqua Abergelle (14.3%) districts and majority of the farmers in Lay Armachiho (72.7%) district use their own (private) grazing and browsing land in addition to the communal grazing and browsing land. All of (100%) the respondents in the study areas use communal grazing and browsing land for their goat production.

Table 21. Goat herding Practices in Ziquala, Tanqua Abergelle and Lay Armachiho districts (by % of respondents within districts)

Herding	Ziquala		Tanqua		Armachiho	
	n	%	n	%	n	%
Within goat flock						
kids are separately herded	63	92.6	69	98.6	58	49.2
all classes of goats herded together	5	7.4	1	1.4	60	50.8
Goat flock is herded						
together with cattle	3	4.4	4	5.7	40	33.9
together with sheep	49	72.1	42	60	2	1.7
separately	16	23.5	24	34.3	76	64.4
Way of herding						
goat of a household run as a flock	56	82.4	61	87.1	65	55.1
goats of more than one household run as a flock	12	17.6	9	12.9	53	44.9

All (100%) respondents in each of the study districts stated that goat feed availability fluctuate seasonally. Respondents in Ziquala (82.6%) and Tanqua Abergelle (78.9%) districts reported that goat feed shortage usually happens from late December to early June. Even though goat feed shortage is not a serious problem in Lay Armachiho district two opposite seasons (rainy and dry seasons) were mentioned by the respondents. Majority (61.4%) of respondents mentioned that their goats usually face feed shortage during rainy (cropping) season, August and September. The reason was not feed unavailability in the area but majority of the land is covered by food crops and goats are confined in small plot of land for higher proportion of day time. On the other hand 32.7% of respondents agreed that goat feed shortage mostly happen during peak dry season from March up to May due to some of the trees shade their leaves. Roughage goat feed supplementation during peak dry season, as mentioned above, in Ziquala and Tanqua Abergelle districts were reported, but not common in Lay Armachiho district. Goat fattening practice and concentrate feeds for goats were not used in all the study areas.

4.7.2. Water sources and watering

In all the study districts and all seasons (dry and rainy seasons) river water was the main source of goat watering, especially in dry season (Table 22.). The current study is in agreement with Workneh and Rownalds (2004) that stated rivers are generally the most important sources of

water during dry and wet seasons in crop livestock system households in Oromia region. Like feed availability status (as mentioned above), relatively water availability both in dry and rainy seasons in Lay Armachiho district was not mentioned as a problem. On the contrary, during group discussions, respondents in Ziquala and Tanqua Abergelle districts reported that during dry season water shortage was one of the main constraints for goat production especially for kids and sick goats.

Majority (>67.1%) of respondents in Ziquala and Tanqua Abergelle districts watered their goat between one and five kilometers distance during dry and rainy seasons. Whereas relatively less proportion (<66.1%) of respondents in Lay Armachiho district watered their goat between one and five kilometers distance during dry and rainy seasons.

Table 22. Source of water, distance to the nearest watering point and frequency of watering for adult goat in dry and wet seasons by district (by % of respondents within districts)

Source, distance and frequency of watering	**Ziquala**		**Tanqua Abergelle**		**Lay Armachiho**	
	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season
Source						
river	47.0	92.6	44.3	82.9	58.5	95.8
spring	32.4	7.4	34.3	17.1	16.1	4.2
rain water	20.6	-	21.4	-	25.4	-
Distance						
watered at home	4.4	0.0	15.7	17.1	22.0	6.8
Less than one Kilometer	8.8	20.6	4.3	15.7	45.8	27.1
One –five kilometer	86.8	79.4	80.0	67.1	32.2	66.1
Frequency						
freely available	91.2	2.9	71.4	11.4	85.6	34.7
once a day	8.8	97.1	28.6	88.6	14.4	65.3

Since water is freely available everywhere during rainy season, majority (>71.4%) of respondents indicated that their goat can freely access water all the day time during rainy season. On the other hand less proportion of respondents in Ziquala (2.9%), Tanqua Abergelle (11.4 %) and Lay Armachiho (34.7 %) districts reported that their goat can freely access water during dry season. During dry season most (>65.3 %) of goat keepers watered their goat once per day. Goat keepers in Ziquala (85.3 %), Tanqua Abergelle (90 %) and Lay Armachiho (68.6 %) districts

watered kids a home. This is because of very young kids (less than one month old) are not able to move together with adult goats in a distance area and goat keepers in Ziquala and Tanqua Abergelle districts need to milk their goat twice per day. Moreover kids are more vulnerable for predators than adults, kids need more attention.

4.7.3. Types of houses and Housing system

Housing is one of the major goat husbandry activities which protect from extreme temperature, rain, wind, predators and theft. In the study areas different types of houses, Housing materials and Housing systems were identified (Table 23).

From Table 23 readers may misunderstand that in Lay Armachiho district 61 respondents use iron sheet for goat house roof construction but the reality was goat keepers share their house either inside or outside (extend of building) for their goat during night time. In the same way readers may be confused that how stone is used as goat house roof construction in Ziquala and Tanqua Abergelle districts, but it is common to construct houses roof from flat stones in Wag and Tigray ethnic communities that they locally call it '*hidimo'*.

a) Cave b) hidimo

Figure 4. Goat houses in Ziquala (a) and Tanqua Abergelle (b)

Table 23. Types of goat houses and Housing materials in Ziquala, Tanqua Abergelle and Lay Armachiho districts

Types of houses and Housing materials	Ziquala (N=68)		Tanqua Abergelle (N=70)		Lay Armachiho (N=118)	
	n	%	n	%	n	%
House with roof	11	16.18	41	58.57	106	89.83
In family house	2	18.18	5	12.20	72	67.92
Separate house	5	45.45	17	41.46	21	19.81
Veranda (extend of building)	4	36.36	19	46.34	13	12.26
House without roof	57	83.82	29	41.43	12	10.17
Yard (enclosed land)	48	84.21	25	86.21	12	100.00
natural cave	9	15.79	4	13.79	0	0.00
Housing materials for roof	11	16.18	41	58.57	106	89.83
Iron sheet	0	0.00	4	9.76	61	57.55
Grass	8	72.73	16	39.02	45	42.45
Stone	3	27.27	21	51.22	0	0.00
Housing materials for wall	37	54.41	61	87.14	103	87.29
Wood	21	56.76	18	29.51	95	92.23
Stone	16	43.24	43	70.49	8	7.77
Housing materials for floor	68	100.00	70	100.00	118	100.00
Wood	3	4.41	13	18.57	24	20.34
Stone	18	26.47	27	38.57	45	38.14
Earth/soil	47	69.12	30	42.86	49	41.53
Kids housed with adult goats						
yes	7	10.29	12	17.14	41	34.75
no	61	89.71	58	82.86	77	65.25
Goats housed together with other animals						
yes	9	13.24	21	30.00	72	61.02
no	59	86.76	49	70.00	46	38.98

NB % for main (bold) heads was calculated from a total sample for each district, N=number of respondents

From group discussions made in all the study districts, all goat keepers sheltered their goat during the rainy season at night. Since the length of rainy season in Ziquala and Tanqua Abergelle districts is very short (usually 60 to 70 days, at the end of June up to very early

September), goat keepers in these districts design temporary goat house to shelter their goat from heavy wind, rain and cold weather. Therefore, the table above did not represent the main rainy season for the above mentioned two districts. Goat houses with roof in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 16.18%, 58.57% and 89.83% respectively and the remaining (without roof) percentages in the same order were 83.82%, 41.43% and 10.17%.

In all the study districts majority of (>65.25%), especially in Ziquala and Tanqua Abergelle districts (>82.86%), respondents housed their kids separately from adult goats. As mentioned above this was mainly because of to protect newly born kids and to milk does for the next day (milking was reported only in Ziquala and Tanqua Abergelle districts).

Majority of (>70.00%) respondents in Ziquala and Tanqua Abergelle districts reported that they did not housed their goat together with other animals. Traditionally, farmers in Ziquala and Tanqua Abergelle districts mixed their sheep and goat together both in day and night time, because they considered goat and sheep as if they are the same species. So in the table below 'other animals' did not include sheep in Ziquala and Tanqua Abergelle districts. On the contrary 61.02% of respondents in Lay Armachiho district housed their goat together with other animals. The main reasons in all districts why farmers housed different animals of species together in one house were for the ease of management and not to construct houses for each species of animal.

4.8. Major Goat Diseases

Diseases have numerous negative impacts on productivity of herds i.e. death of animals, loss of weight, slow down growth, poor fertility performance, decrease in physical power and the likes (CSA, 2012). Gatenby (1986) also stated that maximum productivity in a given system of production is obtained when disease control is optimal.

Major goat diseases (based on index values) and it's most frequently occurring months in a year as mentioned by respondents in each of Ziquala, Tanqua Abergelle and Lay Armachiho districts are presented in Table 24, 25, 26 respectively in ranking order. Even though the quality of service was very poor (as explained by respondents), access to veterinary services in Ziquala,

Tanqua Abergelle and Lay Armachiho districts were 91.18%, 100.00 % and 95.80% respectively.

Table 24. Major goat diseases in Ziquala district

Disease name		1st	2nd	3rd	Index	Mostly occurred
Local	English	rank	rank	rank		
Gurba	Sheep and goat pox	19	17	13	0.26	not seasonal
Entit	Anthrax	14	10	11	0.18	Mar-Jun
Shilimie	PPR	13	12	12	0.18	mar-Jun
Tinan	Coenurosis	6	10	15	0.13	not seasonal
Int. parasites	na	9	2	16	0.12	not seasonal
Ext. parasites	na	6	6	16	0.11	not seasonal
Hagaza	na	0	1	0	0.00	Aug-Sep
Mich	na	2	0	0	0.01	Apr-Jun

PPR = Pest des Petit Ruminants, na=not available

Table 25. Major goat diseases in Tanqua Abergelle district

Disease name		1st	2nd	3rd	Index	Mostly occurred
Local	English	rank	rank	rank		
Nifat	PPR	13	11	8	0.17	mar-Jun
Enfrir	Sheep and goat pox	11	12	6	0.16	not seasonal
Tigtigta	pasteurellosis	11	9	5	0.14	Aug-Dec & Apr-Jun
Megirem	Anthrax	9	8	10	0.13	Mar-Jun
Ex. Parasite	na	5	6	15	0.10	not seasonal
Int. parasite	na	6	7	12	0.11	not seasonal
kinen	Coenurosis	5	7	9	0.09	not seasonal
Echilam	FMD	7	3	0	0.07	Aug-Dec
Woki	Black Leg	1	3	0	0.02	Jul.-Dece

PPR = Pest des Petit Ruminants, FMD = Foot and Mouth Disease, na =not available

From group discussions made in all districts with farmers and peasant association development agents (DAs) the quality (most of the drugs were broad spectrum and near to expiry date) and the quantity (amount of each drug and number of types of drugs) of drugs were not satisfactory.

Table 26. Major goat diseases in Lay Armachiho district

Disease name		1st	2nd	3rd	4th	5th	Index	Mostly
Local name	English	rank	rank	rank	rank	rank		occurred
Afemeyaz	FMD	17	19	18	9	4	0.17	Jun-Oct
Int. parasite	na	6	7	3	3	2	0.05	May-Oct
Adeba/kurba/abrehe	Anthrax	8	17	18	6	2	0.12	mar-Oct
Enkirkirit	Coenurosis	51	24	10	1	2	0.27	not seasonal
Ext. parasites	na	22	20	16	4	2	0.17	Jan-May
yenefas beshita	na	4	15	22	7	2	0.11	not seasonal
diro/sal	na	2	2	3	0	2	0.02	not seasonal
enkit	pasteurellosis	6	9	6	2	1	0.06	Jun-Oct
Chakuwat	foot root	2	2	2	3	4	0.02	Jun-Sep

FMD = Foot and Mouth Disease, na =not available

During linear body measurement and qualitative data observation, occurrence of tick and mange data were recorded from 630 sampled goats. The occurrences of tick in Ziquala, Tanqua Abergelle and Lay Armachiho were 23.1, 17.3 and 4.3 percent respectively. The corresponding values for mange were 53.8, 26.9 and 19.2 percent respectively. Here it is clearly seen that both tick and mange had high prevalence's in Ziquala district which needs immediate intervention.

All respondents in each of the study areas reported that the only veterinary service provider was governmental. Distance to nearest veterinary services in Ziquala district (based on respondents percentages) were 1-5km (47.1%), 6-10km (14.7%) and >10Km (38.2%). The corresponding values for Tanqua Abergelle and Lay Armachiho districts were 8.6%, 54.3%, 37.1% and 32.4%, 26.4%, 41.2% respectively. Because of unsatisfactory veterinary services were delivered in the study areas, majority of goat keepers in Ziquala (61.4%), Tanqua Abergelle (51.1%) and Lay Armachiho (57.9) districts did not sent their sick goats to the nearby animal clinic regularly, but the remaining percentages did. Instead, 48.5%, 57.1% and 28.8% of respondents in Ziquala,

Tanqua Abergelle and Lay Armachiho districts respectively used traditional treatments for their sick goats.

4.9. Indigenous Knowledge of Goat Breeding and Management Practices

4.9.1. Breeding male

As stated by Galal *et al. (*1996) availability of ram in the system considerably affects all biological and financial performances of the flock. Among the interviewed goat keepers in the study districts 97.1% in Ziquala, 98.7% in Tanqua Abergelle and 66.8% in Lay Armachiho had their own indigenous breeding male goat. Birhu (2013) reported the proportion of respondents who had their own breeding buck in Benatsemay 93.33%, Hamer 96.67% and Dasenech 90% districts which were less than in Ziquala and Tanqua Abergelle districts and higher than in Lay Armachiho district when compared with the current study results. From individual interview and group discussions made in all of the study districts there was no cross or pure exotic goat breeds that means all goat populations were pure indigenous goat breeds (Abergelle and Central Highland goat breeds). Average number (± standard deviation) of breeding male goat per household (per farmer) was 1.65(±1.32), 1.26(±1.33) and 0.88(± .45) in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively. As indicated above goat keepers in Ziquala and Tanqua Abergelle districts keep more than one breeding male goat mainly because of their breeding female goats were high and to have reserve incase one of them may die. Average number (± standard deviation) of years that breeding male goat could give mating service in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 2.61(± 0.90), 2.26(±0.63) and 2.08(± 0.15) respectively.

There was no any special management for breeding buck in all of the study districts. Majority of respondents (>98.89%), those who had their own breeding buck, in Ziquala, Tanqua Abergelle and Lay Armachiho districts reported that source of their own breeding buck was from their own goat flock. The primary purpose of keeping buck in all of the study areas was mainly for mating specially for intentionally selected breeding bucks. But in addition to mating prestige was an added value of keeping breeding male goats particularly if the numbers of bucks are higher than two. Selection of male for breeding purpose was common in all the study areas. The average (±

standard deviation) age of breeding male goat selection in months in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 10.01(± 4.39), 10.21(±4.46) and 6.54(± 4.06) respectively. Coat color, body conformation and growth rate were the first, second and third selection criteria for breeding buck respectively in Ziquala and Tanqua Abergelle districts. The corresponding values for Lay Armachiho district were body conformation, growth rate and coat color.

Table 27. Selection criteria for breeding buck in the study districts

Traits	Ziquala				Tanqua Abergelle				Lay Armachiho			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Coat color	30	21	12	0.37	28	22	13	0.35	4	20	31	0.13
Body confor mation	19	24	9	0.29	30	19	6	0.33	77	12	13	0.43
Growth rate	4	13	13	0.13	6	5	20	0.12	18	35	15	0.22
IBFHMY	9	1	12	0.11	2	18	1	0.11	0	0	0	0.00
Libido	1	1	4	0.02	2	2	4	0.03	2	8	5	0.04
Kid body size when born	1	3	2	0.03	1	0	4	0.02	1	5	5	0.03
Good browser/ grazer	2	1	2	0.03	0	1	2	0.01	0	0	0	0.00
Resistance to disease	1	1	3	0.02	0	1	13	0.04	0	2	7	0.02
If born as twin	0	0	0	0.00	0	0	0	0.00	10	16	11	0.12

R1=first rank, R2= second rank, R3= third rank, I=Index and IBFHMY =If born from high milk yielder

Majority of goat keepers, 89.33% in Ziquala, 87.01% in Tanqua Abergelle and 61.06% in Lay Armachiho districts, could be able to identify the sire of kids. Since household goat flock in Ziquala and Tanqua Abergelle districts were kept without mixing with other household goat flocks and the number of breeding male goat in the flock was not more than four, goat keepers in Ziquala and Tanqua Abergelle districts were able to identify the sire of the kids very easily. Whereas in Lay Armachiho district the number of breeding male goat within the close relatives were few in number and goats of close relatives were kept together, goat keepers in this study area were able to identify the sire of the kids to some extent. In all the study areas goat keepers used phenotypic characteristics (coat color, head profile, ear length and orientation, body conformation, height etc) of the kids to trace back the sire of the kids. The current result

(identification of the sire of the kids) is in disagreement with Mahilet (2012) report which was less than 26.8% (i.e 26.8% in Meta, 12% in Babbile and 23.8% in Gurawa districts)

Majority (>93.57%) of respondents in Ziquala and Tanqua Abergelle districts did not allow their buck to serve does other than their own does because they afraid disease transmission, theft and the buck will get tired as a result their does will not get service on time. But they allowed a buck to mate his mother, daughter and sister due to 100% lack of the inbreeding concept. Even some goat keepers were very happy if their selected buck will mate with his mother, daughter and sister; because they believe that the performance (growth and milk yield) of the new born will be good due to cumulative effect (since both buck and doe come from the same pedigree as best animals). The above statements holds true in Lay Armachiho district except the first sentence, because more than one household goat flock were browse together the whole day as a result bucks in this area were not restricted to mate with does other than own flock.

All respondents in all the study districts castrate their buck by their own method (traditionally) using '*gejemo'*, made from metal and '*alelo'*, a ball shape stone (Fig. 5). The major reasons why respondents castrate their buck were to control breeding (29.92% in Ziquala, 37.45% in Tanqua Abergelle, 13.65% in Lay Armachiho districts) and to improve fattening which will ultimately fetch high price (70.08% in Ziquala, 62.55% in Tanqua Abergelle, 86.35% in Lay Armachiho districts). Average (±SD) age of bucks (in years) to be castrated in Ziquala, Tanqua Abergelle and Lay Amachiho districts were 4.46 (± 0.98), 3.94(±1.13) and 3.47(± 2.07) respectively.

a) b)

Figure 5. Buck castration in Ziquala(a) and Lay Armachiho(b) districts

4.9.2. Breeding female

The proportion of respondents who practiced selection for breeding female in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 96.66%, 93.45% and 83.97% respectively. Girum (2010) reported that the proportion of goat keepers who practiced selection of does was 38.7%, which was much less than the current result. Selection criteria for breeding does in the study districts are summarized in Table 28. Based on index value, the first preferred trait for does in Ziquala, Tanqua Abergelle and Lay Armachiho districts were milk yield (0.24), milk yield (0.20) and body Conformation (0.34) respectively. Age (mean ±SD) of selection (months) for breeding does in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 12.35 (± 5.25), 11.90(±5.35) and 8.58(± 6.44) respectively.

Table 28. Selection criteria for breeding doe in the study districts

Traits	**Ziquala**				**Tanqua Abergelle**				**Lay Armachiho**			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Milk production	11	19	17	0.24	14	11	5	0.20	0	0	0	0.00
Twining ability	16	12	9	0.22	7	3	8	0.10	30	28	13	0.29
Body Conformation	12	8	9	0.12	13	5	3	0.15	41	25	16	0.34
Frequent kidding	11	4	3	0.12	9	6	7	0.13	17	17	19	0.19
Coat color	5	6	6	0.09	10	14	9	0.19	2	9	15	0.07
Growth rate	4	5	2	0.07	4	7	8	0.10	6	11	20	0.11
Good browser	2	5	5	0.06	4	6	3	0.08	0	0	0	0.00
Hardship tolerance	2	1	5	0.04	2	3	8	0.06	0	0	0	0.00

R1=first rank, R2= second rank, R3= third rank, I=Index

Single and twin birth occurrences (%) in Ziquala district were 95.46 and 4.54 respectively. Almost the same percentages (with Ziquala district) were reported in Tanqua Abergelle district; single (94.89%) and twin (5.11%). In contrast with Ziquala and Tanqua Abergelle districts, higher proportions of does in Lay Armachiho district give twin birth type and triple birth type was very common. Single, twin and triple birth type occurrences (%) reported in Lay Armachiho district were 21.44%, 72.18% and 6.38% respectively. From personal observation and individual interviews single birth is not expected from does above parity one in Lay Armachiho district, even some times twin birth type is common for parity one. Regarding litter size (birth type) on Abergelle goat breed, Belay (2008) and FARM Africa (1996) reported in agreement with the

current study result conducted on Abergelle goat breed. Belay (2008) reported on single and twin birth types were 96.6% and 3.4% respectively and the corresponding values of FARM Africa (1996) report were 98.7% and 1.3% respectively. FARM Africa (1996) reported 83.00% single, twin 17.00% and triple 0.00% birth types on central Highland goat breed, in disagreement with the current study result on Lay Armachiho district.

Based on index values most of does in Ziquala (0.84) and Tanqua Abergelle (0.84) districts give birth from October to January. Out of twelve months most peak birth occurred in November both in Ziquala (0.46) and Tanqua Abergelle (0.32) districts. So we can conclude that Abergelle goat breed is almost seasonal breeder. This information is vital for breeders specially for community based genetic improvement program to exchange bucks during the peak mating seasons from May to August more specifically June to avoid inbreeding problem and unwanted bucks to mate with does. Comparatively, does in Lay Armachiho district can give birth almost evenly throughout the year. This difference between the study districts may be due to feed unavailability in Ziquala and Tanqua Abergelle districts during dry season almost from December to June.

Table 29. Index values of occurrences of births across twelve months

Months	**Ziquala**				**Tanqua Abergelle**				**Armachiho**			
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I
Jan	0	6	19	0.08	2	14	16	0.12	6	5	8	0.05
Feb	0	5	6	0.04	1	2	3	0.02	5	6	9	0.05
Mar	0	1	1	0.01	0	2	0	0.01	11	11	7	0.09
Apr	0	1	2	0.01	0	5	3	0.03	10	13	4	0.08
May	0	1	1	0.01	0	2	1	0.01	13	6	14	0.09
Jun	0	4	11	0.05	0	1	4	0.01	17	6	9	0.10
Jul	0	3	4	0.02	0	1	4	0.01	2	1	3	0.02
Aug	0	5	3	0.03	0	1	16	0.04	7	6	4	0.05
Sept	0	0	1	0.00	0	1	6	0.02	17	16	13	0.14
Oct	3	7	13	0.09	10	17	7	0.17	15	16	18	0.13
Nov	60	4	0	0.46	40	6	1	0.32	12	17	11	0.11
Dec	5	31	7	0.21	17	18	9	0.23	3	15	18	0.08

R1 = first ranked, R2= second ranked, R3 =third ranked and I= Index

Kidding interval is one of the key components of reproductive performances of a given farm animal production which affects the overall economic return. Kidding interval (mean ±SD in

moths) of does in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 10.89± 1.22, 11.09±1.13 and 8.58±2.02 respectively. Almost similar results were reported by Belay (2008) on Abergelle goat breed (339.3±21.21 days, which is 11.31 months) and somewhat different result on Central Highland goats breeds (307.9±14.20 days which is 10.26 months). As estimated by the respondents, number of kidding per doe life time (mean ±SD) in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 8.65±3.00, 8.10±2.56 and 7.85±5.50 respectively. This shows that goat keepers in Ziquala and Tanqua Abergelle districts can harvest a minimum of eight kids per doe life time. This is in disagreement with the report of FARM Africa (1996) that stated the average number of kids born per breeding female is 2.8 by Abergelle goat breed.

4.10. Goat Marketing

As indicated above the first objective of goat keepers across all the study districts was to generate cash income to cover different expenses (school fee for their children, closing, medical, food grain when drought happen etc.). In all the study districts goat marketing was traditional i.e. they did not use weighing balance and they did not have market information and the price was fixed by negotiation between the buyers and sellers. All respondents reported that they did not have market information except their traditional knowledge as price usually higher during holidays (Easter, New Year, x-mas etc.). The main goat market shade for Ziquala and Tanqua Abergelle goat keepers was Mekelle specially Mekelle International Abattoir and for Lay Armachiho goat keepers Gondar town was the main goat market shade.

Goat keepers (respondents) in all the study areas reported that they usually sell their goat classes by making priority unless they are forced to sell due to urgent money demand in the household. As indicted below (Table.30), across all the study areas goat keepers sell male kid between six months and one year, old doe and old buck in the first, second and third priority respectively. Unlike goat keepers in Ziquala and Tanqua Abergelle districts, goat keepers in Lay Armachiho district sell male and female kids at the age of less than six months because of some kids can attain market weight before six months.

Table 30. Ranking of classes of goats to be sold when cash is needed

Classes of goats	Ziquala				Tanqua Abergelle				Lay Armachiho			
	1st R	2nd R	3rd R	Index	1st R	2nd R	3rd R	Index	1st R	2nd R	3rd R	**Index**
MK <6 m	0	0	0	0.00	0	0	0	0.00	3	5	2	0.03
FK<6 m	0	0	0	0.00	0	0	0	0.00	2	4	5	0.03
BK 6m-1yr	34	3	11	0.30	16	30	12	0.29	54	22	13	0.32
Dk 6m-1yr	1	20	5	0.12	0	9	5	0.06	9	23	17	0.13
BD	0	5	4	0.04	2	1	2	0.02	6	2	4	0.04
BB	2	1	3	0.03	3	4	2	0.05	4	3	9	0.04
Castrated	5	6	14	0.10	12	9	10	0.15	14	6	12	0.10
Old doe	15	15	13	0.22	27	7	14	0.26	11	31	17	0.17
Old buck	11	16	13	0.20	10	9	21	0.17	15	14	21	0.14

MK=male kid, FK=female kid, BK=buck kid,DK=doe kid,BD=breeding doe,BB=breeding buck, m=month

The average market age (mean±SD in months) for male goat in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 8.98±2.01, 9.03±2.16 and 6.25±1.88 respectively. The corresponding values for female counter part were 10.16±2.61, 9.97±2.44 and 7.06± 2.07 respectively. Even though goat keepers in all the study areas did not allow male goats to reach maximum old age, average (mean±SD in years) culling age due to old age for male goat in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 5.17±1.28, 5.23±1.19 and 4.63±1.08) respectively. The corresponding values for female counter part were 8.12±1.28, 7.94±1.11 and 10.63±1.08 respectively.

4.11. Goat production constraints

Identification of major constraints for a given farm animal production in a given area is a prerequisite to plan appropriate intervention strategies. Based on the current study result (Table 31) drought, disease and feed shortage were the first, second and third major constraints respectively for goat production in Ziquala and Tanqua Abergelle districts with varied index values. On the other hand, disease, theft and predator were the first, second and third major constraints respectively in Lay Armachiho district. As indicated below in Table 31, respondents in Ziquala and Tanqua Abergelle districts did not report lack of superior genotypes as a problem.

The reason was they believe that goat breeds (types) other than Abergelle goat breed cannot survive in the area especially during severe dry season (mostly from March to June).

Table 31. Ranking of the main constraints for goat production in the study districts

Constraints	Ziquala				Tanqua Abergelle				Lay Armachiho			
	1st rank	2nd rank	3rd rank	Index	1st rank	2nd rank	3rd rank	Index	1st rank	2nd rank	3rd rank	**Index**
Drought	35	16	7	0.36	28	22	11	0.34	2	1	5	0.02
FS	5	15	19	0.16	7	15	20	0.17	1	4	8	0.03
WS	3	1	2	0.03	3	17	12	0.13	2	3	3	0.02
Disease	20	24	19	0.32	27	7	11	0.26	44	50	29	0.38
Predator	2	6	9	0.07	1	2	6	0.03	11	16	23	0.13
Market	0	1	1	0.01	2	2	1	0.03	0	0	4	0.01
LS	3	3	7	0.06	2	2	1	0.03	6	16	15	0.09
LSG	0	0	0	0.00	0	0	2	0.00	0	4	7	0.02
theft,	0	0	0	0.00	0	0	0	0.00	52	22	7	0.30

FS=feed shortage, WS=water shortage, LS=labor shortage, LSG=lack of superior genotype

4.12. Characterization of Abergelle and Central Highland Goats

4.12.1. Qualitative characters

As indicated in Table 32 majority of Abergelle goat coat color was brown/red (30.40%) and its combination with other coat colors (50.61%), whereas relatively high proportion of Central Highland goat had white coat color (21.66) and its combination with other coat colors (55.09 %). The above mentioned coat colors (red/brown for Abergelle goat and white for Central Highland goat) were fairly proportional between male and female goats within breed. Red/brown coat color dominancy, in line with the current study result on Abergelle goat, were reported by FARM Africa (1996), Biruh (2013) and Sollomon (2013) on Abergelle, Woyto Guji and Abergelle goats respectively. Goat populations with white coat color dominant, in line with the current study result on Central Highland goat, were reported by Grum (2010) and Solomon (2013) on Short Eared Somali goats and Western lowland goats respectively. In contrary to the current study result on Central Highland goat, FARM Africa (1996) described this goat breed as reddish-brown coat color type. The possible reason may be FARM Africa (1996) delineated very

wide areas for Central Highland goat which may not be true; there may be heterogeneity within this breed.

a) Abergelle goat b) Central Highland goat

Figure 6. Sample flock, female and male goat in the study areas

From individual interviews and group discussions we clearly understand that all goat keepers dislike black coat color in both sexes specially in Plain type. It is extremely uncommon to find a goat keeper who is voluntary to slaughter plain black coat color goat in all the study districts. Their justifications regarding black coat color in all the districts were mainly because of three major reasons. 1) Farmers associate black color with devil or Satan. 2) In addition to the conventional uses of farm animals specially on chicken, sheep and goat, farmers use their farm animals for their cultural belief ("*kolie*" or "*wukabi*") practices with specific color type either by slaughtering or as live animal excluding black color. 3) Black color goat usually sold with less price than other colors most probably due to the cumulative effect of the above two reasons.

Unlike Central Highland goat keepers, Abergelle goat keepers do not prefer white coat color goats in both sexes due to three main reasons: 1) They believe that small number of white color goats on grazing land seems many in number than brown color goats for other farmers because of white color is easily visualized by people. Since stone and soil in Ziquala and Taqnqua

Abergelle areas has reddish brown color, brown goats don not easily visualized. Therefore if other farmer specially whom believed to have evil eyes or "*eyne buda*" or "*mikegna*" perceives as farmer x has many goats, farmer x's goat will die. 2) Unfortunately, If farmer x's goat flock having white color damage or destroy some body's food crop, everyone can simply identify the owner of the goat flock. Then the owner will be accused and charged money as compensation which is locally called '*afelama'* in Ziquala and '*kahasa'* in Tanqua Abergelle ". 3) White Coat color goats have high chance to be preyed than brown color goats. Abergelle goat keepers also prefer mixed (white, black and red/brown) coat color goats. Moreover, goat keepers in Ziquala and Taqnqua Abergelle districts most prefer a kind of red brown coat color goat which they locally call it '*liybia'* (Fig 6.) even though the proportion of this kind of goat is very low. The reason was goat keepers traditionally believe that this kind of goat is prolific and productive due to especial gene it has. As indicated below (Fig 7) different '*liybia'* goats were observed.

Figure 7. *Different 'liybia'* goats in Abergelle goat breed

Table 32. Number (N) and percentages (%) of qualitative traits in Abergelle and Central Highland goats

qualitative traits	Levels	Abergelle						Central Highland					
			Female		Male		Total		Female		Male		Total
		N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Coat color	black	19	7.60	2	2.63	21	6.44	5	1.91	5	9.62	10	3.18
type	white	3	1.20	0	0.00	3	0.92	51	19.47	17	32.69	68	21.66
	Red/brown	76	30.40	25	32.89	101	30.98	37	14.12	5	9.62	42	13.38
	Black and white	28	11.20	8	10.53	36	11.04	30	11.45	6	11.54	36	11.46
	Black and red	30	12.00	9	11.84	39	11.96	20	7.63	1	1.92	21	6.69
	White and red	73	29.20	25	32.89	98	30.06	93	35.50	16	30.77	109	34.71
	Black, white and *red*	21	8.4	7	9.21	28	8.59	26	9.92	2	3.85	28	8.92
X^2-test within breed						3.6^{ns}							16.4**
X^2-test between breed													93.5**
Coat color pattern	Plain	98	39.20	27	35.53	125	38.34	93	35.50	27	51.92	120	38.22
	Patchy	93	37.20	37	48.68	130	39.88	106	40.46	19	36.54	125	39.81
	Spotted	59	23.60	12	15.79	71	21.78	63	24.05	6	11.54	69	21.97
X^2-test within breed						3.8^{ns}							6.3*
X^2-test between breed													0.0^{ns}
Head profile	Straight	246	98.40	76	100.00	322	98.77	218	83.21	47	90.38	265	84.39
	Concave	4	1.60	0	0.00	4	1.23	44	16.79	5	9.62	49	15.61
X^2-test within breed						1.2^{ns}							1.7^{ns}
X^2-test between breed													43.5**
Horn presence	Absent	3	1.20	1	1.32	4	1.23	17	6.49	5	9.62	22	7.01
	Present	247	98.80	75	98.68	322	98.77	245	93.51	47	90.38	292	92.99
X^2-test within breed						0.0^{ns}							0.7^{ns}
X^2-test between breed													13.7**
Horn shape	straight	19	7.69	8	10.67	27	8.39	44	17.96	9	19.15	53	18.15

	curved	195	78.95	31	41.33	226	70.19	186	75.92	31	65.96	217	74.32
	spiral	33	13.36	36	48.00	69	21.43	15	6.12	7	14.89	22	7.53
X^2-test within breed						44.4**							4.6 ns
X^2-test between breed													31.5**
Horn orientation	Upward	21	8.50	9	12.00	30	9.32	34	13.88	3	6.38	37	12.67
	Backward	226	91.50	66	88.00	292	90.68	211	86.12	44	93.62	255	87.33
X^2-test within breed						0.8 ns							2.0 ns
X^2-test between breed													1.8 ns
Ear orientation	erect	5	2.00	0	0.00	5	1.53	7	2.67	0	0.00	7	2.23
	semi-pendulous	1	0.40	0	0.00	1	0.31	103	39.37	34	65.38	137	43.63
	carried horizontally	244	97.60	76	100.00	320	98.16	152	58.02	18	34.62	107	54.14
X^2-test within breed						1.9 ns							12.5**
X^2-test between breed													180.1**
Back profile	straight	230	92.00	70	92.11	300	92.02	158	60.31	26	50.00	184	58.60
	slopes up towards the rump	20	8.00	6	7.89	26	7.98	82	31.30	11	21.15	93	29.62
	curved (dipped)	-	-	-	-	-	-		8.40	15	28.85	37	11.78
X^2-test within breed						0.0 ns							17.7**
X^2-test between breed													102.3**
Toggle	Absent	234	93.60	67	88.16	301	92.33	225	85.88	41	78.85	266	84.71
	Present	16	6.40	9	11.84	25	7.67	37	14.12	11	21.15	48	15.29
X^2-test within breed						2.4 ns							1.7 ns
X^2-test between breed													9.2**
Ruff	Absent	249	99.60	0	0.00	249	76.38	250	95.42	16	30.77	266	84.71
	Present	1	0.40	76	100.00	77	23.62	12	4.58	36	69.23	48	15.29
X^2-test within breed						320.5**							140.0**
X^2-test between breed													7.1**
Beard	Absent	238	95.20	11	14.47	249	76.38	192	73.28	23	44.23	215	68.47
	Present	12	4.82	65	85.53	77	23.62	70	26.72	29	55.77	99	31.53
X^2-test within breed						210.5**							17.0**
X^2-test between breed													5.0*

*Ns=not significant at p≤0.05, *= significant at p≤0.05 up to <0.01, and **= significant at p≤0.01*

Unlike Central Highland goat, there is no significant difference ($\alpha>0.05$) with in Abergelle goats in coat color type. Very high significant difference ($\alpha<0.0001$) was observed between Abergelle and Central Highland goats in coat color type. This uniformity coat color within Abergelle goats indicated that Abergelle goat keepers have coat color preferences and selection practices.

Coat color pattern difference within and between Abergelle and Central Highland goats was not significant ($\alpha>0.05$). Coat color pattern observed in Abergelle goat was plain (38.34%), patchy (39.88%) and spotted (21.78%). Almost the same proportion of coat color pattern was also observed in Central Highland goats, plain (38.22%), patchy (39.81%) and spotted (21.97%). Majority of Abergelle (98.77%) and Central Highland (84.39) goats had straight head profile and the remaining percentage for both breeds was concave.

Majority (>90.38 %) of Abergelle and Central Highland goats were horned. The occurrences of polled goats in the study areas, specially in Abergelle goats, were very rare which is in line with the previous studies by FARM Africa (1996), Halima *et al* (2012), Ahmed (2013), Biruh (2013 Sollomon (2013) on Abergelle, Ethiopian indigenous goats, Goats in Horro Guduru Wollega zone, Woyto Guji, and Abergelle goats respectively. Straight (8.39 %), curved (70.19 %) and spiral (21.43 %) Horn shape with Upward (9.32 %) and Backward (90.68) Horn orientation were observed in Abergelle goats. The corresponding value for Central Highland goats were (18.15 %), (74.32 %), (7.53 %), and (12.67 %), (87.33 %). Unlike horn orientation, horn shape and horn presence between Abergelle and Central Highland goats were highly significant ($\alpha<0.001$)

Ear orientation in Central Highland goats were Almost fifty-fifty, semi-pendulous (43.63%) and carried horizontally (54.14) but in Abergelle goats Ear orientation was largely (98.16%) horizontally carried. Back profile in Abergelle goats were almost all (92.02%) straight and the remaining percentage was slopes up towards the rump. Straight (58.60 %), slopes up towards the rump (29.62%) and curved or dipped (11.78%) back profile were observed in Central Highland goats.

Toggle in Abergelle goats were not common in both sexes, female (6.40%) and male (11.84 %), whereas relatively higher frequency were observed in Central Highland goats, female (14.12%) and male (21.15 %). All (100%) Abergelle male and majority of Central Highland male (69.23

%) goats had ruff. The corresponding ruff observations on females were almost none 0.40 % and 4.58% respectively. Beard was more frequent in Abergelle male (85.53%) and Central Highland male (55.77 %) goats than in Abergelle female (4.82%) and Central Highland female (26.72%) goats.

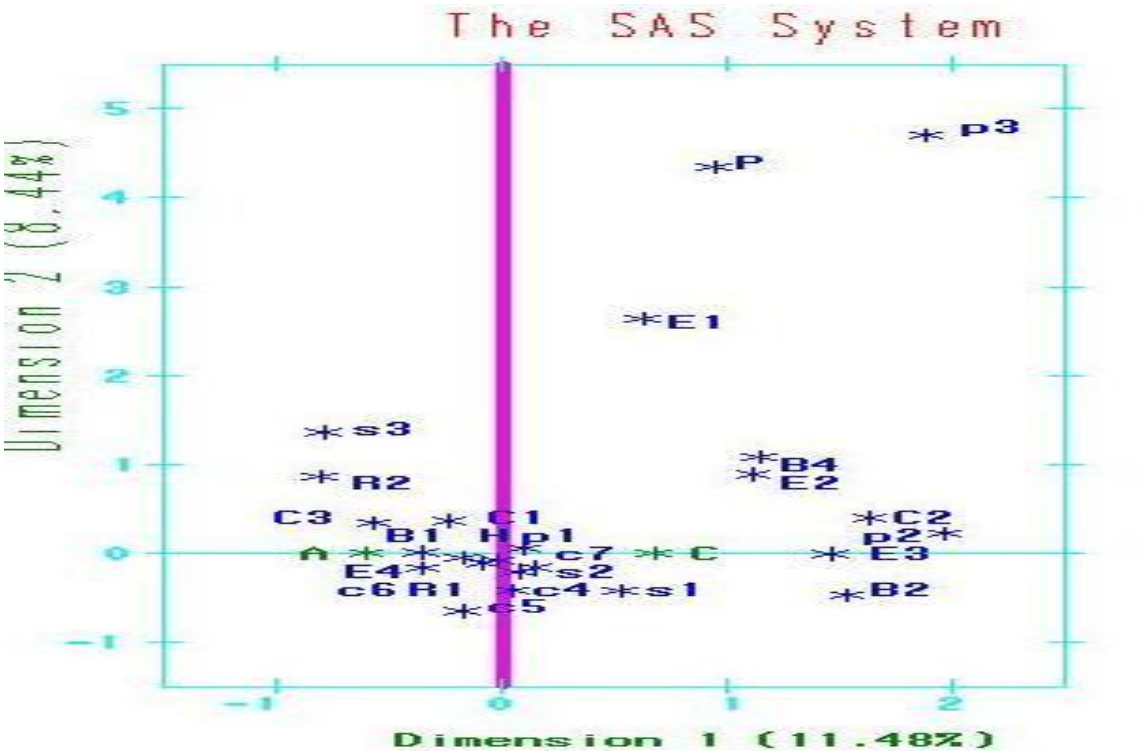


Figure 8. Associations (relations) among different categories of qualitative traits using multiple correspondence analysis technique

Keys for abbreviations of the above figure

Breeds	**Horn presence**	**Coat color pattern**
Abergelle=A	Absent=P	Plain=P1
Central Highland=C	Present=H	Patchy=P2
Coat color type	**Horn shape**	Spotted=P3
Black=C1	Straight=S1	**Back profile**
White=C2	Curved=S2	Straight=B1
Red/brown=C3	Spiral=S3	slopes up towards the rump=B2
Black and white=C4	**Ear orientation**	curved (dipped)=B3
Black and red=C5	Erect=E1	**Ruff**
White and red=C6	semi-pendulous=E2	Absent=R1
Black, white and *red=C7*	carried horizontally=E3	Present=R2

4.12.2. Live body weight and linear body measurements

Least square mean ±SE of body weight and other linear body measurements of Central Highland and Abergelle goats are presented in (Table 33) using breed, sex and breed * sex interactions as fixed factors. Intact males were used in both breeds; castrated males were not used for this specific analysis.

There were very high significant differences (at least $P<0.01$) across breeds in all body measurements except ($p>0.05$) RL and PW. From all the measurements compared, Central Highland goat had higher values except RL, PW and HL. Although there was no significant difference ($P>0.05$) between Abergelle and Central Highland goats, Abergelle goat had numerically higher value on RL and PW, which was not expected relative to other measurements. This may be either of the following two reasons: body conformation difference between these goat populations or these measurements (RL and PW) were not good enough informative (not sensitive) to differentiate population. Horn length on Abergelle goat had higher value ($p<0.0001$) than Central Highland goat, which was expected from field observation and FARM Africa (1996) report.

In general, in all the parameters considered, males showed significantly (at least $P<0.01$) higher measurements than females except RL, PW and EL. This condition was expected since there is hormonal difference between males and females. Moreover, Isaac *et al*. (2005) indicated that sexual dimorphism in body size is clearly widespread among many mammalian taxa, with male-biased dimorphism being the more common, but certainly not the exclusive pattern. The interaction between sex and breed significantly (at least $p<0.05$) affected all the parameters measured. Horn length (HL) in Abergelle male goat was significantly ($p<0.01$) higher than both sexes of Central Highland goats and Abergelle female goat. As a summary, both male and female Central Highland goats had higher (at least $p<0.05$) values in BW, BL, HW, CG, CW and EL measurements than both male and female Abergelle goats.

Table 33. Number (N), Least square mean (LSM)± Standard error (SE) of body weight (kg) and body measurements (cm) by breed, sex, and their interactions

Effects and level		**BW**		**BL**		**HW**		**CG**		**CW**
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Over all	630	29.48	630	59.27	630	67.02	630	71.48	630	14.74
CV%	630	17.10	630	6.51	630	5.74	630	6.09	630	11.51
R^2	630	0.42	630	0.21	630	0.46	630	0.37	630	0.28
Breed		**		**		**		**		**
Abergelle	320	27.52±0.34^{b}	320	58.32±0.26^{b}	320	65.31±0.26^{b}	320	70.21±0.29^{b}	320	14.24±0.11^{b}
CHL	310	33.95±0.40^{a}	310	61.44±0.30^{a}	310	71.02±0.30^{a}	310	74.90±0.34^{a}	310	15.80±0.13^{a}
Sex		**		**		**		**		**
Female	512	28.70±0.22^{b}	512	58.90±0.17^{b}	512	66.36±0.17^{b}	512	70.80±0.19^{b}	512	14.57±0.08^{b}
Male	118	32.77±0.47^{a}	118	60.86±0.36^{a}	118	69.98±0.36^{a}	118	74.31±0.41^{a}	118	15.48±0.16^{a}
Breed X Sex		**		*		**		**		**
CHL male	48	34.79±0.73^{a}	48	62.00±0.56^{a}	48	72.17±0.56^{a}	48	75.65±0.63^{a}	48	15.96±0.24^{a}
Abergelle male	70	30.75±0.60^{c}	70	59.71±0.46^{b}	70	67.79±0.46^{c}	70	72.97±0.52^{c}	70	15.00±0.20^{b}
CHL female	262	33.11±0.31^{b}	262	60.88±0.24^{a}	262	69.87±0.24^{b}	262	74.14±0.27^{b}	262	15.64±0.10^{a}
Abergelle female	250	24.30±0.32^{d}	250	56.92±0.24^{c}	250	62.84±0.24^{d}	250	67.45±0.28^{d}	250	13.49±0.11^{c}

*BW=Body weight, BL= Body Length, HW= Height at Withers, CG= Chest Girth, CW= Chest width, Kg=kilogram, cm=centimeter) *= significant at p≤0.05 up to <0.01 and **= significant at p≤0.01. Means on the same column with different superscripts (^{a,b,c,d}) are significantly different (P<0.05).*

Continued from Table 33

Effects and level		**RL**		**PW**		**HL**		**EL**		**SC**
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Over all	630	12.98	630	12.24	604	17.53	628	13.96	118	23.40
CV%	630	9.99	630	9.69	604	22.34	628	9.61	118	8.60
R^2	630	0.04	630	0.02	604	0.57	628	0.39	118	0.18
Breed		ns		ns		**		**		**
Abergelle	320	13.05±0.09^{a}	320	12.34±0.08^{a}	316	23.30±0.27^{a}	319	12.81±0.09^{b}	70	22.63±0.24^{b}
CHL	310	12.92±0.10^{a}	310	12.20±0.09^{a}	288	15.74±0.32^{b}	309	15.04±0.11^{a}	48	24.52±0.29^{a}
Sex		ns		ns		**		ns		na
Female	512	12.95±0.06^{a}	512	12.21±0.05^{a}	291	15.91±0.18^{b}	510	14.01±0.06^{a}	-	-
Male	118	13.03±0.12^{a}	118	12.32±0.11^{a}	113	23.14±0.38^{a}	118	13.84±0.13^{a}	118	23.57±0.19
Breed X Sex		**		**		**		*		na
CHL male	48	12.67±0.19^{b}	48	12.06±0.17^{bc}	44	16.69±0.59^{b}	48	15.02±0.19^{a}	48	-
Abergelle male	70	13.39±0.15^{a}	70	12.59±0.14^{a}	69	29.59±0.47^{a}	70	12.66±0.16^{b}	70	-
CHL female	262	13.18±0.08^{a}	262	12.34±0.07^{ab}	244	14.80±.0.25^{c}	261	15.06±0.08^{a}	-	-
Abergelle female	250	12.71±0.08^{b}	250	12.09±0.08^{c}	247	17.01±0.25^{b}	249	12.97±0.09^{b}	-	-

*RL= Rump Length, PW= Pelvic Width, HL= Horn Length, EL= Ear Length and SC= Scrotum Circumference, ns=not significant (P>0.05) *= significant at p≤0.05 up to <0.01, **= significant at p≤0.01 and na=not applicable. Means on the same column with different superscripts (^{a,b,c,d}) are significantly different (P<0.05).*

4.12.3. Correlation between body weight and other linear body measurements

Correlation coefficients of live body weight with other quantitative variables for male and female Abergelle and Central Highland goat breeds is presented in Table 34. Except chest width, ear length and scrotum circumference, all linear body measurements showed very high significant ($p<0.01$) associations with body weight positively.

Among measured linear quantitative variables chest girth ($r=0.769$ up to 0.928) was the highest positively associated variable with body weight both for male and female Abergelle and Central Highland goat breeds. This suggests that either this variable alone or by combining with other linear quantitative variables (which will be determined later using multiple linear regression analysis in the next chapter) could provide a good estimate for predicting live body weight of Abergelle and Central Highland goat breeds. In agreement with the current result, chest girth as the most correlated linear quantitative variables with body weight was reported by many researchers Grum (2010), (Mahilet (2012), Ahmed (2013) and Biruh (2013)).

Table 34. Correlations between body weight and other linear body measurements

Linear body measurements	**Goat breed**							
	Abergelle				Central Highland			
	Female		Male		Female		Male	
	N	r	N	r	N	r	N	r
Body Length	250	0.494^{**}	70	0.749^{**}	262	0.645^{**}	48	0.796^{**}
Height at Withers	250	0.471^{**}	70	0.660^{**}	262	0.556^{**}	48	0.856^{**}
Chest Girth	250	0.769^{**}	70	0.842^{**}	262	0.782^{**}	48	0.928^{**}
Chest width	250	0.073^{ns}	70	0.299^{*}	262	0.387^{**}	48	0.678^{**}
Rump Length	250	0.376^{**}	70	0.437^{**}	262	0.376^{**}	48	0.475^{**}
Pelvic Width	250	0.236^{**}	70	0.382^{**}	262	0.436^{**}	48	0.672^{**}
Horn Length	247	0.400^{**}	69	0.634^{**}	244	0.430^{**}	44	0.571^{**}
Ear Length	249	0.130^{**}	70	0.160^{ns}	261	0.228^{**}	48	0.053^{ns}
Scrotum Circumference	-	-	70	0.710^{**}	-	-	48	0.247^{ns}

* = $p<0.05$, **= $p<0.01$, ns=$p>0.05$, N= Number of observations and - =not applicable

Next to chest girth body length (r=0.494 up to 0.796) and height at withers (r=0.471 up to 0.856) were the second and the third most correlated variables with body weight respectively for male and female Abergelle and Central Highland goat breeds except body length showed lower association with body weight in Abergelle male goats.

In contrast, chest width, rump length, pelvic width, horn length, ear length and scrotum circumference did not show consistency across breeds and sexes in addition to the lower correlation coefficient values. From this we can understand that these variables do not have the potential to predict live body weight.

4.12.4. Prediction of body weight from different linear body measurements

Stepwise multiple linear regression analysis was carried out on Abergelle and Central Highland goat breeds to generate models (equations) for prediction of live body weight of matured (4PPI) male and female goats separately (Table 35). For this particular study, five (CG, BL, HW, RL and PW) and four (CG, BL, SC and PW) predictors (quantitative traits) were selected in order to develop the prediction equation for Abergelle female and male goats respectively, based on the values of R^2, R^2 change, root mean square error (RMSE), the nature of trait (e.g. horn) and simplicity of measurement under field condition. Thus best fitted prediction models were selected with smaller C (P), AIC, SBC, RMSE and higher R^2 values. In the same manner, four (CG, BL, CW and HW) and two (CG and HW) predictors were selected for matured female and male Central Highland goats respectively.

In the current study chest girth (CG) was the best predictor variable, which explains more variation than any other linear body measurements in both breeds and sexes. This is in agreement with the results of Tesfaye (2008), Grum (2010), Halima *et al*. (2012), Mahilet (2012),Ahmed (2013), Belete (2013), Biruh (2013) and Hulunim (2014) as chest girth was selected first for prediction of live body weight of animals. The better association of body weight with chest girth was possibly due to relatively larger contribution to body weight of chest girth which consists of bones, muscles and viscera (Thiruvenkadan, 2005). Body length (BL) was the second selected predictor except for male Central Highland goat (which was Height at wither).

Even if the addition of new variables in each steps in the model increases R^2 value (even this is not always true) there may be an increment of the values of C (P), AIC, SBC, RMSE which will ultimately decreases the efficiency of the model. This is because of the addition of unnecessary variable(s) which has weak association with body weight. On the contrary, precision of the model becomes less when we use few variables. So optimization is the only solution to generate best fitted models.

Table 35. Models for prediction of live weight from different linear body measurement for Abergelle and Central Highland goats

Breed	Sex	N/o	Models	R2	R2 change	RMSE
Abergelle	F (4PPI)	250	-23.82 + 0.71CG	0.59	0.06	1.95
			-32.92 + 0.26BL + 0.63CG	0.65	0.01	1.81
			-36.12 + 0.23BL + 0.11HW + 0.60CG	0.65	0.01	1.80
			-37.03 + 0.21BL + 0.11HW + 0.58CG + 0.26RL	0.66	0.00	1.78
			-36.37 + 0.23BL + 0.11HW + 0.59CG + 0.28RL - 0.19PW	0.66	0.00	1.78
	M(4PPI)*	70	-43.89 + 1.02CG	0.73	0.07	2.87
			-53.93 + 0.48BL + 0.76CG	0.8	0.03	2.50
			-57.01 + 0.49BL + 0.59CG + 0.68SC	0.83	0.01	2.35
			-55.96 + 0.54BL + 0.66CG - 0.70PW + 0.68SC	0.84	0.00	2.26
CHL	F (4PPI)	262	-42.2 + 1.02CG	0.63	0.03	3.42
			-47.43 + 0.36BL + 0.79CG	0.66	0.03	3.30
			-49.36 + 0.36BL + 0.75CG + 0.32CW	0.69	0.00	3.16
			-52.44 + 0.34BL + 0.11HW + 0.70CG + 0.32CW	0.69	0.00	3.14
	M(4PPI)*	48	-40.62 + 1.08CG	0.87	0.02	3.16
			-45.91 + 0.32HW + 0.76CG	0.89	0.00	2.98

*=intact male, **N/o**=number of observations, CHL=Central Highland BL=Body Length, HW=Height at Wither, CG=Chest Girth, CW=Chest Width, RL= Rump Length; PW=Pelvic Width, SC=Scrotum Circumference

4.13. On-Farm Performance Evaluation and Monitoring

As presented below in Table 36, a total of 115 goat keeper households having a total of 2270 goats was registered for the on-farm goat performance evaluation and monitoring purpose in Ziquala, Tanqua Abergelle and Lay Armachiho districts from mid July 2013 up to mid August 2014 (13 months) with special emphasis of flock dynamics (in-flow and out-flow), birth weight and growth performances evaluation in each districts. Milk yield performance was monitored in Ziquala and Tanqua Abergelle districts but not in Lay Armachiho district, as goat milk is not consumed in this area by goat keepers.

4.13.1. Base (initial) flock profile

The average of each class of goats kept by the households and composition by age and sex in each of the study districts is presented in Table 36. From all goat classes in the monitored households, the highest proportion was does and weaned females respectively in all the study areas. The first reason was goat keepers need to produce high number of kids to get cash income by selling, since goat keepers' first objective of keeping goat in all the study areas was to get cash income (Table 11). The second reason for Ziquala and Tanqua Abergelle districts was to have high number of does for milk production.

The average flock size per monitored households with standard deviation in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 27.33±1.88, 19.18±1.32 and 13.79± 9.41 goats respectively. The result of survey part (Table 10) and monitoring part (Table .36) regarding flock size per households in the current study is in disagreement, especially for Tanqua Abergelle district. The reason may be most probably due to sample size and area coverage for on-farm performance evaluation and monitoring part was very small as compared with survey part. The standard deviations in the monitored households' goat flock were very much lower than the survey part (Table 10) in Ziquala and Tanqua Abergelle districts that indicated higher variability of flock size per household across sampled households for survey part and the reverse is true for monitoring part.

Table 36. Base flock structure by district

Classes of goats	Ziquala (nhh=33			Tanqua Abergelle (nhh=44)			Lay Armachiho (nhh=38)		
	N	%	Mean±Sd	N	%	Mean±Sd	N	%	Mean±Sd
Male kid	10	1.1	0.30±0.53	76	9.0	1.73±1.83	85	16.2	2.32±1.74
Female kid	9	1.0	0.27±0.67	108	12.8	2.45±2.34	84	16.0	2.24±1.92
Weaned male	90	10.0	2.73±2.90	82	9.7	1.86±1.98	25	4.8	0.66±1.15
Weaned female	275	30.5	8.33±5.27	146	17.3	3.32±3.01	87	16.6	2.18±2.58
Doe	465	51.6	14.09±1.05	387	45.9	8.80±6.23	225	42.9	5.92±4.36
Buck	47	5.2	1.42±2.29	40	4.7	0.91±1.12	17	3.2	0.45±0.60
Castrated	6	0.7	0.18±0.39	5	0.6	0.11±0.32	1	0.2	0.03±0.16
Total	902	100.0	27.33±1.88	844	100.0	19.18±1.32	524	100.0	13.79±9.41
Grand total goats=2270									

nhh=number of households monitored, N=sum of each goat category

The average number of goat holding per household in the current study districts were much more higher than the reports of Endeshaw (2007), Tsedeke (2007), Deribe (2009) and Fikre (2009), which were 4.5, 4.1, 6.5 and 5.98 goats per household respectively while comparable with the reports of Tesfaye (2009), Girum (2010) and Feki (2013) which were 20.0, 32.8 and 36.9 goats per household respectively. The current study result was also much higher than the reports made in different countries in Africa; Francis (1988, 5.0 by Ndamukong *et al. (*1989) in Cameroon, 4.5 Ibrahim (1998) and 4.0 by Ahuya *et al*. (2005) in Kenya, 7.5 by) in Nigeria, 8.0 by Turkson (1992) in Ghana and 9.9 by Jaitner *et al. (2001*) goats in Gambia.

4.13.2. Flock dynamics

At the commencement of (July 2013) the village goat monitoring work a total of 2270 goats (902, 844 and 524 goats in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively) were found from a total of 115 households (33, 44 and 38 households in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively). Goat entry sources (Table. 37) to the monitored household goat flock were through purchasing, birth, gift (given for the family members, usually when daughter or son in the family married and ready to live separately from

their family), exchanging by other livestock species and received as wage, locally known as 'g*wasa'* in Tanqua Abergelle and '*meka'* in Ziquala. G*wasa and* m*eka'* in this localities context was defined as when poor people (usually male from 12 to 25 years old) recruited as goat keeper for the whole goat classes (a minimum of one year contract agreement) by goat owner to be paid one fourth of the new born kids instead of giving money in cash form as salary. On the other hand goat exit routs from the monitored household goat flock were via selling, gift, theft, home slaughtering, death due to different causes and payment for goat keepers as wage ('g*wasa'* in Tanqua Abergelle and '*meka'* in Ziquala). In one year round village goat monitoring period a total of 1197 (540, 363 and 294 goats in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively) and 719 goats (342, 128 and 249 goats in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively) were recorded as inflow and outflow respectively i.e 1916 goats movement was recorded both for inflow and outflow of goats.

In all monitored villages, birth (>79 %) as goat entry sources took the lions share. However, the proportion of the current results of goat entry sources in the study districts via birth (79.63%, 89.81% and 91.84% in Ziquala, Tanqua Abergelle and Lay Armachiho districts respectively) were lower than the report (94.4%) of Deribe (2009) in southern Ethiopia and higher than the report (63%) made by Tsedeke (2007) in the same district (Alaba district, southern Ethiopia).

'*Meka'* in Ziquala district contributed (10.00 %) in second rank as source of goat entry in to the households goat flock. In Tanqua Abergelle (7.71%) and Lay Armachiho (6.80%) districts Purchasing took the second rank as source of goat entry to the households goat flock.

Table 37. Entries and exits of goats in the monitored villages by districts

Descriptors	**Ziquala (nhh=33)**		**Tanqua Abergelle (nhh=44)**		**Lay Armachiho (nhh=38)**		**Overall (nhh=115)**	
	N	%	N	%	N	%	N	%
Initial (July 2013)	902	-	844	-	524	-	2270	-
Inflow								
Purchased	38	7.04	28	7.71	20	6.80	86	7.18
Birth	430	79.63	326	89.81	270	91.84	1026	85.71
Gift	13	2.41	9	2.48	0	0.00	22	1.84
Exchange	5	0.93	0	0.00	4	1.36	9	0.75

'Meka'	54	10.00	0	0.00	0	0.00	54	4.51
Total	540	100.00	363	100.00	294	100.00	1197	100.00
Outflow								
Sold	115	33.63	35	27.34	106	42.57	256	35.61
Gift	15	4.39	14	10.94	0	0.00	29	4.03
Theft	1	0.29	2	1.56	4	1.61	7	0.97
Slaughtered	34	9.94	19	14.84	40	16.06	93	12.93
Exchanged	8	2.34	1	0.78	3	1.20	12	1.67
Died	85	24.85	57	44.53	92	36.95	234	32.55
'Meka'	72	21.05	0	0.00	0	0.00	72	10.01
Others	12	3.51	0	0.00	4	1.61	16	2.23
Total	342	100.00	128	100.00	249	100.00	719	100.00
Final (Aug. 2014)	1100	18.00*	1079	21.78*	569	7.91*	2748	17.39*

*nhh=number of households monitored, N=sum of each goat category, *= % of increment*

The highest proportions recorded for the outflow of goats in monitored villages in Ziquala, Tanqua Abergelle and Lay Armachiho districts were through selling (33.63%), death (44.53%) and selling (42.57%) respectively. Even though exit rout via death were high(>24%) in all the study villages, we can say that nearly fifty percent of the exit routs of goat in Tanqua Abergelle district was due to death by different causes, which needs critical intervention strategy to alleviate the problem. Deribe (2009) reported lower proportion (when compared with the current study result) of exit percentages of goat (17.8%) and sheep (13.8%) in Alaba district, southern Ethiopia, due to death by different causes.

At the end of one year monitoring period, the net increment (inflow-outflow divided by final population) of goat population in monitored villages in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 18.00%, 21.78% and 7.91% respectively. This indicted that farmers in the study areas give attention for goat production specially in Tanqua Abergelle and Ziquala districts which will ultimately contribute for food security in the areas.

Goat inflow and outflow patterns in the study districts across a year by sex and age are presented in Figure 9 and 10. As indicated above in Table 9 the main source of goat entry in to the monitored household goat flock in all study villages was through birth (>79 %) with a very clear cut across a year in Ziquala and Tanqua Abergelle districts. From a total of births recorded during one year monitoring period in Ziquala (430) and Tanqua Abergelle (326) districts 74.65

%(171 male and 150 female, 321) and 54.91% (84 male and 95 female 326) respectively were observed in November. So as speculated above in section 4.9.2 in Table 29 from the survey data, the actual monitoring data confirms that majority of Abergelle goat breed is giving birth in November most probably because of feed availability during the onset of rainy season (May up to June). On the other hand birth pattern in Lay Armachiho district did not show seasonality i.e. does in this study area give birth throughout the year.

From the total inflow goats through purchasing in Ziquala (38), Tanqua Abergelle (28) and Lay Armachiho (86) districts 71.05 % (27), 57.14% (16) and 20.93% (18) respectively were weaned females and does. This indicates that farmers in the study areas need to expand goat production.

The outflow pattern of goats in all the study areas across the year (considering months as the smallest unit of measurement) did not show clear difference which is in disagreement with the report of Deribe (2009), more than 40% of the exits of goats were in months of February, May and August in Alaba district. However, unlike the inflow pattern of goats, all goat classes were observed to exit the monitored household flock due to different routs of exits. From the total outflow of goats because of death in Ziquala (85), Tanqua Abergelle (57) and Lay Armachiho (92) districts 45.88 % (39), 59.65% (34) and 23.91% (22) respectively were weaned females and does. From this observation we can understand that productive classes of goats were died specially in Tanqua Abergelle and Ziquala districts.

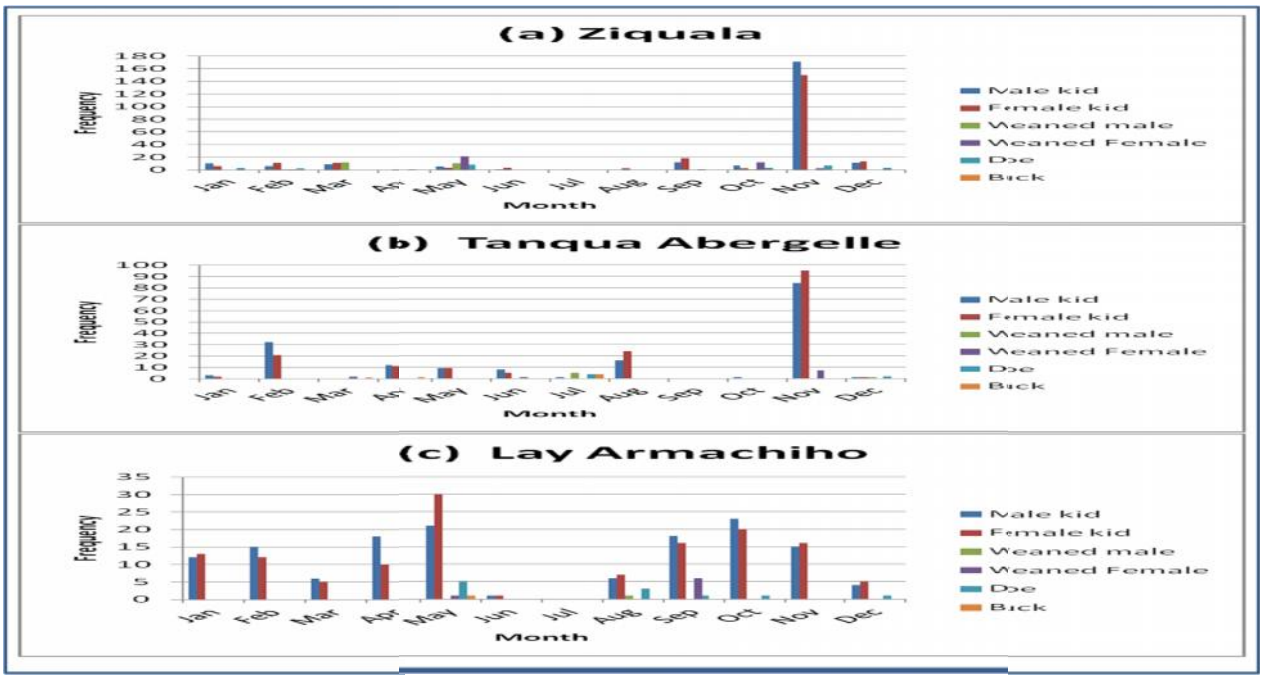


Figure 9. Inflow pattern across a year by sex and age in the study districts (a, b and c)

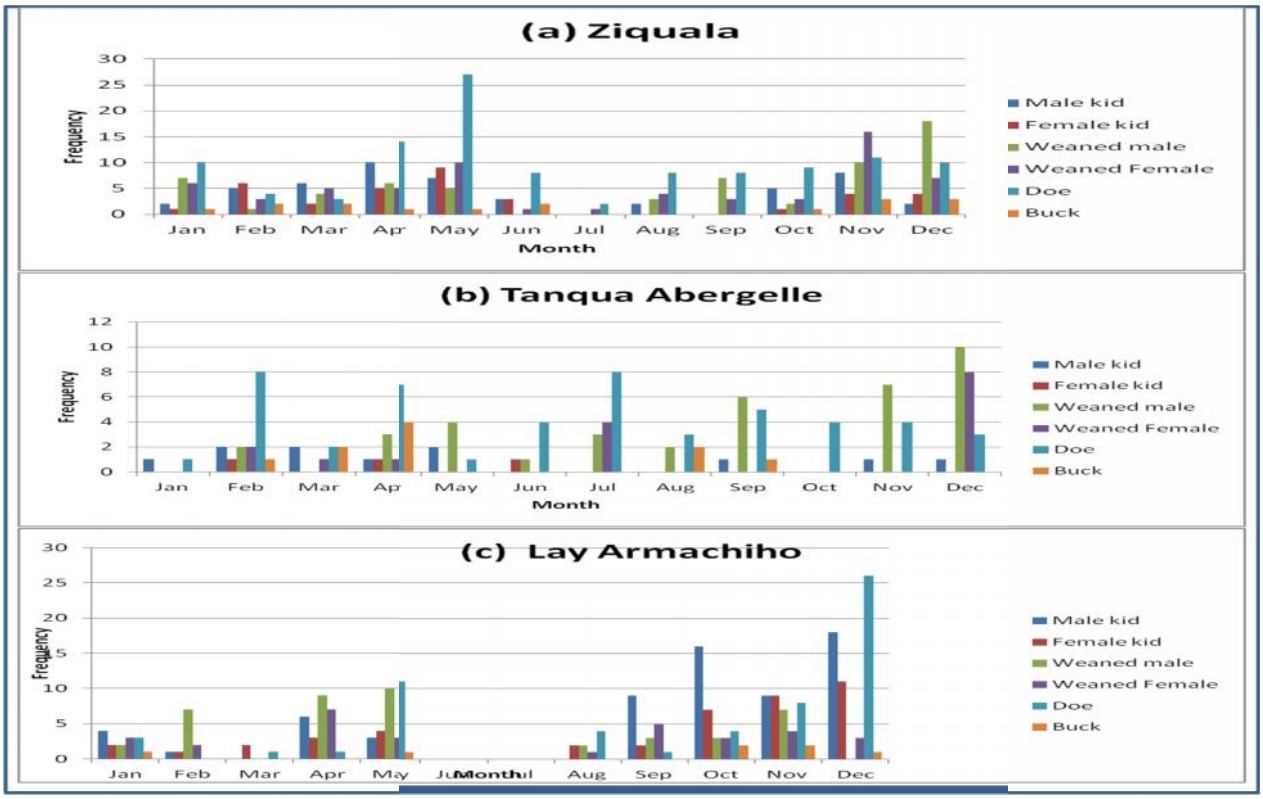


Figure 10. Outflow pattern across a year by sex and age in the study districts (a, b and c)

4.13.3. Birth weight and growth performance of Abergelle and Central Highland goats

Growth is the most important trait in small ruminant production affecting the contribution of the sector to the farm household through live animal sale and meat production (Belay and Mengistie, 2013). Growth performance of Abergelle and Central Highland kids' were studied from birth to at different ages (three, six and nine months) in Ziquala and Tanqua Abergelle districts for Abergelle goat breed and in Lay Armachiho district for Central Hiland goat breed by considering sex of kids, parity of dams and type of births as fixed independent non genetic factors (Table 38 and 39).

4.13.3.1. *Average weight of birth, three,* **six** *and nine months*

In general, Central Highland goat breed in Lay Armachiho district monitoring site significantly ($p<0.001$) outsmarted in all the parameters (in birth weight, three, six and nine months weight) compared with Abergelle goats (in both monitoring sites, Ziquala and Tanqua Abergelle districts) (see Table 38 and Fig. 11). Belay Deribe (2008) concluded that Central Highland goats were higher in most of growth (ADG, average daily gain) and Carcass parameters than Abergelle goats. From the current and previous studies result we can suspect that either the environment or unique gene(s) or both contribute for Central Highland goats to be best performer compared to Abergelle goat breed, which needs to be investigated in the future. Whereas, within Abergelle goat breed at Ziquala and Tanqua Abergelle monitoring sites, birth weight, three and six month weight did not show significant($p>0.05$) differences. But at nine month within Abergelle goat breed, goats at Tanqua Abergelle district monitoring site showed better performance than goats in Ziquala district monitoring site. This may be most probably due to relatively better environment (feed and water) and health services effect in Tanqua Abergelle district monitoring site (personal observation).

The overall least square means (±SE) for birth, three, six and nine month weights (kg) of Abergelle goat kids at Ziquala district monitoring site were 1.98± 0.06, 7.30± 0.21, 9.25±0.31 and 11.21±0.53 respectively. For the same breed at Tanqua Abergelle district monitoring site for the above age categories (kg) were 1.97± 0.06, 7.43± 0.23, 11.08±0.33 and 13.24±0.55

respectively. The corresponding values for Central Highland goats in Lay Armachiho district monitoring site were 2.31±0.04, 10.67± 0.17, 17.53±0.24 and 22.66±0.44 respectively.

The current study result of overall least square mean birth weight of Abergelle goat breed at Ziquala monitoring site had lower value (1.98± 0.06 kg) than the report (2.29 kg) of Zeryhun (2006) and somewhat higher than the report (1.91±0.04 kg) of Belay and Mengistie (2013) for the same breed. Higher birth weight values (2.70±0.05 kg for Bati goats, 2.42±0.05kg for Borena and 2.19±0.08kg for Short-eared Somali goats) were reported by Hulunim (2014). On the contrary, lower birth weight (1.5 kg) was reported by Tucho *et al*. (2000) for Mid Rift Valley goat kids. Sex, parity and type of birth had effect on birth weight of Abergelle goat breed at Ziquala monitoring site at $p<0.05$, $p<0.001$ and $p<0.05$ significant levels respectively. Accordingly, male, parity ≥ 4 and single birth type showed heavier birth weights. Similar reports (by Ahuya *et al*., 2009 and Belay and Mengistie, 2013) were observed for the significant effects of sex, parity and type of birth on birth weight by suggesting their own expectations and speculations. On the other hand sex, parity and type of birth had no significant ($p>0.05$) effect on three, six and nine months of kids body weight consistently for Abergelle goat breed at Ziquala monitoring site. Except sex effect ($p<0.05$) only at nine month of kids body weight (Table 38), sex, parity and type of birth had no significant ($p>0.05$) effect on birth weight, three, six and nine months of kids body weight for Abergelle goat breed at Tanqua Abergelle monitoring site. Male kid's heavier weight both at birth and somewhere in its age (in our case at nine month) may be associated with hormonal differences (Nkungu *et al*., 1995) between male and female kids, probably androgen play role for male kid's heavier weight.

The observed overall least square mean birth weight (2.31±0.04kg) of Central Highland goat breed at Lay Armachiho district monitoring site was more or less comparable for many of the reports made on different Ethiopian indigenous goat breeds birth weight. For instance 2.42±0.05kg for Borena and 2.19±0.08kg for Short-eared Somali goats reported by Hulunim

Table 38. Least square means (±SE) birth, three, six and nine month weights (kg) for Abergelle and Central Highland goat breeds by sex, parity and birth type

Monitoring Site	Factors	BW		3MW		6MW		9MW	
		N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
	over all	1308	***	852	***	654	***	375	***
	Ziquala	473	1.98± 0.06^{b}	380	7.30± 0.21^{b}	315	9.25±0.31^{c}	176	11.21±0.53^{c}
	Tanqua	376	1.97± 0.06^{b}	232	7.43± 0.23^{b}	185	11.08±0.33^{b}	142	13.24±0.55^{b}
	Arma	459	2.31±0.04^{a}	240	10.67± 0.17^{a}	154	17.53±0.24^{c}	57	22.66±0.44^{a}
AZ	sex	473	*	380	ns	315	ns	176	ns
	male	241	2.09±0.04^{a}	197	7.80±0.25	168	10.11±0.33	90	11.37±0.48
	female	232	2.02±0.04^{b}	183	7.79±0.24	147	9.94±0.35	86	11.20±0.44
	parity	473	***	380	ns	315	ns	176	ns
	1	88	1.98±0.05^{b}	68	7.96±0.31	51	10.19±0.42	29	11.25±0.57
	2	67	2.08±0.05a^{b}	55	7.86±0.32	47	9.83±0.43	26	11.17±0.58
	3	108	2.00±0.05^{b}	72	7.74±0.28	61	10.05±0.37	32	11.23±0.52
	4	90	2.10±0.05^{a}	78	7.78±0.29	69	9.91±0.38	39	11.08±0.54
	≥5	120	2.013±0.04^{a}	107	7.65±0.25	87	10.13±0.36	50	11.67±0.46
	BT	473	*	380	ns	315	ns	176	ns
	single	452	2.14±0.02^{a}	365	7.91±0.45	305	10.56±0.63	170	11.514±0.16
	twin	21	1.97±0.07^{b}	15	7.69±0.09	10	9.49±0.11	6	11.05±0.85
ATA	sex	376	ns	232	ns	185	ns	142	*
	male	200	2.17±0.16	120	7.78±0.27	93	11.28±0.36	67	13.76±0.47^{a}
	female	176	2.00±0.17	112	7.75±0.26	92	11.01±0.36	75	13.17±0.48^{b}
	parity	376	ns	232	ns	185	ns	142	ns

Continued from Table 38

	1	90	2.26±0.18	50	7.85±0.31	41	11.10±0.42	35	13.43±0.50
	2	50	2.03±0.21	31	7.77±0.36	26	11.59±0.46	20	13.94±0.57
	3	69	2.06±0.20	45	7.98±0.32	40	11.16±0.41	28	13.34±0.52
	4	66	2.02±0.20	39	7.73±0.34	30	11.14±0.44	21	13.55±0.53
	≥5	10	2.06±0.17	67	7.57±0.28	48	10.75±0.40	38	13.05±0.52
	BT	376	ns	232	ns	185	ns	142	ns
	single	362	2.12±0.06	220	7.82±0.11	178	11.40±0.13	139	13.67±0.14
	twin	14	2.05±0.30	12	7.73±0.47	7	10.89±0.66	3	13.26±0.90
CHLA	sex	459	***	240	*	154	*	57	ns
	male	222	2.34±0.03^{a}	117	11.13±0.31^{a}	74	18.47±0.51^{a}	20	22.83±1.58
	female	237	2.25±0.03^{b}	123	10.38±0.30^{b}	80	16.87±0.49^{b}	37	22.51±1.01
	parity	459	*	240	ns	154	ns	57	ns
	1	89	2.20±0.04^{b}	51	10.74±0.41	36	17.29±0.65	14	23.34±1.63
	2	120	2.25±0.04^{b}	77	10.74±0.34	47	17.82±0.57	14	23.98±1.54
	3	99	2.35±0.04^{a}	50	10.42±0.42	27	16.96±0.75	12	21.07±1.71
	4	52	2.30±0.05^{ab}	22	11.40±0.61	16	18.06±0.97	6	21.34±2.32
	≥5	99	2.36±0.04^{a}	40	10.48±0.49	28	18.20±0.80	11	23.63±1.91
	BT	459	***	240	ns	154	ns	57	ns
	single	152	2.47±0.03^{a}	82	11.23±0.32	52	18.25±0.53	12	23.28±1.73
	twin	266	2.24±0.02^{b}	133	10.94±0.25	84	17.63±0.91	38	21.77±0.91
	triple	41	2.18±0.05^{b}	25	10.09±0.57	18	17.11±0.42	7	22.96±2.20

*AZ=Abergelle goat breed in Ziquala district, ATA= Abergelle goat breed in Tanqua Abergelle district, CHLA=Central Highland goat breed in Lay Armachiho district, Arma= Armachiho, N= number of monitored kids, BT=birth type, BW=birth weight, 3MW=3 month weight, 6MW= 6 month weight, 9MW=9 month weight, Means in the same column with different superscripts are significantly different at indicated significant level; * p<0.05, ** p<0.01, *** p<0.001 ns =not significantly different*

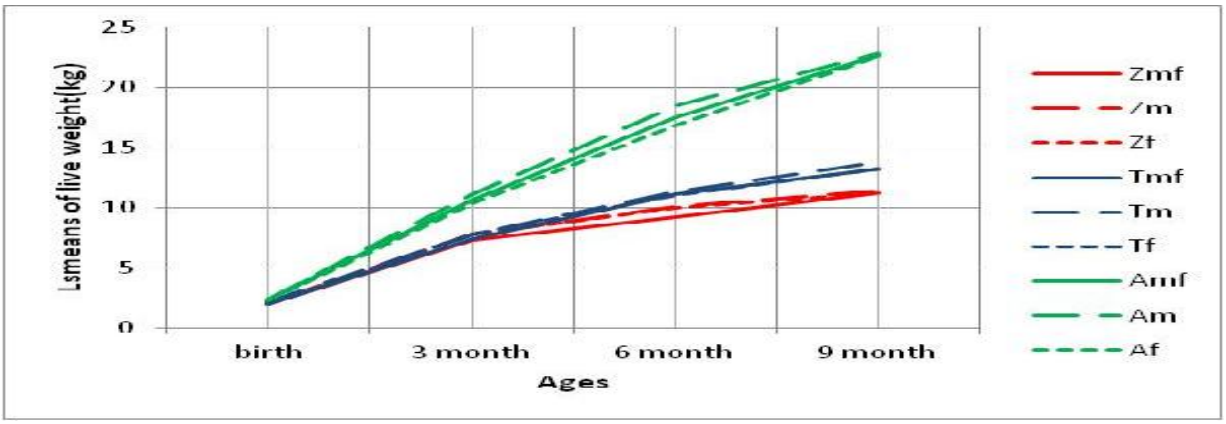
(2014), 2.34 kg for Boran Somali goats reported by Tucho *et al*. (2000) and 2.28±0.04 kg Tesfaye Tsegaye (2009) in Metema district are some of the reports. Sex, parity and type of birth showed effect on birth weight of Central Highland goat breed at $p<0.001$, $p<0.05$ and $p<0.001$ significant levels respectively.

As discussed above for Abergelle goat breed, male Central Highland goats had significantly ($p<0.001$) heavier birth weight (2.34±0.03kg) than their female counter parts (2.25±0.03kg). But sex effect decreased ($p<0.05$) after birth and did not exert its effect ($p>0.05$) on nine month old kids. On the other hand parity and type of birth effects ($p>0.05$) were not happened after birth. Hulunim (2014) reported that parity on Borena and for Short-eared Somali goats had no effect after birth but on Bati goat kids until three months of age. In general, Central Highland does parity ≥ 3 had heavier birth weight kids. Regarding on birth type effect on birth weight of kids for Central Highland goat breed, single born kids showed highest birth weight followed by twin born kids than triple born kids.

As conclusion, Central Highland goat breed had significantly ($p<0.001$) heavier birth weight and body weight up to nine month than Abergelle goat in both sexes. Similarly male goats were heavier (at least numerically) than female goats across all monitoring sites and breeds (Table 38 and Fig. 11).

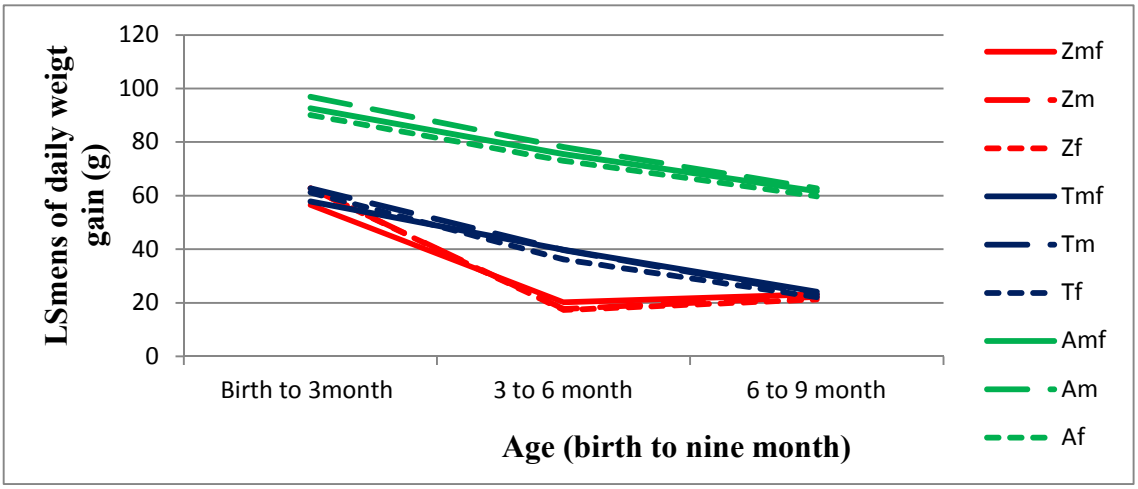
4.13.3.2. Average daily weight gain (g)

Observed least square means of daily weight gain at three months of interval from birth up to nine months of age for Abergelle and Central Highland goat kids is summarized in Table 39.The overall least square means of daily weight gain between monitoring sites (districts) from birth to three, from three to six and from six to nine months were highly significant ($p<0.001$). Using mean separation techniques, it was possible to conclude that this strong significant difference was mainly because of Central Highland goats are fast growing goats (Fig. 11). Whereas within Abergelle goats daily weight gain was significantly ($p<0.001$) different only from three month to six month age of kids.



Zmf=Ziquala male and female, Zm=Ziquala male, Zf=Ziquala female,Tmf=Tanqua Abergelle male and female, Tm =Tanqua Abergelle male, Tf= Tanqua Abergelle female, Amf=Lay Armachiho male and female, Am= Lay Armachiho male, Af= Lay Armachiho female

Figure 11. Growth trends (birth to nine months) of male, female and the averages of both sexes for Abergelle goats (at Ziquala and Tanqua Abergelle districts) and Central Highland goats (at Lay Armachiho district)



Zmf=Ziquala male and female, Zm=Ziquala male, Zf=Ziquala female,Tmf=Tanqua Abergelle male and female, Tm =Tanqua Abergelle male, Tf= Tanqua Abergelle female, Amf=Lay Armachiho male and female, Am= Lay Armachiho male, Af= Lay Armachiho female

Figure 12 Least square means of daily weight gain trends (birth to nine months) of male, female and the averages of both sexes for Abergelle goats (at Ziquala and Tanqua Abergelle districts) and Central Highland goats (at Lay Armachiho district)

Abergelle goat at Tanqua Abergelle monitoring site (39.81±2.57 g) showed higher daily weight gain than Ziquala monitoring site (39.81±2.57). From the calculated all daily weight gains (birth to three, three to six and six to nine months) the highest daily weight gain was observed from birth to three month in all the parameters (sex, parity and type of birth) and in all the study areas (Fig. 12).

Even though not significant ($p>0.05$), least square means of daily weight gain of males were heavier than their female counter parts for all age categories in the present study at all the monitoring sites. Male body weight dominancy as compared with their female counter parts were also reported by different authors (Naik *et al*., 1985; Belay and Mengistie, 2013; Hulunim, 2014; Shumuye et al., 2014)

Like sex effect on daily weight gain, Parity did not show significant ($p>0.05$) effect on daily weight gain of all age categories and in all the monitoring sites. Moreover, in this study parity did not indicate any consistency (increasing or decreasing order across parity number) on daily weight gain at least numerically. However, different authors reported that pre- weaning daily weight gain is affected by parity (Belay and Mengistie, 2013; Hulunim, 2014; Shumuye et al., 2014).

Type of birth (single, twin and triple) like sex of kids did not significantly ($p>0.05$) affected growth performance of all age category studied kids in all the study areas. Even though not significant ($p>0.05$), type of birth effect for Abergelle goat kids indicated clear trends (numerically) that single born kids showed higher daily weight gain than twins from birth to nine month but for Central Highland goat single birth was higher than twins and twins were higher than triples only at birth. Most literatures supported that single born kids are heavier than twin and twins are heavier than triple (Belay and Mengistie, 2013; Bushara *et al*., 2013; Hulunim, 2014; Shumuye et al., 2014).

Table 39. Least square means (±SE) of daily weight gain (g) for Abergelle and Central Highland goat breeds by sex, parity and birth type

Monitoring Site	Factors	ADWG g/day (BW TO 3MW)		ADWG g/day (3MW TO 6MW)		ADWG g/day (6MW to 9MW)	
		N	LSM±SE	N	LSM±SE	N	LSM±SE
	over all	852	***	654	***	375	***
	Ziqual	380	56.50±2.33[b]	315	20.19±2.42[c]	176	23.20±3.40[b]
	Tanqua	232	57.82±2.49[b]	185	39.81±2.57[b]	142	24.20±3.48[b]
	Arma	240	92.62±1.84[a]	154	75.47±1.93[a]	57	61.65±2.78[a]
Ziquala	sex	380	ns	315	ns	176	ns
	male	197	62.75±2.67	168	17.74±1.84	90	22.21±2.32
	female	183	62.73±2.79	147	17.33±1.97	86	21.26±2.48
	parity	380	ns	315	ns	176	ns
	1	68	63.80±3.40	51	17.68±2.35	29	22.11±2.97
	2	55	63.85±3.57	47	16.53±2.39	26	18.30±3.04
	3	72	62.03±3.15	61	18.48±2.09	32	22.96±2.71
	4	78	62.77±3.20	69	18.08±2.14	39	22.30±2.80
	≥5	107	61.23±2.78	87	16.91±2.01	50	22.99±2.40
	BT	380	ns	315	ns	176	ns
	single	365	64.08±4.97	305	18.99±0.64	170	22.44±0.82
	twin	15	61.39±1.01	10	16.08±3.53	6	21.03±4.43
Tanqua	sex	232	ns	185	ns	142	ns
Abergelle	male	120	62.70±3.00	93	39.66±3.68	67	23.22±2.20
	female	112	61.22±2.90	92	36.23±3.75	75	22.12±2.24
	parity	232	ns	185	ns	142	ns
	1	50	62.74±3.51	41	37.68±4.31	35	23.71±2.35
	2	31	61.99±4.06	26	42.72±4.75	20	20.86±2.68
	3	45	63.62±3.61	40	34.73±4.23	28	24.33±2.43
	4	39	61.84±3.81	30	37.40±4.59	21	22.17±2.49
	≥5	67	59.61±3.08	48	37.20±4.09	38	22.29±2.43
	BT	232	ns	185	ns	142	ns
	single	220	63.07±1.23	178	39.07±1.37	139	24.04±0.64
	twin	12	60.85±5.21	7	36.83±6.78	3	21.30±4.22
Lay	sex	240	ns	154	ns	57	ns
Armachiho	male	117	96.94±3.34	74	78.14±4.30	20	62.79±10.99
	female	123	90.06±3.23	80	73.04±4.09	37	59.71±7.03
	parity	240	ns	154	ns	57	ns
	1	51	92.83±4.39	36	81.17±5.46	14	81.80±11.36
	2	77	93.82±3.72	47	70.24±4.79	14	61.96±10.75
	3	50	89.99±4.52	27	77.84±6.29	12	53.38±11.95
	4	22	99.99±6.60	16	68.32±8.11	6	48.93±16.16
	≥5	40	89.87±5.33	28	80.37±6.69	11	60.17±13.30

Continued from Table 39

BT	240	ns	154	ns	57	ns
single	82	99.57±3.45	52	73.13±4.46	12	62.65±12.05
twin	133	95.60±2.74	84	74.07±3.55	38	52.56±6.33
triple	25	85.34±6.17	18	79.57±7.63	7	68.54±15.32

*N= number of monitored kids, BT=birth type, BW=birth weight, 3MW=3 month weight, 6MW= 6 month weight, 9MW=9 month weight, ADWG g/day =average daily weight gain in gram per day, Means in the same column with different superscripts are significantly different at indicated significant level; * p<0.05, ** p<0.01, *** p<0.001, ns =not significantly different*

4.13.4. Milk production performance of Abergelle goats

Least square means (±SE) of milk yield for Abergelle goats recorded from 850 does for a year (from mid July 2013 to mid August 2014) in Ziquala and Tanqua Abergelle districts is presented in Table 40 by considering parity, season, district, milking time and season by district interactions as fixed independent non genetic factors. The overall least square means (±SE) of milk yield per day per doe for Abergelle goats was 346.36±10.08 ml, which is lower than milk yield (500 ml per day per doe) of most Ethiopian indigenous breeds of goats in their natural habitat (MOA, 1999) but almost comparable with the results (380±0.06) of Kidus Nigussie (2010), in Eastern and Southern Ethiopia.

Majority of goats (72.20% in Ziquala and 61.14% in Tanqua Abergelle districts) had complete milk yield records up to twelve weeks even though milk yield trend was in decreasing manner specially after nine weeks in both districts (Fig. 13). From the remaining percentages (27.80% in Ziquala and 38.86% in Tanqua Abergelle districts) some proportions of does ceased giving milk before twelve weeks, which indicated that twelve weeks were the maximum lactation length for Abergelle goats. Almost similar result (3.07±0.13 months) for lactation length was reported by Kidus Nigussie (2010) for indigenous goats in Eastern and Southern Ethiopia. The overall milk production of 850 goats was within the range of 146 ml to 496 ml. Regarding milk yield trends across lactation weeks, milk production was increased from birth to the first two weeks and decline thereafter in both monitoring sites (Fig. 12). Highest average daily milk yield was recorded at fourth week lactation and then declined after fourth week in Black Bengal goats in West Bengal (Dhara *et al*., 2012) This immediate decline milk yield of Abergelle goat may be

due to environmental stresses (feed and water), because of majority of Abergelle goats give birth on the onset of dry season (mainly November).

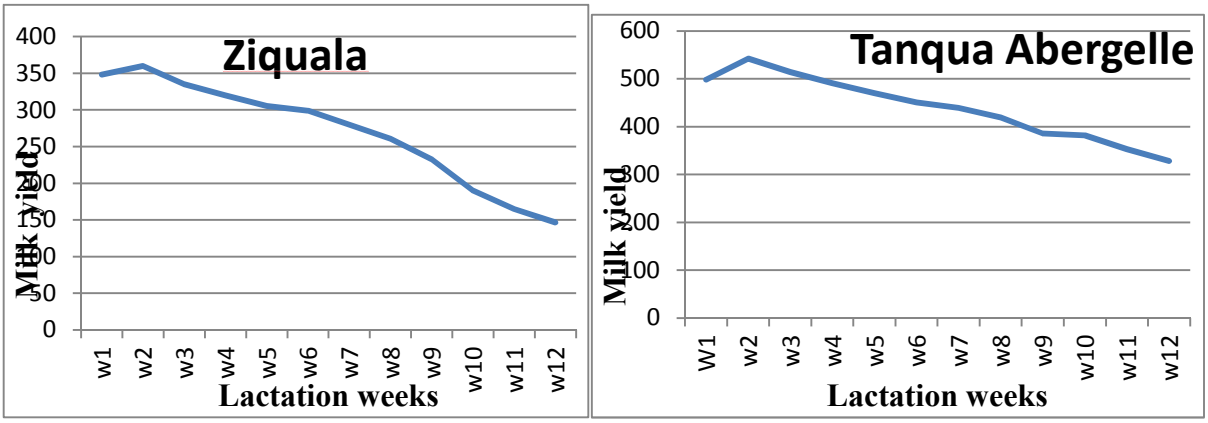


Figure 13. Milk yield trends across lactation weeks (1st week lactation up to 12th week lactation) in Ziquala and Tanqua Abergelle districts

In this study, daily milk yield was affected ($p<0.05$) by parity (Table 40) where maximum daily milk yield was observed at middle parity number i.e. parity three. It was observed from this investigation that milk production was higher from parity three to parity five than parity number greater than or equal to six and parity number less than or equal to two. Similar results were reported by Hossain et al. (2004) and Dhara *et al*. (2012) as parity number increased daily milk yield also increased, specially peak daily milk yield was observed at parity three.

Within Abergelle goats, Tanqua Abergelle monitoring site (407.35±5.56 ml) had significantly ($p<0.001$) higher daily milk yield than Ziquala monitoring site (264.27±5.72 ml). This may be, as mentioned above, attributed due to relatively better environment (feed, water, management) and health conditions in Tanqua Abergelle district. In the same way season strongly affected ($p<0.001$) daily milk yield of Abergelle goats. This is noticeably; both districts had animal feed shortage usually from early January to June. Thus the current study result of daily milk yield as affected by season in general (for both districts i.e. Considering Abergelle goat by season) and season by district interactions effect in particular are logically acceptable from the reality (feed availability of the study areas in wet and dry season).

Milking time (Morning and evening) also significantly ($p<0.001$) influenced daily milk yield of Abergelle goats. Daily milk yield at evening (179.83±2.91 ml) was higher than daily milk yield at morning (165.39±2.91 ml). In agreement with the current study result, Morning milk yields were 6% lower than evening milk yields in the study of Ouweltjes (1998). In the same study, differences became smaller as lactation advanced, and were smaller for heifers than for older cows. However, to the contrary of the current study result, Islam (2001) reported that higher milk collection occurred at morning (52.77%) than evening (47.24%).

Table 40. Least square means (±SE) of milk yield (ml) across parity, season, district and season by district interactions for Abergelle goats

Factors	N	LSM±SE	Factors	N	LSM±SE
Overall	**850**	**346.36±10.08**	**Season**	**850**	***
Parity	**850**	*	wet	619	369.05±4.21[a]
1	187	318.12±7.57[c]	dry	231	302.57±6.79[b]
2	121	330.18±9.35[bc]	**District*season**	**850**	***
3	164	355.31±8.14[a]	Ziquala wet	339	285.42±5.64[c]
4	159	344.58±8.43[ab]	Ziquala dry	107	243.12±9.92[d]
5	137	334.57±11.37[abc]	Tanqua Abergelle wet	280	452.68±6.15[a]
≥6	82	332.11±8.95[abc]	Tanqua Abergelle dry	124	362.03±9.19[b]
District	**850**	***	**Milking time**	**1138†**	***
Ziquala	446	264.27±5.72[b]	Evening (6:00pm)	569	179.83±2.91[a]
Tanqua Abergelle	404	407.35±5.56[a]	Morning(6:00 am)	569	165.39±2.91[b]

*N= number of monitored does, Means in the same column with different superscripts are significantly different at indicated significant level; * =p<0.05, ***= p<0.001, ns =not significantly different, †=complete lactation milk yield was recorded from 569 does but due to double count (morning and night) the number of does seams 1138 but actually 569 does.*

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1.Summary

Ethiopia is home for diverse indigenous goat populations parallel to its diverse ecology, production systems and ethnic communities. However goat in Ethiopia is among neglected farm animals in agricultural research and development programs. Apart from limited experiences of FARM Africa in crossbreeding of local goats with exotic dairy goats for improved milk production in the Hararghe Highlands and the SNNPR there has been no organized goat improvement program in the country.

Performance recording is an important tool to suggest the breeding policy for a given area. However, recording in general is hardly practiced in any livestock species in Ethiopia, to identify the performance and management gaps. Very often, the results obtained from on-station research are of little relevance to traditional production systems and may not contribute much towards understanding of the specific adaptation of animals to farmer's conditions. One further attraction of on-farm performance study is that it provides information in location specific production conditions that could lead to breed improvement options that are appropriate to the system. Thus characterizing these goat genetic resources and evaluation of their performance in their existing production environment is very useful to plan different developmental strategies like community-based genetic improvement program and others. Therefore, the objectives of this study were to characterize (phenotypic), describe the production environment and their production system, evaluate and document on-farm performances of Abergelle and Central Highland goat breeds in their existing production environments as an input for designing community-based goat genetic improvement program and other developmental issues in the future.

Data were collected from secondary data sources, stakeholders meeting, pretested semi-structured questionnaire, employing field measurements, organizing group discussions and on-farm performance recorded data. Data collected through questionnaire (survey) were described by descriptive statistics using SPSS. Observations on qualitative traits were analyzed separately for male and female goats using frequency procedure of Statistical Analysis System. Multiple

Correspondence analyses were employed to see the associations of the qualitative traits by breed. Quantitative data (Body weight and other body measurements, growth performances of kids, milk yield) were analyzed using the General Linear Model (GLM) procedures of the Statistical Analysis System. The stepwise multiple linear regression analysis was done to obtain models for estimation of live body weight from other linear body measurements for each breed and sex separately.

Goat population per household (mean ± SD) in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 36.1±61.9, 38.2±63.9 and 10.5±7.5 respectively. Within a given household goat flock in Ziquala district one can find 16.02% male kids less than six months, 16.57% female kids less than six months, 11.31% males between six month to one year, 14.73% females between six month to one year, 7.92% males greater than one year (intact), 30.92% females greater than one year and 2.53% castrated. The corresponding values for Tanqua Abergelle district were 14.48%, 15.80%, 9.60%, 14.97%, 7.71%, 35.05% and 2.38% respectively. In the same way, 17.80%, 16.64%, 7.78%, 12.67%, 9.60%, 33.44% and 2.07% respectively were the observed corresponding values for Lay Armachiho district. The ratio between males (intact) greater than one year of age and their female counterparts in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 1:4, 1:5 and 1:4 respectively. These particular study results were in agreement with that of Wilson (1988) who reported ratios of between1:4 and 1:6 for small ruminants in traditional livestock production systems of Africa.

In all the study districts cash income was the primary goat production objective. Milk production in Ziquala and Tanqua Abergelle districts was the 3rd objective of goat rearing next to manure. Whereas, goat milk consumption in Lay Armachiho district is strictly a cultural taboo. From the current survey result milk yield per doe per day (in liter) in the rainy season and in the dry season in Ziquala district were 0.43±0.24 and 0.15±0.14 respectively. The corresponding values for Tanqua Abergelle district were 0.48±0.24 and 0.19±0.29 respectively. However, the actual on-farm milk yield record was lower than the survey result for both districts. Thus the actual on-farm milk yield records per doe per day (in milliliter) for Abergelle goats at Ziquala monitoring site in wet and dry season were 285.42±5.64 and 243.12±9.92 respectively. The corresponding values for Tanqua Abergelle monitoring site were 452.68±6.15 and 362.03±9.19 respectively. Generally, lactation length in the rainy season is shorter than dry season because of the feed and

water availability that will in turn create conducive environment for does to conceive and kids to wean shortly. Average lactation lengths (in months) in Ziquala district in the rainy and dry seasons were 4.21±2.02 and 4.32±1.40 respectively. Similarly, the corresponding values for Tanqua Abergelle district were 3.59±2.11 and 4.46±2.00 respectively. Average weaning age of kids (in months) in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 4.85±1.81, 4.84±1.73 and 4.5 respectively.

Communal natural pasture was the major source of goat feed both in dry and wet seasons in each of the three districts. Goat feed supplementation was not practiced in Lay Armachiho district both in dry and rainy seasons. According to the respondents in Ziquala and Tanqua Abergelle districts, feed supplementation for goats was prioritized based on the reproductive status, body condition, health condition, age, candidate goat to be slaughtered or sold in the near future and season of the year.

Selection of male and female for breeding purpose was common in all the study areas specially for males. Coat color, body conformation and growth rate were the first, second and third selection criteria for breeding buck respectively in Ziquala and Tanqua Abergelle districts. The corresponding values for Lay Armachiho district were body conformation, growth rate and coat color. Based on index value, the first preferred trait for does in Ziquala, Tanqua Abergelle and Lay Armachiho districts were milk yield (0.24), milk yield (0.20) and body Conformation (0.34) respectively. Majority of Abergelle goat coat color was red/brown (30.40%) and its combination with other coat colors (50.61%), whereas relatively high proportion of Central Highland goat had white coat color (21.66) and its combination with other coat colors (55.09 %). Goat keepers in Ziquala and Taqnqua Abergelle districts most prefer '*liybia' goat.* The reason was goat keepers traditionally believe that this kind of goat is prolific and productive due to especial gene it has.

Drought, disease and feed shortage were the first, second and third major constraints respectively for goat production in Ziquala and Tanqua Abergelle districts. The corresponding values for Lay Armachiho district were disease, theft and predator.

In one year round village goat monitoring period a total of 1197 and 719 were recorded as inflow and outflow respectively i.e. 1916 goats movement was recorded both for inflow and outflow of

goats. In all monitored villages, birth (>79 %) as goat entry sources took the lions share. Whereas the highest proportions recorded for the outflow of goats in monitored villages in Ziquala, Tanqua Abergelle and Lay Armachiho districts were through selling (33.63%), death (44.53%) and selling (42.57%) respectively. At the end of one year monitoring period, the net increment (inflow-outflow divided by final population times by 100) of goat population in monitored villages in Ziquala, Tanqua Abergelle and Lay Armachiho districts were 18.00%, 21.78% and 7.91% respectively. This indicted that farmers in the study areas give attention for goat production specially in Tanqua Abergelle and Ziquala districts which will ultimately contribute for food security in the areas.

The overall least square means (±SE) for birth, three, six and nine month weights (kg) of Abergelle goat kids at Ziquala district monitoring site were 1.98± 0.06, 7.30± 0.21, 9.25±0.31 and 11.21±0.53 respectively. For the same breed at Tanqua Abergelle district monitoring site for the above age categories (kg) were 1.97± 0.06, 7.43± 0.23, 11.08±0.33 and 13.24±0.55 respectively. The corresponding values for Central Highland goats in Lay Armachiho district monitoring site were 2.31±0.04, 10.67± 0.17, 17.53±0.24 and 22.66±0.44 respectively.

5.2. Conclusions and Recommendations

The ratio of male to female in all of the three districts at the age of less than six months was proportional. However, above six months female proportions were high especially at age of greater than one year. This is because of male goat greater than one year is frequently sold whenever cash is needed in the household. Here intervention is needed to control negative selection to improve the reproductive and productivity of goats particularly for males because of farmers usually sell good body condition males (which may have good genetic makeup) to get high price.

Health condition of goats and health services delivered in all the study districts was poor, especially in Ziquala district. To improve reproductive and productivity of goats, disease prevention and treatment strategies should be designed in all the study districts. Moreover research on economical important diseases and ethno veterinary (traditional treatments of diseases by farmers) practices of farmers should be conducted.

Goat keepers in Ziquala and Taqnqua Abergelle districts most prefer '*liybia' goat.*The reason was goat keepers traditionally believe that this kind of goat is prolific and productive due to especial gene it has. This traditional knowledge should be scientifically prove/disprove whether this goat genetic makeup is different or similar with other ordinary goats.

Abergelle goat breed is almost seasonal breeder. This information is vital for breeders specially for community based genetic improvement program to exchange bucks during the peak mating seasons from May to August more specifically June to avoid inbreeding problem and unwanted bucks to mate with does.

In all the study districts goat marketing was traditional i.e. they did not use weighing balance and they did not have market information and the price was fixed by negotiation between the buyers and sellers. Farmers should use weighing balance and should get current market (price per kg) information in their locality.

From different literature reviews, majority of Central Highland goat's physical (both qualitative and quantitative traits) description as studied by different researchers including FARM Africa's (1996) report did not fit (agree) with the current study results in Lay Armachiho district. Therefore, further cluster studies should be conducted for the uniformity (if so as one breed) or dissimilarity (if not as more than one breeds/ecotypes) for the areas delineated by FARM Africa (1996) for Central Highland goat.

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7. APPENDICES

Appendix 1. Semi-structured questionnaire for the Survey part

Area: _____

GPS waypoints:
East:
North:
Elevation :

Part 1. General information on households

Questionnaire number: _____ Name of enumerator_____
Date: _____ Kebele/Village_____
Zone:_____ Woreda_____

1.1 Respondent and Owner details

RESPONDANT [1. Owner; 2. Shepherd;	
GENDER OWNER [1 = Male, 2 = Female]	
Age (years)	
Can read and write. 1 = Yes, 0 = No	
Instruction (level)	
Type of schooling (1=General; 2=Vocational)	
Farming experience (years)	
Experience in goat farming (years)	
Marital status (code)	
Religion group	

Age group codes	**1**=<20	**2**=[20-<30[	**3**= [30-	**4**=[40-<50[**5**= [50-<60]
	2= Primary	**4**= Higher school		
Marital status codes	**1**= Single	**2**=Married	**3**= Divorced	**4**= Widow
Religion codes	**1** =	**4** = Seventh Day Adventist		**6** = Traditional African
	2=	**3** = Muslim	**5**= Protestant (all except for	= Hindu

1.2 Owner's position in the household (HH): [….] 1. Male head, 2. Female head, 3. Relative, 4. Son, 5. Daughter, 6. Others (specify) _____

Household family size (number): Male _____ Female_____ Total _____

1.4 What is your major farming activity? [….] 1. Livestock production 2. Crop production 3. Crop - livestock production 4. Other (Specify)_____

Non-farm activities [……] 1. Hand craft 2. Trading 3. Daily labor 4. Others (specify) _____

Rank your farming and non-farm activities according to the respective criteria

Rank	Major HH food source	Major HH Cash income
1st		
2nd		
3rd		
4th		
5th		
6th		

Activities codes	1=	3= Handcraft	5= Daily labor
	2= Crop	4= Trading	6= Other

1.7 Please provide the following information for the area of land used (in ha)

Land area owned (including **own*** grazing for fodder area)	Area [__ _ _]
How much of your owned land has a title deed?	All [__] (1 = Yes No=0) Part (specify area) [_ __]

How much of the land area is rented in?	Area[___] Rent paid per year [__]
How much of your land do you rent out?	Area [__] Rent earned per year [.]

*Excluding public or community land

1.8 Trend in land holding 1. Decreasing, 2. Increasing, 3. Stable

If decreasing why? _____

If increasing why? _____

1.9 Please give the following details for each plot you cultivate, including the homestead.

Plot no	Rainy (cropping) season		Dry (non-cropping) season	
	Crops (code)	Area (same unit	Crops (code)	Area (same unit as
1	[__] x [__] x [__]		[__] x [__] x [__]	
2	[__] x [__] x [__]		[__] x [__] x [__]	
3	[__] x [__] x [__]		[__] x [__] x [__]	
4	[__] x [__] x [__]		[__] x [__] x [__]	
5	[__] x [__] x [__]		[__] x [__] x [__]	
6	[__] x [__] x [__]		[__] x [__] x [__]	

Food crops codes		***Cash crop codes***	
00=Garden/Homestead	**10** = Cabbages	**30** = Cowpeas/pigeon pea	**41** = Rice
01= Maize	**11** = Onions	**31** = Other vegetables for sale	**42=** Eucalyptus/Podocarpus
02 = Sorghum	**12** = Yams/taro	**32** = Coffee	**43=** Sugarcane
03 = Cassava	**13** = Carrots	**33**= Tea	**44=** Sesame
04 = Haricot bean	**14** = Bananas	**34** = Cocoa	45= Groundnuts
05 = Irish potatoes	**15** = Arrow roots	**35** = Palm tree	**46**= Planted pastures (grass or forbs)
06 = Sweet potatoes	**16** = Cucumber	**36** = Fruit/tree crop	**47=** Fallow/unimproved pasture
07 = Okra	**17** = Green pepper	**37** = Hibiscus	**48=** Elephant grass/Napier grass
08 = Tomatoes	**18** = Pawpaw	**38** = Raphia	**49=** Chat
09 = Amaranthus	**19** = Soybean	**39** = Moringa	**50** = Others
20. Tef	**25.** Rice	**40.** Cotton	
21. Barley	**26.** Oat		
22. Horse bean	**27.** Ensete		
23. Noug	**28.** Wheat		
24. Millet	29. Others		

**Ensure that the sum of the different plot areas is the same as the sum of area indicated in 1.7

Part 2. Production and management systems

2.1. General

Please indicate the number of animals for the different species that are currently owned by your household.

Livestock	**Total number owned**	**Number owned specifica**	**Number owned specifica**	**Numb er owned**	**Numb er owned**	**Most importa nt**

		by the household	lly by men	lly by women	by male children	by female children	(Rank)
Cattle	Indigenous						
	Exotic/cross						
Goat	Indigenous						
	Exotic/cross						
Sheep	Indigenous						
	Exotic/cross						
Donkey	Indigenous						
	Exotic						
Horse	Indigenous						
	Exotic						
Camel	Indigenous						
	Exotic						
Chicken	Indigenous						
	Exotic						
Pig	Indigenous						
	Exotic						
Other poultry, specify							
Rabbit							
Bees (# *bee hives***)**							
Aquaculture (# fish ponds)							
Other (specify)							

2.1.1. Please indicate the type of goats you keep on your farm, their breed types, number kept on the farm and number owned by your household.

Goat type	**Breed Grade**	**Breed name**	**Number on farm**	**Number owned**

Codes: For any question dealing with goat type, breed grade and breed names, please use the following codes.

Goat type codes			
1 = Male kids < 6 **2** = Female kids < 6 **3** = Male 6 months to 1	**5** = Male > 1 year (Intact) **6** = Female > 1 year **7** = Castrate		
4 = Female 6 months to			
Breed grade codes			
1 = Pure	**2** = High grade	**3** = Low grade	**4 =** Indigenous
Breed name codes			
Exotic breeds		**Indigenous breeds**	
1 =	**4** =	**6=**	**9=** Unknown
2 =	**5=**	7=	**10=** Others (specify)
3 =		8=	

2.1.2. When did you start keeping goats? Year [__ __ __ __]
2.1.3. With how many goats did you start your goat farming with? [___] (Number)
2.1.4. Where did you get your first goats from? [__] (Code)

1= Inherited (from mother or father?)	**6**= Obtained from a development project as loan
2= Purchased from neighboring farm/ market	**7**= As a gift from relatives/friends
3 = Purchased from a distant farm/market	**8**= As a loan from relative/friend/ neighbor payment
4 = Purchased from a friend	**9** = Purchased from a neighbor
5 = Obtained from a development project as gift	**10** = Other (specify) _____

2.1.5. If you have cross breed and/ non-local goats, when did you acquire your first cross breed and/or grade goat? (*Whichever is first – acquisition of pure or cross breeds*) [__)
2.1.6. If you have cross breed and/or pure breed (grade) goats, how did you first acquire the goat? [__] (code)

Source of pure/cross breed goat	
1= Inherited (from mother or father?)	**6**= Obtained from a development project as loan
2= Purchased from neighboring farm/ market	**7**= As a gift from relatives/friends
3 = Purchased from a distant farm/market	**8**= As a loan from relative/friend/ neighbor payment
4 = Purchased from a friend	**9** = Purchased from a neighbor
5 = Obtained from a development project as gift	= Other (specify) _____

2.1.7. For **the year 2012**, did you **purchase/acquire** any goat? [___] (code) 1 = Yes 0 = No
If yes for question 2.1.7. why?_____
2.1.8. For **the year 2012**, did you **sale/reduce** any goat? [___] (Code) 1 = Yes 0 = No
If yes for question 2.1.8. why? _____
2.1.9. Do you keep any kind of records for your goat enterprise? [__] (code) 1 = Yes 0 = No
2.1.10. If yes, what types of records do you keep? [__] [__] [__] [__] [__] [__]

1 = Breeding records	**4** = Sales and purchases	**7** = Extension visitors book
2 = Production records	**5** = Births	**8** = Feeding records
3 = Veterinary (treatment) records	= Deaths	**9** = Other (specify)_____

2.1.11 how do you usually identify your goat? (code) [__] [__] [__] [__] [__]

0 = No identification	**2** = Ear tag	**4** = Parentage
1 = Name	**3** = Color	**5** = Others (specify)

2.1.12. Mobility pattern [___] (code) 1. Sedentary, 2. Seasonal, 3. Pastoral
2.1.13. Reason for mobility 2 & 3 of 2.1.12 [___] (code) 1. In search of feed, 2. In search of food, 3. Security issues, 4. Disease outbreak, 5. Others _____
2.1.14. Flock movement [___] (code) 1. Whole flock, 2. Adults only, 3. Others ____
2.1.15 which is the main (first) purpose that you keep goats for? [_____] [code]
2.1.16. Which is the second most important purpose that you keep goats for? [___] (Code)

1 = Sale (cash income)	**2** = Consumption	**3** = Manure
4 = Meat	**5=** Milk	**6=** Blood
7= Skin	**8=** Saving	**9=** Ceremonies (gift/wedding, sacrifices)
10. Others (specify)_____		

2.1.17. If you use goats for milk production

Criteria	**Rainy (cropping) season**	**Dry (non-cropping) season**
Milk		
Lactation length		
Frequency of milking		
Milk feeding to weaning		
Uses made of milk (can be more than		

Milk/day (Litres):	1 = < 1l,	2 = 1l-2l	3 = 2l-3l 4=>3l
Milking codes(freq)	1 = Once a day	2 = Twice a day	3 = Thrice
Milk feeding to weaning codes	1= Unrestricted suckling	2= Restricted suckling	3=Bucket feeding
Uses made of milk codes	1 = Market	2 = Household	= Others_____

2.1.18. If the family is making use of it, the way of preparation and utilization is [___] (code)
Raw milk, 2. Boiling, 3. Pasteurization, 4. Skimming/making butter out of it, 5. others
2.1.19. The type of mechanism you use to wean kids [___] (code) 1. Natural, 2. Assisted
2.1.20. Average weaning age of kids is [___] months _____
2.1.21. Members of household and hired labour responsibilities for goat production activities [_√_] (tick the appropriate answer)

Activities	**Family**				**Hired labour**			
	female		**male**		**female**		**male**	
	≤15yeas	**>15yeas**	**≤15yeas**	**>15yeas**	**≤15yeas**	**>15yeas**	**≤15yeas**	**>15yeas**
Purchasing								
Selling								
Herding								
Breeding								
Caring sick animals								
Feeding								
Milking								
Making dairy								

products								
Selling dairy products								
Barn cleaning								
Slaughtering								

2.2. Feeding and grazing management

2.2.1. Feed source (√ tick the appropriate answer) *and rank them*

Type of feed source	**Wet season**	**Rank**	**Dry season**	**Rank**
Natural pasture				
Established pasture				
Hay				
Crop residues				
Fallow land				
Concentrates				
Others/specify ____				

2.2.2. The five major crop residues used for goats' feed (Rank according to priority)

Cash/food crop (Code)	**Rank**

Food crops codes		***Cash crop codes***	
00 = Garden/Homestead	**10** = Cabbages	**30** = Cowpeas/pigeon pea	**41** = Rice
01= Maize	**11** = Onions	**31** = Other vegetables for sale	**42**= Eucalyptus/Podocarpus
02 = Sorghum	**12** = Yams/taro	**32** = Coffee	**43**= Sugarcane
03 = Cassava	**13** = Carrots	**33**= Tea	**44**= Sesame
04 = Haricot bean	**14** = Bananas	**34** = Cocoa	45= Groundnuts
05 = Irish potatoes	**15** = Arrow roots	**35** = Palm tree	**46**= Planted pastures (grass or forbs)
06 = Sweet potatoes	**16** = Cucumber	**36** = Fruit/tree crop	**47**= Fallow/unimproved pasture
07 = Okra	**17** = Green pepper	**37** = Hibiscus	**48**= Elephant grass/Napier grass
08 = Tomatoes	**18** = Pawpaw	**38** = Raphia	**49**= Chat
09 =	**19** = Soybean	**39** = Moringa	**50** = Others

Amaranthus **20.** Tef **21.** Barley **22.** Horse bean **23.** Noug **24.** Millet	 **25.** Rice **26.** Oat **27.** Ensete **28.** Wheat 29. Others	**40.** Cotton

2.2.3. Major five forage plant species for goats, ranking order and seasonality

Local name	**Common name**	**Rank**	**Seasonality**	**Picture number**
			annual	**Perennial**

2.2.4. Grazing land ownership [ ] Code 1. Private ; 2. Communal ; 3. Both

2.2.5. Grazing/browsing method during **dry** season [ ] Code 1.Roaming ,2. Tethered, 3. Herding, 4. Paddock, 5. Zero, 6. Others/specify ____

2.2.6. Grazing/browsing method during **wet** season [ ] Code 1.roaming ,2. tethered, 3. Herding, 4. Paddock, 5. Zero, 6. Others/specify ____

2.2.7. Length of grazing and/ or browsing time during **dr**y season [ ] Code 1. Morning, 2. Afternoon, 3. Whole day

2.2.8.Length of grazing and/ or browsing time during **wet** season: [ ] Code 1. Morning, 2. Afternoon, 3. Whole day

2.2.9.Trend in communal grazing areas*?* [….] 1. Decreasing 2. Increasing 3. Stable

What do you think the reason? _____

2.2.10 how is goat flock herded during the day time? [.....] Code 1. Male and female are separated, 2. kids are separated; 3. Male and female goats are herded together; 4. All classes goats herded together

2.2.11. Goat flock is herded [.....] Code 1. Together with cattle, 2. Goats herded separately, 3. Together with sheep, 4. Together with camel, 5. Together with calves, 6. Together with equines, 7. All herded together

2.2.12. Way of herding [.....] Code 1. Goats of a household run as a flock, 2. Goats of more than one household run as a flock, 3. Others/Specify _____

2.2.13.Is there seasonal fluctuation in feed supply? [.....] Code 1= Yes, 2= No

2.2.14. At which month(s) of the year do you experience most feed shortage?_____

_____

2.2.15. Do you supplement your goats? [.....] Code 1= Yes 2= No

2.2.16. If your answer is yes for question 2.2.15 what is your supplementation (Rank according to importance)

Supplement type	**Wet season**	**Rank**	**Dry season**	**Rank**
Roughage				
Minerals (salts)/vitamins				
Concentrates				
Others (specify)				

2.2.17. Concentrates used for goats feeds(*rank the most frequent used 1 and so on*)

Type	Rank
Homemade grain	

Oil seed cakes	
Local brewery by-products	
Flour by-products	

Others (Specify_____

2.2.18. Do you practice goat fattening [.....] 1= Yes 2=No

2.2.19. If your answer is yes for question no. 2.2.18, which categories of animals do you fatten?(you can tick more than 2) [.....] Older males

Older female

Castrates

Young males

Young female

Culled young male

Culled Young female

NB Name 3 categories of animals you use for fattening in order of importance

1._____ 2. _____ 3._____

2.2.20. At which periods of the year do you commonly fatten goat? _____

Season Fattening duration (in months) Reason

_____ _____ _____

2.2.21. What type of feed resources you use to fatten goats? [.....] Naturel Pasture

Crop residues

Concentrate

Others(specify) _____2.3. Watering

Source of water(√ tick the appropriate answer)

Source	**Wet season**	**Dry season**
Water well		
Dam/pond		
River		
Spring		
Rain water		
Pipe water		

Others (specify) _stance to nearest watering point

Distance	**Wet season**	**Dry season**
Watered at home		
<1km		
1–5 km		
6–10 km		
>10 km		

Are kids watered with the adults? [.....] 1= Yes 2= No

If no, describe watering distance and frequency of kids:Distance(meter) =____, Frequency =

Frequency of watering(√ tick the appropriate answer)

Frequency	**Wet season**	**Dry season**
Freely available		
Once a day		
Once in 2 days		
Once in 3 days		

Others		

Housing

Housing/enclosure for adult goat (*Tick one or more boxes)*

With roof	In family house	
	Separate house	
	Veranda (extend of building)	
Without roof	Kraal (enclosed village)	
	Yard (enclosed land)	
	None	
Others (specify)		

Housing materials(√ tick the appropriate answer)

Type	**Roof**	**Wall**	**Floor**
Iron sheets			
Grass/Bushes			
Wood			
Stone/bricks			
concrete			
Earth/mud			
others			

Are kids housed with adult goat? [.....] 1= Yes 2=No

If no, reason_____

Are goats housed together with other animals? [.....] 1= Yes 2= No.

If yes, what are the advantages and disadvantages you noticed? _____

Health

What are the major goats diseases occur frequently in your area? List **in order of importance.**

_____Clinical signs_____

_____Clinical signs_____

Do you have access to veterinary services [.....] 1. Yes 2. No

If yes, which type of veterinary service you accessed? [.....] Government veterinarian/nurses

Private veterinarian NGOs

Community association health workersDistance to nearest veterinary services [.....]

1-5km 6-10km >10km

Other (specify)_____Most animals are provided with veterinary treatment when they are sick [.....]

Never, why? _____

occasionally regularly

Most animals are subject to traditional treatments [.....]

never, why ? _____

occasionally regularly

Adaptability traits of goats

Adaptability	**good**	**moderate**	**less**
Disease			
Internal parasite			
External parasite			
Heat			

Frost			
Drought			
Feed shortage			
Water shortage			

Breeding practices

2.6.1. Do you have breeding buck? [.....] 1= Yes 2= No

If yes, Number of crossbred breeding buck? _____

Number of exotic breeding buck? _____

Number of local breeding buck? _____

2.6.2. If you have exotic and/or crossbred buck, how do you have it? [.....]

1= Inherited (from mother or father?)	**6**= Obtained from a development project as loan)
2= Purchased from neighboring farm/ market	**7**= As a gift from relatives/friends
3 = Purchased from a distant farm/market	**8**= As a loan from relative/friend/ neighbor payment
4 = Purchased from a friend	**9** = Purchased from a neighbor
5 = Obtained from a development project as gift	= Other (specify) _____

2.6.3. If you have more than one breeding buck, why do you need to keep more than one? [.....]

2.6.4. For how many years on the average is the one buck serving in your flock? [.....]

2.6.5. Is there any special management for breeding buck? [.....] 1= Yes 2= No

2.6.6 If yes, specify type of management_____

2.6.7. Source of breeding buck [.....]

1= Inherited (from mother or father?)	**6**= Obtained from a development project as loan)
2= Purchased from neighboring farm/ market	**7**= As a gift from relatives/friends
3 = Purchased from a distant farm/market	**8**= As a loan from relative/friend/ neighbor payment
4 = Purchased from a friend	**9** = Purchased from a neighbor
5 = Obtained from a development project as gift	= Other (specify) _____

2.6.8. Purpose of keeping buck [.....] 1. Mating; 2. Socio-cultural; 3. Fattening; 4. ther(specify)_____

2.6.9. Do you practice selection for breeding male [.....] 1. Yes, 2. No

2.6.10 Do you practice selection for breeding female [.....] 1. Yes, 2. No

2.6.11. Which attributes or traits do you consider in selecting breeding buck and doe? **Rank the traits in order of importance for selection.**

For buck (with their respective rank) 5max.	rank	For doe (with their respective rank) 5max.	rank

Associated attributes/Traits code	
1 = Growth rate	**8** = **Coat color (please record the names!)**
2 = Fertility (kidding interval)	**9** = Resistance to disease
3 = Fertility (litter size)	**10** = Temperament/behavior
4 = **K**id weights	**11** = Hardship tolerance
5 = Meat production	**12** = Body size
6 = Meat quality	**13**= Feed intake

7 = Market value	= Other (specify) _____

2.6.12. Age of selection (months); Breeding male _____, Breeding female _____

2.6.13 Type of mating used [.....] 1. Controlled; 2. Uncontrolled/Random2.6.14. If uncontrolled, what is the reason? [.....] 1. Goats grazed &/or browse together, 2. Lack of awareness, 3. Insufficient number of bucks, 4. Others/specify ____

2.6.15. Could you be able to identify the sire of a kid? [.....] 1= Yes 2= No

If yes**,** specify the criteria used to identify _____

2.6.16.Do you allow a buck to mate his

	1. Yes	2. No	Reason ___
a. Mother			_____
b. Daughter			_____
c. Sister			_____

2.6.17. Do you allow your buck to serve does other than yours?

		Reason
1. Yes		_____
2. No		_____

2.6.18. Do you allow your doe to be served by anyone else buck?

		Reason
1. Yes		_____
2 . No		_____

2.6.19. Occurrences of birth type per 100 doe in your goat flock?

1) Single _____ 2) twin_____ 3) triple_____ 4) not constant

2.6.20. On average, what is the kidding interval of your doe (in month)?_____

2.6.21. Average number of kidding per doe life time _____

2.6.22. Kidding pattern, occurrence of most births*(Tick one or more boxes then rank top three)*

	January		July		Top 3 months most births occur
	February		August		_____
	March		September		_____
2.6.23.	April		October		_____
	May		November		
	June		December		

Do you castrate your buck? [.....] 1= Yes 2= No

2.6.24. If you castrate your buck, what are your reasons for castration? [.....] Control breeding

Improve fattening

Better price

Others(Specify)_____2.6.25. Specify Castration method you used [.....]

By your own (traditional) ; 2) Veterinarians(modern)

2.6.26. If you castrate traditionally, what type of materials you used for castration?

_____

2.6.27. At what age do you castrate bucks? _____

2.7. Marketing

Which class of goat do you sell first in case of cash needed?

Class	**Rank**
male kids less than 6 months	
Female kids less than 6 months	
Buck kids between 6 months and one year	
Doe kids between 6 months and one year	
Breeding does	
Breeding bucks	
Castrated	
Old does	
Old bucks	

Average market age in month male_____ female_____

Average culling age in years due to old age male_____ female_____

Goat production constraints

2.8.1. What are the main constraints for goat production? (Rank with significance)

Thank you very much!!!

Appendix 2. Linear body measurements and physical descriptions recording format with keys for abbreviations and pictorial explanations

Part 4. Field observation and measurement recording formats

Sheet No. _____ Date: _____ Location:_____

Name of enumerator_____ Owner HH Code_____

Zone/Location: _____

A. Qualitative observations recording sheet

No.	sex	Coat color	Coat color pattern	Head (facial) profile	Horn presence	Horn shape	Horn orientation	Ear orientation	Back profile	Toggles	Ruff	Beard	Photo #	Ticks Y/N	Mange Y/N
1															
2															
3															

B. Quantitative measurements recording sheet (continued from A)

No.	BW	BL	HW	CG	CW	RL	PW	HL (*)	EL (*)	SC
1										
2										
3										

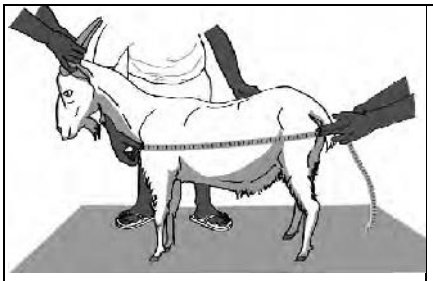
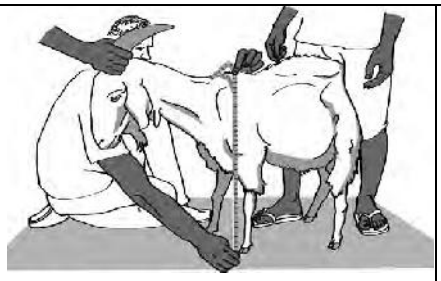
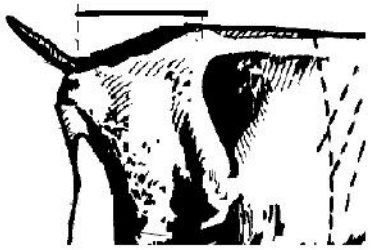
BW=Body weight, BL= Body Length, HW= Height at Withers, CG= Chest Girth, CW= Chest width, RL= Rump Length, PW= Pelvic Width, HL= Horn Length, EL= Ear Length and SC= Scrotum Circumference
(*): Only one side or both?

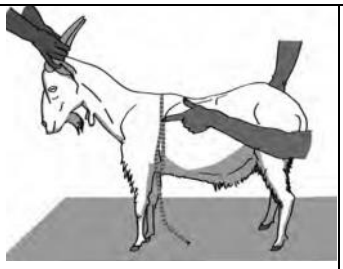
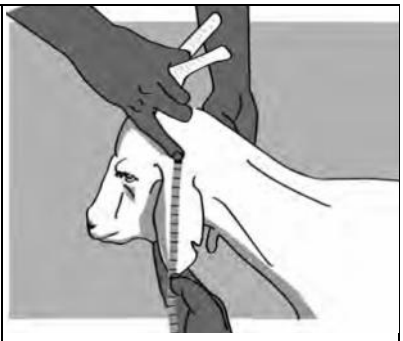
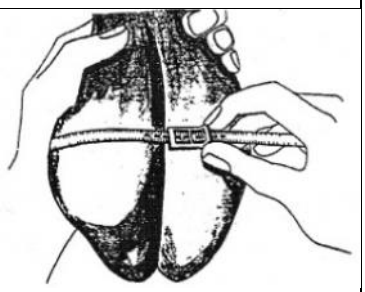
Indications for field observation in domestic goats

Sex	1= Male	2= Female	3=Castrate	
Coat color	1=Black		2= White	3=Brown/Red
Coat color pattern	1=Plain	2=Patchy	3=Spotted	
Head profile	1 = Straight	2 = Concave	3= Convex	4= Ultra convex
Horn shape (*)	1= straight	2= curved	3= spiral	4= corkscrew
Horn orientation	1= Lateral	2= Upward	3= Backward	4=Not clear
Ear orientation	1= erect	2= pendulous	3= semi-pendulous	4= carried horizontally
Back profile	1= straight	2= slopes up towards the rump	3= slopes down from withers	4=curved (dipped)
Horn – Ruff – Beard - Toggles	1= Absent	2= Present		

(*): <u>Mention if horns are broken with asterisk and look some pictorial descriptions below</u>

			
Straight	Curved	Spiral	Corkscrew

		
Body Length (BL)	Height at withers (HW)	Rump length (RL)

		
Chest girth (CG)	Horn length (HL)	Ear length (EL)
		
Pelvic width (PW)	Chest width (CW)	Scrotal Circumference (SC)

Appendix 3. On-Farm performance evaluation and monitoring data recording format

Goats owned by a Farmer at the beginning of flock inventory (Base Flock)

Date first surveyed_____Farmer's Name _____ Village:

_____Enumerator_____

NO.	ID	Age (Dentations)	Goat category *1. Male kid* *2. Female kid* *3. Weaned male* *4. Weaned Female* *5. Doe* 6. *Bucks*	Color *1. brown* *2. white* *3. black* 4. *mixed* 5. *Others*	Parity	Reproductive status 1. Open 2. Pregnant	Remark

Flock profile of the household

Goat category	**Male kid**	**Female kid**	**Weaned male**	**Weaned Female**	**Doe**	**Bucks**	**Fattened**	**Castrate**

Amount in number								

Monitoring of Flock Dynamics (In-Flow and Out-Flow)

		Exit			**Entry**		
NO	ID	Date of Exit	Goat category *1. Male kid 2. Female kid 3. Weaned male 4. Weaned Female 5. Doe 6. Bucks*	Reasons for exit *1. Sold (include price in birr) 2. Gift 3. Theft 4. Slaughtered 5. Exchanged 6. Death (Specify cause of death) 7. Others*	Date of addition	Goat category *1. Male kid 2. Female kid 3. Weaned male 4. Weaned Female 5. Doe 6. Bucks*	Reasons for addition *1. purchased (include price in birr) 2. birth 3. gift 4. Exchange 5. others*

Milk Recording Format

Doe ID	Doe Age	Parity	**Milk Yield**																	
			Week1_____			Week_____			Week_____			Week_____			Week_____			Week_____		
			Date	AM	PM	Date	AM	PM	Date	AM	PM	Date	AM	PM	Date	AM	PM	Date	AM	PM

Birth Recording Format

No.	Date of birth	Doe ID	Kids ID	Kids sex *1. Male* 2. *Female*	Buck ID *(Only after the selection program)*	Birth Type (*1. Single, 2. Twine, 3. Triple)*	Birth Weight (Kg)	Does weight	Remark

Body Weight Recording Format

	Body weight

ID	3 month weight	Date taken	6 month weight	Date taken	9 month weight	Date taken	12 month weight	Date taken

Appendix Table 1. Goat outflow pattern across a year by sex and age in Ziquala

Exit Months	**Male kid**	**Female kid**	**Weaned male**	**Weaned Female**	**Doe**	**Buck**	**Total**
Jan	2	1	7	6	10	1	27
Feb	5	6	1	3	4	2	21
Mar	6	2	4	5	3	2	22
Apr	10	5	6	5	14	1	41
May	7	9	5	10	27	1	59
Jun	3	3	0	1	8	2	17
Jul	0	0	0	1	2	0	3
Aug	2	0	3	4	8	0	17
Sep	0	0	7	3	8	0	18
Oct	5	1	2	3	9	1	21
Nov	8	4	10	16	11	3	52
Dec	2	4	18	7	10	3	44
Total	50	35	63	64	114	16	342

Appendix Table 2. Goat outflow pattern across a year by sex and age in Tanqua Abergelle

Exit Months	***Male kid***	***Female kid***	***Weaned male***	***Weaned Female***	***Doe***	***Buck***	**Total**
Jan	1	0	0	0	1	0	2
Feb	2	1	2	2	8	1	16
Mar	2	0	0	1	2	2	7
Apr	1	1	3	1	7	4	17
May	2	0	4	0	1	0	7
Jun	0	1	1	0	4	0	6
Jul	0	0	3	4	8	0	15
Aug	0	0	2	0	3	2	7
Sep	1	0	6	0	5	1	13
Oct	0	0	0	0	4	0	4
Nov	1	0	7	0	4	0	12
Dec	1	0	10	8	3	0	22
Total	11	3	38	16	50	10	128

Appendix Table 3. Goat outflow pattern across a year by sex and age in Lay Armachiho

Exit Months	***Male kid***	***Female kid***	***Weaned male***	***Weaned Female***	***Doe***	***Buck***	**Total**
Jan	4	2	2	3	3	1	15
Feb	1	1	7	2	0	0	11
Mar	0	2	0	0	1	0	3
Apr	6	3	9	7	1	0	26
May	3	4	10	3	11	1	32
Jun	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0
Aug	0	2	2	1	4	0	9
Sep	9	2	3	5	1	0	20
Oct	16	7	3	3	4	2	35
Nov	9	9	7	4	8	2	39
Dec	18	11	0	3	26	1	59
Total	66	43	43	31	59	7	249

Appendix Table 4. Goat inflow pattern across a year by sex and age in Ziquala

Entry Months	***Male kid***	***Female kid***	***Weaned male***	***Weaned Female***	***Doe***	***Buck***	**Total**
Jan	10	6	0	0	3	0	19
Feb	6	11	1	1	2	0	21
Mar	9	11	12	0	0	0	32
Apr	0	1	0	0	1	0	2
May	5	3	10	21	8	0	47
Jun	1	3	0	0	0	0	4
Jul	0	0	0	0	0	0	0
Aug	0	2	0	0	0	0	2
Sep	12	18	0	1	0	0	31
Oct	7	2	1	12	3	0	25
Nov	171	150	0	2	7	0	330
Dec	11	13	0	0	3	0	27
Total	232	220	24	37	27	0	540

Appendix Table 5. Goat inflow pattern across a year by sex and age in Tanqua Abergelle

Entry Months	***Male kid***	***Female kid***	***Weaned male***	***Weaned Female***	***Doe***	***Buck***	**Total**
Jan	3	2	0	0	0	0	5
Feb	32	21	0	0	0	0	53

Mar	0	0	0	2	0	1	3
Apr	12	11	0	0	0	1	24
May	9	9	0	0	0	0	18
Jun	8	5	0	1	0	0	14
Jul	1	0	5	0	4	4	14
Aug	16	24	0	0	0	0	40
Sep	0	0	0	0	0	0	0
Oct	1	0	0	0	0	0	1
Nov	84	95	0	7	0	0	186
Dec	1	1	1	0	2	0	5
Total	167	168	6	10	6	6	363

Appendix Table 6. Goat inflow pattern across a year by sex and age in Lay Armachiho

Entry Months	***Male kid***	***Female kid***	***Weaned male***	***Weaned Female***	***Doe***	***Buck***	**Total**
Jan	12	13	0	0	0	0	25
Feb	15	12		0	0	0	27
Mar	6	5	0	0	0	0	11
Apr	18	10	0	0	0	0	28
May	21	30	0	1	5	1	58
Jun	1	1	0	0	0	0	2
Jul	0	0	0	0	0	0	0
Aug	6	7	1	0	3	0	17
Sep	18	16	0	6	1	0	41
Oct	23	20	0	0	1	0	44
Nov	15	16	0	0	0	0	31
Dec	4	5	0	0	1	0	10
Total	139	135	1	7	11	1	294

Appendix Table 7. Analysis output of GLM ANOVA for different linear body measurements of Abergelle and Central Highland goat breeds for the effect of breed, sex and breed by sex interactions

Dependent Variable	**Source variation**	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
BW	breed	1	3850.832389	3850.832389	151.50	<.0001
	Sex	1	1539.935012	1539.935012	60.58	<.0001
	Sex*breed	1	529.786413	529.786413	20.84	<.0001
BL	breed	1	908.4471337	908.4471337	61.08	<.0001
	Sex	1	356.1789240	356.1789240	23.95	<.0001

	Sex*breed	1	65.2638698	65.2638698	4.39	0.0366
	breed	1	3033.140551	3033.140551	204.52	<.0001
HW	Sex	1	1224.034036	1224.034036	82.53	<.0001
	Sex*breed	1	165.320038	165.320038	11.15	0.0009
	breed	1	2041.186124	2041.186124	107.81	<.0001
CG	Sex	1	1148.435700	1148.435700	60.66	<.0001
	Sex*breed	1	375.040912	375.040912	19.81	<.0001
	breed	1	226.6017220	226.6017220	78.67	<.0001
CW	Sex	1	77.2730507	77.2730507	26.83	<.0001
	Sex*breed	1	33.6795138	33.679513	11.69	0.0007
	breed	1	1.47610981	1.47610981	0.88	0.3492
RL	Sex	1	0.57469807	0.57469807	0.34	0.5590
	Sex*breed	1	32.77949587	32.77949587	19.49	<.0001
	breed	1	1.79140524	1.79140524	1.27	0.2596
PW	Sex	1	1.15133379	1.15133379	0.82	0.3661
	Sex*breed	1	13.77643274	13.77643274	9.79	0.0018
	breed	1	5036.566962	5036.566962	328.25	<.0001
HL	Sex	1	4617.845766	4617.845766	300.96	<.0001
	Sex*breed	1	2517.057374	2517.057374	164.05	<.0001
	breed	1	460.5095144	460.5095144	255.89	<.0001
EL	Sex	1	2.8561063	2.8561063	1.59	0.2082
	Sex*breed	1	1.8139986	1.8139986	1.01	0.3158
	breed	1	101.957637	101.9576372	25.17	<.0001
SC	Sex	0	0.0000000	-	-	-
	Sex*breed	0	0.0000000	-	-	-

Appendix Table 8. Analysis output of GLM ANOVA for growth traits of Abergelle goat in Ziquala district monitoring site for the effect of sex, parity and birth type

Dependent Variable	Source variation	DF	Type III SS	Mean Square	F Value	Pr > F
Birth weight	parity	4	1.63009535	0.40752384	3.83	0.0045
	Sex	1	0.49896434	0.49896434	4.68	0.0309
	Birth type	1	0.58873846	0.58873846	5.53	0.0191
3month weight	parity	4	4.21784585	1.05446146	0.37	0.8324
	Sex	1	0.00908664	0.00908664	0.00	0.9552
	Birth type	1	0.64965938	0.64965938	0.23	0.634
6month weight	parity	4	4.87885090	1.21971272	0.32	0.8668
	Sex	1	2.27814571	2.27814571	0.59	0.4425
	Birth type	1	10.69541637	10.69541637	2.78	0.0967
9month weight	parity	4	9.04391351	2.26097838	0.56	0.6934
	Sex	1	1.25359715	1.2535971	0.31	0.5788
	Birth type	1	1.19369569	1.19369569	0.29	0.5880

Appendix Table 9. Analysis output of GLM ANOVA for growth traits of Abergelle goat in Tanqua Abergelle district monitoring site for the effect of sex, parity and birth type

Dependent Variable	Source variation	DF	Type III SS	Mean Square	F Value	Pr > F
Birth weight	parity	4	3.26777434	0.81694359	0.66	0.6223
	Sex	1	2.73892779	2.73892779	2.20	0.1386
	Birth type	1	0.0649285	0.06492851	0.05	0.8194
3month	parity	4	5.07628004	1.26907001	0.50	0.7391
weight	Sex	1	0.25117362	0.25117362	0.10	0.7545

6month weight	Birth type	1	0.07727151	0.07727151	0.03	0.8623
	parity	4	8.46690306	2.11672577	1.00	0.4068
	Sex	1	0.07871155	0.07871155	0.04	0.8470
	Birth type	1	0.63298824	0.63298824	0.30	0.5844
9month weight	parity	4	11.05885508	2.76471377	1.15	0.3344
	Sex	1	11.73767951	11.73767951	4.90	0.0286
	Birth type	1	0.49536147	0.49536147	0.21	0.6502

Appendix Table 10. Analysis output of GLM ANOVA for growth traits of Central Highland goat in Lay Armachiho district monitoring site for the effect of sex, parity and birth type

Dependent Variable	**Source variation**	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
Birth weight	parity	4	1.63010215	0.40752554	3.05	0.0169
	Sex	1	0.92255062	0.92255062	6.91	0.0089
	Birth type	2	6.68308252	3.34154126	25.01	<.0001
3month weight	parity	4	16.19160104	4.04790026	0.52	0.7215
	Sex	1	31.45630858	31.45630858	4.04	0.0457
	Birth type	2	24.6047998	12.30239993	1.58	0.2085
6month weight	parity	4	85.01110028	21.25277507	3.18	0.0155
	Sex	1	46.01378719	46.01378719	6.88	0.009
	Birth type	2	50.15958556	25.07979278	3.75	0.0259
9month weight	parity	4	79.21095796	19.80273949	0.68	0.6112
	Sex	1	1.16938813	1.16938813	0.04	0.8424
	Birth type	2	21.25007412	10.62503706	0.36	0.6973