PHENOTYPIC CHARACTERIZATION AND OESTRUS SYNCHRONIZATION OF INDIGENOUS GOATS FOR IMPROVED REPRODUCTIVE EFFICIENCY IN MIRAB-ABAYA AND ARBAMINCH-ZURIA DISTRICTS OF GAMO-GOFA ZONE, SOUTHERN ETHIOPIA

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Phenotypic Characterization and Oestrus Synchronization of Indigenous Goats for Improved Reproductive Efficiency in Mirab-Abaya and Arbaminch-Zuria Districts of Gamo-Gofa Zone, Southern Ethiopia

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DEDICATION

I dedicate this piece of work first to God! Secondly my wife and beloved parents (my Dad: Dea Damana and Mam: Sonam Batamo) in the success of my life. Their ceaseless support, esteem, care and schooling fulfilled all my desires beyond their capabilities, nursed me with affection, shaped my life and enabled me to contribute this to final.

STATEMENT OF THE AUTHOR

I declare and confirm that this Thesis is my own work. All sources of materials that are included in the Thesis have been given recognition through citation. This Thesis has been submitted in partial fulfillment of the requirements for MSc. degree in School of Animal and Range Sciences, at the Hawassa University and will be deposited at the College's Library to be made available to borrowers under rules of the Library. I solemnly declare that this Thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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LIST OF ABBREVIATIONS

AFK	Age at First Kidding
AnGR	Animal Genetic Resources
AIA	Artificial Insemination
ARTs	Assisted Reproductive Technologies
BCS	Body Condition Scoring
BL	Body Length
BWt	Birth Weight
CD	Chest depth
CG	Chest Girth
CIDR	Controlled Internal Drug Release
CL	Corpus Luteum
CSA	Central Statistical Authority
DNA	Deoxyribo Nucleic Acid
EARO	Ethiopia Agricultural Research Organization
EL	Ear Length
ESGPIP	Ethiopia Sheep and Goat Productivity Improvement Program
FAO	Food and Agricultural Organization

FSH	Follicle Stimulating Hormone
GnRH	Gonadotropin Releasing Hormone
GPS	Global Positioning System
HHs	House Holds
HeL	Head Length
HeW	Head Width
HW	Height at Whither
HoL	Horn length
KI	Kidding Interval
LBM	Linear Body Measurement
LH	Luteinizing Hormone
LIVES	Irrigation Value chains for Ethiopian Smallholders
LS	Litter Size
MC	Muzzle Circumference
MOET	Multiple Ovulation and Embryo Transfer
NA	Not Available
PGF2α	Prostaglandin F2α
PPI	Pair of Permanent Incisor
RL	Rump Length

RW	Rump Width
SC	Scrotum Circumference
SMWt	Sixth Month Weight
SNP	Single Nucleotide Polymorphic
TL	Teat Length
WWt	Weaning Weight
YWt	Yearling Weight

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Phenotypic Characterization and Oestrus Synchronization of Indigenous Goats for Improved Reproductive Efficiency in Mirab-Abaya and Arbaminch-Zuria Districts of Gamo-Gofa Zone, Southern Ethiopia

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ABSTRACT

The present study was designed with the objectives of describing the goat production systems, morphological features and evaluate oestrus synchronization of indigenous goats in Arba-Minch-Zuria and Mirab-Abaya districts of Gamo-Gofa zone. A total of 120 HHs were interviewed for goat production survey while 615 goats (151 males and 464 females) were used for morphological measurements and 60 does for oestrus synchronization from the two districts. The results confirmed that goats ranked 2nd after cattle and were primarily produced for generating income and saving purposes in the study areas. The major mating system was uncontrolled (80.83%). Goat castration (65.83%) and culling (93.33%) were common goat breeding practices whereas kid weaning was not well practiced. Body size, pedigree and prolificacy were the magnificent selection criteria for breeding does whereas color incorporated for bucks. Communal browsing areas were the main goat feed sources in which January through March months were commonly known for the feed shortage. Male goats have higher off-take rate at early age (94.17%) to the market than females (82.50%). Feed shortage (30.37%) followed by labor limitation (23.33%) and land shortage (15.56%) were the major goat production challenges identified. In morphological measurements, the predominant coat color pattern was plain for male (63.82%) and (70.02%) for females. Brown coat color for males (32.24%) and (34.05%) for females was possessed predominantly. Horned goats were (86.84% for males and 94.55% for females), toggle (14.47% for males and 9.85% for females), bearded (53.29% for males and 22.06% for females. The prominent horn shape was straight (93.13% for males and 93.11% for females). About 61.83% of male and 78.95% of female goats were characterized by possessing obliquely upward horn orientation. Except Body length, males possessed higher values for Body weight, Rump lenght, Head width and Horn length than females ($P<0.05$). Goats in Arbaminch-Zuriya district possessed significantly ($P<0.05$) higher values on BW, BL, CG, RW, HeW and SC than in Mirab-Abaya district. In males, positive and strong association were depicted between BW and BL ($r=0.68$), WH ($r=0.62$), CG ($r=0.61$) and HoL ($r=0.63$). In case of females, positive and moderate associations were observed between BW and CG ($r=0.38$), RW($r=0.37$) and HeL ($r=0.31$). CG was a single importance variable in the prediction of body weight in females where as BL in males ($P<0.05$). Regarding to the oestrus synchronization, about 85% of the does expressed oestrus within 55.68±19.92 hours after hormone administration where as the overall conception rate was 81.67%. Doe body weight, body condition, parity and age have significantly affected ($P<0.05$) oestrous response and conception rate where as location has not significantly ($P>0.05$) affected. Morphological traits' variations suggest that this goat ecotype has not yet been selected through structured selective breeding. While conducting oestrus synchronization on goat, considering body weight, BCS, parity and age factors was better to reflect higher conception rate.

Key words: *Goat, Phenotypic characterization, Estrus Synchronization*

1. INTRODUCTION

In Ethiopia, the total number of goat is estimated to be 29.1 million heads, of which, 71.08% are females and 28.92% are males (CSA, 2015). The indigenous goat population of the country constitutes the largest proportion (99.9%) while the remaining 0.01% is hybrid and/or exotic breeds. The Southern Region, with 5.09 million (17.5%) heads of goat population, ranks third after Amhara (20.83%) and Oromia (26.96%) regions (CSA, 2015). Small ruminant husbandry is the most important and usually the only living source for people inhabiting in regions not suitable for crop cultivation and cattle production (Daskiran et al., 2006) and are known as the “poor man's cow” (Ajala, 2004). Goats (*Capra hircus*) inhabit in wide range of environments extending from supper-arid to humid and over the whole range of production systems from intensive smallholder production to very extensive nomadic pastoralism (Payne and Wilson, 1999). Goats are an under-used and poorly understood resource; though an interest in goat production in the tropics has grown in recent years (Tsegahun *et al*., 2000).

Although indigenous goats in Ethiopia have been considered genetically less productive when compared to other temperate breeds before application of performance improvement interventions (Mohammed et al., 2012), they specifically contribute significantly for diversifying production to the livelihood of resource-poor farmers in Ethiopian agricultural systems (Sebsibe, 2006). In addition to their small body size, broad feeding habits, adaptation to unfavorable environmental conditions; goats have a short reproductive cycle when compared to large ruminants and prolific, which is ideal to serve as source of income, food (meat and milk), manure and cultural values under traditional production systems (Assen and Aklilu, 2012; Hassen *et al*., 2012).

A comprehensive survey of goats in Ethiopia identified four families and 12 eco-types based almost entirely on morphological characteristics (FARM-Africa, 1996). Classification of the tropical goats by function has not so far found a great deal of support because they have been selected mainly for survival (FAO, 1999). Therefore, there has been little differentiation into major types related to their production objectives, alarmingly changing climate and functions. On the other hand, indiscriminate crossbreeding of indigenous goats can cause dilution of their genetic diversity and reduction of adaptive value and opportunities for efficient utilization of the existing adapted goat genetic resources (FAO, 1999).

The productivity of the indigenous genetic goat resources can be increased by systematic breeding program (FAO, 2012). Characterization and identification of the genetic potentials of indigenous animal genetic resources would play a crucial role for designing suitable breeding program aimed at conserving these potentials for sustainable utilization. Through phenotypic characterization studies, it would be possible to describe the type of environment in which they are reared, their degree of adaptation to specific diseases or climatic challenges as well as production potentials in those specific environments and the compatibility of the genotypes with the farmers' breeding objectives (Markos, 2006; FAO, 2012). Still, there are major gaps in the coverage of characterization activities and information for monitoring populations' trends and hence unknown current risk status for many breeds (FAO, 2015). Gaps are particularly prominent in developing countries like Ethiopia. At within-breed level, advanced technologies (molecular characterization tools) such as those related to the prediction of breeding values for individual animals and genomic selection have huge potential, but require phenotypic data. If developing countries lack characterization and performance data, they will be unable to take advantage of new technologies of this kind and high-quality studies that separate genetic and environmental factors, particularly for locally adapted breeds (FAO, 2015).

Indigenous goat breeds have special adaptive features for wide range of agro-ecologies and diseases; reproduce and produce at scarce and low quality feed and water resources (Kosgey and Okeyo, 2007). However, goats in particular has not received due attention in research and development endeavors and lack of systematic goat breeding programs is also an important factor in Ethiopia (Tsegahun *et al*., 2000). For instance, male goats have fast breed improvement potential than females; but most traditional goat producers in the country remove fast growing young bucks (negative selection) to the market resulting in a loss of genetic potential (CSA, 2015). Therefore, there is a need to design and implement appropriate breeding strategies to improve the livelihoods of the smallholder farmers and to satisfy the growing demand of meat for domestic consumption as well as international market.

To overcome the growing demand for goat products, there have been a few attempts of genetic improvement program of goats through upgrading the exotic genetic blood levels by FARM-Africa for dairy, and Ethiopia sheep and goat productivity improvement program (ESGPIP) for meat goat development program (Gebremeskel, 2000; Alemu *et al*., 2009). In general, Shumuye *et al*., (2014) said that many cross-breeding programs of small ruminants in tropics were not successful and the crossbreds had lower performance than local breeds under similar management conditions. This was because of the incompatibility of the genotype with the farmers breeding objectives, management methods and the prevailing environment of the tropical low input production systems (Solomon, 2015). Thus, establishing community-based selective pure breeding programs is the recent genetic improvement approach recommended for low input traditional smallholder farming systems of the native flocks (Wurzinger *et al*., 2011; Tatek, 2016). This is because community based breeding programs take into account the indigenous knowledge of the communities on breeding practices, breeding objectives and production systems from planning to operation of the given breeding program (Gizaw *et al*., 2013).

Goats and sheep show a marked reproductive seasonality in temperate regions mainly due to a photoperiod effect. The annual variation of the daily luminosity duration is perceived by the retina of animals and the pineal gland was responsible for production of melatonin, a key hormone, during short days/darkness periods (Malpaux*et al*., 2001). However, in tropical conditions are either non-seasonal breeders or exhibit only a weak seasonality of reproduction. Females ovulate and exhibit estrus almost the whole year round, even though some short periods of anestrous are detected depending on several factors such as latitude, thermal stress, breed, feed scarcity, physiological stage and buck effect (Simões, 2015; Dereje, 2018). Regarding to photoperiod effect, females are insensitive to photoperiod, or the amplitude of the photoperiodic changes is too small to induce seasonality. The principal advantage of non-seasonal breeding regime is a continuous supply of milk, meat and surplus animals to producers. However, this strategy produces low milk yields, lowers kid survival and growth whenever late pregnancy and birth fall into periods with suboptimal forage availability (Girma, 2009; Delgadillo, 2015).

The variability in the length of the oestrus cycle and oestrus has necessitated the use of oestrus synchronization in the reproductive management of goats (Omontese *et al*., 2016). In order to breed females out of season (artificially), estrous synchronization is a key assisted reproductive technology used to fix breeding time (Rahman *et al*., 2008). During the breeding and non-breeding seasons, various complex hormonal alteration, natural (bio-stimulation) or mixed protocols: prostaglandins, progestagens and more recently simple manipulation of the "buck effect" are employed for oestrus synchronization to improve the reproductive management of indigenous goats in tropics (Ak *et al*., 1998; Leboeuf *et al*., 1998;Whitley, 2004; Omontese *et al*., 2016). However, the choice of hormone and estrus synchronization protocols depend on cost effectiveness, ease of application, and resultant fertility (Zeleke, 2015). However, information regarding response to Ethiopian small ruminants for prostaglandin dose and application protocol is scanty although some initiations for Menz sheep breed (Zeleke, 2015).

Although phenotypic characterization of indigenous goat populations is a neglected system which warrants the traits make them unique and preferable, it is a prior gateway before any community-based breeding schemes operation. However, difficulties on reproductive management, i.e., estrous detection, early pregnancy diagnosis, and unknown time of ovulation, cause low reproduction performance of goats (Baldassarre and Karatzas, 2004, Getnet, 2016). Recently reviewed assisted reproductive biotechnologies (estrus synchronization and early pregnancy diagnosis tools) are catalysts to enhance reproductive efficiency of local goat populations in smallholder breeding programs. Hence, the current study was designed with the following objectives:

- To describe indigenous goats' production system and breeding practices;
- To phenotypically characterize indigenous goat populations of the study districts as an input for designing community based goat breeding in the study areas; and
- To improve the reproductive efficiency and planned kid production through oestrus synchronization for community-based goat breeding programs.

2. LITERATURE REVIEW

2.1 Goat production systems of Ethiopia

Goats are found in all agro-ecological zones from lowland to highland and over the whole range of production systems from intensive smallholder production to very extensive nomadic pastoralists (Payne and Wilson, 1999). Goat production in Ethiopia is described under low input production system and is operated by smallholder farmers (IBC, 2004) and evolved largely as a result of natural production environments, the limited demand for inputs and socio-economic circumstances of farmers/pastoralists (IBC, 2004; Abegaz, 2014). In Ethiopia, goats are maintained under two broad production systems: mixed crop-livestock system and agro-pastoral and/or pastoral system (EARO, 2000).

2.1.1 Mixed crop-livestock system

Mixed crop-livestock system is commonly practiced in the most crop dominant areas of high land and mid-altitude of the country, with altitude ranges of 1500 to 3000 m. The area receives good amount of rainfalls and has moderate temperature. Goats are kept by smallholders and graze together with sheep and/or other livestock species like cattle. The integration and the importance of small ruminants (goat) in the system vary from place to place. The integration is lower in southern part of the country where perennial crop production is more important (Gizaw *et al.*, 2010a). In these mixed-species grazing systems, goats complement cattle and sheep rather than compete with them for feed, because of their inherent ability to utilize a wider variety of plant species and their preference to browse high above the ground (Lebbie, 2004 cited by Yoseph, 2007).

2.1.2 Agro-pastoral and pastoral system

In pastoral and agro–pastoral production systems, which are situated in the arid and semi-arid agro–ecological zones, goats are kept by nearly all the pastoralists, often in mixed flocks with sheep, camel and cattle freely grazing or browsing in the rangelands. This production system is associated with the purely livestock based pastoralists and transhumance pastoral production systems based largely on range, primarily using natural vegetation. In the lowlands of Ethiopia, livestock is comprised of large flocks and herds of sheep and goats, cattle and camels, where only surplus animals are sold at the local markets or trekked to major consumption centers. Extensive livestock keeping is the backbone of the economies of the lowlands (EARO, 2000).

2.2. Goat breeds of Ethiopia

A domestic animal population may be regarded as a breed if the animals fulfill the criteria of: being subjected to a common utilization pattern; sharing a common habitat/distribution area; representing largely a closed gene pool and being regarded as distinct by their breeders in general (FAO, 2012). In the developed countries, breeds are defined in terms of a set of phenotypic standards, the use of breed herd books and the existence of formalized breed societies that are often supported by legislation where as in developing countries livestock-keeping communities and governments apply the term more loosely and identify breeds more with geographic localities, ethnic identities and the traditions of their owners than with their phenotypic attributes (FAO, 2012). Goat breeds found in Ethiopia have been identified and classified based on their differences in physical characteristics and genetic make-up (Alemu *et al*., 2009).

Based on differences in physical characteristics, four families and 12 breeds of goats have been identified in Ethiopia and Eritrea (Farm-Africa, 1996; ESGPIP, 2009). However, Tesfaye (2004) reported only eight distinctively different breeds based on microsatellite markers analysis. A family is a group of breed that is genetically more related and physically more similar than breeds outside the group. The families and breeds are usually named after their geographical location, the ethnic communities maintaining them, or based on some identifying physical features. It should be noted that some breeds are known by different local names in different localities. Breeds are also not bounded by political boundaries and the same breed can be present in different neighboring countries (Solomon *et al.*, 2009). The different goat breeds of Ethiopia reported in litretres are indicated in Table 1.

Table 1: Goat breeds of Ethiopia and their geographical distribution

Family name	Breed name	Other local names	Distribution
Nubian family	Nubian	Barka, Begayit	West Tigray
Rift Valley family	Afar	Adal, Danakil	Afar region, Northern and Western
	Abergelle		Along Tekeze river Tigray region, Wag Himra, East Gondar
	Arsi-Bale	Gishe, Sidama	Arsi, Bale and Western Hararghe
	Woito-Guji	Woyto, Guji, Konso.	South Omo, Southern Sidama and Wolayita
Somali family	Hararghe Highland		Hararghe
	Short-eared Somali	Denghier or Deghiyer	Northern and Eastern Ogaden
	Long-eared Somali	Large-white Somali, Degheir, Digodi, Melebo	Ogaden, Lowland of Bale and Borena
Small East African family	Central Highland	Brown goat	Centeral highlands, West of the rift valley Wollo, Gondar and Shoa
	Western Highland	Horro	Highland of South Gondar, Gojam, Wollega and West Shoa
	Western Lowland	Gumz	Along the area bordering the Sudan
	Keffa		Highlands and Lowlands of Keffa and South Shoa Zone

Source: Farm-Africa (1996); Tesfaye (2004); ESGPIP (2009) and Gizaw *et al*. (2010a)

2.2 Characterization of animal genetic resources (AnGR)

Basic decision making in livestock development and breeding program requires a good understanding of breed characteristics (FAO, 2007). Breed characterization includes all activities related with the description of the origin, development, structure, population, quantitative and qualitative characteristics of the breeds in defined management and climatic conditions (Gizaw *et al.*, 2011). Describing and classifying of livestock breeds and species at molecular level by measuring frequencies of genotypes and alleles, degrees of polymorphism, allelic diversity (observed and expected hetrozygosity) and genetic distances activities are also another complementary breed characterization (Abegaz, 2014) so that breeds are characterized by both phenotypic and advanced-molecular level.

2.2.1 Phenotypic characterization

Phenotypic characterization is the process of identifying distinct populations and describing their external and production characteristics within a given production environments and geographical distributions; taking into consideration the social and economic factors that affect (FAO, 2015). The external characteristics for breeds descriptors are (coat color, ear type and shape, horn shape and type), linear body measurements (such as height at wither, heart girth, body length, ear length), production traits (body weight, milk yield) and reproductive traits (such as age at first kidding, litter size) (FAO, 2012). Phenotypic characterization provides a crude estimate of the average of the functional variants of genes carried by a given individual or population (FAO, 2007) and is comparatively easy and cheap means of breed characterization (Gizaw *et al.*, 2011).

2.2.2 Molecular characterization

Identification and classification of breeds based on physical characteristics can be supported by advanced tools. Advanced classification is based on differences between and within breeds in their DNA genetic make-up (Gizaw, 2009).

Different categories of polymorphic DNA markers reveal different aspects of the history of livestock. Mitochondrial DNA (mtDNA) is transmitted maternally and has been instrumental in identifying ancestor species, estimating the number of female founders, identifying the geographic regions of domestication and reconstructing migration routes; mammalian Y-chromosomal variation is transmitted via the paternal line and is a powerful tool for tracing gene flow by male introgression, whether in the distant past or more recently and autosomal variation is transmitted via both parents. Microsatellite markers have been widely used for analyzing autosomal variation and are still useful. However, they are being replaced by high-density SNP (single nucleotide polymorphism) analysis. Autosomal loci are commonly used for population diversity estimations, detection of the subdivision and differentiation of populations, calculation of genetic distances and quantification of genetic admixture (FAO, 2015).

2.3 Goat genetic improvement strategies

Animal breeding is aimed to genetically improve population of livestock like goat is achieved through variations' selection of the best individuals of the current generation and using them as parents of the next generation (ILCA, 1994). Any genetic improvement programs falls under three major genetic improvement pathways: within breed selection; selection between breeds-breed substitution and crossbreeding. Small ruminant (goat) breeding programs in tropical country are less organized and largely fragmented (Solomon, 2014). Many of the programs were based on upgrading of the indigenous animal to exotic breeds. The crossbred were often good in terms of growth and some other production traits under on station evaluation. Yet, the performance of the crossbred at smallholder level is low (Solomon, 2014). In general, most of the crossbreeding activities were not successful and sustainable due to incompatibility of the breeding objectives and the management approaches of the existing production system of the area (Kosgey *et al*., 2006). Therefore, in tropical countries like Ethiopia, it is very useful to understand the level of performance and the potential of genetic improvement through selection within the indigenous breeds before implementing any breeding strategy (Philipsson *et al*., 2011). The most important things to be considered in designing breeding program are: description of production environment and production system, characterization of the available genotype, definition of breeding objectives, identification of traits to be selected, decision about breeding methods (FAO, 2010).

According to Kosgey*et al*. (2006), lack of performance and pedigree recording, low level of literacy, and lack of organizational structure, hinders within breed selection in tropics. To solve these gaps, nucleus (open and closed) breeding schemes are the most used and recommended tools for goat genetic improvement programs in tropical countries (Tibbo *et al*., 2006). The selected animals (mostly male animals) will be distributed to participating farmers to disseminate the genetic superiority obtained at the nucleus to the whole population (Solomon, 2014). Open nucleus breeding scheme allow the flow of animals in both directions from the nucleus to the population (Tibbo, *et al*., 2006; Philipsson *et al*., 2011). However, many nucleus breeding programs in tropics failed due to the lack of sustainable support and inadequate involvement of the community at the beginning of the program (Kosgey and Okeyo, 2007).

Community based breeding program is a recently promoted option for tropical traditional low-input goat production systems (Haile *et al*., 2011). It takes account of the indigenous knowledge of the communities on breeding practices and breeding objectives, consider the production system and involve the local community at every stage, from planning to operation of the breeding program (Baker and Gray, 2004; Gizaw *et al*., 2013). The breeding structure of such a program is commonly single-tiered with no distinction between the breeding and production units, i.e., the farmers are both elite goats' breeders and producers (Gizaw *et al*., 2013).

2.4 Performance of indigenous goats

Evaluation of the performance of economically important traits of goat is very useful input for a breeding program plan. The most important traits of livestock (goat) are broadly classified into two categories: production and reproduction traits.

2.4.1 Growth Performance

To increase economic return from goat meat production requires improvements in market weight of kids and mature goats. Growth performance may be separated in pre-weaning (birth weight, weaning weight and pre-weaning growth rate) and post-weaning (six months weight, yearling weight and mature weight). The growth performance of goats is influenced by many genetic and non genetic factors. The early stage of growth performance of kids is largely influenced by genotype and the milk yield of the does. Parity, type of birth, sex, season and year of birth also influence the growth performance of goats (Dadi *et al.,* 2012; Bedhane *et al.*, 2013; Derbie and Taye, 2013 qoated in Solomon, 2014).

Kids which are heavier at birth are usually singles or are those produced by does with larger body sizes and good feeding conditions (Devendra and McLeroy, 1988). Kids born as singles and twins had significantly higher birth weight than kids born as triplets (Saddul *et al.*, 1999). Most of Ethiopia goats' adult body weight range from 25-40 kg (Peacock, 1996). Mean production performance of some indigenous Ethiopian goat breeds are presented in table 2.

Table 2: Birth, weaning, six months and yearling body weights of some Ethiopian goat breeds

Breed	Management type	BWt	WWt	SMWt	YWt	Source
Abergelle	Traditional	1.91	6.84	9.13	14.25	Deribe and Taye (2013)
Western Lowland	Traditional	2.28	12.00	NA	NA	Tsegaye (2009)
Central high land	Traditional	2.01	9.02	13.82	20.61	Deribe (2008)
Arsi-Bale	Station	1.91	6.65	9.00	14.32	Bedhane *et al* (2013)
Arsi-Bale	Traditional	2.80	8.39	NA	NA	Weldu *et al*. (2004)
Keffa	Traditional	2.78	9.00	NA	NA	Shenkute (2009)
Somali	Station	3.19	11.67	NA	NA	Zeleke (2007)

BWt=birth weight, **WWt**= weaning weight, **SMWt**= six month weight and **YWt**= yearling weight

2.4.2 Reproductive Performance

Reproductive performance is an important criterion when evaluating the structure of the strength and weakness of the breeds in particular production environments (Browing *et al*., 2006). Mukasa Mugerwa *et al*. (2002) stated that reproduction failure is the first indicator of decreased flock productivity. Litter size, age at first kidding and kidding interval are economically important reproductive traits and their values of some of Ethiopian goat breeds under different management conditions are summarized in Table 3.

Table 3: Reproductive performance of some of Ethiopian goat breeds under different management conditions.

Breed	Management type	LS	AFK (days)	KI (days)	Source
Abergelle	Traditional	1.04	448	339	Deribe (2008)
Central high land	Traditional	1.16	408	308	Deribe (2008)
Arsi-Bale	Station	1.64	854	293	Dadi *et al*. (2008)
Arsi-Bale	Station	1.60	575	280	Kebede *et al*. (2012a)
Keffa	Traditional	1.70	375	237	Shenkute (2009)
Western Lowland	Traditional		408	252	Tsegaye (2009)

LS= litter size, **AFK**= age at first kidding and **KI**= kidding interval

2.5 Oestrus synchronization

Oestrus synchronization is the manipulation of the estrous cycle or induction of estrus to bring a large percentage of a group of females into estrus and ovulation at a short, predetermined breeding season. Synchronization of goats helps to match kidding with feed available seasons and for breeding and to induce does' estrus for shortening kidding interval (Girma, 2009; Gizaw, 2016). It is important that adequate nutrition and good farm management practices be provided to ensure a successful oestrus synchronization program in goats (Omontese *et al*., 2016).

2.5.1 Common protocols used for oestrus synchronization in goats

The two common methods used for estrus synchronization are: use of exogenous hormones: Progesterone and prostaglandins or their synthetic forms and male effect are the two classes of hormones available for does estrus synchronization during the breeding and also in the non-breeding seasons. Hormonal estrus synchronization techniques can artificially shorten or lengthen progesterone dominance of the luteal phase (Girma, 2008). However, the choice of hormone and estrus synchronization protocols for planned mating depend on cost effectiveness, ease of application, and the resultant fertility (Zeleke *et al.,* 2015).

2.5.1.1 Progesterone

Progestagin-containing vaginal pessaries of Y-shaped device called "controlled Internal Drug Release (CIDR) extends luteal phase of estrus cycle to the life of the corpus luteum (CL) (Girma, 2008). Progesterone synthetic analogues are norgestomet, fluorogestone acetate (FGA) (Imasuen *et al*., 2009) and marketed as Chronogest® and Veramix sponges®. Factors that affect the success of an oestrus synchronization program when progestagens are applied include species, breed, co-treatment, management, stage of the oestrus cycle and duration of treatment (Wildeus, 2000). Following exogenous progesterone supplement withdrawal, does usually show release of GnRH, stimulating FSH and LH release leading to estrus and ovulation within 48 hours (Ak *et al.,* 1998; Girma, 2008). The addition of gonadotrophins to progestagen protocols ensure a tighter synchrony and/or induces a super-ovulatory response in treated does (Lehloenya, 2013).

2.5.1.2 Prostaglandin

Prostaglandin and its synthetic analogues are another method of oestrus synchronization protocol in goats. The synthetic analogues that have been used are dinoprostthromethamine, marketed as Lutalyse® and cloprostenol sodium, marketed as

Estrumate® (Omontese *et al*., 2012). They shorten the luteal phase and effective when only an active CL is present at time of application by regressing CL to induce the follicular phase of the oestrous cycle (Girma, 2008). Since consumers demand food produced by "clean, green and ethical" methods (Martin *et al*., 2004), prostaglandins are a good alternative to progestagens, because prostaglandins are rapidly metabolized in the lungs and therefore, do not accumulate in the tissues (Piper *et al*., 1970).

Factors reported to affect oestrus response and fertility following administration of prostaglandin or its analogues include the dose level of the prostaglandin, the interval between administration of the prostaglandin, the responsiveness of the corpus luteum to the prostaglandin/ stage of the oestrus cycle, season and the inclusion of gonadotrophins as co-treatment (Omontese *et al*., 2016).

Prostaglandins are mainly administered intramuscularly and subcutaneously (Omontese *et al*., 2013a). It is worthy to note that administration of PGF2a will cause abortion at any stage of pregnancy in goats (Oyeyemi *et al*., 2012). Prostaglandin can be injected either in single or double dose. In does, it is often difficult to know the phase of the oestrous cycle (Abecia *et al*., 2012). Thus, double injection consistently results in higher oestrus response rates than single injection in 14 days apart (Voh *et al*., 2003; girma, 2008). By so doing, almost all the does would be with sure functional CL regress, but economic feasibility to the small holder farmers may be a factor (Girma, 2008).

2.5.1.3 The male effect

In an attempt to reduce the amount of exogenous hormones employed in animal production worldwide because of the growing concerns in terms of residues in food products (meat, milk), there has been an increasing interest in the use of clean, green and non-hormonal methods in improving livestock productivity (Martin *et al*., 2004). One of such method is the use of the “male effect: bio-stimulation” (Delgadillo *et al*., 2009). The “male effect” is described as the influence of a male on estrus behavior and ovarian activity among the female co-species. This phenomenon is mediated via pheromones in females’ urine and reproductive organs which is received and processed by the females.

Does isolated for 2-3 weeks from the males and then sudden introduction of the males can stimulate estrus by increasing of secreting follicle stimulating hormone (FSH) and Luteinizing hormone (LH), which results an ovulation of does after 4-7 days depending on within breed sex activity and libido of the bucks, the aggressiveness of the buck, intensity of the stimulation, body condition and nutritional status of the buck and does (Martin *et al*., 2004; Girma, 2008). The use of the “male effect” is reported to improve oestrus efficiency and fertility when used in combination with prostaglandins (Amarantidis *et al*., 2004) and progestagens (Omontese *et al*., 2013b). The stimulation of auditory, olfactory and visual sensations plays essential roles in the overall response to the “male effect”, although the olfactory stimulation is suggested to be the most important (Omontese *et al*., 2016).

2.5.2 Effect of oestrus synchronization in goats

Assisted-reproductive technologies are the application of techniques and practices to ensure genetic improvement in goat (ARTs) (Rahman *et al*., 2008). Oestrus synchronization is one of such reproductive management technologies that enables concentrated breeding that ensures uniform kid crop and proper management of pregnant does (Baldas, 2004). Exogenous hormones are used to modify the physiological chain of the oestrus cycle, while the non-hormonal methods involve the use of light exposure to a male. It is essential that any estrus synchronization technique should not only establish synchrony, but also ensure reasonable levels of fertility in the synchronized cycle (Rahman *et al*., 2008). The advantages of estrus synchronization in goats include better oestrus detection, increased application of artificial insemination (AI), multiple ovulation and embryo transfer (MOET), shortening of kidding intervals, control mating season and concentration of kid crop occurs at favorable seasons, improved management of pregnant does and the more efficient use of labor and animal facilities (Zeleke, 2015; Abecia *et al*., 2011 qoated in Omontese et al., 2016). It is vital in does because there exists some variability in the duration of both the oestrous cycle and oestrus and especially, because oestrus detection cannot be accomplished safely without a buck (Jainudeen *et al*., 2000). Does are in oestrus when they stand to be mounted by a buck. In addition, creamy vulval discharge may be observed during oestrus of goats (Abu *et al*., 2008).

2.6 Pregnancy detection

Establishing whether bred animals are pregnant or not is important to the producers. The most accurate tests are those that measure or detect something that is only produced by a viable fetus and that is always present when the pregnant animal has reached a certain stage. Methods of pregnancy diagnosis include (Girma, 2009):

2.6.1 Non-return to estrus

Frequent checking of animals after the normal estrus cycle (17 days for sheep and 21 days for goats) for visual signs of estrus is the simplest method. Animals not returning to estrus after the normal period are considered to be pregnant.

2.6.2 Progesterone test

Where facilities are available, progesterone assay in milk (in dairy breeds) or in blood samples is a common test. Although progesterone in goats is produced by ovaries only, measurement after 19 to 24 days of breeding will give an accuracy of 87 % for pregnant animals.

2.6.3 Ultrasonography

Ultrasonographic examination can be done as early as 28–30 days using intra-rectal examination. Transabdominal ultrasonography is done after 40 days post-breeding. Both methods can give good accuracy.

2.7 Goat production constraints in Ethiopia

Goat production and productivity in Ethiopia are generally low which is as a result of a combination of low reproduction rate, high mortality rate and slow growth rate (Solomon *et al*., 2010). They are said to be late in age at first kidding, low fertility, prolificacy and weaning rate and mature body weight (Dhaba *et al*., 2013). The average carcass weight of Ethiopian goats is 10 kg, which is the second lowest in sub-Saharan Africa (Adane and Girma, 2008) and indigenous goats are genetically less productive as compared to temperate breeds (Mohammed *et al*., 2012).

Long distance traveling for feed and water searching; seasonal feed and water shortages, both in quality and quantity; diseases prevalence and parasites infestation, particularly for early mortality on young stocks; poor veterinary services; and traditional goat management system is not market oriented, underdeveloped marketing information and infrastructure system, and lack of financial facility (Solomon *et al*., 2010). Thus, the adoption and use of improved livestock technologies is very limited throughout the country (Alemayehu, 1998).

Performance recording is also another important tool to suggest the breeding policy for a given area. However, recording in general is hardly practiced in any livestock like goat species in the country, to identify the performance and management gaps (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).The research approach has not also invited the end users for active participation. Improvements were too slow due to lack of identifying the actual on-farm situations and weighing the socioeconomic and cultural benefits of the animals for the poor farmers (Deribe, 2009).

3. MATERIALS AND METHODS

3.1 Description of the study areas

The study was conducted in two districts (Arbaminch-Zuria and Mirab-Abaya) of Gamo-Gofa zone, southern Ethiopia. Gamo-Gofa zone is geographically located between $5^0$57"-$6^0$71"N latitude and $36^0$37"- $37^0$98"E longitude. Mirab-Abaya district was bordered on the east by Lake Abaya, Arbaminch-Zuria on the south, on the west by Chencha, on the northwest by Boreda districts and on the north by the Wolayta zone whereas Arbaminch-Zura district is bordered on the south by the Dirashe, on the west by Bonke, on the north by Dita and Chencha and on the southeast by the Amaro districts .

The temperature, rainfall distribution and altitude range in Arba-Minch Zuria district were 10-25 C^o, 854-1,527 mm and 746-3,478 m.a.s.l while the corresponding parameters in M/Abaya district were 10-25 C^o, 854-1,278 mm and 746-2,539 m.a.s.l. The two districts were characterized by mixed livestock-crop farming system and have highland, midland and lowland agro-ecologies. Humic Alisols, Humic Nitosols, Eutric Fluvisols were the major soil types in these study areas.

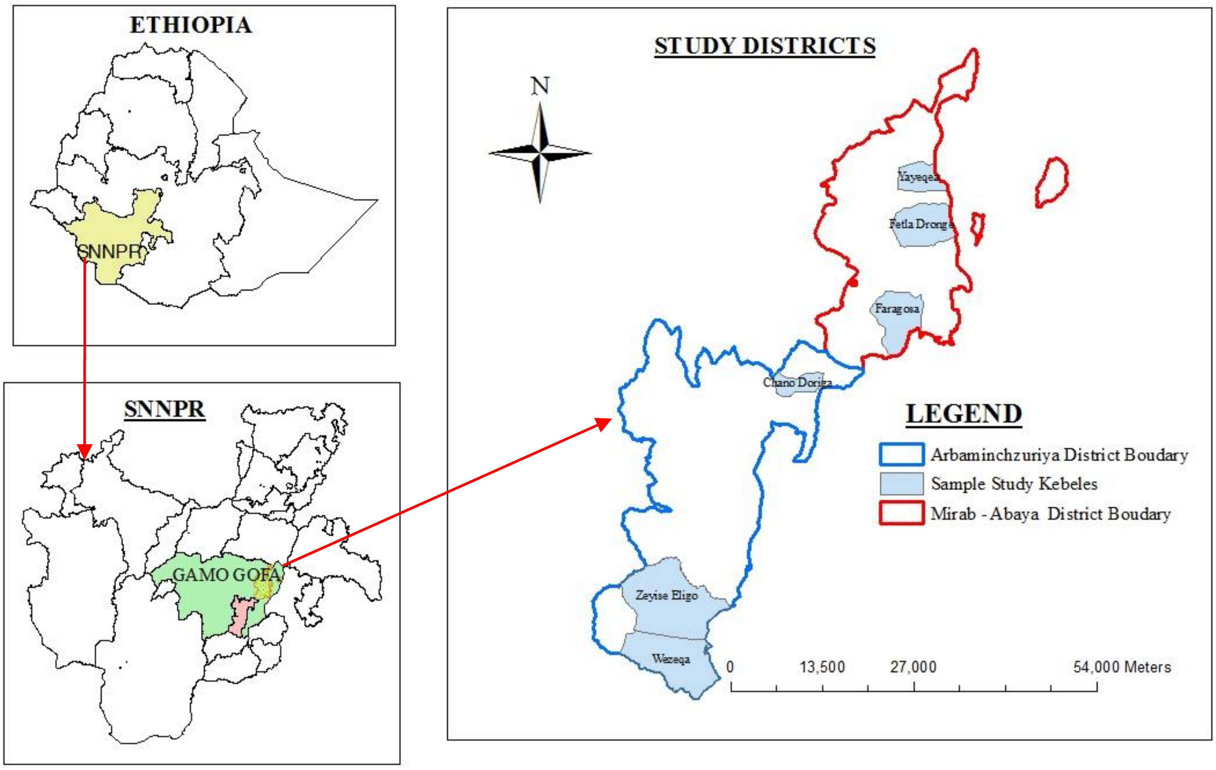

Figure 1: Location map of study areas

3.2 Sampling procedures

A rapid reconnaissance survey was carried-out prior to the actual survey work with zonal and district livestock experts, development agents, local farmers, village leaders and socially respected individuals who had known to have better knowledge to locate the distribution of goat and production system. Then, phenotypic characterization was conducted in two districts (Mirab Abaya and Arbaminch-Zuria). The two districts were selected purposively based on goat population potential. Three kebeles (Zayse-Wozeka, Zayse-Elgo and Chano-Dorga from Arbaminch-Zuria district and Yaike, Fetele and Faragosa from Mirab Abaya district) were also selected purposively based on the accessibility and potentiality of goat population size. This was followed by identification of 20 households from each kebele based on the number of goat flock (those who keep at least three mature goats). The total number of households selected for production system survey were 120 (2 districts * 3 kebeles *20 HHs).

A total of 151 males and 464 females from two districts were sampled (Table 4) following the phenotypic descriptor of FAO (2012) to develop linear body measurements indices. Measurements were taken early in the morning to avoid the effect of feeding and watering on the animal's size and conformation and when they are on normal standing position during same seasons (dry) (FAO,2012).

The age of the animals was estimated by recall and dentition methods. Adult goats were used according to five age groups classification systems: no pair of permanent incisor (0PPI), one pair of permanent incisor (1PPI), two pair of permanent incisor (2PPI), three pair of permanent incisor (3PPI) and four pair of permanent incisor (4PPI) to represent age 0-1 year, 1-2 years, 2-3 years, 3-4 years and 4-5 years, respectively based on (FAO, 2012; Gerald, 1994) for tropical goat breeds.

Regarding to the oestrus synchronization, 21 doelings and 39 late-stage lactating and/or open does totaling 60 females were selected randomly from Fetele (22), Faragosa (18) and Chano-Dorga (20) kebeles. Females those either assumed not healthy, emaciated, showed heat sign within five days, non-cyclic, lactating or pregnant were culled for synchronization since prostaglandin hormone was effective only on active CLs (Kefyalew, 2015). Pregnancy diagnosis was also conducted before hormone administration with Pregtone (field ultrasound) to minimize abortion due to the hormone. The synchronization agent used was Prostaglandin-based Lutalyse® (dinoprosttromethamine sterile solution equivalent to 5 mg dinoprost per ml) hormone, which was administered intramuscularly at 2.5 ml single shot as recommended earlier (Zeleke, 2015). Immediately after hormone administration, does were randomly allocated to mate with selected bucks from the same kebeles based on 1:10 buck-does ratio. Two weeks before and during the breeding period, the breeding bucks were supplemented with 300 gm concentrate per day to maintain their body weight. The bucks run with synchronized does during the day for 4 days. Does show oestrus were served with buck within 96 hours (Hamed *et al.*, 2012). Oestrous response to hormone treatment was determined based on expression of standing heat when does were exposed to bucks. Pregnancy diagnosis was conducted after one month using the Pregtone® or upon visual observation or kidding records to confirm conception.

Table 4: Summary of the total number of samples in the study areas

District	Kebele	Altitude (m.a.s.l)	Linear Body Measurement	Survey (HHs)	Oestrus Synchronization (Female)	Focus group discussion
Arba-Minch Zuria	Chano-Dorga	1240	101	20	18	1
	Zayse-Elgo	1220	95	20	-	1
	Zayse-Wozeka	1350	98	20	-	1
Mirab-Abaya	Fetele	1450	112	20	22	1
	Yaike	1240	111	20	-	1
	Faragosa	1260	98	20	20	1
Total	**6**	**-**	**615**	**120**	**60**	**6**

m.a.s.l= meter above sea level, HHs= Households

3.3 Data collection procedures

For production system survey data, semi-structured questionnaire was prepared and pre-tested on selected respondents. Quantitative data was collected by using textile-measuring tapes and weighing scale (50 Kg spring balance) and for qualitative data: coding sheets, global positioning system (GPS, Garmin 6.2) and digital camera were used.

Focal group discussion was conducted in six round with 20 respective local elders and leaders, district and kebele livestock and marketing experts after the end of the field survey.

Quantitative variables collected were: body weight (BW), body length (BL), height at wither (WH), chest girth (CG), chest depth (CD), rump length (RL), rump width (RW), head length (HeL), head width (HW), muzzle circumference (MC), horn length (HoL), ear length (EL), teat length (TL) and scrotum circumference (SC) (FAO, 2012). Kids and pregnant animals were excluded from the measurement to avoid under and over estimation, respectively.

Qualitative variables collected were: sex; estimated age class by dentition; coat (color and pattern); horn (presence, shape and orientation); ear orientation; head profile; presence of wattle, beard and ruff; body condition scoring; scrotum type (Halima et al., 2012). According to FAO (2012) and Gerald (1994), body condition score (BCS) was assessed subjectively using a five point scale (1 = very thin, 2 = Thin, 3 = Average, 4 = Fat and 5 = Very fat/Obese. The score of an animal was done by feeling the backbone and the ribs with the thumb and finger tips.

Data collected for oestrus synchronization include the study goat owners' name, goat number presented, age by dentition, initial body weight, body condition score, health condition, parity, number of does treated with PGF2α, does those responded to PGF2α treatment and does conceived/pregnant and does gave kid, gestation length, kid birth weight and sex, litter size and abortion rate.

3.4 Data analysis

The data obtained from the questionnaire survey and qualitative data (non-parametric data) were described using basic statistics (frequency and percentage). Indices were calculated for all ranking data according to a formula: Index = sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) given for an individual attribute divided by the sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) for overall attributes.

All morphoetric data were analyzed using GLM proc of SAS version 9.4 (SAS, 2012) and described by mean, standard deviation and frequency. Means were separated by using Duncan's Multiple Range Test method (α=0.05). Pearson's correlation coefficient was estimated between body weight and other linear body measurements for each sex. The stepwise multiple regression procedure of SPSS software was used to obtain models for estimation of body weight from linear measurements. Descriptive statistics, multivariate test and binary logistic regression analyses were employed to determine the statistical significance of the effects of location, age, parity, body weight and body condition on oestrous response and conception rates by using SPSS Software ver. 20.

3.5 Models for data analysis

3.5.1 Model for the analysis of body weight and linear body measurements (LBM)

$$\mathbf{y_{ijk} = \mu + A_i + S_j + D_k + (AS)_{ij} + e_{ijk}}$$

Where:

$\mathbf{y_{ijk}}$ = the observation of body weight and LBMs in the i^{th} age group, j^{th} sex and k^{th} district

$\boldsymbol{\mu}$ = overall mean

$\mathbf{A_i}$ = the fixed effect of i^{th} age group (I = 0PPI, 1PPI, 2PPI, 3PPI, 4PPI)

$\mathbf{S_j}$= the fixed effect of j^{th} sex (j = female and male)

$\mathbf{D_k}$= the fixed effect of k^{th} district (K = Arbaminch-zuria and Mirab-abaya)

$\mathbf{(AS)_{ij}}$= the interaction effect of i^{th} age group and j^{th} sex

$\mathbf{e_{ijk}}$ = random residual error

3.5.2 Multiple regression model used for the estimation of body weight from linear body measurements for both males and females

Male:

$$\mathbf{Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots + \beta 12\ X_{12} + e_j}$$

Where:

$\mathbf{Y_j}$ = the response variable (body weight)

$\boldsymbol{\alpha}$ = the intercept

$\mathbf{X_1 \ldots, X_{12}}$ = the explanatory variables (BL, WH, CG, CD, RL, RW, HeL, HeW, MC, HoL, EL and **SC**)

$\boldsymbol{\beta_1 \ldots, \beta_{12}}$ = regression coefficients of the variables $\mathbf{X_1 \ldots, X_{12}}$

$\mathbf{e_j}$ = random error

Female:

$$\mathbf{Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots + \beta_{12} X_{12} + e_j}$$

Where:

$\mathbf{Y_j}$ = the dependent variable body weight

$\boldsymbol{\alpha}$ = the intercept

$\mathbf{X_1 \ldots, X_{12}}$ = independent variables (BL, WH, CG, CD, RL, RW, HeL, HeW, MC, HoL, EL and TL)

$\boldsymbol{\beta_1 \ldots, \beta_{12}}$ = regression coefficients of the variable $\mathbf{X_1 \ldots, X_{12}}$

$\mathbf{e_j}$ = random error

4. RESULTS

4.1 Farming system

Farmers in Arba-Minch Zuria district gave almost equal importance for both livestock and crop production where as crop farming slightly dominates in Mirab-Abaya (index= 0.52) as presented on Table 6. Major crop types produced in the study areas were banana, maize, teff, sorghum, mango and avocado.

Table 5: Farming systems in the study areas

Activities	Arba-Minch Zuria				Mirab-Abaya			
	R1	**R2**	**R3**	**Index**	**R1**	**R2**	**R3**	**Index**
Farming activity								
Livestock	33	27	-	0.50	30	30	-	0.48
Crop	33	27	-	0.50	42	18	-	0.52

Index= sum of (3 X farming system ranked first + 2 X farming system ranked second + 1 X farming system ranked third) given for each activity divided by sum of (3 X farming system first + 2 X farming system ranked second + 1 X farming system ranked third) for all farming systems.

4.2 Livestock composition

As it was presented in Table 7, cattle, goat and poultry were ranked 1st, 2nd and 3rd respectively. Sheep was the lowest livestock species kept in both districts. However, 75.44% the respondents said that goat keeping trend is increasing as compared to cattle (Table 9).

Table 6: Livestock structure and composition in the study areas

Livestock Species Owned	Arba-Minch Zuria				Mirab-Abaya			
	R1	R2	R3	Index	R1	R2	R3	Index
Cattle	44	16	-	0.45	42	18	-	0.44
Goat	26	34	-	0.40	37	23	-	0.42
Poultry	-	-	48	0.13	-	-	48	0.13
Sheep	-	-	9	0.03	-	-	3	0.08

Index= sum of (3 X livestock species ranked first + 2 X livestock species ranked second + 1 X livestock species ranked third) given for each livestock species divided by sum of (3 X livestock species first + 2 X livestock species ranked second + 1 X livestock species ranked third) for all livestock species.

4.3 Goat flock structure and composition

Goat flock structure and composition in the study area by their sex and age category were presented in Table 8. The overall mean size of breeding doe, doe kid, breeding buck, buck kid, wether, male and female kids were 5.12, 2.00, 0.27, 0.43, 0.29, 1.00 and 1.49, respectively. Farmers in the study districts keep more females than males.

Table 7: **G**oat flock structure and composition in the study areas

Goat Flock Structure	Flock Composition	Arba-Minch Zuria		Mirab-Abaya		Overall	
		Mean(STD)	**%**	**Mean(STD)**	**%**	**Mean(STD)**	**%**
Female	Breeding Doe (>1year)	4.95(2.35)	48.37	5.28(2.64)	48.18	5.12(2.49)	48.27
	Doe kids(0.5-1 year)	1.97(1.10)	19.22	2.03(1.13)	18.54	2.00(1.12)	18.87
Male	Breeding Buck (>1 year)	0.25(0.44)	2.44	0.28(0.45)	2.58	0.27(0.44)	2.52
	Buck kids (0.5-1year)	0.37(0.49)	3.58	0.50(0.57)	4.56	0.43(0.53)	4.09
	Wether	0.33(0.48)	3.26	0.25(0.44)	2.29	0.29(0.46)	2.75
Kid	Male kids (<0.5year)	0.82(0.75)	7.98	1.18(0.95)	10.79	1.00(0.87)	9.43
	Female kids (<0.5year)	1.55(1.03)	15.15	1.43(0.96)	13.07	1.49(0.99)	14.07
Flock per household						10.6(6.9)	100

Means on the same row were not significantly different (P>0.05)

N= Number of observation, **STD**= Standard Deviation

Table 8: Trend of goat keeping practices in the study areas

	District					
Status	**Arba-Minch Zuria**		**Mirab-Abaya**		**Overall**	
	N	**%**	**N**	**%**	**N**	**%**
Increasing	41	73.24	45	77.59	86	75.44
Stable	9	16.07	8	13.79	17	14.91
Decreasing	6	10.71	5	8.62	11	9.65

N= Number of observation, **%** = percent

4.4 Purpose of goat keeping

The relative purposes for keeping goat are related to the farmers need in the long or short term. In Arba-Minch Zuria district, goats were primarily preferred for generating income (index= 0.46) (for emergency cases) and saving (index= 0.41) (using goats as "village bank") where as the corresponding value in Mirab-Abaya district was 0.36 (Table 10). Goats were also kept for meat and breeding purposes in the study areas. Manure was largely preferable by-product in Mirab-Abaya (index= 0.11) than in Arba-Minch Zuria district (0.03) for fertilizer application on cultivating lands.

Table 9: Purpose of goat keeping in the study districts

Purpose of Goat Keeping	**Arba-Minch Zuria**				**Mirab-Abaya**			
	R1	R2	R3	**Index**	R1	R2	R3	**Index**
Income	47	12	-	0.46	46	14	-	0.36
Breeding	6	7	17	0.09	3	3	20	0.08
Meat	-	3	32	0.11	-	3	33	0.09
Manure	-	-	10	0.03	-	-	52	0.11
Saving	38	17	-	0.41	44	17	-	0.36

Index= sum of (3 X purpose of goat keeping ranked first + 2 X purpose of goat keeping ranked second + 1 X purpose of goat keeping ranked third) divided by sum of (3 X purpose of goat keeping first + 2 X purpose of goat keeping ranked second + 1 X purpose of goat keeping ranked third) for all purposes.

4.5 Goat breeding management

Goat owners in the study areas follow different breeding practices as indicated in Table 11. As respondents said, the sources of breeding buck were mainly from neighbor (75.28%) followed by own flock (24.72%). The major mating system practiced in the study areas was uncontrolled (80.83%) for the reasons of majority of goat flock mix-up (75.70%) followed by lack of awareness (14.02%) and lack of buck (10.28%). According to the respondents, about 65.83% of goat owners in the study areas practice goat castration by using modern burdizzo (51.02%) and traditional stone (48.98%) and castrate at the age of between 1.6-2 years (50 %) when castrated bucks were needed.

Farmers in the study areas have goat culling practice for breeding. About 93.33% of the households cull does for the reasons of their poor body condition (48.09%) followed by being old age (32.86%) were as about 57.50% of respondents reported that bucks were mainly culled due to disease (26.80%) after poor body condition (73.20%).

Almost all respondents said that goat keepers in the study areas do not practice artificial kid weaning mainly due to does themselves prevents when get conceived (66.46%) and difficulty to manage (64.71%) followed by lack of awareness (35.29%) and for better kid growth (33.54%). Kids in the study areas mostly wean naturally (60.00%) at the age of 5-6 months followed by 20.91% (3-4 months) and 19.09% (above 6 months).

According to the respondents, the frequent birth type occurring in the study area was single (66.67%) followed by twins (27.78%) and triples (5.56%).

Table 10: Goat breeding practices in the study areas

	Districts					
Breeding practices	Arba-Minch Zuria		Mirab-Abaya		Overall	
	N	%	N	%	N	%
Source of breeding buck						
Own flock	13	28.26	9	20.93	22	24.72
Neighbor	33	71.74	34	79.07	67	75.28
Mating System						
Uncontrolled	52	86.67	45	75.00	97	80.83
Partially Controlled	8	13.33	15	25.00	23	19.17
Reason of Uncontrolled Mating						
Goat Flock mix-up	32	78.05	49	74.24	81	75.70
Lack of Buck	3	7.32	8	12.12	11	10.28
Lack of Awareness	6	14.63	9	13.64	15	14.02
Castration						
Yes	41	68.33	38	63.33	79	65.83
No	19	31.67	22	36.67	41	34.17
Method of castration						
Modern	22	44.00	28	58.33	50	51.02
Traditional	28	56.00	20	41.67	48	48.98
Age of castration (year)						
1-1.5	10	26.32	11	34.37	21	30.00
1.6-2	19	50.00	16	50.00	35	50.00
Above 2	9	23.68	5	15.63	14	20.00

N= number of observations, **%**= percent

Table 11: continued….

Breeding practices	Arba-Minch Zuria		Mirab-Abaya		Overall	
	N	**%**	**N**	**%**	**N**	**%**
Female culling practice						
Yes	56	93.33	56	93.33	112	93.33
No	4	6.67	4	6.67	8	6.67
Reason of Female Culling						
Disease	22	20.18	18	17.82	40	19.05
Old age	35	32.11	34	33.66	69	32.86
Poor Body condition	52	47.71	49	48.52	101	48.09
Male culling practice						
Yes	38	63.33	31	51.67	69	57.50
No	22	36.67	29	48.33	51	42.50
Reason of Male Culling						
Disease	16	29.09	10	23.81	26	26.80
Poor Body appearance	39	70.91	32	76.19	71	73.20
Kid's artificial weaning practice						
Yes	-	-	-	-	-	-
No	100	100.00	100.00	100.00	100.00	100.00
Reason for not weaning						
For increased kid growth rate	25	23.58	28	27.18	53	33.54
Doe herself prevents when conceived	54	50.94	51	49.51	105	66.46
Difficulty to manage	15	14.15	18	17.48	33	64.71
Lack of awareness	12	11.32	6	5.83	18	35.29
Kids' weaning (month)						
3- 4	12	20.00	11	18.33	23	20.91
5-6	38	63.33	38	63.33	66	60.00
Above 6	10	16.67	11	18.33	21	19.09
Birth type						
Single	60	68.97	60	64.52	120	66.67
Twin	21	24.14	29	31.18	50	27.78
Triple	6	6.89	4	4.10	10	5.56

N= number of observations, **%**= percent

4.6 Goat breeding season

Goats showed their own breeding season in all study areas according to Figure 2. According to the respondents, the most frequent goat breeding season occurs between

September and January. Goat mating happens lower during March, April, July and August months.

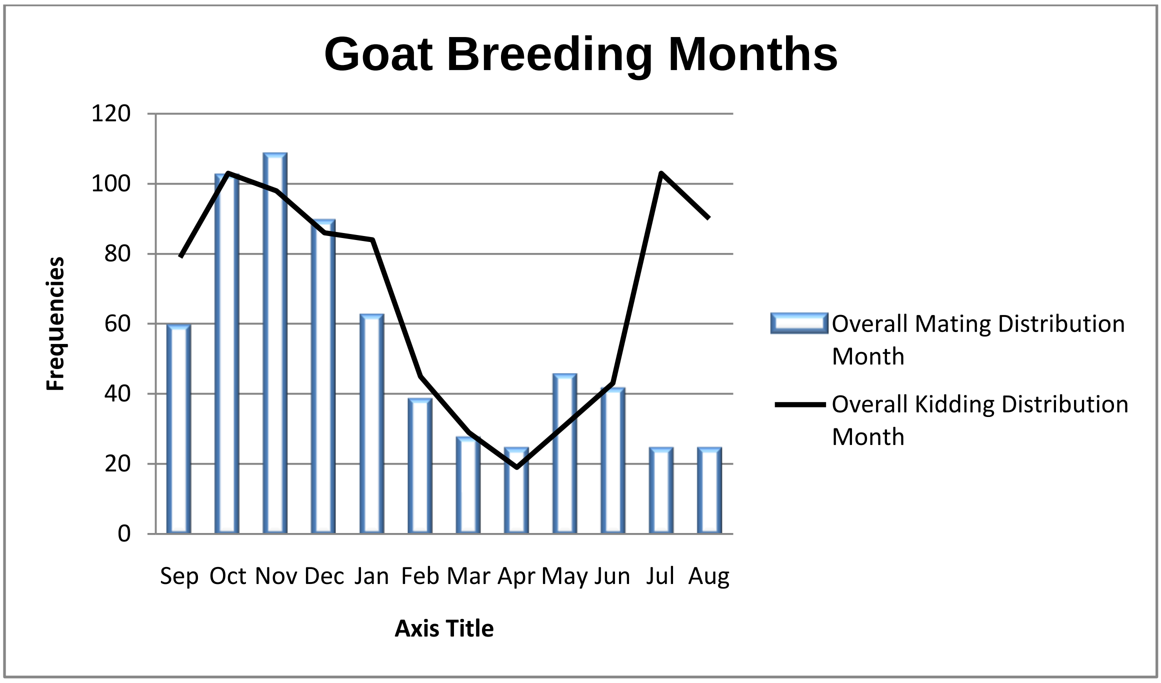

Figure 2: Goat breeding seasons in the study areas

4.7 Goat reproductive performances

The overall reproductive performance of the study goats was indicated in Table 12. According to the respondents' perception, mean age at first mating for females was 10.40 months whereas age at first service for bucks was 10.33 months. Age at first kidding and kidding interval were 15.67 and 6.48 (twice per year) months, respectively.

Table 11: The reproductive performances of goats in the study areas

Reproductive Traits	Arba-Minch Zuria Mean(STD)	Mirab-Abaya Mean (STD)	Overall Mean(STD)
Age at first mating for female/ month/	10.68(1.52)	10.22(1.62)	10.40(1.57)
Age at first service for buck / month/	10.48(1.61)	10.12(1.71)	10.33(1.66)
Age at first kidding / month/	15.81(1.62)	15.65(1.61)	15.67(1.61)
Kidding interval (Month)	6.45(0.65)	6.48(0.57)	6.48(0.61)

Means on the same row (for mean ±SE) were not significantly different (P>0.05)

STD= Standard Deviation

4.8 Selection criteria for breeding goats

As presented in Tables 13 and 14, respondents in all study areas preferred different traits of preference as selection criteria for both breeding does and bucks.

4.8.1 Breeding does selection criteria

Selection criteria for breeding doe in the study area are presented in Table 13. According to the respondents, body conformation (index=0.41), pedigree (0.29) and prolificacy (0.14) were the first three selection criteria in Arba-Minch Zuria district whereas the corresponding values in Mirab-Abaya district were (index= 0.43, 0.21 and 0.23). Udder size, coat color and kidding interval were also traits of preferences in Arba-Minch Zuria district, but doe udder size was not considered in Mirab-Abaya district. Pictures of breeding bcks and breeding does are indicated in Figure 3.

Table 12: Selection criteria for breeding does

Selection criteria	Arba-Minch Zuria				Mirab-Abaya			
	R1	R2	R3	Index	R1	R2	R3	Index
Body Conformation	60	-	-	0.41	60	-	-	0.43
Twinning Ability	8	15	13	0.14	10	28	10	0.23
Kidding Interval	-	8	4	0.05	-	-	12	0.03
Udder Size	-	12	-	0.06	-	-	-	-
Color	-	-	24	0.06	-	10	22	0.10
Pedigree	19	37	-	0.29	8	31	9	0.21

Index= sum of (3 X selection criteria ranked first + 2 X selection criteria ranked second + 1 X selection criteria ranked third) given for each trait divided by sum of (3 X selection criteria ranked first + 2 X selection criteria ranked second + 1 X selection criteria ranked third) for all traits.

Figure 3: Breeding buck and does in the study areas

4.8.2 Selection criteria for breeding bucks

According to the respondents (Table 14), farmers in Arba-Minch Zuria district select their breeding bucks' primary based on body conformation (index= 0.57), pedigree (0.22), color

(0.10), growth rate (0.05), horn shape (0.04) and scrotum size (0.02) in descending order. In case of Mirab-Abaya district, body conformation (index= 0.57), pedigree (0.19), color (0.17), growth rate (0.06) were also selection criteria in descending order.

Table 13: Selection criteria for breeding bucks

Selection criteria	**Arba-Minch Zuria**				**Mirab-Abaya**			
	R1	**R2**	**R3**	**Index**	**R1**	**R2**	**R3**	**Index**
Body Conformation	60	-	-	0.57	60	-	-	0.57
Growth rate	4	1	3	0.05	5	2	1	0.06
Horn shape	-	4	4	0.04	-	-	-	-
Scrotum Size	-	-	6	0.02	-	-	-	-
Color	-	8	16	0.10	-	15	24	0.17
Pedigree	12	13	7	0.22	7	12	7	0.19

Index= sum of (3 X selection criteria ranked first + 2 X selection criteria ranked second + 1 X selection criteria ranked third) given for each trait divided by sum of (3 X selection criteria ranked first + 2 X selection criteria ranked second + 1 X selection criteria ranked third) for all traits.

4.9 Feed resources

Goats in all study areas fed on various feed resources depending on locally available materials (Table 15). In descending order; communal browsing (index= 0.62), private browsing areas (0.23), aftermath feeding (0.11) and home leftovers (0.05) were the major goat feed resources in Arba-Minch Zuria district. Similar trends were also obtained in Mirab-Abaya district. Although there was goat feed shortage, respondents reported that goats can better maintain their body condition during the dry season by feeding on tree leaves' debris than cattle. However, months of January through March were known for the shortage of feed resources in the study areas (Figure 4).

Table 14: Major feed resources in the study areas

Feed resources	**Arba-Minch Zuria**				**Mirab-Abaya**			
	R1	**R2**	**R3**	**Index**	**R1**	**R2**	**R3**	**Index**
Communal browsing areas	49	11	-	0.60	45	15	-	0.62
Private browsing areas	11	16	1	0.23	15	23	-	0.34
Aftermath feeding	-	6	24	0.11	-	-	8	0.03
Home Leftovers	-	-	7	0.05	-	-	4	0.01

Index= sum of (3 X feed resources ranked first + 2 X feed resources ranked second + 1 X feed resources ranked third) given for each feed resource divided by sum of (3 X feed resources ranked first + 2 X feed resources ranked second + 1 X feed resources ranked third) for all feed resources.

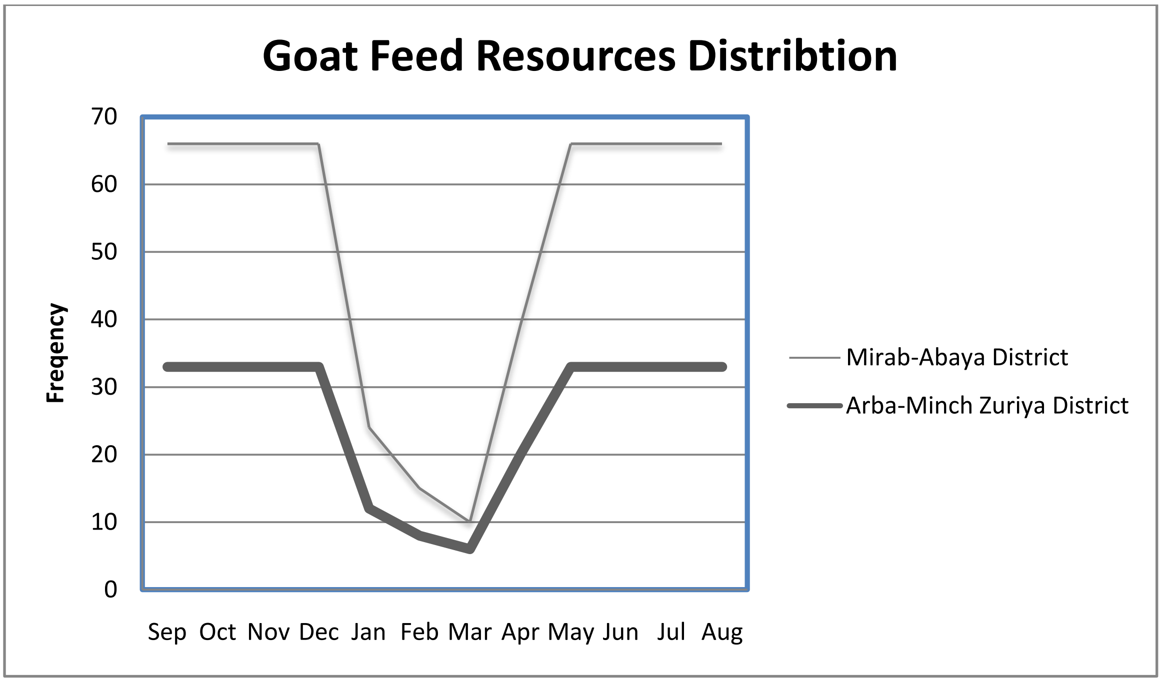

Figure 4: Goat feed resource distribution months in study areas

4.10 Goat Housing System

As it is indicated in Table 16, goat-housing systems in two districts do vary considerably. According to the respondents, all goats reared in Mirab-Abaya district were housed in sheltered either in separate house (91.67%) or yarded with cattle (8.33%) whereas about 40% of goats are provided with separate house in Arba-Minch Zuria district and the rest were outdoor. Leaving goats outdoor in Arba-Minch Zuria district was a common practice. Pictures indicating types of goats' houses are indicated in Figure 5.

Table 15: Goat housing systems in study areas

Type of Housing	Arba-Minch Zuria		Mirab-Abaya		Overall	
	N	%	N	%	N	%
Separate house	24	40.00	55	91.67	69	62.72
Yarded with cattle	-	-	5	8.33	5	4.55
No shelter	8	13.33	-	-	8	7.27
Sheltered aside main house	15	25.00	-	-	15	13.64
Open barn	13	21.67	-	-	13	11.82

Figure 5: Goat houses in Mirab-Abaya and Arbaminch-Zuria districts (left to right).

4.11 Marketing of Goat

In view of the fact that the study areas were situated along with the main roadside, there was a formal goat market established (Shelle market in Arbaminch-Zuria district while Mirab market in Mirab-Abaya district) (Table 17). About 80% of the goat market was targeted the local markets while the remaining 20% was at regional markets like Wolaita. About 94.17% of the respondents said male goats have higher off-take rate at early age of

(7-12 months) than females (82.50%). Yearling goats were the first class of animals to be sold to cover immediate cash needs.

Table 16: Goat marketing age and market targeted in the study areas

Market		**Arba-Minch Zuria**		**Mirab-Abaya**		**Overall**	
		N	**%**	**N**	**%**	**N**	**%**
Market targeted							
Regional		24	28.57	6	9.10	30	20.00
Local		60	71.43	60	80.90	120	80.00
Market Age (month)							
Male	7-12	56	93.33	57	95.00	113	94.17
	Above 12	4	6.67	3	5.00	7	5.83
Female	7-12	49	81.67	50	83.33	99	82.50
	Above 12	11	8.33	10	16.67	21	17.50

N= number of observations, **%**=percent

4.12 Animal health management

4.12.1 Major goat diseases and parasites

As respondents said, there were different types of goat parasites infestation and infectious diseases affecting goat production in common across the study areas (Figure 6). Ecto-parasites like (ticks, mange and mites), respiratory disease like coughing and orf (Contagious ecthyma) were frequently occurring parasites and diseases of goat given that farmers keep large number of flocks together in the study areas.

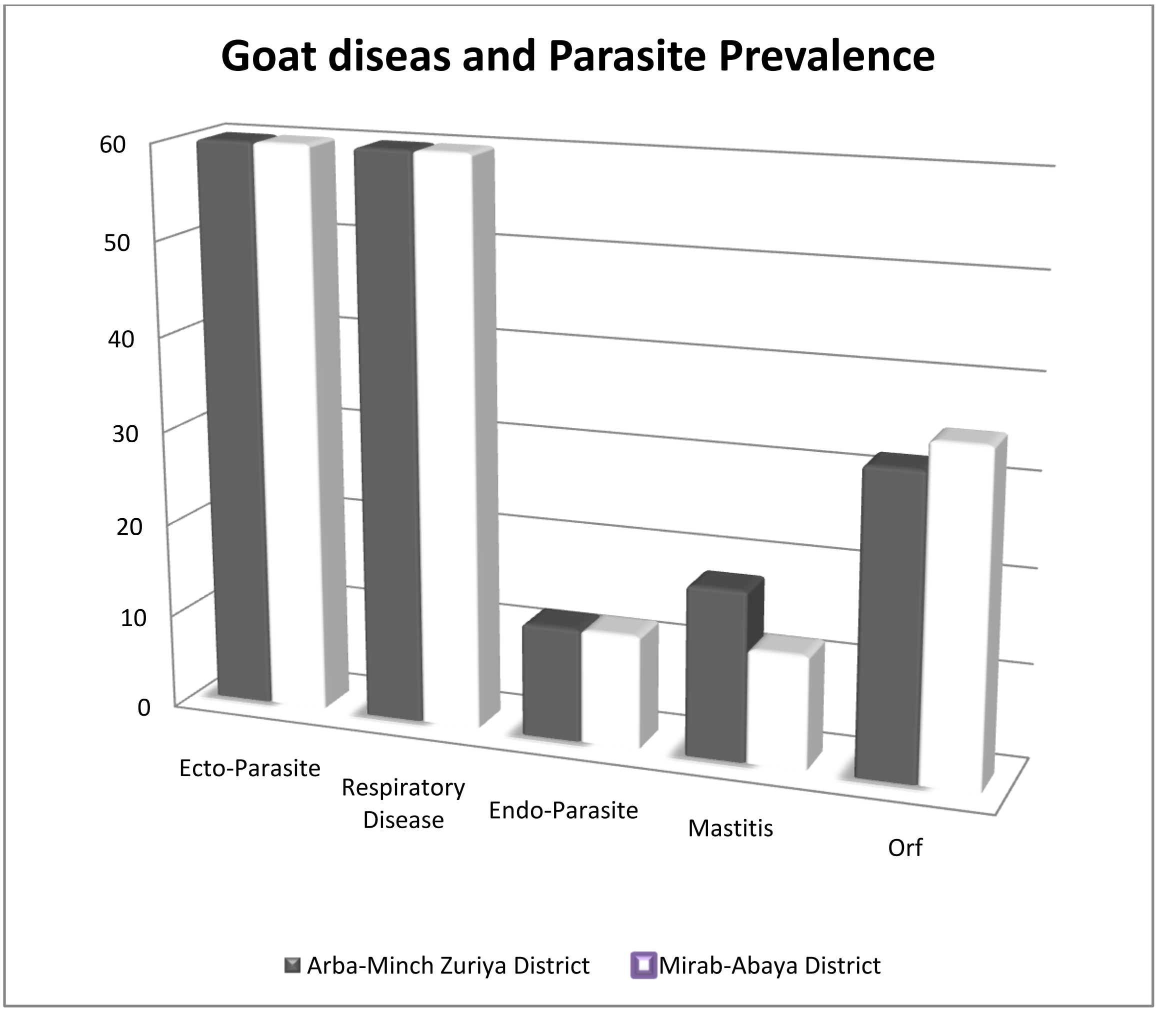

Figure 6: Goat diseases and parasites in study areas

4.12.2 Goat parasites' and diseases' prevention and control methods

Almost all respondents (100.00%) said that there was regular goat disease prevention and control system followed like treatment and vaccination in the study areas (Table 18). About 70.16%, 20.97% and 8.87% of the respondents said that they prevent and/or control when disease outbreaks occur, before disease outbreak and any time, respectively. Of the respondents, 75.00%, 14.38% and 10.62% said that they get medicine from government animal health clinics, traditional healers and private Veterinary house, respectively.

Table 17: Major goat disease's prevention and control method and source of medication in the study areas

	Arba-Minch Zuria		Mirab-Abaya		Overall	
	N	**%**	**N**	**%**	**N**	**%**
Disease Prevention and Control						
Yes	60	100.00	60	100.00	120	100.00
No	-	-	-	-	-	-
Period of Prevention and Control						
When disease out brake occur	47	75.81	40	64.52	87	70.16
Any time in a year	7	11.29	4	6.45	11	8.87
Before disease outbreak	8	12.90	18	29.03	26	20.97
Source of Medicine						
Animal health clinic	60	70.59	60	80.00	120	75.00
Private Veterinary house	12	14.12	5	6.67	17	10.62
Traditional healers	13	15.29	10	13.33	23	14.38

N= number of observations, **%**=percent

4.13 Goat production constraints

There were area specific goat production constraints as illustrated in Table 19. According to the respondents, feed shortage (30.37%) followed by labor limitation (23.33%) and land shortage (15.56%) were the major goat production challenges identified in the study areas. However, land limitation (23.02%) was the second most constraint after feed shortage in Arba-Minch Zuria district where as labor shortage (25.19%) in Mirab-Abaya district accordingly. Disease (12.59%), drought (7.78%), predator (5.92%) like monkey against kids and thief (4.44%) against breeding does and bucks were also some challenging issues in the study areas. Water limitation was found to be not a big challenge across the study areas.

Table 18: Goat production constraints in the study areas

	Districts					
Constraints	**Arba-Minch Zuria**		**Mirab-Abaya**		**Overall**	
	N	**%**	**N**	**%**	**N**	**%**
Feed	42	30.22	40	30.53	82	30.37
Labor	30	21.58	33	25.19	63	23.33
Land	32	23.02	10	7.63	42	15.56
Disease	14	10.07	20	15.27	34	12.59
Water		-		-		-
Drought	6	4.32	15	11.45	21	7.78
Predator	7	5.04	9	6.87	16	5.92
Thief	8	5.75	4	3.05	12	4.44

N= number of observations, **%**=percent

4.14 Phenotypic characterization of goats in the study areas

4.14.1 Qualitative traits

About eleven qualitative traits were used for indigenous goats' characterization in both districts as illustrated in Table 20. The most frequent coat color patterns of male and female goats across both districts were plain, patchy and spotted in descending order. The predominant coat color patterns observed across the study districts were plain for male (63.82%) and (70.02%) for females followed by patchy for male (26.32%) and (19.06%) for females. The predominant coat color types observed across the study districts were brown for male (32.24%) and (34.05%) for females followed by black for male (20.39%) and (23.06%) for females and black dominant for male (14.47%) and (11.42%) for females. From the findings, goats with horned were (86.84% for males and 94.55% for females), with toggle (14.47% for males and 9.85% for females), with beard (53.29% for males and 22.06% for females), present with ruff (9.21% for males and 11.13% for females) across all study districts. Pictures depicting goat population indicated in Figure 7.


Figure 7: Goat population in the study areas

The predominant horn shape across the study districts were straight (93.13% for males and 93.11% for females) followed by curved (6.87% for males and 6.89% for females). About 61.83% of male and 78.95% of female goats were characterized by possessing obliquely upward and 32.82% of male and 18.55% of female goats possess obliquely backward horn orientation. Regarding to the ear orientation, 83.55% of male and 79.33% of female goats were characterized by horizontal where as 9.21% of male and 10.33% of female goats possess semi-pendulous ear orientations. From the study districts, 75.66% of male and 80.73% of female goats showed straight head profile followed by 18.42% of male and 5.14% of female goats possess slightly concave head profile. About 60.16% and 38.34% of the bucks possessed single and partially-split scrotum types, respectively.

Table 19: Qualitative traits of goats in the study areas

Qualitative traits	**Arba-Minch Zuria**		**Mirab-Abaya**		**Overall**	
	Male N (%)	**Female N (%)**	**Male N (%)**	**Female N (%)**	**Male N (%)**	**Female N (%)**
Coat color pattern						
Plain	37(52.86)	141(61.84)	60 (73.17)	186(77.82)	97(63.82)	327(70.02)
Patchy	27(38.57)	67(29.39)	13(15.85)	22(9.01)	40(26.32)	89(19.06)
Spot	6(8.57)	20(8.77)	9(1.09)	31(12.97)	15(9.87)	51(10.92)
Coat color type						
White	10(18.52)	15(6.64)	7(8.54)	28(11.76)	17(11.18)	43(9.27)
Brown	10(18.52)	47(20.79)	39(47.56)	111(46.64)	49(32.24)	158(34.05)
Grey	5(9.26)	28(12.39)	0(0.00)	3(1.26)	5(9.62)	31(6.68)
Black	17(31.48)	60(26.55)	14(17.07)	47(19.75)	31(20.39)	107(23.06)
White Dominant	4(7.41)	20(8.85)	12(14.63)	29(12.18)	16(10.53)	49(10.56)
Brown Dominant	10(18.52)	16(7.08)	2(2.44)	7(2.94)	12(7.89)	23(4.96)
Black Dominant	14(25.93)	40(17.69)	8(9.76)	13(5.46)	22(14.47)	53(11.42)
Horn presence						
Present	59(84.29)	214(93.86)	73 (89.02)	233(97.49)	132(86.84)	347(94.55)
Absent	11(15.71)	14(6.14)	9 (10.98)	6(2.51)	20(13.16)	20(4.45)
Toggle						
Present	14(20.00)	25(10.97)	8 (9.76)	21(8.79)	22(14.47)	46(9.85)
Absent	56(80.00)	203(89.03)	74 (90.24)	218(91.21)	130(85.53)	421(90.15)
Beard						
Present	39(55.71)	44(19.29)	42 (51.22)	59(24.69)	81(53.29)	103(22.06)
Absent	31(44.29)	184(80.71)	40 (48.72)	180(75.31)	71(46.71)	364(77.94)

Table 20: continued...

Qualitative traits	Arba-Minch Zuria		Mirab-Abaya		Overall	
	Male N (%)	**Female N (%)**	**Male N (%)**	**Female N (%)**	**Male N (%)**	**Female N (%)**
Ruff						
Present	14(20.00)	45(19.74)	0 (0.00)	7(2.93)	14(9.21)	52(11.13)
Absent	56(80.00)	183(79.36)	82 (100.00)	232(96.07)	138(90.79)	415(88.87)
Horn Shape						
Straight	2(3.39)	12(5.61)	7(9.72)	12 (5.15)	9 (6.87)	24 (6.89)
Curved	57(96.61)	202(94.39)	65(90.28)	221 (94.85)	122 (93.13)	324 (93.11)
Horn Orientation						
Lateral	1(1.69)	12(5.61)	6(8.33)	9 (3.86)	7 (5.34)	11 (2.52)
Obliquely Upward	38(64.41)	165(77.10)	43(59.72)	180 (77.25)	81 (61.83)	345 (78.95)
Obliquely Backward	20(33.89)	37(17.29)	23(31.94)	44 (18.88)	43 (32.82)	81 (18.55)
Ear Orientation						
Erect	0(0.00)	0(0.00)	11(13.42)	34 (14.23)	11(7.24)	34(10.33)
Carried-Horizontal	59(84.29)	206(90.35)	68(82.93)	193 (80.75)	127(83.55)	261(79.33)
Semi-Pendulous	11(15.71)	22(9.65)	3(3.66)	12 (5.02)	14(9.21)	34(10.33)
Head Profile						
Straight	45(64.29)	152(66.67)	70(85.37)	225 (94.14)	115(75.66)	377(80.73)
Slightly Concave	4(5.71)	54(23.68)	5(6.09)	12 (5.02)	9(5.92)	66(14.13)
Slightly Convex	21(30.00)	22(9.65)	7(8.54)	2 (0.84)	28(18.42)	24(5.14)
Scrotum Type						
Single	31(62.00)	-	46(58.97)	-	77(60.16)	-
Partially Split	19(38.00)	-	32(41.03)	-	51(38.84)	-

4.14.2 Live body weight and linear body measurement traits

The overall body weight and linear body measurements and the effect sex, district, age and sex by age interaction of the study goat population were presented in Table 21.

Sex effect: Body weight, body length, rump length, head width and horn length were significantly affected by sex ($P<0.05$) whereas height at withers, chest girth, chest depth, rump width, head length, muzzle circumference and ear length were not significantly affected ($P>0.05$). Except for body length, males possessed higher linear body measurement values than females.

District effect: There was significant difference in linear body measurements between districts. Body linear measurements except height at withers and muzzle circumference were significantly affected across study areas ($P<0.05$). Goats in Arbaminch-Zuriya district possessed higher values on body weight, body length, chest girth, rump width, head width and scrotum circumference. In other cases, the measurements of chest depth, rump length, head length, horn length, ear length and teat length were higher in Mirab-Abaya goat populations ($P<0.05$).

Age effect: Age had significant effect on all linear body measurements ($P<0.05$). These linear body measurements increase when the goats get older (Table 21).

Sex by age interaction: The interaction effect of sex by age is significant for all linear measurements ($P<0.05$). Except body length, aged males possessed higher values on linear body measurements than females in general ($P<0.05$).

Table 20: Quantitative traits (Mean ±SD) of indigenous goats in the study areas

Parameters	BW	BL	WH	CG	CD	RL	RW…
Overall means	29.9±4.33	62.2±8.23	60.6±5.39	68.7±7.02	44.4±5.75	16.7±2.80	15.8±2.36
CV	12.69	11.25	8.33	8.91	10.77	13.33	13.72
R^2	0.25	0.29	0.14	0.26	0.32	0.38	0.18
Sex	*	*	NS	NS	NS	*	NS
Male	30.2±5.61^{a}	57.2±8.86^{b}	60.0±6.11	68.4±8.39	44.7±6.68	17.2±3.37^{a}	15.5±2.69
Female	29.8±3.83^{b}	63.8±8.25^{a}	60.4±5.13	68.8±6.51	44.3±5.42	16.6±2.58^{b}	15.8±2.24
District	*	*	NS	*	*	*	*
A.Zuriya	30.4±4.45^{a}	65.0±9.41^{a}	60.4±5.74	71.4±5.81^{a}	41.9±6.00^{b}	15.7±2.93^{b}	16.4±2.34^{a}
M.Abaya	29.5±4.19^{b}	59.6±4.92^{b}	60.7±5.06	66.3±7.16^{b}	46.7±4.41^{a}	17.7±2.32^{a}	15.2±2.32^{b}
Age	*	*	*	*	*	*	*
0PPI	25.4±3.86^{e}	54.4±7.30^{d}	55.9±5.44^{d}	65.1±5.70^{d}	41.6±6.53^{d}	15.9±2.26^{c}	15.1±2.56^{ab}
1PPI	27.7±3.23^{d}	60.4±9.01^{c}	58.7±4.78^{c}	67.7±5.37^{c}	43.4±5.78^{c}	16.4±2.93^{ab}	15.5±2.32^{ab}
2PPI	28.9±3.60^{c}	61.2±8.15^{b}	60.0±5.24^{b}	67.1±6.22^{c}	44.2±6.31^{b}	16.5±3.08^{ab}	15.8±2.38^{ab}
3PPI	30.5±3.94^{b}	63.8±8.32^{a}	61.3±5.71^{a}	68.4±7.48^{b}	45.8±5.01^{a}	17.2±2.56^{a}	16.0±2.61^{a}
4PPI	31.3±4.59^{a}	63.0±7.13^{a}	61.6±4.67^{a}	70.9±6.99^{a}	43.9±5.68^{c}	16.5±2.70^{ab}	15.7±2.01^{ab}
Sex by Age	*	*	*	*	*	*	*
Female,0PPI	27.8±4.97^{d}	60.4±10.08^{e}	54.6±5.29^{g}	65.0±5.88^{f}	46.4±4.21^{a}	17.0±2.83^{bc}	15.8±2.44^{b}
Female,1PPI	27.3±3.29^{d}	64.4±9.87^{b}	57.0±5.35^{e}	67.5±5.62^{e}	42.6±4.82^{c}	16.4±2.64^{c}	15.7±2.15^{b}
Female,2PPI	28.8±3.46^{c}	62.7±8.38^{cd}	59.8±5.39^{d}	66.9±5.31^{c}	43.9±6.44^{c}	16.0±2.92^{cd}	15.6±2.30^{b}
Female,3PPI	29.9±3.43b^{c}	65.1±8.66^{a}	60.7±5.27^{c}	68.3±6.87^{d}	45.4±4.78^{b}	16.9±2.26^{c}	16.1±2.44^{a}
Female,4PPI	30.8±4.03^{c}	63.2±7.26^{bc}	61.4±4.39^{b}	70.6±6.47^{b}	43.7±5.39^{c}	16.5±2.62^{c}	15.7±2.02^{b}
Male,0PPI	24.8±3.29^{e}	52.7±5.39^{i}	56.2±5.53^{f}	65.1±5.76^{f}	40.3±6.49^{d}	15.7±3.37^{d}	14.9±2.62^{c}
Male,1PPI	28.2±3.13^{c}	55.5±4.34^{h}	60.7±3.01^{c}	67.9±5.14$_{e}$	44.4±6.73^{c}	16.5±3.30^{c}	15.3±2.55^{b}
Male,2PPI	29.4±4.02^{bc}	56.7±5.40^{g}	60.7±4.78^{c}	67.5±8.48^{e}	44.9±5.94^{c}	17.9±3.17^{ab}	16.1±2.60^{a}
Male,3PPI	32.6±4.71^{b}	59.7±5.35^{f}	63.2±6.67^{a}	69.0±9.22^{c}	46.9±5.56^{a}	18.2±3.17^{a}	16.1±4.02^{a}
Male,4PPI	36.1±6.91^{a}	60.9±5.37^{e}	63.8±6.59^{a}	74.2±10.68^{a}	45.8±7.96^{ab}	16.7±3.51^{bc}	15.4±1.85^{ab}

BW=body weight, **BL**=body length, **WH**=wither height, **CG**=chest girth, **CD**=chest depth, **RL**=rump length, **RW**=rump width

Note: all linear measurements except body weight (Kg) were measured by cm.

Table 21: Cont'd…

…Effect and level	HeL	HeW	MC	HoL	EL	TL	SC
	LSM±SD	LSM±SD	LSM±SD	LSM±SD	LSM±SD	LSM±SD	LSM±SD
Overall	18.9±1.90	14.5±2.49	20.7±2.23	10.4±3.60	13.5±1.99	3.2±0.64	20.9±3.19
CV	9.26	13.71	10.39	30.24	12.42	18.50	12.06
R^2	0.17	0.38	0.09	0.26	0.30	0.14	0.41
Sex	NS	*	NS	*	NS	NS	NS
Male	18.8±2.21	15.4±2.91^{a}	20.9±2.64	11.9±4.13^{a}	13.5±2.04	-	20.9±3.19
Female	18.9±1.78	14.2±2.26^{b}	20.7±2.08	9.9±3.29^{b}	13.5±1.97	3.2±0.64	-
District	*	*	NS	*	*	*	*
A.Zuriya	18.8±1.79^{b}	15.6±2.45^{a}	20.8±1.75	9.8±3.78^{b}	12.6±1.71^{b}	3.1±0.69^{b}	21.6±3.54^{a}
M.Abaya	19.0±1.99^{a}	13.5±2.08^{b}	20.6±2.59	10.9±3.33^{a}	14.3±1.88^{a}	3.4^{a}±0.56^{a}	20.6±2.88^{b}
Age	*	*	*	*	*	*	*
0PPI	17.4±1.95^{c}	13.7±1.79^{bc}	19.7±1.73^{c}	7.8±3.66^{d}	12.5±2.13^{b}	2.6±0.52 ^{b}	19.5±3.41^{c}
1PPI	18.4±1.89^{b}	15.9±3.08^{a}	20.5±2.07^{ab}	8.4±3.02^{c}	13.1±1.83^{ab}	2.8±0.70 ^{b}	21.6±2.30^{ab}
2PPI	18.7±1.92^{b}	14.6±2.58^{b}	20.2±2.27^{bc}	10.0±3.41^{b}	13.3±1.91^{ab}	3.1±0.66 ^{a}	20.2±2.57^{bc}
3PPI	19.3±1.92^{a}	14.6±2.49^{b}	20.9±2.13^{ab}	10.5±3.47^{b}	13.6±2.04^{a}	3.4±0.57 ^{a}	21.6±3.53^{ab}
4PPI	19.1±1.68^{a}	15.4±3.09^{a}	21.1±2.33^{a}	11.4±3.58^{a}	13.9±1.91^{a}	3.3±0.62 ^{a}	22.5±3.02^{a}
Sex by Age	*	*	*	*	*	NS	NS
Female,0PPI	18.5±1.93^{b}	15.8±3.11^{b}	20.0±2.08^{b}	5.0±0.82^{i}	12.9±2.69^{c}	2.6±0.52 ^{b}	-
Female,1PPI	18.5±1.82^{b}	14.5±2.77^{bc}	19.9±1.58^{c}	6.8±2.44^{h}	12.8±1.76^{c}	2.8±0.70 ^{b}	-
Female,2PPI	18.5±1.97^{b}	14.4±2.51^{bc}	19.7±1.92^{c}	9.4±3.14^{f}	13.2±1.86^{b}	3.1±0.66 ^{a}	-
Female,3PPI	19.3±1.82^{a}	14.6±2.34^{bc}	20.9±1.84^{ab}	9.8±3.01^{f}	13.3±2.05^{b}	3.4±0.57 ^{a}	-
Female,4PPI	19.0±1.59^{a}	13.6±1.75^{d}	21.0±2.26^{a}	11.0±3.23^{d}	13.9±1.88^{b}	3.3±0.62 ^{a}	-
Male,0PPI	17.0±1.86^{c}	16.1±3.12^{a}	19.6±1.66^{c}	8.4±3.75^{g}	12.4±1.99^{c}	-	19.5±3.41^{c}
Male,1PPI	18.3±1.99^{b}	16.5±3.13^{a}	21.2±2.39^{a}	10.4±2.47^{e}	13.5±1.89^{b}	-	21.6±2.30^{ab}
Male,2PPI	19.3±1.66^{a}	15.2±2.73^{ab}	20.1±3.27^{b}	12.0±3.52^{c}	13.5±2.09^{b}	-	20.2±2.57^{bc}
Male,3PPI	19.3±2.22^{a}	14.8±2.94^{bc}	20.8±2.89^{ab}	13.2±3.64^{b}	14.4±1.84^{a}	-	21.6±3.53^{ab}
Male,4PPI	19.8±2.34^{a}	14.8±1.82^{bc}	21.8±2.84^{a}	14.6±5.03^{a}	13.2±2.04^{ab}	-	22.5±3.02^{a}

HeL=head length, **HeW**=head width, **MC**=muzzle circumference, **HoL**=horn length, **EL**=ear length, **TL**= teat length and **SC**=scrotum circumference **Note:** all linear measurements except body weight (Kg) were measured by cm.

4.14.3 Correlation between body weight and linear body measurements

The Pearson's correlation coefficient depicted very weak to strong correlations between body weight and linear body measurements for male and female separately as illustrated in Table 22.

In males, positive and strong association were depicted between body weight and body length (r=0.68), wither height (r=0.62), chest girth (r=0.61) and horn length (r=0.63). Rump width (r=0.39), muzzle circumference (r=0.38) and head length (r=0.39) have moderate and positively correlated with body weight. Chest depth (r=0.29), rump length (r=0.19) and head width (r=0.16 have weak and positively correlated with body weight.

In case of females, positive and moderate association were found between body weight and chest girth (r=0.38), rump width (r=0.37) and head length (r=0.31). Muzzle circumference (r=0.25), chest depth (r=0.22), horn length (r=0.28), body length (r=0.24), wither height (r=0.29), rump length (r=0.23) and head width (r=0.21) have weak and positively correlated with body weight.

For both sexes, ear length was not significantly correlated with body weight (P>0.05).

Table 21: Coefficient of correlation between body weight and linear body measurements in goats

(Above diagonal for Male and below diagonal for Female)

	BW	BL	WH	CG	CD	RL	RW	HeL	HeW	MC	HoL	EL
BW		0.68^{*}	0.62^{*}	0.61^{*}	0.29^{*}	0.19^{*}	0.39^{*}	0.39^{*}	0.16^{*}	0.38^{*}	0.63^{*}	0.15^{NS}
BL	0.24^{*}		0.38^{*}	0.37^{*}	0.29^{*}	0.27^{*}	0.38^{*}	0.28^{*}	0.09^{NS}	0.27^{*}	0.34^{*}	0.17^{*}
WH	0.29^{*}	0.02^{NS}		0.54^{*}	0.18^{*}	0.19^{*}	0.34^{*}	0.51^{*}	0.21^{*}	0.45^{*}	0.59^{*}	0.17^{*}
CG	0.38^{*}	0.35^{*}	0.27^{*}		0.02^{NS}	-0.03^{NS}	0.22^{*}	0.34^{*}	0.26^{*}	0.49^{*}	0.58^{*}	0.08^{NS}
CD	0.22^{*}	-0.01^{NS}	0.24^{*}	-0.17^{*}		0.62^{*}	0.29^{*}	0.23^{*}	0.11^{NS}	0.14^{NS}	-0.02^{NS}	0.16^{NS}
RL	0.23^{*}	-0.02^{NS}	0.26^{*}	-0.04^{NS}	0.61^{*}		0.59^{*}	0.47^{*}	0.26^{*}	0.22^{*}	0.02^{NS}	0.15^{NS}
RW	0.37^{*}	0.41^{*}	0.16^{*}	0.37^{*}	0.14^{*}	0.16^{*}		0.36^{*}	0.59^{*}	0.35^{*}	0.11^{NS}	-0.10^{NS}
HeL	0.31^{*}	0.19^{*}	0.18^{*}	0.12^{*}	0.33^{*}	0.44^{*}	0.36^{*}		0.18^{*}	0.38^{*}	0.39^{*}	0.09^{NS}
HeW	0.21^{*}	0.47^{*}	-0.04^{*}	0.17^{*}	0.16^{*}	0.13^{*}	0.52^{*}	0.32^{*}		0.21^{*}	0.00^{NS}	-0.11^{NS}
MC	0.25^{*}	0.11^{*}	0.18^{*}	0.39^{*}	0.11^{*}	0.14^{*}	0.22^{*}	0.34^{*}	0.19^{*}		0.32^{*}	0.09^{NS}
HorL	0.28^{*}	-0.11^{*}	0.35^{*}	0.04^{NS}	0.18^{*}	0.22^{*}	0.02^{NS}	0.11^{*}	-0.09^{NS}	0.08^{NS}		0.27^{*}
EL	0.05^{NS}	-0.38^{*}	0.17^{*}	-0.16^{*}	0.11^{*}	0.18^{*}	-0.24^{*}	0.09^{*}	-0.41^{*}	-0.05^{NS}	0.23^{*}	

BW=Body weight, **BL**= Body length; **HW**= Height at whither; **CG**=Chest girth; **CD**=Chest Depth; **RL**= Rump Length; **RW**= Rump Wedth; **HeL**=Head Length; **HeW**=Head Width; **MC**=Muzzle Circumference; **HoL**=Horn Length; **EL**= Ear length; **SC**=Scrotum Circumference

* Correlation is significant at the 0.05, **NS** =Correlation is not significant at the 0.05

4.14.4 Prediction of body weight from linear body measurements

In order to predict body weight from linear measurements, multiple regressions procedure was carried out for female and male separately based on independent variables which had positive correlation with body weight as presented in Table 23. In this study, regression equation was developed for estimation of body weight of females using seven linear body measurements (BL, WH, CG and CD, RW, HoL and EL) and for males by using four linear measurements (BL, WH, CG and CD). The results of the stepwise multiple regression analysis revealed that chest girth was the single variable of utmost importance in the prediction of live body weight in females where as body length in males. However, the prediction of live weight increased as the variables increased for both sexes.

The estimated regression model of male and females for predicting the mean body was given as follows.

BW= -27.20+0.42BL+0.25WH+0.19CG+0.09CD **for male**

BW= -6.98+0.04BL+0.07WH+0.17CG+0.13CD +0.29RW +0.24HoL+0.24EL **for female**

Table 22: Regression of live body weight on different body measurements for does and bucks

Sex	Equation	Intercept	Regression coefficients							
		α	β1	β2	β2	β4	β5	β6	β7	R^2
Does	CG	14.58	0.22							0.14
	CG+CD	3.28	0.25	0.21						0.22
	CG+CD+RW	2.37	0.19	0.18	0.36					0.26
	CG+CD+RW+EL	-1.69	0.20	0.17	0.42	0.26				0.28
	CG+CD+RW+HeL+EL	-3.65	0.19	0.14	0.34	0.27	0.22			0.29
	WH+CG+CD+RW+HeL+EL	-5.07	0.06	0.18	0.13	0.33	0.26	0.19		0.29
	BL+WH+CG+CD+RW+HoL+EL	-6.98	0.04	0.07	0.17	0.13	0.29	0.24	0.24	0.30
Bucks										
	BL	-7.16	0.65							0.46
	BL+WH	-21.96	0.49	0.39						0.62
	BL+WH+CG	-24.72	0.45	0.27	0.18					0.67
	BL+WH+CG+CD	-27.20	0.42	0.25	0.19	0.09				0.68

BL=body length, **WH**=height at withers, **CG**=chest girth, **CD**=chest depth, **RW**= rump width, **HoL**=horn length and **EL**=ear length

4.14.5 Multivariate analysis

Multivariate discriminant analysis was also conducted using quantitative traits for does and bucks separately to distinguish significant discriminative traits as indicated in Table 24.

4.14.5.1 Stepwise discriminant analysis

The stepwise discriminant analysis procedure identified seven (CG, CD, RW, EL, HeL, WH and BL) most significant discriminating traits between does while it was four (BL, WH, CG and CD) in bucks. As depicted by the respective partial $R^2$and F-values; CG was found to have the highest discriminating power in does followed by CD, RW, EL, HeL, WH and BL in descending order. In the meantime, BL had the highest discriminating power in male followed by WH, CG and CD from the highest.

Table 23: Quantitative characters selected by stepwise discriminant analysis

Sex	Step	Variable Entered	Partial R^2	Model R-Square	F Value	Pr > F
Does	**1**	Chest Girth	0.1410	0.1410	75.34	<.0001
	2	Chest Depth	0.0846	0.2256	50.04	<.0001
	3	Rump Width	0.0359	0.2615	22.20	<.0001
	4	Ear Length	0.0168	0.2782	10.58	0.0012
	5	Head Length	0.0117	0.2900	7.52	0.0063
	6	Wither Height	0.0062	0.2962	4.00	0.0461
	7	Body Length	0.0065	0.3026	4.21	0.0408
Bucks						
	1	BodyLength	0.4582	0.4582	125.16	<.0001
	2	WitherHeight	0.1568	0.6150	59.86	<.0001
	3	ChestGirth	0.0515	0.6664	22.52	<.0001
	4	ChestDepth	0.0124	0.6788	5.59	0.0193

4.15 Goat oestrus synchronization in the study areas

4.15.1 Oestrous response and conception rates

About 85% of the does expressed oestrus within 55.68±19.92 hours after 2.5ml lutylase hormone administration/doe (Table 23). The overall conception or pregnancy rate of does was 81.67%. The rate of abortion found was 6.12% across the study areas.

Table 24: Overall goat performance of oestrus synchronization in study areas

Parameters	N	%
Total females presented for estrus synchronization	60	100.00
Does gave response to hormone injection	51	85.00
Does conceived	49	81.67
Does aborted	3	6.12

N= Number of observations, **%=** percent

4.15.2 Performance of synchronized does and kids

The productive and reproductive performances of the does across three kebeles were presented in Table 26. The overall mean initial body weight of females was 25.32±3.13 kg. The synchronized kids' overall mean birth weight recorded was 2.49±0.33 kg. The gestation length of does was 152.6±2.56 days whereas litter size was 1.31±0.46. The efficiency of pregtone® tool to diagnose early pregnancy before hormone administration was 100%. Figure 8 indicates where hormone administration and other activities were undertaken.

Table 25: The overall mean values for synchronized kids' and does performance in study areas.

Parameters	N	Mean	STD
Doe body weight (kg)	60	25.32	3.13
Birth Weight (Kg)	58	2.49	0.33
Male	33	2.60	0.33
Female	25	2.34	0.27
Gestation Length (day)	50	152.62	2.56
Oestrus response after hormone injection (hours)	51	55.68	19.92
Liter size	59	1.31	0.46

N=Number of observations, **STD**=Standard deviation

Figure 8: Hormonal synchronization of goat

4.15.3 Factors affecting oestrous response and conception rate

Doe body weight was found to be a significant factor (P<0.05) determining oestrous response to hormone treatment (Table 27). The regression analysis indicates that there would be 33.9% more chance of oestrous response for an increase of one kg in body weight. Conception rate was found to be not significantly affected by body weight (P>0.05).

Across the study sites, there is no statistically significant difference for both hormonal response and conception rate (P>0.05). On a parity of 0-5, does of parity between 0-4 have showed significantly higher difference for both hormonal response and conception rate than those of parity 5 does. Body condition score has been found to significantly influence oestrous response to hormone treatment and conception rate. In the current study, does with body condition score of 3 and 4 were more responsive and conceive compared to body condition of 2 (Table 28). Age has also significant effect on hormonal response and pregnancy rate. Does with four pairs of permanent incisors had showed higher oestrus response than lower age groups. Efficiency of conception rate was also revealed increased rate as age increased.

Table 26: Effect of body weight on oestrous response and conception rate of does

Reference category	β	Sig.	Exp (β)
Response	0.339	0.036	1.403
Conception	0.261	0.052	1.298

Table 27: Variation in oestrus rate to PGF2α and pregnancy rate in the study areas

	Number of Observations	Rate of Response of Does to PGF2α (%)	Pregnancy/Conception Rate (%)
Overall	**60**	**51(85.00)**	**49 (81.67)**
Sites		NS	NS
Chano-Dorga	20	17 (85.00)	17(85.00)
Fetele-Doronje	22	19 (86.36)	18(85.71)
Faragosa	18	15 (83.33)	14(77.78)
Parity		*	*
0	21	20(95.24)^{a}	19(90.48)^{a}
1	4	4 (100.00)^{a}	4(100.00)^{a}
2	5	5 (100.00)^{a}	5(100.00)^{a}
3	17	15 (88.23)^{a}	15(88.23)^{a}
4	7	7 (100.00)^{a}	6 (85.71)^{a}
5	6	0^{b}	0^{b}
BCS		*	*
2	12	6(50.00)^{b}	5(41.67)^{b}
3	32	30(93.75)^{a}	29(90.63)^{a}
4	16	15(93.75)^{a}	15(93.75)^{a}
Age		*	*
0PPI	8	8(100.00)^{a}	8(100.00)^{a}
1PPI	14	13(92.86)^{a}	12 (85.71)^{b}
2PPI	6	6(100.00)^{a}	6(100.00)^{a}
3PPI	17	17(100.00)^{a}	17(100.00)^{a}
4PPI	15	7(46.67)^{b}	6 (40.00)^{c}

Columns with different superscripts were statistically significant (P<0.05)

* Statistically significant (P<0.05), NS= statistically not significant (P>0.05)

5. DISCUSSION

5.1 Livestock production systems

The predominant farming system was mixed crop-livestock production system in both districts which agrees the finding of Hulunim (2014) in Bati areas. This disagreed with the work of Tsigabu (2015) who stated that the production systems were both pastoral and agro-pastoralist for Nuer goats in Gambela region. Major crop types produced in the study areas were banana, maize, teff, sorghum, mango and avocado which create good opportunities for livestock feed resource especially during dry seasons.

Goats were the second largest livestock population in number after cattle across the study areas. According to Fredu *et al*. (2009), livestock species which constitute the largest share in the value of livestock assets of a household are described as the principal animal.

The current study indicated that the trend of goat keeping was increasing. This may indicate that browsing land shortage (due to increasing land cultivation for crop) coupled with drought tolerant and high reproduction rate were enforcing goat owners to keep more goats per household than cattle.

The proportion of the different classes of goats reflects the management decision of the producers (Solomon *et al*., 2010). In this study, breeding does made a major share followed by doe kids greater than 6 months in all areas. The higher proportion of breeding females in the flock was in agreement with the findings of (Tesfaye, 2009; Belete, 2009). The higher proportion of adult females than other age groups indicates that there was a practice of retaining females for breeding purposes (Hulunim, 2014).

Indigenous goat breeds have a range of functions that differ from place to place. Identification of the reasons is prerequisite for deriving operational breeding goals (Hulunim, 2014). The study goats were primarily preferred for generating income and saving followed by breeding and meat across districts. This was analogous to the reports of

(Tesfaye, 2009; Grum, 2010, Ahmed *et al*., 2015) whereas disagrees the report of Mekete (2016) for Woyto-Guji goat in Nyangatom and Male districts of South Omo zone in which milk was primarily preferred. Additionally, manure is the most preferable by product in Mirab-Abaya district for as fertilizer application on cultivating lands. This would benefit farmers by reducing costs related to the purchase of artificial fertilizer.

Although more than half number (75.28%) of breeding bucks was obtained from neighbors, back scarcity was not a serious problem in the current sites. Dhaba *et al.* (2013) has also reported almost similar finding that 26% of farmers in Ilu Abba Bora zone of western Ethiopia had their own breeding bucks. The most frequent mating system practiced in study areas was uncontrolled for the reasons of majority of goats browse by flock which is in line with the finding of Ahmed *et al.* (2015) who reported that 72.22% of the farmers in Western Ethiopia practiced uncontrolled mating system. This indicated that the respondents were incapable to identify kids' sire in the study areas, perfectly.

Goat castration practice in the current study was observed to be lower than the report of Hulunim (2014) in which 97.39% in Siti areas practice goat castration. In contrast, Tsigabu (2015) reported that about 85.55% in Nuer zone, Gambella region was not practicing goat castration. About 50% of respondents who castrate their bucks using modern method of castration in study areas indicated that there was increased awareness on the important of improved method of castration. The reported age of castration (years) in this study was in line with (Hulunim, 2014).

Goat culling is mainly practiced for females than males. Females were culled primarily for the reasons of poor body appearance followed by aging. On the other hand, culling for males mainly happen due to disease followed by poor body appearance which contradicts the findings of Ahmed *et al.* (2015) in which farmers give priority to cull goats in relation to reproductive problems followed by old age. Being old age is not a factor for culling males for the reason where farmers do not wait bucks until they get too old.

Kid weaning was not practiced by the households across all the study areas. The main reasons for no kid weaning practice were the respondents assume that dams themselves prevent kid suckling naturally when they get pregnant and weaning was also difficult to manage. This tradition may be better for kids' growth, however kidding interval increases as reported by current study that above 60% of the respondents said kids wean when their age attains more than five months.

The most frequent birth type occurring in the study area was single followed by twin and in rare cases triple. These findings were in agreement with those of Dhaba *et al.* (2013) for goats reared in Ilu Aba Bora Zone. Farmers assume that twining depends on level of management.

The most frequent goat mating starts from September-January although goats mate throughout the year. July and August months were considered as less frequently mating months as it is not suitable for goat mating (wet season) as well as February-April because of feed scarcity. Although kidding occurs throughout the year, July-December months are the most common ones. Similar finding was reported by Dhaba *et al.* (2013) in Ilu Aba Bora Zone for kidding seasons. The period of high kidding percentage is characterized by small rainy seasons with adequate feed.

The study goat population attain slowly for age at first mating for female and service for after 10 months. Age at first kidding and kidding interval of the current study were in line with the report of Tsegaye (2009) for Western Lowland goat.

Body conformation was the most preferable goat selection criteria for both sexes. This finding was in line with the report of Mahilet (2012) in East Hararghe zone and Hulunim (2014) in Bati, Borena and Siti areas of Ethiopia. Twining rate and pedigree were additional most preferable traits of preferences for does where as pedigree and coat color for males' selection across all the study districts. Ahmed *et al.* (2015) reported that growth rate and body appearance were the first and second selection criteria for breeding buck, respectively.

Flocks feeding on communal and private lands were reported as the main goat feeding areas followed by aftermath feeding and home leftovers during dry and wet seasons in study areas. This agreed with the finding of Deribe (2009) in Halaba, southern Ethiopia. However, goat browsing areas were decreasing over time because of increasing cultivation for crop-land and soil and water conservation programs. Goat feed shortage was not challenging issue as compared to cattle because goats can better maintain their body condition by feeding on tree leaves' debris. However, January through March was known months for the feed shortage across study areas. Similar finding was reported by Hulunim (2014) in Borena areas.

Goat housing system in two districts varied considerably. Accordingly, all goats in Mirab-Abaya district were kept in sheltered house whereas small proportion of goat flocks were provided with shelter in Arba-Minch Zuria district. The result in Arba-Minch Zuria district contradicts the finding reported by Deribe (2009) in which animals were sheltered in Halaba special woreda, southern Ethiopia. However, keeping goat outdoor during night time may cause for various environmental and internal factors which may reduce their performance.

Both study areas depend primarily on both local (Shelle and Mirab-Abaya) followed by regional (Wolayta Soddo) goat market places located along with the main roadside. Therefore, there was a trend of selling young animals to cover immediate cash needs. Hence, male goats have higher off-take rate at young age than females. This result was higher than reported by Solomon et al. (2010) in Dale and Alaba districts of SNNP. This indicated that there was negative selection practiced by the farmers hence fast-growing young bucks were sold to market before they transfer their breeding value for the next generations.

Ecto-parasites, respiratory disease and orf were frequently occurring parasites and diseases of goat in all study areas to affect goat performance coupled with keeping large number of flocks together. Similar result was reported by Solomon *et al.* (2010) in Ethiopia. There were also regular goat disease prevention and control systems including treatment and vaccination in the study areas. This indicated that a Zonal and district governments were providing better due attention for goat disease prevention and control policy.

Feed, labor and land shortage were the most common goat production constraints identified in the study areas. This result agrees with the findings of Solomon *et al*. (2010) in Ethiopia. Feed and land shortage were related to presence of increasing cropland cultivation and controlled watershed areas for soil and water conservation area. Labor shortage was due to children go to school full-day. Predators like monkey against kids and thief against breeding does and bucks were also some of challenging issues in the study areas. However, water shortage was not a limiting factor because nearby river and water hole were the major source of water.

5.2 Phenotypic description of goat population in the study areas

5.2.1 Qualitative characteristics

About eleven qualitative traits were used for the characterization for both males and females goats separately in both districts. The predominant coat color pattern observed across the study districts was plain for both males and females. This agrees with the work of Tsigabu (2015) for Nuer goat in which plain coat color was 47.78% for females and 41.79% males. Brown coat color followed by black and black dominant coat colors for both male and females were the predominant ones observed in both Arba-Minch Zuria and

Mirab-Abaya districts. Present of horn and beard, absent of toggle and ruff were predominantly observed across the study districts for both sexes.

The predominant horn shape was straight for both sexes where as horn orientation was mainly obliquely upward for males and obliquely backward for females. Ear orientation, head profile and scrotum type; ear was mostly carried horizontally, head was straight and bucks possessed single scrotum types, respectively. These findings suggest that goats in study areas were genetically heterozygous.

5.2.2 Live body weight and linear measurements

Except for body length, males possessed significantly higher ($P<0.05$) values for body weight, rump length, head width and horn length than females. Tsigabu (2015) reported that sexual dimorphism in body size is clearly widespread with male-biased dimorphism being the more common, but definitely not the exclusive model. Usually males have higher body weight than females. This sex influenced differences in body weight and linear measurements might be partly due to release of androgen hormone (which is known to have growth and weight – stimulating effects) in male animals after the testes are well developed (Frandson and Elmer, 1981).

There was significant difference in linear body measurements between districts except height at withers and muzzle circumference. Goats in Arbaminch-Zuriya district possess higher values on body weight, body length, chest girth, rump width, head width and scrotum circumference than in Mirab-Abaya district ($P<0.05$). This could be related with better management in Arbaminch-Zuriya district since goats do not move long distance to search feed and water.

In the current study, body weight had significant difference in all age (dentition) groups and the same was true for all linear body measurements. Increment of body weight and linear body measurements when the animal gets older (increase in age) is in agreement with the finding of Yoseph (2007) in which Arsi bale and Boran goats attained their highest weights in the oldest age class.

The interaction effect of age by sex is significant for body weight and all linear body measurements ($P<0.05$). The mean body weight of males in age group 1PPI (28.2) and age group 3PPI (32.6) in this study were higher than Hararghe Highland goats 23.67 and 23.37, respectively for each age class as reported by Mahilet (2012). Bucks in each age category are higher in body weight than does in the respective age category and body weight increases with age in both sexes.

5.2.3 Correlation and prediction of body weight from linear body measurements

Very weak to strong correlations were observed between body weight and linear body measurements. In males, positive and strong association were depicted between body weight and body length, wither height, chest girth and horn length. In case of females, positive and moderate association was found between body weight and chest girth, rump width and head length. These linear body measurements were highly affected by the change in body weight; hence, they are more important in prediction of live body weight of the animal. Sound skill in estimating weight is essential for the stockman to know weight where a weighing scale is not available (Singh and Mishra, 2004). The correlation coefficient between body weight and all parameters for males and females in the current study were lower than Nuer goats reported by Tsigabu (2015). From the finding, males have depicted higher relationship between body weight and linear measurements than in females.

For the regression equation as well as stepwise discriminant analysis, seven linear body measurements (body length, height at wither, chest girth, chest depth, rump width, head length and ear length) for females where as four (body length, height at wither, chest girth and chest depth) for males were identified for the estimation of body weight. Chest girth was identified as the single importance variable in the prediction power of live body weight in females where as body length for males. This implies that bucks required slightly fewer traits of measurements to differentiate within population than does. The current finding disagrees Hulunim (2014) where chest girth was the only discriminating power for both sexes.

Even though the magnitude of improvement varied in both sexes, the inclusion of their respective linear measurements with chest girth for females as well as body length for males improved the accuracy of the prediction model (R^2) in all cases.

5.3 Goat oestrus synchronization

The average oestrous response and conception rate achieved in the current study were within the range of the response and conception in the literature. In Ethiopian sheep breeds, Zelelek et al. (2016) reported 55–65% oestrous response rate. The oestrous responses in Nigerian goat breeds ranged from 20 to 100% and conception rate from 65.0 to 100% (Omontese *et al.*, 2016).

Effect of factors (body weight and body condition score) on oestrous response to hormone treatment and conception rate in the current study agree the report of Santoralia et al. (2011) in which high body condition score has been associated with an increase of ovulation, with a score of < 2 and > 3 resulting in the lowest and the highest pregnancy rates in sheep, respectively. It was also found that a one unit reduction in body condition score resulted in a 2.4-fold increase in pregnancy loss (López-Gatius et al. 2002). As parity of does increases, the response and conception rate decreased in the current study. In contrast, Ungerfeld and Sanchez-Davila (2012) found a significantly higher oestrous response to hormone treatment in multiparous ewes (91.5%) than in primiparous ewes (75.0%), but the conception rates were statistically similar (59.6% and 50.0% in multiparous and primiparous ewes). Decreased response and conception rate due to increased age in the current study was in line with the report of Trigg (2003) on Black Bengal goat synchronization has resulted in super ovulation in younger goats. However, studies on dairy cattle oestrous synchronization found a higher oestrous expression in cows (90.9%) than in heifers (63%), but non-significant difference in conception rates between cows and heifers (Bayemi et al. 2015).

The overall mean birth weight (2.49 kg) recorded for kids was higher than the finding of Deribe and Taye (2013) for Abergelle goat where as lower than the report of Weldu *et al* (2004) for Arsi-Bale goat under traditional management system. The gestation length was in line with Girma (2009) who reported. Liter size was 1.31 which contradicted with the finding of Shenkute (2009) for Kaffa goat under traditional management system. The percent of abortion (mechanical) encountered during the study indicated that pregtone tool was efficient to diagnose early 30-40 days pregnancy as recommended by Renco Corporation (2000) before hormone injection.

6. CONCLUSION

Farmers give almost equal importance for both livestock and crop production so that goats have good opportunity from crop by-products as feed resources. Goat rank 2nd after cattle in the study districts. Hence, this creates good opportunity to introduce goat improvement technologies. Farmers in the study districts keep more females than males which creates better chance to have high number of kids. Goats are primarily preferred for generating income and saving followed by breeding and meat across the districts. Most the mating system practicing in the study area was uncontrolled which may lead difficulty for fast genetic improvement. However, there were practices of goat castration and culling. There was no kid weaning practice which may increase kidding interval. Birth type occurring in the study area was single which indicates that the study goat population were low prolific. The most frequent goat breeding season occurs between September and January which predicts when breeding strategies should gear. Body conformation, pedigree and prolificacy were the most important selection criteria for does where as body appearance and pedigree for breeding bucks. Goat-housing systems in two districts do vary considerably. All goats were provided with shelter in Mirab-Abaya district whereas about 40% of goats are provided with separate house in Arba-Minch Zuria district. Male goats have higher off-take rate at early age to the local and regional market than females which can direct to negative selection.

Ecto-parasites, respiratory disease and orf were frequently occurring goat contagious parasites and diseases. However, there were good regular goat disease prevention and control systems like treatment and vaccination in the study areas.

Feed shortage followed by labor limitation and land shortage were the major goat production constraints identified in the study areas.

Regarding to the morphological data, the predominant coat color patterns observed on both sexes were plain. The dominant coat color types in both study districts were brown followed by black. Majority of goats in the study areas possessed horned, absent toggle, beard, ruff and males were prominently with single scrotum type.

Generally, body weight and linear body measurements of the study goat were significantly ($P<0.05$) affected by sex, district, age and sex by age interaction. Males showed better linear body measurement values than females in general. Linear body measurements increase when the goats get older. Stepwise multiple regression analysis revealed that chest girth was the single utmost importance trait in the prediction of live body weight in females where as body length in males.

The overall oestrus response of does after hormone administration was 85% where as pregnancy rate was 81.67% which was observed as better for small holder farers goat production. Doe body weight, body condition score, parity and age affect significantly on oestrous response to hormone treatment and conception rate whereas location does not have significant effect. In general, as body weight and body condition score increase, oestrus response and conception rate increase where as the reverse is true for parity and age. Pregtone ® was identified as an efficient pregnancy diagnosis tool for early pregnancy diagnosis before hormone administration so that abortion rate can be minimized.

7. RECOMMENDATIONS

Based on the findings of the current study, the following recommendations were set.

- Goat was the most important livestock species after cattle. Hence, it is better considering the identified traits of preference for improvement strategies.
- A trend of uncontrolled mating system was difficult for goat genetic improvement so that it is better to have deliberate goat castration and culling practices.
- Goat breeding strategies should coincide on their natural breeding seasons through improved management systems like improved feeding and housing practices,
- Higher off-take rate of the fast growing male goats to the market at early age before attaining puberty must be stopped by the communities so that negative selection reduced.
- Although there are some goat parasites infestations and diseases incidences, the existing goat disease prevention and control trends should be strengthened further.
- The morphometric trait differences suggested that further genetic analysis studies need to be taken to conserve these animal genetic resources under their production environment.
- Linear measurements like body length for males and chest girth for females could be valuable to estimate live body weight for those farm communities where sensitive weighing scales are not readily available.
- Breeding does can deliver kids during feed and water abundance seasons through hormonal oestrus synchronization intervention so that reduced kid mortality and increased genetics. Hence, considering the suggested does' live body weight, body condition score, parity and age categories supported with early pregnancy diagnosis tools to minimize abortion rate are important under low input production systems.

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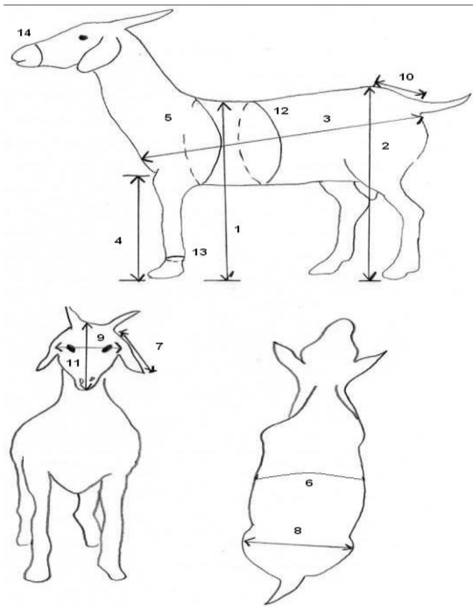
APPENDICES

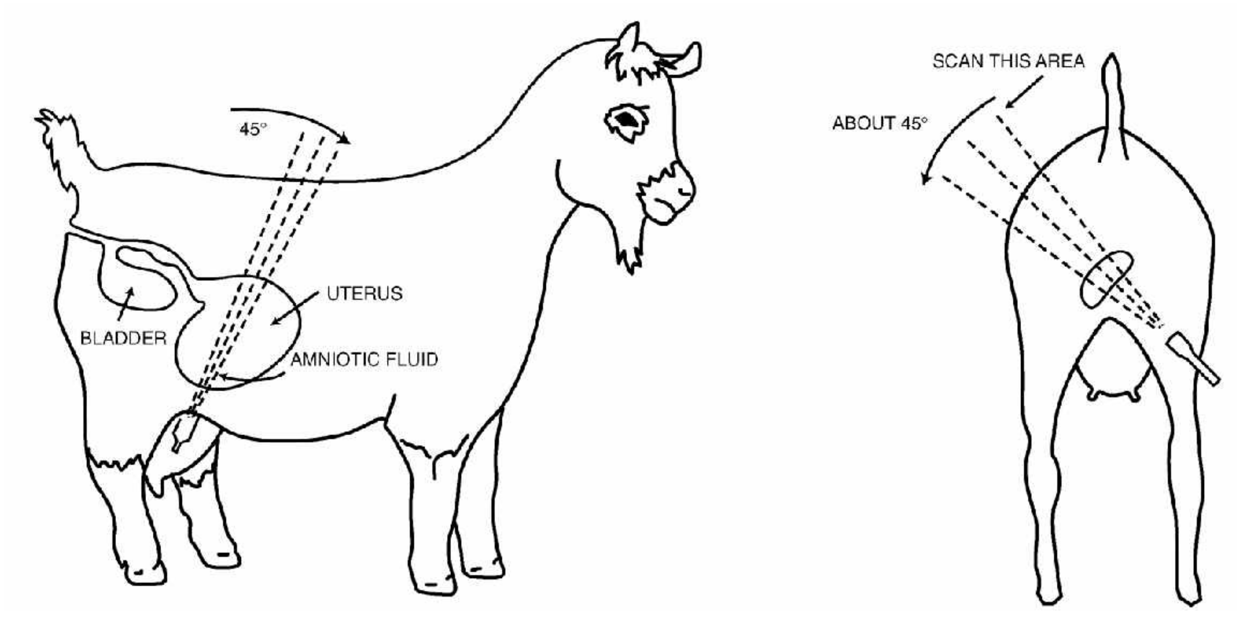
Appendix A: Different appendix figures and tables



1. Withers height (WH)	9. Head width (HW)
2. Rump height (HR)	10. Rump length (RL)
3. Body length (BL)	11. Head length (HL)
4. Sternum height (SH)	12. Heart girth (HG)
5. Body depth (RD)	13. Cannon bone
6. Bi-costal diameter (BD)	Circumference (CC)
7. Ear length (EL)	14. Muzzle diameter (DH)
8. Rump width (RW)	

Appendix figure 1: Goat linear body measurement indices

Source: Edilberto *et al*. (2011)



Appendix figure 2: Procedure of pregnancy diagnosis method by preg-tone tool
Source: Renco Corporation (2000)

Appendix table 1**:** Analysis of binary logistic regression for the effect doe body weight on response and conception rate

Parameters	**Variables in the Equation**					
Hormone response	β	S.E.	Wald	df	Sig.	Exp(β)
	0.339	0.162	4.388	1	0.036	1.403
Conception rate	0.261	0.134	3.780	1	0.052	1.298

Appendix B: Description of quantitative traits measured for each sample animal

Measurements	**Description**
Body weight (BW)	The live body weight taken using spring balance (in kilograms)
Body length (BL)	The horizontal distance from the point of shoulder to the pin bone to the nearest centimeter
Height at wither (WH)	the (vertical) height (in centimeters) from the bottom of the front foot to the highest point of the shoulder between the withers
Chest girth (CG)	the circumference of the body (in centimeters) immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body
Chest width (CW)	The width of the chest between the briskets to the nearest centimeter
Rump length (RL)	Distance from the most cranial and most dorsal point of the hip to the most caudal point of the pin bone
Pelvic width (PW)	The distance between the pelvic bones, across dorsum to the nearest centimeter
Horn length (HoL)	From the base of the horn at the skull along the dorsal surface to the tip of the horn using tape meters to the nearest centimeter
Ear length (EL)	The length of the ear on its exterior side from its root at the poll to the tip to the nearest centimeter
Scrotal Circumference (SC)	Pushing the testicles to the bottom of the scrotum and the widest Circumference measured to the nearest centimeter

Appendix F: Descriptions of body condition score

Score	Condition	Features
1	Very thin	Back bone prominent and sharp, ends of short ribs are sharp, easy to press between, over and around
2	Thin	Backbone prominent but smooth, short ribs are well rounded ends can feel between, over and around smoothly
3	Average	Backbone can be felt but smooth and rounded, short ribs ends are smooth and well covered and felt with firm pressure
4	Fat	Backbone detected with pressure on the thumb, individual short ribs can be felt with firm pressure
5	Obese	Back bone can be felt with firm pressure and hard to felt short ribs even with firm pressure

Appendix B: Semi structured questionnaire prepared for indigenous goat survey

Part 1: General

1. Date of Interview:___Zone:_______District:_____Kebel:______
2. Agro-ecology: **A)** Dega **B)** Woyna-Dega **C)** Kola
3. Altitude Range____________ Rainfall Distribution_______

Part 2: Household (HH) Characteristics

1. Name of HH:__Sex of HH Head___ Age of HH Head (year)____
2. Education of HH Head: **A)** Illiterate **B)** Reading and Writing **C)** Primary **D)** Secondary
3. What is your major farming activity? **A)** Livestock **B)** Crop **C)** Both
4. Please tell us species of livestock you have and their numbers prioritized?

Species	**Number**	**Rank**
Cattle		
Goat		
Sheep		
Poultry		

5. Please tell us the number of goats you have at different age class?

S/No.	Goat Flock Structure	Number
	Class	
1	Breeding Doe (> 1 years)	
2	Breeding Buck (> 1 years)	
3	Doe Kids (0.5- 1 year)	
4	Buck Kid (0.5-1 years)	
5	**Kid (< 0.5 year)**	
5.1	Male	
5.2	Female	
6	Castrate	

6. Trend of goat keeping practice. **1**. Increasing 2. Decreasing 3. Stable

7. What are the major purposes of goat rearing in your area?

Use	Tick	Rank
Income		
Meat		
Saving		
Manure		
Other (specify)		

Part 3: Goat breeding practices

1. What is the average age at 1st mating of females (month)? ______ Age at 1st serving of males (month)? ___

2. What is the average age at 1st kidding (month)? ____________________

3. What is the average kidding interval (month) ? ___________________

4. What is the frequent type of birth? 1. Single 2. Twin 3. Triple

5. Please tell us the months where frequent mating season is occurring in your area---

6. Please tell us the months where frequent kidding season is occurring in your area--

7. Do you have your own buck? **A.** Yes **B.** No

8. If your answer is No, where do you get buck?

   A. from own flock **B.** purchase from market **C**. From neighbors **D.** By rent

9. Do you control goat mating practice? **A.** Yes **B.** No

10. If your answer is no, why?

    A. Goats brows together in flock **B.** Lack of buck **C.** Lack of awareness

11. Do you practice goat castration? **A.** Yes **B.** No

12. If your answer is yes, what are the reasons?

    A. Control mating **B.** Fattening **C.** Better Temperament D**.** Others (specify)____

13. At what age do you castrate your goat? ________Why__________

14. What type of method you use for goat castration?

    A. Traditional (specify) ____________ B. Modern (specify)__________

15. Do you practice culling of female goat? **A.** Yes **B.** No

16. If your answer is yes, what is the reason? **A.** Disease **B.** Old age **C.** Sterility **D.** Poor physical condition **E.** Low milk yield **F.** Poor mothering ability

17. Do you practice culling of male goat? 1. Yes 2. No

18. If your answer is yes, what is the reason?

    A. Disease **B.** old age **C.** Poor physical condition **D.** Bad color **E.** Poor libido

19. Do you wean your kids? **A.** Yes **B.** No

20. If yes, at which age?________Why?______________

21. If No, why__________If No, at which age kids wean naturally?__________

22. Selection criteria for both breeding does and bucks:

Breeding does	**Tick, Rank for preference**	**Breeding bucks**	**Tick, Rank for preference**
Body conformation(size)		Body conformation	
Twinning ability		Color	
Udder size		Scrotum size	
Kidding interval		Growth rate	
Color		Horn shape	
Pedigree		Pedigree	
Others		If other, specify	

Part 4: Feeds and Feeding

1. What is the major goat feed resources in your area?

Feed Resource		Dry season	Rank	Wet season	Rank
1	Communal grazing and browsing				
2	Private grazing and browsing				
3	Grazing after math				
4	Home leftovers				
5	Others				

2. List months were plenty goat feed resources available, rank_____________

3. List months where scarce goat feed resources occur, rank_____________________

Part 5: Housing system

1. What type of shelter do you have for your goat? **A.** No shelter **B.** Separate house for goat **C.** Sheltered aside main house **D.** Open barn

Part 6: Goat Market

1. Is there any established market for goats before? Yes___________ No________
2. Markets targeted: Regional market_________national market______local market__
3. What is average market age of male goat? ______ Female goat? _______(year)

Part 7: Goat Health

1. Please specify the major goat local name of disease, their symptoms, season of occurrences and cultural treatment

Local name	**Scientific name**	**symptoms**	**Season of occurrences**	**Reason of occurrences**	**Is it contagious**	**Which age group**	**Local treatment**	**Service provide by**

2. Do you get vaccination service for your goat? **A.** Yes **B.** No
3. If your answer is yes, when the service is given?
   A. When disease out brake occur **B.** Any time in a year **C.** Before disease outbreak
4. Where you get medicine and vaccination?
   A. Animal health clinic **B.** Cultural treatment **C.** Private Veterinary house

Part 8: Goat Production constraints

1. What are the major problems of goat production? (Rank according to their severity)?

Constraints	**Tick**	**Rank**
Disease		
Feed/land shortage		
Water Shortage		
Labor shortage		
Predator/thief		
Drought		
Others		

Appendix C: Goats physical description recording format and respective codes

S/No.	Sex	Body condition	Coat color pattern	Coat color	Head profile	Horn presence	Horn shape	Horn orientation	Ear orientation	Back profile	Wattles	Ruff	Beard	Scrotum type
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														

Sex: F= Female M= Male, **Coat color pattern**: 1= plain 2= Patchy/pied 3= Spotted, **Coat color**: 1 = White, 2=red, 3 = Black, 4= Grey, 5 = light red, **Head profile**: 1 = Straight, 2 = concave, 3= convex, **Horn presence**: 1= Present 2= Absent 3= Rudimentary, **Horn shape**:1= straight, 2= curved, 3= spiral, 4= corkscrew, **Horn orientation**: 1= lateral(sideways), 2= obliquely upward, 3= back ward, **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), **Wattles**: 1= Present 2= Absent, **Ruff**: 1= Present 2= Absent, **Beard:**1= Present 2= Absent, **Scrotum type:** 1= single, 2= Partially split, Split

Appendix D: Quantitative traits measurement recording format

S/No.	BW	BL	HW	CG	CD	RL	RW	HeL	HeW	MC	HoL	EL	SC	TL

BW=Body weight, **BL**= Body Length, **HW**= Height at Withers, **CG**= Chest Girth, **CD**= Chest Depth, **CW**= Chest width, **RL**= Rump Length, **RW**= Rump Width, **HoL**= Horn Length, **EL**= Ear Length, **HeL**= Head Length, **HeW**= Head Width, **MC**=Muzzle Circumference, **TL**= teat length and **SC**= Scrotum Circumference

Appendix E: Estrus Synchronization Data

District____________Kebele______Type of Hormone Prescribed **Lutylase (2.5 ml/Doe)** Doe Breed_______________ Buck Breed________

S/No.	Owner Name	Age by dentition	BCS (1=Very thin; 2=Thin; 3=Moderate; 4= Fat 5=V.Fat)	Doe Color	Parity	Last Kidding Date	Health Status (Good/Poor)	Any history of abortion (Yes/No)	List if there are any medicaments administered recently	Body Weight	Buck Color/ID
1											
2											
3											
4											

PD test before synchronization (+/-)	Hormone Injection		Response to Hormone (Yes/No)	Oestrus Sign		Buck Mating		PD Result after 1 month (+/-)	Doe delivered kid	Doe Aborted	Kid			
	Date	Time		Date	Time	Date	Time				Sex	Birth		
												Date	Weight	Type

BIOGRAPHICAL SKETCH

The author, Dereje Dea was born in Kucha woreda, Gamo-Gofa zone, SNNP region on July 31, 1987. He attended his elementary and junior school education at Chaba Beless and Gella Elementary Schools, and secondary school education at Selamber secondary and preparatory school in Gamo-Gofa zone and Soddo Secondary and Preparatory School in Wolaita Zone.

After completion of high school education, he joined Debrebirhan University, Department of Animal Sciences in 2008 and Graduated with BSc degree in Animal Science and Range Management in 2010. Soon after graduation, he joined Kucha Woreda, Bureau of Agriculture (BOA) and served as an Animal production expert for two and half years. After that, he got an opportunity to join Arbaminch Agricultural research center under SARI (Sothern Agricultural Research Institute) where he served as a junior researcher-II for two years.

Then in October 2014, he joined the School of Graduate Studies (SGS) of Hawassa University to pursue his MSc study in Animal Breeding and Genetics in the School of Animal and Range Sciences.