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THESIS

FEEDING STRATEGY ON GROWTH AND REPRODUCTIVE PERFORMANCE OF WOYTO-GUJI GOAT

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LIST OF ABBREVIATIONS

ADG	=	Average daily gain
BCS	=	Body condition score
BW	=	Body weight
CCPP	=	Contagious Caprine Pleuro Pneumonia
CHG	=	Central highland goat
CP	=	Crude protein
CSA	=	Central Statistical Authority
CV	=	Co-efficient of Variation
DM	=	Dry matter
DP	=	Dressing percentage
FSH	=	Follicle Stimulating Hormone
g	=	gram
h	=	Time in hour
GnRH	=	Gonadotropin- Releasing Hormone
JARC	=	Jinka Agricultural Research Center
kcal	=	kilo calorie
kg	=	Kilogram
KU	=	Kasetsart University
LES	=	Long Eared Somali goat
LH	=	Luteinizing Hormone
m	=	Meter
mm	=	Millimeter
ME	=	Metabolisable Energy
MJ	=	Mega joules
MP	=	Multiparous
N	=	Number of observation or records
NDF	=	Neutral Detergent Fiber
PCDP	=	Pastoral Community Development Project
PP	=	Primiparous

LIST OF ABBREVIATIONS (Continued)

PPA	=	Post-partum anoestrus
PPR	=	Peste des petits ruminants
PPW	=	Post-partum dam weight
PR	=	Pregnancy rate
SARI	=	Southern Agricultural Research Institute
SD	=	Standard Deviation
SAS	=	Statistical Analysis System
SE	=	Standard Error
SNNPR	=	Southern Nations, Nationalities and Peoples Region
SPSS	=	Statistical Package for Social Sciences
TDMI	=	Total dry matter intake

FEEDING STRATEGY ON GROWTH AND REPRODUCTIVE PERFORMANCE OF WOYTO-GUJI GOAT

INTRODUCTION

Ethiopia has the largest ruminant livestock population among all the countries in Africa. It has been estimated that there are approximately 22.6 million heads of goats in the country of which 99.8% of them are indigenous genotypes (CSA, 2012). The majority of goat populations are found in the arid and semiarid lowlands of the country raised in large flocks by pastoral and agro-pastoral households. The indigenous Ethiopian goats have been classified into 14 phenotypic types (FARM-Africa, 1996). However, in a molecular study these goats are grouped into eight distinct genetic entities, viz., Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergelle, Afar, Highland and Somali goats (Tesfaye, 2004).

The role of goats in improving the income and livelihood of rural people in the country is currently gaining importance (Kocho *et al.*, 2011). However, it is believed that the indigenous Ethiopian goat genotypes have evolved through a process of natural selection that resulted in goats selected for adaptation and survival rather than production per se (Kassahun and Abegaz, 2008). Annual meat production from sheep and goats in Ethiopia is 8–10 kg per animal slaughtered (Sebsibe, 2008). These values are very low when compared with those in neighboring countries. A major cause contributing to such low meat yield is the fact that animals are commonly slaughtered at immature body weights, 18–20 kg for sheep and 16–18 kg for goats (Sebsibe, 2008).

Sheep and goat production in Ethiopia suffers from nutritional constraints and this is aggravated by seasonal availability of forage and by recurrent and prolonged drought in the arid and semiarid lowlands of the country (Yami, 2008). The nutritional stress, consequently, is ensuing slow growth rate, loss of body condition and increased susceptibility to diseases and parasites, contributing to lower production and reproductive performances of the animals (Tolera *et al.*, 2000). Thus, effective utilization of the available feed resources and appropriate supplementation of poor quality natural pastures and appear to be the necessary steps to alleviate the nutritional constraint (Tolera *et al.*, 2000). Moreover, under semiarid conditions early mating and kidding of goats before the hot dry season is crucial to ensure high kids survival and success in reproductive performances of goats (Hary, 2002).

Woyto-Guji goats, with an estimated population of 900, 000 are one of the eight indigenous goat breeds that are distributed widely in the south western arid and semiarid areas of the country (FARM-Africa, 1996). However, there is not adequate information on their management practices, growth and reproductive performances; however, a study regarding diseases (Mekuria *et al.*, 2008) have been conducted. Most Ethiopian goats have undergone little selection for improved meat production and true breed potentials are not known (Tsegahun *et al.*, 2000; Kassahun and Abegaz, 2008). Therefore, an understanding of the systems of goat production and animal performances would be a key step to provide the practical recommendations to goat keepers and breeders for improving goat production (Oliver *et al.*, 2005; Alexandre *et al.*, 2010).

OBJECTIVES

In line with the above mentioned justification, the main objective of this study is to assess goat management practices in pastoral and agro-pastoral districts of South Omo Zone (south western Ethiopia) and to evaluate growth and subsequent reproductive performances of Woyto-Guji goats under various levels of supplementation.

The specific objectives of the study are:

1. To describe goat management practices and production constraints in pastoral and agro-pastoral districts of South Omo Zone.

2. To describe goat breed preferences and selection criteria of pastoral and agro-pastoral households in South Omo Zone.

3. To evaluate the effect of meal concentrate supplementation before breeding on feed intake and growth rates of female Woyto-Guji goats.

4. To evaluate the effect of meal concentrate supplementation before breeding on subsequent reproductive performances of female Woyto-Guji goats.

5. To evaluate the effect of meal concentrate supplementation before breeding and end of gestation on behavioral characteristics at parturition of Woyto-Guji goats.

LITERATURE REVIEW

Overview of goat production in Ethiopia

Ethiopia has the largest ruminant livestock population among all the countries in Africa. It has been estimated that there are approximately 22.6 million heads of goats in the country of which 99.8% are indigenous genotypes (CSA, 2012). The majority of goat populations are found in the arid and semiarid lowlands of the country raised in large flocks by pastoralists. The ancestors of Ethiopian goats are closely associated with goat types which migrated from the Middle East and North Africa (Tesfaye, 2004).

According to FARM-Africa (1996), indigenous Ethiopian goats have been classified into 4 families (Nubian, Rift valley, Somali and Small East African) and into 14 phenotypic types. Tesfaye (2004), however, categorized the indigenous Ethiopian goat populations into eight genetic entities, viz., Arsi-Bale, Gumez, Keffa, Woyto-Guji, Abergelle, Afar, Highland (previously separated as Central and North West Highland goats) and the goats previously known as Hararghe, Southeastern Bale and Southern Sidamo provinces (Hararghe Highland, Short-eared Somali and Long-eared Somali goats). The Arsi-Bale, Afar and Woyto-Guji goats belong to the Rift valley families of goats (FARM-Africa, 1996).

Sheep and goat production systems in Ethiopia are classified into five–the highland sheep–barley system, mixed crop–livestock system, the pastoral and agro-pastoral system, and the less practiced ones ranching and urban and peri-urban (landless) sheep and goat production systems. The pastoral and agro-pastoral sheep and goat production systems in Ethiopia are found in altitudes below 1500 meter above sea level (Solomon *et al*., 2008a). Goat production in the lowlands relies on browsing and grazing whereas in the highlands communal grazing, fallow lands, and crop residues are the major feed resources. Usually, goats receive little to no supplementary feeding and minimum health interventions in the country (Tsegahun *et al.*, 2000).

However, the role of goats in improving the income and livelihood of rural people in the country is currently gaining importance (Kocho *et al*., 2011). Goats in the country provide their owners with a vast range of products and services such as immediate cash income, meat, milk, skin, manure, risk spreading/management and used in various social functions (FARM-Africa, 1996). Sheep and goats contribute a quarter of the domestic meat consumption; about half of the domestic wool requirements; about 40% of fresh skins and 92% of the value of semi-processed skin and hide export trade and it is estimated that 1,078,000 sheep and 1,128,000 goats are used in Ethiopia for domestic consumption annually (Yirpa and Abebe, 2008).

There is also a growing export market for sheep and goat meat in the Middle Eastern Gulf States and some African countries. At optimum off-take rates, Ethiopia can export 700,000 sheep and 2 million goats annually. The current annual off-take rate of sheep and goats is, however, only 33 and 35%, respectively. The increased domestic and international demand for Ethiopian sheep and goats has established them as important sources of Inland Revenue as well as foreign currency. This increased demand also creates an opportunity to substantially improve food security of the population and alleviate poverty (Yirpa and Abebe, 2008).

However, inadequate research and extension programs in the production, processing and marketing of goat meat, inadequate knowledge and technologies to make optimal use of local animal feed resources in diets, livestock diseases and inadequate veterinary support services, lack of constant and uniform supply of goats, inadequate infrastructures on the routes and at the markets and lack of marketing information and cooperative system are among the constraints for export marketing of goats in the country. Therefore, appropriate breeds and technologies have to be used to increase the off-take as well as productivity per animal with acceptable quality and to ensure a constant and uniform supply of goats (Sebsibe, 2006).

Ethiopian goat types vary with respect to potential growth rates and mature weight (FARM-Africa, 1996; Sebsibe, 2008). It is believed that the indigenous Ethiopian goat genotypes have evolved through a process of natural selection that resulted in goats selected for adaptation and survival rather than production per se (Kassahun and Abegaz, 2008). Annual meat production from sheep and goats in Ethiopia is 8–10 kg per animal slaughtered. These values are very low when compared with those in neighboring countries (Sebsibe, 2008). A major cause contributing to such low meat yield is that animals are commonly slaughtered at immature body weights, 18–20 kg for sheep and 16–18 kg for goats, poor feeding, improper management, diseases, parasites and low genetic potential (Sebsibe, 2008).

Furthermore, most Ethiopian goats have undergone little selection for improved meat production and true breed potentials are not known. However, considerable selection has been exerted on some of the goat populations by the societies keeping them. The Ethiopian Somali goat, for example, has clearly been selected for milk production, against twinning (to the point where it is virtually eliminated), and for production and survival in harsh environments. Its uniformly white coat appears also to have been selected for. The high prolificacy of the Western Lowland, Western Highland, Keffa and Woyto-Guji goats of Ethiopia has clearly shown their selection by societies for whom milk is not so important (Kassahun and Abegaz, 2008). There is a significant diversity in reproductive traits of Ethiopian goat genotypes due to agro-ecology, breed and/or age class (Mekasha *et. al.*, 2007).

Description of the studied goat

The Woyto-Guji goats are also known as Woyto, Guji or Konso goats. The origin of the goats belong to part of the Rift Valley family of goats with subtypes and races related to the Arsi-Bale goat of Ethiopia. The goats are distributed in semi-arid and arid areas of south western Ethiopia (North and South Omo, southern Sidamo and parts of Wolayta) and kept mainly by pastoral ethnic groups (Tsemay, Malie, Hamer, Benna, Dasenatch, Bumie and Guji) and by a few agricultural groups (Konso and Gardula). Less distinct types of this goat are also kept by the Wolayta, Gofa and Gamo people in North Omo. More notably, this goat type inhabits those areas in Sidamo known to be endemic with trypanosomiasis, especially the Gelo valley to the south of Lake Abaya and the western Ghenale catchment area of south western Ethiopia (FARM-Africa, 1996).

Figure 1 and 2 show photograph of female and male Woyto-Guji goats. The physical characteristic of the goats was presented on Table 1. Key identifying features of the goat include brown, black or red color with a shiny, smooth coat and small head with a straight or concave facial profile. Coat colors of the goats are often marked with black or brown stripes along the back, on the underside or on the front of the legs. The Woyto-Guji goat is a medium-sized goat with a mainly straight (89%) to concave (11%) facial profile. Straight horns occur on 71% of the males, curved on 26%, with polled goats forming 3% of the population. Horns mainly point backwards (75%) or upward (21%) and in a few cases laterally (2%). The coat is mainly short, smooth and shiny (76%), with a few goats with coarse hair (6%) or hair on the thighs (6%) and 11% being hairy. The predominant colors are reddish-brown (49%) and black (12%) in a patchy pattern (50%). Black or brown stripes on a dark background are common. A beard is present on 96% of all males, a ruff on 91% and wattles are present on 10% (FARM-Africa, 1996).

Table 1 Physical characteristics of adult Woyto-Guji goats

Sex	Height at withers (cm)	Weight (kg)	Chest girth (cm)	Ear length (cm)	Horn length (cm)
Male	72.9±5.0	39.0±6.3	80.8±6.6	12.5±1.3	17.6±7.2
Female	66.4±3.5	28.8±5.0	72.5±4.2	12.5±1.0	10.8±3.7

Source: FARM-Africa (1996)

Figure 1 Photograph of a female Woyto-Guji goat

Source: FARM-Africa (1996)

Figure 2 Photograph of a male Woyto-Guji goat

Source: FARM-Africa (1996)

Feeding strategies for goats in dry environments

Feed resources are a major component of economic animal production in various animal enterprises. Feed availability and efficiency of use in specific agro-ecological zones and in smallholder production systems dictate to a very large extent the performance of both ruminants and non-ruminants. In Ethiopia, generally, green fodder (grazing) is the major feed source (about 39 percent) followed by crop residues (3 percent). Hay and by-products are also used as animal feeds which comprising about 12 and 3 percent of the total feeds, respectively. Moreover, very small amount of improved feed (like alfalfa, only about 1 percent) is being used as animal feed and other types of feed account about 12 percent in the country (CSA, 2012).

The major constraints of sheep and goat production related to nutrition and feeding in Ethiopia include the following: (1) Inadequate feed supply, mainly due to small land-size and overstocking brought about by the shrinking amount of land reserved for grazing, (2) Low feeding value of available feed resources resulting in low efficiency of utilization, and (3) Marked seasonal variation in the quantity and quality of feed supply. Generally, sheep and goat production in Ethiopia suffers from feed shortages at all levels with an estimated 40% deficit in the national feed balance. This is aggravated by seasonal availability of forage and crop residues in the highlands and by recurrent and prolonged drought in the lowlands (Yami, 2008).

According to Mengistu (1985) the strategy for feed improvement would incorporate improvement of feed availability and quality. Moreover, matching sheep and goat production systems to available feed resources and more efficient use of agricultural and industrial by-products as sources of feed have been suggested as a strategy for ensuring appropriate nutrition of small ruminants in the country (Yami, 2008).

Martin *et al.* (2004) reported that “focused feeding” is one of the strategies to improve the reproductive performance of small ruminants in ways that lead to “clean, green and ethical” animal production. The strategy is based on our knowledge of the responses to nutrition and aims to develop short programs of nutritional supplements that are precisely timed and specifically designed for individual events in the reproductive process, such as gamete production, embryo survival, fetal programming and colostrum production.

Promising techniques and technologies to alleviate feed shortage in small ruminants in dry areas include feed blocks and pellets based on local agro-industrial by-products, ensiling some agro-industrial by-products alone or with some shrubs species, the establishment and targeted utilization of promising multi-purpose shrubs and trees, improvement of crop residues and conservation of forages. However, the development of appropriate solutions and feeding techniques requires investigation on the constraints encountered by farmers in the field and fully exploration and characterization of the intervention zone (Salem and Smith, 2008).

Growth performance in goats

Growth and development of animal are the basis for meat production. Warriss (2000) described the process of growth as the combination of increase in the total body cell mass and differentiation of these cells in to tissues and organs leading to a change in shape as well as size. Meat is the edible postmortem component originating from live animals. It contains those tissues exclusively originating from an animal carcass—a proportion amounting to about one-half to three-fourths of the animal live weight. This carcass proportion of the live animal weight is classically calculated as dressing percentage (DP) and can vary considerably (Kauffman, 2001).

Biological production in a livestock system oriented on meat production basically consists of the accumulation of live weight through the growth of individual animals and through an increase in number of animals (Erasmus, 2000). Compared to sheep and cattle, knowledge of yield and quality of goat meat is limited. The primary source of scientific knowledge on commercial production of meat from goats has been negligible compared to other livestock and poultry species, and even in the goat species more attention has been directed towards dairy and pashmina goats (Shrestha and Fahmy, 2007b).

Worldwide, despite the high prolificacy of meat goats, their growth rate is disappointingly low, considerably lower than that of sheep. For example, goats grow 150 to 230 g per day, while sheep grow 300 to 400 g per day on a similar ration (Ensiminger, 2002). Nevertheless, through genetic improvement increased growth rates may be obtained. Dressing percentages for goat carcass ranging from 37 to 55%, which is lower than those of sheep. Thus, goats are considered as not efficient meat producers compared to the other four-footed farm animals since they are raised under extensive (range) conditions, which include lack of feed and management, and their adaptation to normal production conditions relates more to survival than to production (Ensiminger, 2002).

Factors affecting growth performance in goats

Breeds

African goats are grouped into three main families: the Dwarf goats of West and Central Africa, the Savannah goats of sub-Saharan Africa and the Nubian type goats of North Africa (FAO, 1991). The horn of Africa harbors the highest densities of small ruminants in Africa. It has been stated that nearly 50% of the variability in a species exists between breeds while the remaining 50% is within breeds (Scherf, 2000). Goats, as with sheep, cattle and poultry, can be classified as early, medium or late maturing genotypes. Mature size of goats can vary ten-fold between breeds, with consequent variations in growth rates. Maturity types are differentiated in terms of carcass development and the degree of lean and fatness (Casey and Webb, 2010). Effects of genetic and non genetic factors (maturity, physiological state, nutrition, sex and birth rank) poorly understood in goats (Warmington and Kirton, 1990).

Shrestha and Fahmy (2007a) examined the role of crossbreeding and composite population in improving economically important traits necessary for commercial production of meat goats. In general, the authors reported that the crossbreeding of indigenous goats or established breeds with one or more breeds (Alpine, Beetal, Boer, Jamunapari, Nubian and Saanen) that have demonstrated genetic merit in the performance traits of economical importance rely on specific cross and back cross to achieve increased productivity. Thus, the genetic improvement of performance may be based on a simple means of identification, measurement and recording of morphological characteristics and production performance necessary for estimating breeding values followed by prompt dissemination of goats with potential genetic merit to many commercial herds (Shrestha and Fahmy, 2007b).

Growth and carcass characteristics of three Ethiopian goat breeds, the Afar, Central Highland (CHG) and long-eared Somali (LES), have been evaluated under feedlot conditions (Sebsibe, 2006). The study showed that LES had better growth rates, heavier body and carcass weights with a higher fat content than the other two breeds. However, Addisu and Tegegne (2002) reported lower DP value for LES (43.5±0.16) compared with the DP values of 45.5±0.17, 45.4±0.16, and 45.2±0.02, respectively, for Afar, Arsi-Bale and Woyto-Guji goat of Ethiopia.

Birth and weaning weights

Flock meat output is dependent upon the weight of progeny produced. Weight gain is therefore an important factor of variation in animal productivity (Alexandre and Mandonnet, 2005). Birth weight of animals has a positive correlation with subsequent body weight development. Weight at birth, sex, birth type and season of kidding also affect the survival and growth rate of small ruminants. It was evident that survivability of kids increased with the increase of birth weight of kids and milk yield of dams (Husain *et al.*, 1995). Birth weight of kids and milk yield of dams had a relationship with survivability during the pre-weaning period with maximum kid mortality occurring at or below a birth weight of 2.5 kg (Bajhau and Kennedy, 1990).

Devendra and Burns (1983) reported birth weights of 1.8−4.9 and 1.8−4.4 kg for single and twin born female tropical kids and 1.6−4.2 and 1.7−3.9 kg for single and twin born male tropical kids, respectively. Berhane and Eik (2006) reported body weight at birth of 2.6−2.4 kg, weaning weight 6.0−8.9 kg and an ADG value of 33−35 g/day for Abergelle goats in north Ethiopia. The birth weight, weaning weight and ADG values for Adilo goats in south Ethiopia were 2.19 kg, 8.44kg and 69.4 g/day, respectively (Legesse, 2008).

The mean 150-day corrected weaning weight (corrected weaning weights actual weaning weights/age in days at weaning × 150) over a period of 12 years for Boer goat kids under extensive conditions in the Eastern Cape of South Africa was 27.72 kg (Erasmus, 2000). It has been reported that birth weight had a more than twice the effect on kid growth than milk consumption and a more than 10 times effect than breed. When kids were compared at the same birth weight, no significant difference in growth was observed between breeds (Bajhau and Kennedy, 1990).

Nutrition

The production of goat meat and the quality of the carcass and the meat can be influenced by applying management procedures through genetic and physiological routes. The management of physiological responses through nutrition and by limiting stressful environments and situations favors optimum growth rates and ultimately improve the quality of the carcass and the meat (Casey and Webb, 2010). The type and level of supplementation also affects growth performances of sheep and goats (Kaitho *et al.*, 1998).

Rift Valley goats of Ethiopia grazing natural pastures and supplemented with a concentrate had an average growth rate of 72 g per day (Abule *et al.*, 1998). Legesse *et. al.* (2006) reported average daily gain (ADG) of 32, 54 and 5 g for growing male indigenous Ethiopian (Somali and Arsi-Bale) goats under intensive, semi-intensive and extensive systems, respectively. Solomon *et al.* (2008b) observed ADG of 41.7, 65.3 and 55.6 g for male Sidama goats of Ethiopia fed a basal ration of grass hay with

200, 300 and 400 cotton seed meal supplementation, respectively. Similarly, an ADG value of 36.7, 34.7 and 43.9 g have been reported for male Afar, Central highland and long eared Somali goats of Ethiopia stall-fed with a grainless diet (Sebsibe *et al.*, 2007).

Data on growth rate of indigenous female goats of Ethiopia is limited. However, ADG values of 35 to 53 g have been reported for indigenous dairy type (Begait) female goats of Ethiopia under varying legume hay supplementation (Berhane and Eik, 2006). These authors also reported an ADG of 28 to 46 g for female indigenous meat type (Abergelle) goats of Ethiopia on a similar diet. Chentouf *et al.* (2011) observed post-weaning ADG values of 36.0±6.0 g and 20.0±7.0 g for female adult Moroccan indigenous goats under high and low nutritional groups, respectively.

Reproductive performance in goats

In small ruminants the profitability of suckling systems of production depends primarily on the efficiency of offspring production and the most important factor affecting flock efficiency is reproduction. Therefore, increasing reproduction is the most important ways of improving meat production in the tropics (Alexandre and Mandonnet, 2005).

Oestrous and ovulation

Productivity in farm species is controlled by many factors, including oestrous and ovulation rate. Oestrous cycles in goats is classified as short (<17 days), normal (17–25 days) or long (>25 days) duration (Chemineau *et al.*, 1992). The duration of oestrous is 24–36 hours, with considerable variation, a lower estimate of 30 hours has been recorded for Barbari goats, and still shorter average oestrous length of 17.0±9.7 hours, was reported for West Africa Dwarf goats (Devendra and Burns, 1983).

In cattle, single ovulations occur most frequently and in sheep and goats the number of ova released can range from one to many depending upon the breed (Hunter *et al.*, 2004). Tropical goats appear to be very sensitive to circulating oestrogens and the relationship between oestrous and ovulation is not definite as to other species. This means studies relaying on observations of oestrous behaviour alone must be interpreted cautiously since oestrous without ovulation and ovulation without oestrous may occur.

The processes of follicular recruitment and selection determine the number of ovulatory follicles in all these species with follicle stimulating hormone (FSH) and subsequently luteinizing hormone (LH) playing major roles (Hunter *et al*., 2004). A pattern of 3 or 4 follicular waves per cycle have been reported for Anglo-Nubian goats under a hot and humid environment (Tenório Filho *et al.*, 2007).

Age at puberty and kidding

Age at puberty is highly variable and is dependent upon the genetic make-up, nutrition, environment and the management system (Abi-Saab *et al.*, 1997). Ovaries of goat kids were found to have primordial, primary, secondary and small tertiary follicles at birth and corpora lutea were observed at 5 months of age. The uterus at 3 months was well developed with numerous endometrial glands, caruncles and a well-developed myometrium (Bukar *et al.*, 2006).

Information on age at puberty for tropical goat breeds is scarce, and available information in the literature is not consistent (Mekasha, 2007). Certain early maturing goat breeds have been reported to attain puberty at 3 months (Shelton, 1978). The age at first estrus in West African dwarf goats was reported to be 5–7 months (Akusu *et al.*, 1986). Puberty (based on gross and histological observation of corpora lutea) was attained at 5 months of age in female Sahel goat kids under traditional management systems (Bukar *et al.*, 2006). Freitas *et al*. (2004b) reported that Saanen female kids mature earlier than Anglo-Nubian kids in semiarid regions of Brazil, consequently, demanding different reproductive management systems.

Age at first successful mating of 7.4 months has been reported for sheep and goats in Ada district at the central part of Ethiopia (Abebe, 2008). However, goats in the tropics usually first mated at age of 14 to 17 months in the extensive system since young breeders are very likely to abort (Peacok, 1996). Tropical goats and sheep are often reported as being able to reproduce throughout the year and most goat breeds in the tropics can kid by one year old. The earliest possible age at first kidding is approximately 147 days after the first ostrous (Devendra and Burns, 1983). Abergelle and Begait goats in northern Ethiopia kidded at 12–14 months of age (Berhane and Eik, 2006). Many tropical goat breeds can kid twice yearly, and kidding three times in two years is common (Devendra and Burns, 1983).

Pregnancy rate and embryonic mortality

Gestation in farm animals is often divided into three stages: (1) the ovum from 0–13 days, (2) the embryo from 14 days, when germ layers begin to form until 45 days, and (3) the fetus from 46 days until parturition (Ball and Peters, 2004). Embryonic mortality during early pregnancy causes a significant reduction in the reproductive performance of farm animals. Few studies have focused on the cause of embryonic mortalities in goats, while factors influencing embryonic survival have been studied mostly in cattle and sheep. One of the major causes of embryonic loss is thought to be inadequate luteal function (Nancarrow, 1994). Akif and Kuran (2004) reported increased pregnancy rate and litter size in Gonadotropin- releasing hormone (GnRH) administered goats due to GnRH effect on increasing embryo survival through enhanced luteal function.

Maternal recognition of pregnancy in the goat occurs between days 15 and 17 (Gnatek *et al.* 1989). In goats embryonic losses early in pregnancy are usually much higher than fetal losses at later stages of gestation, and can be as high as 20–30%, due to the complexity of events associated with fertilization and implantation. Embryo mortality is also influenced by extrinsic factors such as doe age, environmental and nutritional stress. Abortions during the early stages of gestation can usually not be readily differentiated from failure to conceive. During these early stages of pregnancy, the embryo is sensitive to a variety of drugs and mineral deficiencies. In goats, in contrast to sheep, the placenta does not provide sufficient progesterone, and is dependent on secretions from an active corpus luteum to support pregnancy. Hence, spontaneous (non-infectious) abortions resulting from luteal insufficiency are more common in goats. Under nutrition, vitamin and mineral deficiencies, toxic plants, and certain drugs (i.e. levamisole) can contribute to non-infectious abortions.

Fertility and Prolificacy

An animal is fertile if it produces normal spermatozoa and ova capable of fertilization. An animal is prolific if it produces numerous offspring’s. Prolificacy in goats is best expressed as litter size (number of kids per birth). The latter expression gives full credit to non-seasonal goat breeds which have the capacity to kid twice per year, whereas for seasonal breeders, litter size is equivalent to annual birth rate (Devendra, 1985). In Europe, a breed is considered prolific when its litter size per birth is two or above. Devendra (1985), however, reported that 1.6 or more kids per birth as prolific goat breed in the tropics. A number of factors (age, body weight, sequence of kidding, type of birth, effect of sire, season of the year, breed and level of nutrition affect litter size in goats (Devendra, 1985; Amoah *et al.*, 1996).

Nubian goats have a prolificacy of 1.38 kids per parturition under an intensive management system in a dry tropical environment (Dickson-Urdaneta *et al.*, 2000). Mascarenhas *et al.* (1995) reported a prolificacy of 1.73 in mature Serrana goats. Alpine or Saanen goats have mean prolificacy of about 1.6–1.8 (Amoah *et al.*, 1996). Goonewardene *et al.* (1997) reported average litter size of 1.76 with artificial insemination in Alpine and Saanen goats. The most prolific tropical breeds are the Sudanese Desert and the Criollo, followed by four breeds belonging to the Indian subcontinent, namely the Barbari, Damani, Dera Din Panah and Ganjam. None of them, however, quite reaches the reported prolificacy of the Chinese Ma T’ou breed, a non-seasonal breeder averaging almost 4.5 kids per year (Devendra and Burns, 1983).

Twining is reported to occur 17–36 % of births of the Small East African goat families of Ethiopia; whereas the Somali goats of Ethiopia had the lowest twining rate (0.2 to 3%). This is attributed to the traditional selection of Somali goats of Ethiopia for milk production, against twinning (FARM-Africa, 1996). It is reported that the improved boar goat is early maturing and boasts high fecundity, with 2.09 kids born per doe kidded and a relatively large proportion of does (33%) have triplets (Erasmus, 2000). Prolificacy, kidding interval and gestation length, among others, are traits influenced by genetic, environmental, and management factors and they have economic significance since they determine reproductive performance and the productivity of a goat enterprise. Infertility causes a culling decision in large dairy goat herds managed under intensive conditions (Malher *et al.*, 2001).

Post-partum anoestrus (PPA)

In the tropics, anoestrus and difficulty to get conceived after parturition are the main fertility problems in both large and small ruminants. In tropical goats the interval from kidding to first postpartum heat has been reported to vary from one to three months or even longer (Devendra and Burns, 1983). They may exhibit prolonged periods of anoestrus as a result of poor nutrition or unfavorable environmental conditions. The start of oestrous activity during the postpartum period is important to obtain a suitable kidding interval. Saanen goats that are more specialized for efficient milk production showed a longer PPA in primiparous females and had greater difficulty in returning to normal oestrous behavior (Freitas *et al.*, 2004a).

Factors affecting reproductive performance in goats

Management practices

Ruminant livestock in the tropics are integrated into a variety of production systems each with different constraints, management practices, production goals and farmer priorities. In these areas, breed substitution of exotics for the indigenous breeds and crossbreeding with breeds from temperate regions have been widely used.

But this have invariably been unsuccessful or unsustainable in the long-term (Kosgey *et al.*, 2006) due to incompatibility of the genotypes with the breeding objectives and management approaches of the prevailing low-input traditional production systems (Ayalew *et al.*, 2003).

Many goat breeds in developing countries and/or under extensive production systems are also not characterized because in these areas characterization becomes more demanding (Galal, 2005). In some goat projects that failed in the tropics, it was found that definition of comprehensive breeding objectives incorporating the specific, immediate, and long-term social and economic circumstances of the target group as well as ecological constraints was lacking (Kosgey *et al.*, 2006). Therefore, the establishment of a specific breeding program requires a good understanding of the ecological region, farming system and the required farm organizations prior to improvement activities (Bett *et al.*, 2009).

Understanding reproductive processes in the goat will also help producers to manage their herd more efficiently, and breed their does to produce kids that will fit a specific market niche to command a maximum price. Mascarenhas *et al.* (1995) reported that Serrana goats (Portuguese breeds of goats) have a period of anoestrus from January to May and fertility in the beginning of the breeding period (May) could be improved by adequate management techniques so that most parturition occur in October/November.

Therefore, effective breeding strategies to exploit the biological ceiling of goat species need to take into consideration the diversity of breeds and their husbandry practices, diet, climatic condition, natural vegetation and terrain, labor surplus to household requirements, availability of trained personnel and equipment, social and cultural attributes, economic reality and proximity to markets (Shrestha and Fahmy, 2005).

Season

Under tropical conditions, where the amplitude of photoperiodic changes is lower, it is known that goats reproduce year round (Devendra and Burns, 1983; Amoah and Gelaye, 1990), and it is believed that environmental factors other than the photoperiod (e.g., feed availability, rainfall, temperature and humidity variations) may affect the breeding season of tropical breeds of goat (Prasad and Bhattacharyya, 1979). Under intensive conditions in a hot arid environment, season of mating was a significant risk factor for pregnancy rate in goats mated in summer than goats mated in fall (Mellado *et al.*, 2006). In the humid tropics, higher incidence of ovulation in goats was observed during October and December (78.8%) and lowest in June (54.3%) (Suttiyotin *et al.*, 1991). However, the factors contributed for this periodic change in reproductive activities have not been reported.

Significant year and season effect on total milk production, lactation length, litter size and litter weight at kidding, on post-kidding body weight and efficiency of Alpine, Granadina, Nubian, Saanen and Toggenburg crossbred goats have been reported in a stall-fed sub-tropical environment (Montaldo *et al.*, 1995). Gestation period, litter size, and birth weight in goats is also affected by month of mating (Amoah *et al.*, 1996). Pen-fed Saanen goats do not show seasonality for oestrus behavior and rainfall appeared to be an extero-receptive factor influencing the quality of sexual activity and performance in these goats when reared in intensive condition of Northeast Brazil (Lopes Júnior *et al.*, 2001).

Heat stress

Heat stress affects negatively reproductive performance of female farm animals. Heat stress in goats can be defined as the disruption of homeostasis by ambient temperatures which are greater than an animal’s upper critical temperature, resulting in heat production due primarily to a rise in body temperature (Lu, 1989). Optimal climatic conditions for sheep and goats is an air temperature of 13 to 20ºC, a wind velocity of 5 to 18 km per hour, relative humidity of 55 to 65% and a moderate level of sunshine (El-Sobhy, 2005). Heat stress causes low fertility, late sexual maturity, long kidding intervals in tropical goats and the introduced temperate breeds are more susceptible (Devendra and Burns, 1983). Lu (1989) reported prolonged anoestrus, embryo or fetal loss, inadequate milk yield and depression of feed intake and reduction in production in heat-stressed goats.

Elevated ambient temperature during days 8–17 of pregnancy increases plasma concentrations of progesterone and 13, 14-dihydro-15-ketoprostaglandin F2α (PGFM) in pregnant goats (Emesih *et al.*, 1995). A rise in uterine prostaglandin secretion may influence corpus luteum function during early pregnancy and affect conceptus growth and development. Mellado *et al.* (2006) reported that the temperate dairy goat breeds (Saanen, Toggenburg and French Alpine) were nine times less likely to become pregnant compared with Nubian and Granadina goats under intensive conditions in a hot arid environment.

Nutritional factors

Female goats in lower body condition have a shorter breeding season, more abnormal oestrous cycles, and fewer ovulations than does in greater body condition (De Santiago-Miramontesa *et al.*, 2009). Anoestrous period in goats also coincided with the dry season and less body condition scores of goats (Fitz-Rodriguez *et al.*, 2009). Amoah *et al.* (1996) also reported that gestation period, litter size, and birth weight in goats is affected by mating weight. Other studies indicate that reproductive success in goats in a hot arid environment increased with birth weight (Mellado *et al.*, 2006). Production of cashmere from productive genotypes is responsive to energy nutrition and strategic benefits can be obtained by enhancing the growth of young does prior to mating and for higher producing Cashmere goats (McGregor, 1998).

Under-nutrition can reduce ovulation rate and pregnancy rate in goats and cause for embryo loss up to 30 days of pregnancy (Fitz-Rodriguez *et al.*, 2009). Pre-natal under nutrition may exert some effects on adult fecundity and fertility via an increased incidence of ‘metabolic syndrome’ (Gardner *et al.*, 2009). Dietary energy restriction during pre-breeding decreases the proportion of does showing estrous; reduce conception rate and fertility in goats (Kusina *et al.*, 2001). However, nutritional supplementation improves ovulation and pregnancy rates in female goats managed under natural grazing conditions (Fitz-Rodriguez *et al.*, 2009). Titi *et al.* (2008) also reported that does fed supplemental fat at 3 % during post partum period recovers cyclicity late in the breeding season.

Supplementing grazing Begait and Abergelle goats with leguminous vetch hay resulted in improved reproductive performance and higher live weight gains of goats and young stock and more goats in the high supplemented groups were able to sustain pregnancy during the dry season and kid towards the end of the rains with more favorable conditions for growth and survival of kids (Berhane and Eik, 2006). Eik (1991) also reported that goat milk can be successfully produced on a 75% roughage (DM basis) based diet in early lactation. It is suggested that meal concentrates should normally be fed according to yield and roughage intake, and limited to 50% of diet (DM basis).

Tropical native goats are well adapted to fodder shortage condition, during dry seasons due to their efficient utilization of nutrients (Kumagai and Ngampongsai, 2006). Toggenburg goats were able to perform and thrive reasonably well under low-input farming conditions (Ahuya *et al.*, 2009). On the other hand, Pralomkarn *et al.* (1995) suggested that raising cross-bred goats under village environment in the humid tropics needs to consider both nutrition and parasite control and the interaction of these two factors.

Maternal behavior

Kid mortality is a major constraint for improving the efficiency of small ruminant production systems in the tropics (Devendra and Burns, 1983). This variable varies greatly according to the type of production (intensive or extensive) and the handling conditions. In fact, the value can range from 7 to 51% (Mellor and Stafford, 2004), the greatest number of deaths occurred during the first and second day of life (neonatal mortality). Some random variables, such as birth weight, sex, and litter size, affect the pre-weaning mortality (Awemu *et al.*, 1999; Marai *et al.*, 2002; Hailu *et al.*, 2006). At the same time, the survival rate of the kids will depend on the maternal care and on the activity of the newborn kids to guarantee suckling. Both maternal behavior and kid activity influence neonatal mortality (Alexander and Peterson, 1961; Poindron *et al.*, 2007b).

The defining characteristic of mammals is that females nurse and care for their young; without this, the neonate has no chance to survive. Studies on wild and domestic species show that the neonatal period is the most critical step in the lifetime of a mammal and after birth, survival of the newborn will depend largely upon the quality of the interactions with the mother (Nowak *et al.*, 2000). Arnold and Morgan (1975) reported that poor maternal behavior *per se* was the cause of 16% of lamb deaths in sheep; while 37.4% of twins died compared with 9.6% of singles due to inadequate care of twins by Merino ewes (Stevens *et al.*, 1982). In domestic goats, the opportunity to express certain social behaviors can be limited by captivity and management systems, especially in modern production systems, where goats are reared intensively under high stocking densities, sexual segregation, early separation of kids from their mothers, frequent regrouping, and manipulation during critical periods, including gestation and weaning (Miranda-de la Lama and Mattiello, 2010).

The first 2–4 h after parturition is a sensitive period for the establishment of the relationship between a mother and her kid (Delgadillo *et al.*, 1997). Results from earlier research (Bordi *et al.*, 1994) showed that maternal selectivity in goats is developed within 4 h after parturition. The mother–offspring relationship can be split into three phases: (1) 0–1 week: *ad libitum* suckling and complete dependence on the dam; (2) 2–5 weeks: the kid remains largely dependent on milk for food, but the dam starts to reject solicitations to suckle and rejections increase in frequency; 3) >5 weeks: the kid becomes less dependent on milk and begins to eat other foods (Bungo *et al.*, 1998). If the practice on a commercial farm is to have the kids suckled by their mother (typical in extensive systems), to allow the proper development of the mother–offspring bond it is important to avoid disturbing the animals during the sensitive period (Lickliter, 1982). When the mother-young bond is not established quickly after birth (sensitive period), the acceptance of kids is reduced drastically and kids may even become totally rejected (Poindron *et al.*, 2007a). There is little information concerning the relationship between does and their kids during late lactation and weaning.

The effect of Parity

Multiparous (MP) does have shown greater inclination to withdraw from con-specifics prior to parturition, to become increasingly aggressive to herd mates, and to more actively defend their young compared to primiparous (PP) does indicating the importance of parity as a determinant of maternal behavior in domestic goats (Lickliter,1982). This study also suggested that previous reproductive experience may serve to increase the likelihood of activation and maintenance of maternal responsiveness in domestic goats. Dwyer *et al.* (1999) reported that the existence of two motivational dimension in maternal behavior in sheep: (1) Ewe grooming attention which is hard wired and associated with maternal estrogen in late gestation (largely physiological), and (2) Ewe response to lamb suckling behavior which is more affected by previous experience of ewe.

Maternal nutrition during late gestation

Nutritional supplementation in late pregnancy had a marked effect on does and kids. Severity of low nutrition was evident in significant weight losses in feral and crossbred goats (Bajhau and Kennedy, 1990). Under nutrition during gestation result depressed maternal behavior and increased neonatal mortality, while supplementary feeding has the opposite effects (Langeneau and Lerg, 1976). Other studies also indicate that maternal (visual and/or acoustic) recognition of kids can be influenced by the level of maternal nutrition in late pregnancy (Poindron *et al.*, 2007a). Berhane and Eik (2006) reported that supplementation of the dam sustained pregnancy in does during the dry season and the does are able to kid towards the end of the rains with more favorable conditions for growth and survival of kids. Allan *et al.* (1991) reported that doe nutrition (prenatal feeding) contributed to ease of birth in does and this was reflected in positive care giving behavior of does. The authors also indicated that maternal care giving behavior of the doe is not inadequate even under conditions of moderate protein deficiency.

Conclusion

Effective breeding strategies to exploit the biological ceiling of goat species need to take into consideration the diversity of breeds and their husbandry practices. Growth performances of goats can be influenced by applying management procedures through genetic and physiological routes. Understanding reproductive processes in the goat will also help producers to manage their herd more efficiently, and breed their goats to produce kids that will fit a specific market niche to command a maximum price.

However, growth rate, estrus cycle, ovulation rate, prolificacy, kidding interval and gestation length in goats, among others, are traits influenced by genetic and management factors. They have economic significance since they determine the productivity of a goat enterprise. Poor growth performances and pre-or post-partum infertility causes a culling decision in large dairy goat herds managed under intensive conditions. Thus, efficient utilization of goat genetic resources needs to take into consideration their management practices, physiological responses and behavioral characteristics.

The Woyto-Guji goats are one of the eight indigenous goat breeds that are adapted to the recurrent drought and water shortage conditions of south western Ethiopia. However, there is not adequate information on their management practices including their feeding, growth and reproductive performances which is required for possible improvement of the goats.

MATERIALS AND METHODS

Experiment 1

Assessment of goat management practices and production constraints in pastoral and agro-pastoral districts of South Omo Zone

Descriptions of the studied area

The study was conducted in Hamer and Bena-Tsemay pastoral and agro-pastoral districts of South Omo zone. The districts are located between 04° 59.00″ and 05° 58.40″ N and 36° 12.45″ and 37° 30.25″ E in the Southern Nation, Nationalities and People's Region (SNNPR) of Ethiopia (Figure 3). The climate of the districts is hot to warm semiarid with altitudinal variation of 500 to 1800 meters above sea level. Rainfall in the districts is bimodal, the main rain occurring in March to May and a short rain occurs in September to October.

According to the National Meteorological Agency, the 2000 to 2010 mean annual rainfall in the upper part of Bena-Tsemay district (Keyafer) was 1400 mm and the average daily temperature range was 15.6°C to 26.5°C; whereas in Hamer district, the 2000 to 2010 mean annual rainfall was 929 mm (at Dimeka) and 680 mm (at Turmi). The average daily temperature range at Dimeka was 16°C to 35°C (NMA, 2011). Generally, traveling from north to south of the South Omo zone, temperature increases and rainfall decreases. The 2000 to 2010 monthly rainfall and temperature of the locations in the study districts was presented in Appendix Figures B1, B2 and B3.

The vegetation of the districts is dominated by varying densities of Acacia, Grewia and Solanum woody species and 35 herbaceous species of grasses and legumes are found (Admasu *et al.*, 2010). The dominant types of land use in Hamer district is pastoralism while that of Bena-Tsemay is agro-pastoralism. More than 48% of the total land area of the districts is used for grazing and/or browsing by cattle, sheep and goats (Terefe *et al.*, 2010). Ownership of the rangeland in both districts is communal except small plots of range enclosures around homesteads and croplands (Admasu *et al.*, 2010). Sorghum, maize, millet, barley, wheat, and tef are the main crops grown in the districts (Terefe *et al.*, 2010). The two districts possess 60% of the goat population of the pastoral and agro-pastoral districts of South Omo zone (SOFEDB, 2009).

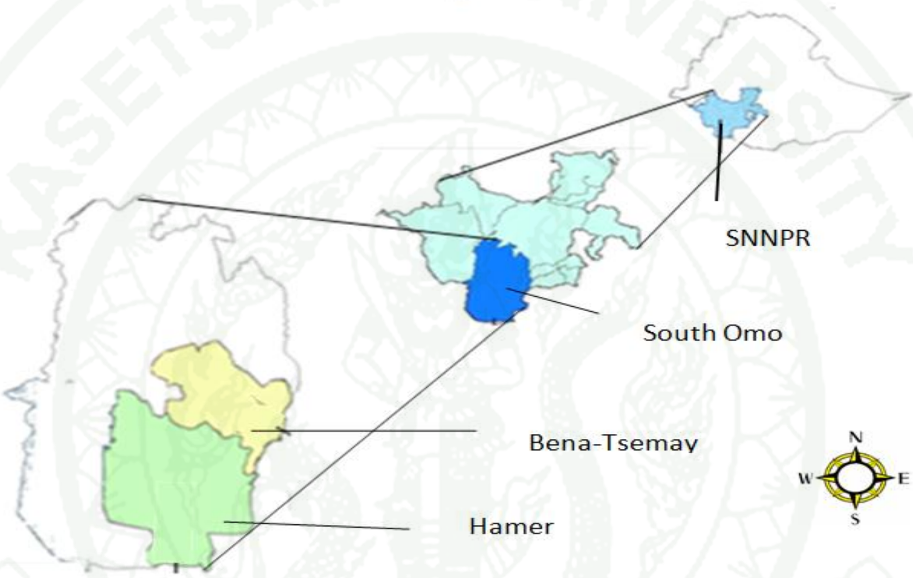

Figure 3 Map of Southern Nation, Nationalities and Peoples Region (SNNPR) of Ethiopia showing South Omo zone and location of the study districts

Methods

Sampling procedure

After selection of the two districts namely; Hamer (representing the pastoral area) and Bena-Tsemay (representing the agro-pastoral area) a two stage sampling technique was used (Bethlehem, 2009). In the first stage, Kebele's (lowest administrative sub-units) and villages were selected from each district based primarily on distribution of ethnic groups and population of goats. In the second stage, respondent households were selected randomly using systematic sampling procedures from the selected villages (three to five respondents per village). The distribution of samples in each district was presented on Table 2. Data for the study was collected by formal and informal survey methods. The informal survey was undertaken through group discussions and key informant interviews with knowledgeable goat producers and community leaders (Appendix Figures 7 to 9). Moreover, a secondary data pertinent for the study was collected from relevant district offices.

Table 2 Distribution of the sample in different sampling units (in numbers)

	Sampling unit[1]			
District	Kebele[2]	Village	Households	Ethnic groups interviewed
Hamer	38 (9)	217(27)	122	Hamer, Arbore
Bena-Tsemay	31 (9)	220(45)	128	Bena, Tsemay, Birale, Ari
Total	69(18)	437(72)	250	

[1] Numbers in parentheses represent selected sampling units

[2] Lowest administrative sub-units

The formal survey was undertaken using a structured questionnaire (Appendix C) administered by trained enumerators. The questionnaire was translated from English to Amharic (official language) and pre-tested and modified based on the feedback obtained. A single-visit, multiple-subject survey method (ILCA, 1990) was followed to gather the necessary information. The data were collected from January to May 2011. A household was used as a unit of analysis.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 17. Means were compared using descriptive statistics such the Chi-square test, means, standard deviations and percentages. Weighting of rankings was calculated (for example, Table 5) as Rank Index = Sum of [5 × rank 1 (Number of households in rank 1) + 4 × rank 2 + 3 × rank 3 + 2 × rank 4 + 1 × rank 5] divided by sum [5 × rank 1 + 4 × rank 2 + 3 × rank 3 + 2 × rank 4 + 1 × rank 5] of all items in that district (Kosgey *et al.*, 2008).

Experiment 2

Evaluation of Feed Intake, Growth Rate and Subsequent Reproductive Performances and Behavioral Characteristics at Parturition of Woyto-Guji Goats under various Meal Concentrate Supplementation

Location

The experiment was conducted for nine months from February to October 2011 at Jinka Agricultural Research Center, south western Ethiopia. The area is located at latitude 5°47′ North, Longitude 36°34′ East and situated at an altitude of 1490 meter above sea level. The climate of the area is hot to warm semiarid. The rainfall, mean monthly minimum and maximum temperatures, relative humidity and sunshine hours during the experimental period were presented in Figures 4 and 5.

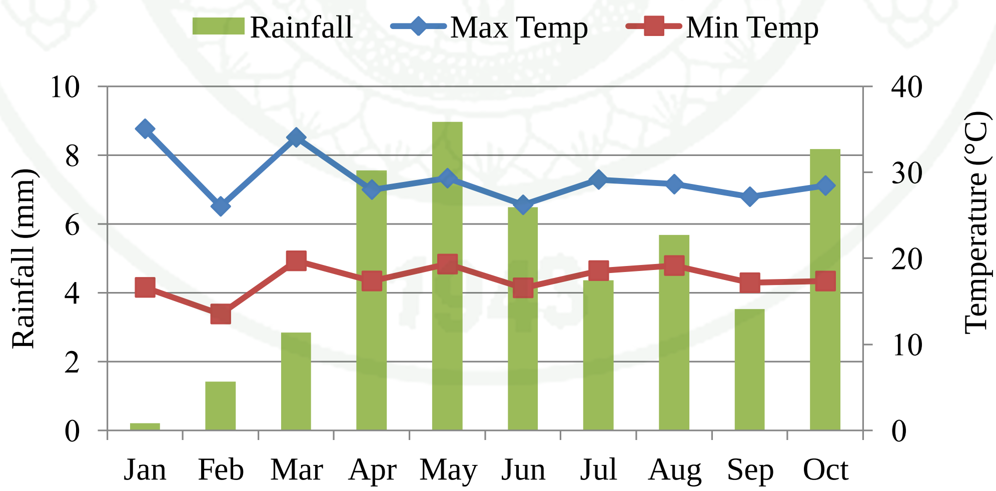

Figure 4 Average monthly rainfall and temperatures during the experimental period

Source: NMA (2011)

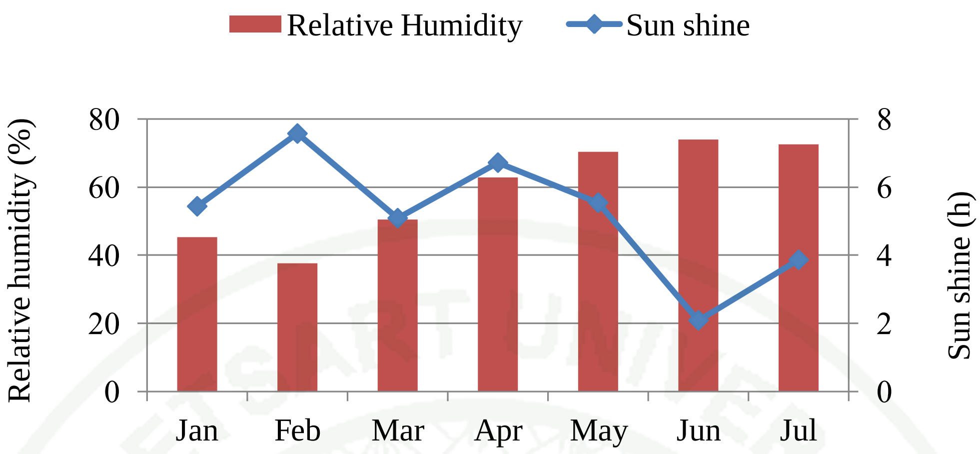

Figure 5 Monthly relative humidity and sunshine hours in the experimental period

Source: NMA (2011)

Materials

Animals

Forty five primiparous female Woyto-Guji goats 14.3±0.49 months old, 15.05±0.23 kg body weight (BW) and body condition score (BCS) of 2.9±0.05 were used for the experiment. The goats were purchased from pastoral villages in Hamer district (south west Ethiopia) after an arrangement and price negotiations were made with local traders and goat farmers who are willing to sell healthy and non-bred yearling female goats. The animals were brought to the goat farm at JARC, ear tagged and further examined for parasites, diseases and treated with Oxy tetracycline 20% L.A, (Chengdu Q. Vet. Phar., China) and Vectocid (Ceva Interchem, Tunisia) to control respiratory diseases. Tetramisol and Ivermectin 1% (Chengdu Q. Vet. Phar., China) was injected to control internal and external parasites. All goats were vaccinated against Peste des petits ruminants (PPR). The goats were allowed to graze at day-time and provided with grass hay at night for one month before the start of the experiment.

Feed and feeding

Three treatments of feeding were used for the experiment, viz.:

T_0 = No meal concentrate (control)

T_1 = 200 g meal concentrate per goat daily (as-fed basis)

T_2 = 400 g meal concentrate per goat daily (as-fed basis)

Rhodes grass (*Chloris gayana*) hay was fed *ad libitum* as whole plant for all goats. The concentrate used was commercially prepared by Alema Koudijs Feed PLC, Debrezeit, Ethiopia containing 18.5% crude protein and a metabolisable energy (ME) of 9.544 MJ/kg DM. The ingredients in the concentrate were wheat bran 20%, wheat middling 18%, noug (*Guizotia abyssinica*) seed cake 15%, cassava peel 18%, corn 12%, rye bran 10%, molasses sugarcane 6%, limestone 2% and salt 1%.

Methods

Feed intake and Growth performances

Experimental procedures

Starting from February 2011, the experimental animals were randomly divided into three groups in a completely randomized design. The goats were housed in separate pen as a group and allotted to the three treatment feeds and fed in individual pens for 90 days. Flow chart of concentrate feeding was presented on Figure 6. Body weight of all does was weekly measured, before offered the morning feed. Live weight gain was calculated as a difference between initial and final live weight over specified intervals. Amount of both hay offered and refusals were removed and weighed daily to derive feed intake. Dry matter (DM) of feeds was determined by oven drying at 105 °C for 14 h and organic matter (OM) was quantified by ignition in a muffle furnace at 600 °C for 6 h. Crude protein (CP) concentration was determined by the micro-Kjeldahl method (AOAC, 1990). Concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), cellulose and hemicelluloses were determined with procedures of Van Soest *et al.* (1991). For the determination of calcium (dry ash method, procedure 4.8.03) and phosphorus (photometric method, procedure 4.8.14) of AOAC (2000) was used. Gross energy content of the feed was determined via bomb calorimetry (Parr Instruments, Moline, IL).

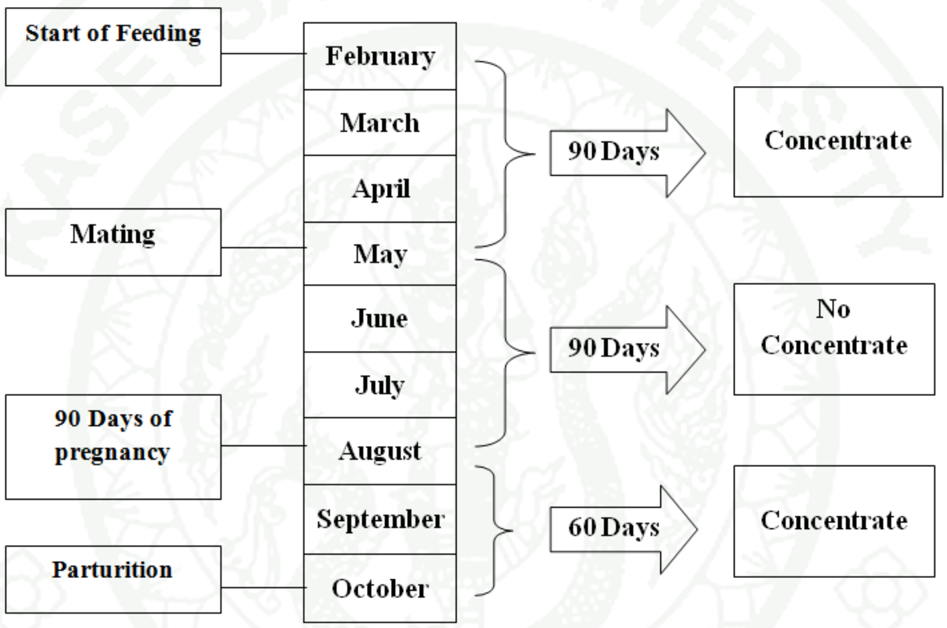

Figure 6 Flow chart of meal concentrate supplementation during the experimental period

Statistical Analysis

Feed intake, feed per gain, body weight changes and average daily gain data were analyzed using a one-way ANOVA, between subjects design in SAS GLM procedures (using the MEANS statement) (SAS, 2002). Diets were used as a fixed effect and when differences between the treatments were observed the Tukey's range test (Steel and Torrie, 1990) was applied to compare treatment means.

Cost and income variables

Experimental procedure

Total cost of variables (hay and concentrate) was calculated from daily feed intakes and income values of supplementary feeding were calculated from ADG during the growth period. Cost of grass hay was 35 Ethiopian Birr per a bale of 18 kg. The concentrate was purchased at a cost of 223.41 Birr/100kg. Meat price of Birr 150/kg was used to calculate income value from ADG. Profit was calculated as income value minus total variable cost, all value in October 2011.

Reproductive performances

Experimental procedure

Blood was collected from 5 goats per treatment in April 2011, before mating, through jugular vein puncture (Appendix Figure 17) to assess ovarian activities of the goats. The blood was collected twice a week (9:00 to 10:00 hours before feeding) for one estrus cycle (21 days). Serum progesterone concentration was analyzed in the Ethiopian Health and Nutrition Research Institution laboratory using Immunoassay system (Elecsys 2010, Roche Diagnostics, Germany).

In mid May 2011, goats were allowed to graze on an outdoor paddock of native pasture for four hours per day (between 0800 and 1000 hours and between 1600 and 1800 hours) to facilitate mating and during this period two entire bucks were introduced for 42 days to detect oestrous behavior of the does and allowed for mating. Signs of oestrous were recorded in the morning and evening grazing hours and a female was recorded in oestrous if she stood-still when mounted by the male. Dates for first sign of oestrus and successful mating were recorded and the does that were not exhibited oestrous up to 42 days after mating were considered pregnant.

Meal concentrate was discontinued after the mating period as shown on Figure 6. All non-pregnant does within 42 days of buck introduction were excluded from the experiment. The supplementation was resumed after 90 days of pregnancy for goats in T_1 and T_2 treatment groups as previous supplementation. During pregnancy period, a basal ration of Rhodes grass hay was provided for all goats *ad libitum* and all had free access to fresh water and salt blocks. Body weight of the goats was recorded weekly and their BCS was recorded before feeding, at mating, at 90 days of pregnancy and at parturition. The five-point scale was used for scoring body condition of the goats (Villaquiran *et al.*, 2004).

The reproductive traits of goats recorded consisted of the following:

(1) Pregnancy rate (number of pregnant goats (kidding and aborting animals)/number of goats mated × 100)
(2) Gestation length (difference between mating and parturition dates)
(3) Kidding rate (the number of goats kidding/number of goats pregnant × 100)
(4) Litter size (number of total kids born/number of goats kidded)
(5) Abortion rate (number of aborted goats/ number of pregnant goats × 100)
(6) Kid’s birth weight (recorded with in 24 h of birth)

Statistical Analysis

The data on BW, BCS, mating days, gestation length, kidding days, kid birth weight and litter size were analyzed using a one-way ANOVA, between subjects design in SAS PROC GLM (SAS, 2002). Diets were used as fixed effect and the LSMEANS procedure was used to calculate mean values, and the PDIFF option was used to separate means. The data on proportion of does in oestrous, doe mated and kidded, pregnancy and kidding rates were compared using the SAS PROC Freq Chi square procedure (SAS, 2002).

Behavioral characteristics at Parturition

Experimental procedure

Description of doe and kid behavioral characteristics recorded in the study period was presented in Table 3. Birth difficulty was assessed on a score of 1 (no assistance) to 4 (major assistance). New born kids were marked for identification with tags attached to neck-chains. All the data on occurrence of kid and maternal behavioral characteristics were recorded through direct observations and using a digital camera (Canon, IXUS 95IS (ORO), JP).

Statistical analysis

Data on length of labor and on times taken for standing and suckling by the kids were analyzed using a one-way ANOVA, between subjects design in SAS PROC GLM using the LSMEANS procedure for unbalanced data (SAS, 2002). Frequency and percentages were used to present the effects of treatments on birth difficulty score and other doe's behavioral characteristics at parturition.

Table 3 Description of doe and kid behavioral characteristics recorded in the study period.

Behavioral expression	Description
Doe behavior	
Before parturition	
Number of does showed increased restlessness	Pacing, lying to standing and vice-versa
Number of does with frequent vocalization	20 or more per hour
At parturition	
length of labor (minutes)	Interval between first appearance of fluid to expulsion of a kid
Kids behavior	
Latency to attempt to stand	kid on knees, supports part of its weight on at least 1 foot
Latency to successful stand	kid supports itself on all 4 feet for at least 5 seconds
Latency to suckling attempt	Kid in parallel inverse position, head beneath doe in udder region, prevented from sucking by doe movement or leaves udder region within 5 seconds
Latency to successful suck	Kid has teat in its mouth, in correct position, appears to be sucking for at least 5 seconds

RESULTS AND DISCUSSION

Experiment 1

Results

Household characteristics

The family size per household in the studied districts was presented on Table 4. Average family size per household in Hamer and Bena-Tsemay district was 6.7 and 6.6 persons, respectively. Female and male children (<15 years of age) occupy more than 40 % of the family size in both districts. Male headed households comprise 81 and 86% of respondents in Hamer and Bena-Tsemay district, respectively. About 90% and 72% of the household heads in Hamer and Bena-Tsemay, respectively, were illiterate. However, the respondents in Hamer and Bena-Tsemay districts had goat keeping experience of 24.5±13.1 and 19.9±14.5 years, respectively.

Table 4 Family size (number of persons) per households in the study districts

Family by age	Hamer	Bena-Tsemay
Children		
Female <15 year	2.1±1.0	2.3±1.6
Male <15 year	2.3±1.3	2.2±1.2
Adult		
Female 15–65	1.6±0.9	1.5±0.8
Male 15–65	1.7±1.0	1.5±1.2
Female >65	1.1±0.3	1.0±0.0
Male >65	1.0±0.0	1.0±0.0
Total average	6.7±2.2	6.6±3.0

Ranks on income sources by the households were presented in Table 5 and 6. Table 7 shows the major crops grown by the households. In both districts, sale of livestock is the main source of income. Sale of livestock products such as milk, butter and honey in Hamer and sale of crops such as sorghum, maize, millet, barley, wheat and tef in Bena-Tsemay are the second greatest source of income for the respondents. In both districts, goats are the greatest income source from livestock types followed by cattle. However, the proportion of households ranking goats as the first income source was significantly higher in Hamer district than Bena-Tsemay.

Table 5 Sources of income and their relative importance as ranked by households

Income source	Hamer (n=122)			Bena-Tsemay (n=128)			Chi-Square
	HH[a]	HH[b]	Ranking[c]	HH[a]	HH[b]	Ranking[c]	
Livestock	122	97	1.249	116	75	1.126	6.94*
Livestock products	116	12	0.857	114	4	0.753	20.03***
Honey	105	6	0.833	96	14	0.678	26.86***
Crop	70	6	0.354	113	32	0.857	51.19***
Petty trading	48	1	0.202	30	4	0.145	6.78

* and *** show significance at 10% and 1%, respectively

[a] Number of households considering the item as important source

[b] Number of households ranking the item as first income source

[c] Rank index calculated as used by (Kosgey *et al.*, 2008)

Table 6 Livestock types and their relative importance as an income source as ranked by households

	Hamer (n=122)			Bena-Tsemay (n=128)			
Livestock types	HH[a]	HH[b]	Ranking[c]	HH[a]	HH[b]	Ranking[c]	Chi-Square
Cattle	120	18	1.210	121	44	1.305	28.796***
Goats	122	101	1.532	125	74	1.444	17.041***
Sheep	107	1	0.985	87	0	0.705	18.157***
Beekeeping	102	1	0.866	92	7	0.755	16.491***
Donkey	23	-	0.129	25	0	0.129	1.941
Poultry	63	2	0.414	112	1	0.755	10.870*
Camel	6	-	0.022	5	0	0.009	5.238*

* and *** show significance at 10% and 1%, respectively

[a] Number of households considering the livestock as important source

[b] Number of households ranking the livestock as first income source

[c] Rank index calculated as used by (Kosgey *et al.*, 2008)

Livestock holding and herd composition

Livestock holdings by households in the districts are presented in Table 8. Almost all households in the study districts raised cattle and goats followed by sheep. Bee keeping is practiced by 70% of the respondents in the study districts. Goat holdings were higher in Hamer than Bena-Tsemay district, the average per household being 66.7±54.2 and 41.8±31.2, respectively.

Table 7 Major crops grown by households in the study districts

Crop type	Hamer (n=122)			Bena-Tsemay (n=128)			Chi-square
	HH[a]	HH[b]	Rankings	HH[a]	HH[b]	Rankings	
Maize	12	122	0.324	87	128	0.325	88.454***
Sorghum	110	122	0.394	39	121	0.287	86.450***
Millet	-	28	0.037	-	79	0.116	11.596**
Teff	-	9	0.011	2	58	0.073	3.988
Haricot bean	-	118	0.234	2	118	0.199	36.835***

** and *** show significance at 5% and 1%, respectively

[a] Number of households considering the item as important source

[b] Number of households ranking the item as first income source

[c] Rank index calculated as used by (Kosgey *et al.*, 2008)

Table 8 Livestock holdings per household in the study districts (in numbers)

Livestock types	Hamer		Bena-Tsemay	
	Mean	%HH	Mean	%HH
Cattle	24.4±23.0	95.9	24.3±25.6	93.0
Goats	66.7±54.2	100.0	41.8±31.2	98.4
Sheep	16.7±14.8	76.2	11.7±10.4	65.6
Ox	2.9±1.6	63.1	3.3±1.5	93.8
Chicken	9.3±6.0	38.5	12.5±7.3	89.8
Donkey	3.3±2.1	6.6	2.7±2.2	15.6
Camel	1.1±0.4	6.6	1.6±0.5	5.5

In Hamer district, 13.9% households possess 1–20 goats, 26.2% (20–40), 23.8% (40–70), 18.9% (70–100) and 17.3 % (>100) goats. In Bena-Tsemay district, 34.4% of the households possess 1–20 goats, 24.2% (20–40), 21.9% (40–70), 14.1% (70–100) and 5.5 % (>100) goats. Adult male (>1year), adult females (>1year), weaners (6–12 months) and kids constitute 21.6, 43.9, 21, and 13.4% of the goat flock in Hamer district. The corresponding values for Bena-Tsemay district was 20.6, 40, 24.4, and 15%, respectively. Overall, male and female goats constitute 38.6 and 61.3% of the flock composition in Hamer and 30.2 and 59.8% in Bena-Tsemay district, respectively.

Trend of goat production

A decline in goat production in the last 5–10 years (2001 – 2010) was reported by 71.6 and 44.4% of the households from Hamer and Bena-Tsemay district, respectively. According to the households, prevalence of diseases and drought are the major factors for the decline. Other reasons for the decline in Hamer district include shortage of grazing land, cultural obligations to sacrifice large number of goats for various ceremonies, raids during conflicts and predators. In Bena-Tsemay district, in addition to diseases and drought, shortages of grazing land due to expansion of cultivations was reported as a factor for the decline. On the other hand, 21 and 47% of the households in Hamer and Bena-Tsemay districts, respectively, stated an increase in goat numbers for the last 5–10 years. Availability of health services and grazing resources and increase in goat producers are among the reasons for the increase in goat numbers.

Purpose of keeping goats

The households in the studied districts raise goats for multiple purposes which are categorized into three (adapted from Ayalew *et al.*, 2003): (1) Socio-economic (cash, asset, security); (2) Production (yield attributes) (meat, milk, blood); and (3) Socio-cultural (rites, ceremony, dowry) purposes. Rankings on the purposes by the households were presented on Table 9. In both districts, goats are kept primarily for socio-economic purposes and secondly for socio-cultural functions. The role of goats as a source of meat, milk and blood was ranked third. However, the proportion of households ranking goats as a source of meat, milk or blood was significantly higher ($P < 0.05$) in Hamer than Bena-Tsemay district. On the other hand, a significantly higher number of households rear goats as a source of cash in Bena-Tsemay than Hamer district (P < 0.05).

Table 9 Purpose of keeping goats and their relative importance as ranked by households (HH)

Purposes	Hamer (n=122)			Bena-Tsemay (n=128)			Chi-Square
	HH[a]	HH[b]	Ranking[c]	HH[a]	HH[b]	Ranking[c]	
Production (yield attributes)	98	26	0.622	125	14	0.532	9.18**
Socio-economic	99	49	0.747	127	73	0.832	8.99**
Socio-cultural	99	23	0.628	124	40	0.644	3.44

** Shows significance at 5%

[a] Number of households considering the purpose important

[b] Number of households ranked the purpose first

[c] Rank index calculated as per (Kosgey *et al.*, 2008)

Source of genotypes and perception on traits

All households in the studied districts own indigenous goat genotypes which are identified by their locality or tribe names as Hamer, Borana, Dasenech, Galeb, Bena, Tsemai, Ari, Malle, Kenya or Gebere goats. The majority of pastoral households reported that the origin of goats was from Borana (west of the study districts), Dasanech and north Kenya (South of the study districts) whereas some of the households in the upper part of Bena-Tsemay district reported Malle area and Gofa zone (North of the study district) as the source for their goat types.

The households have varying perceptions on performances of goat types within their locality. The Hamer ethnic groups perceive their goats (Hamer goats) as inferior to Borana goats in terms of body size and milk production. However, they believe that their goats are superior to the Dasenech or Geleb goats in growth performances. On the other hand, the agro-pastorals in the north extreme parts (Argo meda area) stated that Malle goats are superior to the goats in the lowland pastoral areas in terms of body size, milk production and twining potential. The households also indicated that there is high variability in performance traits within their goat genotypes.

The proportion of households rating for adaptation and productive traits of goats was presented in Table 10. Generally, the households rated highly for adaptation traits of goats such as tolerance to drought and resistance for diseases above growth performance trait. With respect to birth types of goats, 95% of households in Hamer and 82% in Bena-Tsemay districts stated that the goats are frequently giving birth to singles whereas twining in goats was reported only by 5 and 18% of the households in the respective districts.

Breed preferences

The households, 88% in Hamer and 70% in Bena-Tsemay districts preferred dual purpose goat genotypes (meat and milk) than either meat or milk types. However, a significantly higher proportion of households prefer for meat type goats in Bena-Tsemay than Hamer district (27.3 vs. 6.5%). On the other hand, the proportion of households demanding for milk type goats is higher in Hamer district than Bena-Tsemay (4.9 vs. 2.3%).

Generally, higher demand for improved goat genotype was observed by the households in Bena-Tsemay district than Hamer. In other words, as a constraint, the households in Bena-Tsemay district prioritized according to their importance disease, shortage of feed, water scarcity, lack of improved goat genotype and access to market. However, for the majority of Hamer pastorals improved goat genotype is the least in priority (Table 22).

Selection criteria of buck and doe for breeding

The pastoral and agro-pastoral households in the study districts consider the body size and reproductive performances of the individual and its relatives when selecting replacement animals for the next generation. However, breeding practice in both districts is uncontrolled since goats are herded and living together throughout the year. The proportion of households selecting bucks for breeding are 97 and 66 % in Hamer and Bena-Tsemay districts, respectively.

Table 10 Proportion of households rated for adaptation and productive traits of goats

Traits	Hamer (n=122)		Bena-Tsemay (n=128)	
	Highly rated	Lowly rated	Highly rated	Lowly rated
Drought tolerance	106(86.9)*	16(13.1)	123(96.1)	2(1.6)
Disease resistance	84(68.9)	35(28.7)	81(63.3)	28(21.9)
Reproductive potential (Prolificacy)	75(61.5)	34(27.9)	76(59.4)	36(28.1)
Growth performance	28(23)	88(72.1)	43(33.6)	61(47.7)

* Numbers in parentheses represent percent values

The sources of breeding buck for the households were presented on Table 11. Within owner's herd was the main source of breeding bucks for 98 and 90% of the households in Hamer and Bena-Tsemay districts. Sharing bucks from neighbors is the second source of buck for breeding. Breeding bucks were selected in their order of importance based on large body size (including length, height and conformation), coat color, horn, and relative's performance history. Bucks with brown or red colors with black or brown spots/stripes are the preferred colors whereas bucks with whole or dominantly black colors are not preferred due to their low market values. The respondents also stated that bucks with brown, red or black spots/stripes (mixed colors) reproduce more than other bucks. Bucks with horns are selected for breeding and bucks with large, curved and good looking horns are also considered as a prestige and have high market value.

The proportion of households selecting does for breeding are 77 and 31 % in Hamer and Bena-Tsemay districts, respectively. The households selection criteria for replacement does in their order of importance was based on fast kidding interval (twice a year), good maternity (alertness, long and wide tail, long and large teat), large body size and conformation and prolificacy of parents (Table 12). The main reason for making culling decision of goats is sickness due to diseases, poor performances and old age. The culling age for female and male goats was 6.0±2.1 and 6.6±1.9, in Hamer district and 7.3±3.0 and 6.7±3.2 in Bena-Tsemay district, respectively.

Table 11 Source of breeding buck for households in the study districts

	Hamer	Bena-Tsemay	Overall
Source	Frequency (%)	Frequency (%)	Frequency (%)
Own breed	120(98.4)*	115(89.8)	235(94)
Neighbor	72(59)	65(50.8)	137(54.8)
Communal	40 (32.8)	13(10.2)	53(21.2)
Own purchased	21(17.2)	32(25)	53(21.2)
Donated	2(1.6)	1(0.8)	3(1.2)
Unknown	10(8.2)	10(7.8)	20(8)

* Numbers in parentheses represent percent values

Table 12 Criteria of bucks and does selection by households in the studied districts

Criteria	Hamer (n=122)	Bena-Tsemay (n=128)	Overall
Buck			
Body size and conformation	106(86.9)	81(63.3)	187(74.8)
Color	90(73.8)	67(52.3)	157(62.8)
Horn	62(50.8)	17(13.3)	79(31.6)
Character (libido)	38(31.1)	14(10.9)	52(20.8)
Doe			
Kidding frequency	74(60.7)	33(25.8)	107(42.8)
Twinning ability and maternity*	67(54.9)	28(21.9)	95(38)
Body size and conformation	50(41.0)	27(21.1)	77(30.8)
Prolificacy of parents	38(31.1)	14(10.9)	52(20.8)
Color	2(1.6)	2(1.6)	4(1.6)

* Alertness, long and large teat, long and wide tail

Source of feeds

Feed sources, type and number of grazing sites for households in the study districts are presented on Table 13. In Hamer and Bena-Tsemay districts, 83 and 80% of households, respectively, stated that natural pastures from rangelands (pasture grasses, legumes, fodder tree and shrubs) are major feed sources for livestock. Some agro-pastoral households in the studied districts also use crop residues mainly from maize and sorghum harvests and graze their livestock on stubbles after crop harvests. Grazing lands are mainly communal and the households have different grazing sites with varying distances. Riverside grazing and enclosures that are owned either communal or private are used for grazing especially during the dry season.

Availability of feeds

Table 14 shows seasonal calendar of feed in the studied districts. The pattern of rainfall and, accordingly, feed availability is similar in the two districts. Rainfall is the main factor which determines availability of grazing in the studied districts. Higher feed availability in the studied districts is in the main rainy season (March to April). The rainfall, however, is relatively higher and longer in Bena-Tsemay district (Appendix Figure B1). Therefore, in Bena-Tsemay district, availability of feed is higher (extends up to October). The hot dry season (November to February) is the period of feed scarcity in both districts and during which high mortality of kids and adult goats have been reported (Table 14).

Grazing management

The households have different grazing sites and herd management strategies for cattle and small ruminants. Cattle graze on communal rangelands far away from the homesteads and herded by young boys who live in camps around the grazing site. On the other hand, sheep and goats, including a few lactating cows and some sick animals, graze in community rangelands around the homesteads. In Hamer and Bena-Tsemay districts, 85 and 46% households co-graze sheep and goats which are usually herded by small boys or girls. Cattle are usually herded and separated from small ruminants since they travel long distances for grazing. According to the respondents, goats spent grazing 8 to 10 hours per day. Suckling kids were retained within the household's enclosure during the day time and provided with stubbles or tree leaves but confined in the evening and/or in the morning in a separate kraal until the does are milked.

Table 13 Major Feed sources and grazing sites for households in the studied districts

	Hamer (n=122)		Bena-Tsemay (n=128)		Overall (n=250)	
	Frequency	%	Frequency	%	Frequency	%
Major feed source						
Rangeland	101	82.8	101	78.9	202	80.8
Crop residue	11	9.0	19	14.8	30	12
Others	10	8.2	8	6.3	18	7.2
Type of grazing						
Communal	90	73.8	103	80.5	193	77.2
Private	17	13.9	15	11.7	32	12.8
Other	15	12.3	10	7.8	25	10
Number of grazing sites						
1 to 2	72	59.0	91	71.1	163	65.2
3 to 5	39	32	30	23.4	69	27.6
>5	11	9.0	7	5.5	18	7.2
Distance of grazing sites (km)						
1 to 5	64	52.4	83	64.8	147	58.8
5 to 10	19	15.6	29	22.6	48	19.2
10 to 20	23	18.8	16	12.5	39	15.6
>20	16	13.1	0		16	6.4

Table 14 Seasonal feed calendar in the study districts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Rainy season			xxx	xxx	xxx			x	xx	xx		
Feed availability		x	xxx	xxx	xx	x	x	x	xx	xx	x	
Pasture grasses and legumes			xxx	xxx	xxx	x	x	x	xx	x		
Fodder tree and shrubs				xxx	xxx	xx	xx	xx	xx	xx	x	
Crop residues (maize, sorghum, etc.)							xxx	xxx	xxx			
Feed shortage	xxx	xxx	x							x	xx	xxx
Kids mortality	xxx	xxx	xx								xx	xxx
Adult mortality	xxx	xxx	xx	x							x	xxx

Where: x= Low; xx= Medium; xxx= High

Strategies to alleviate dry season feed shortage

Table 15 summarizes the strategies suggested by key informants to alleviate dry season feed shortage in the studied districts. Mobility is the main strategy for the households to alleviate dry season feed shortage. During times of long dry season (November to February), when feed and water becomes critical, pastoral household's move their livestock (including sheep and goats) towards the big rivers Woyto, Mago or Omo in search of feed and water. A few pastoral households have forage enclosures to supplement animals.

Tree lopping is the common practice to supplement goats during the long dry season for 49 and 32% of households in Hamer and Bena-Tsemay districts, respectively. Supplementation of concentrates is not familiar for most households and some of them stated that concentrate is unaffordable due to the large number of goats they have. However, crop by-products and food left over are available for fattening animals especially in agro-pastoral areas.

Pastoral households in Hamer district supplement a local salt called 'kuti' once per week for goats, especially when goats get sick. However, greater proportions of households supplement salt in Bena-Tsemay (22.6 vs. 7.4 %) and practice goat fattening (40 vs. 28%) compared with Hamer district (Table 16).

Table 15 Strategies suggested by key informants to alleviate dry season feed shortage in the studied districts

Strategies	Current use/practice	Major Constraint	Suggested solution
Mobility	Communal grazing	Ethnic conflict	Government intervention to ease conflicts
Reduce livestock numbers	Sale	Lack of market	Facilitate marketing
Use of Forage enclosures	Grazing/cut and carry	Limited enclosures, over-grazing	Establishment of enclosures on key sites and promote proper use
Use of fodder tree, shrubs and other supplements	Tree lopping	Over-use, lack of alternative feeds and feeding systems	Training and introduction of suitable feeds and feeding systems
Range/pasture rehabilitation, conservation and development	Communal grazing	Water shortage, poor soil fertility, over-grazing and lack of suitable technologies	Training on proper rangeland management and introduction of suitable technologies

Table 16 Feed utilization practices by households in the studied districts

Practice	Hamer (n=122)		Bena-Tsemay (n=128)		Overall	
	Frequency	%	Frequency	%	Frequency	%
Supplementation						
Feed[1]	60	49.2	41	32.0	101	40.4
Mineral/salt	9	7.4	29	22.6	38	15.2
Fattening[2]	34	27.9	51	39.8	85	34
Crop cultivation	122	100	128	100	250	100
Feed conservation	3	2.5	42	32.8	45	18

[1] Tree lopping

[2] Tree leaf, crop by-products and food left over

Watering frequency of goats

Households watering frequency for adult goats and distance for water sources in the study districts during the dry season was presented in Table 17. Water shortage is one of the major constraints limiting animal production in the study districts. Availability of water is dependent on the rainfall in the area. Water shortage both for humans and animals is a common occurrence during the long dry season beginning December. During the dry season rivers, hand dug wells, bore holes or shallow wells are sources of water for households in pastoral areas.

In pastoral areas of Hamer district, with the advancement of the dry season rivers often dry completely and the pastoralists rely on water dug from sandy river beds and on shallow wells for their animals. In drought years, pastoralists forced to travel with their animals to the big rivers such as Omo and Woyto in search of water and grazing. Unlike cattle herds of the pastoralists, goats are usually kept around homesteads together with some sick cattle, lactating cows or calves which are not required to travel long distances in search of grazing or water. However, in the dry season the majority of households water their goats once in three days.

Table 17 Watering frequency and distance for water sources during the dry season

	Hamer		Bena-Tsemay		Total	
	Frequency	%	Frequency	%	Frequency	%
Watering frequency						
Freely available	2	1.6	3	2.3	5	2
Once a day	40	32.8	48	3.7	88	35.2
once in 3 days	80	65.6	77	60.1	157	62.8
Distance for water sources						
< 1 km	4	3.3	8	6.2	12	4.8
1−5 km	45	36.9	55	42.9	100	40
6−10 km	47	38.5	58	45.3	105	42
> 10 km	26	21.3	7	5.5	33	13.2

Kidding pattern of goats

The kidding season, kidding interval and birth type of goats was presented on Table 18. Breeding practice in both districts is uncontrolled since goats are herded and living together throughout the year. According to the respondents, August to October is the main kidding period for goats. During the hot dry season (December to February) high incidence of abortion and kids mortality has been reported (Table 19).

Table 18 Households perception on birth type and kidding pattern of goats

Parameter	Hammer		Bena-Tsemay	
	Frequency	%	Frequency	%
Kidding Season				
Dry (December to February)	3	2.6	11	9.2
Wet (March to May and September to October)	111	97.4	109	90.8
Kidding interval				
Once a year	27	22.3	28	22.0
Twice per 3 year	27	22.3	7	5.5
Twice a year	60	49.6	85	66.9
Birth type				
Single	116.0	95.0	105	82.0
Twin	6	5.0	23	17.9

Table 19 Households perception on incidence of abortion in goats

Abortion	Hammer		Bena-Tsemay	
	Frequency	%	Frequency	%
Prevalence				
High	22	18.2	6	4.8
Occasional	82	67.8	85	67.5
Low	17	14.0	35	27.8
Season of occurrence				
Dry (December to February)	85	73.3	68	61.8
Wet (March to May and September to October)	31	26.7	42	38.2

Diseases and other constraints

Household's perception on disease prevalence in the study districts was presented on Table 20. All households in the districts reported Contagious Caprine Pleuro Pneumonia (CCPP) as the most prevalent disease causing high morbidity and mortality in goats, occurring twice a year, i.e., in the main rains (March to May) and short rainy season (September to November). Mange mites, ticks and internal parasites are the next important diseases of goats in the study districts. Detailed study on disease constraints in the study districts was given by Mekuria *et al.* (2008). In the study districts 84% of the respondents have access to public veterinary services. However, in Hamer district compared to Bena-Tsemay the households access to private veterinary service is low (18 vs. 38%) and cost of drugs/medicine is high (69 vs. 24%) (Table 21).

Table 20 Households perception on disease prevalence in the studied districts

Type of disease	Hamer			Bena-Tsemay		
	HH[a]	HH[b]	Rankings	HH[a]	HH[b]	Rankings
CCPP	118	71	2.073	127	107	1.823
Mange mites	101	10	1.440	109	6	1.220
Ticks	75	17	1.163	50	2	0.491
Internal Parasites	50	3	0.679	14	2	0.113
Foot rot	17	1	0.197	1	0	0.012
FMD	1	-	0.015	4	-	0.021
Liver disease	35	3	0.482	9	0	0.088
Head disease	6	0	0.075	8	1	0.085
Tsetse	8	3	0.124	6	0	0.064

[a] Number of households considering the disease important

[b] Number of households ranking the disease first

[c] Rank index calculated as used by (Kosgey *et al.*, 2008)

Table 21 Households perception on access to veterinary services and cost of medicine in the studied districts

	Hamer		Bena-Tsemay	
	Frequency	%	Frequency	%
Access to veterinary service				
Public	103	84.4	108	84.4
Private	22	18.0	49	38.3
open market	18	14.75	1	0.8
Cost of drug/medicine				
Low	3	2.5	8	6.3
moderate	31	25.4	75	58.6
High	84	68.9	31	24.2

The Major constraints and their relative importance as ranked by households were presented on Table 22. According to the respondents, prevalence of animal diseases, shortage of grazing and water are the major constraints for goat production in the districts. However, proportion of households ranking for shortage of grazing is higher ($P<0.001$) in Hamer than Bena-Tsemay district. Occurrence of frequent drought, increase in both livestock and human population and expansion of cropping lands are among the major factors reported for shortage of grazing and water in the districts.

Table 22 Major constraints and their relative importance as ranked by households

Constraints	Hamer (n=122)			Bena-Tsemay (n=128)			Chi-square
	HH[a]	HH[b]	Ranking[c]	HH[a]	HH[b]	Ranking[c]	
Disease	121	76	1.004	122	72	1.137	4.85
Shortage of grazing land	121	43	0.968	105	32	0.911	17.4***
Water scarcity	108	2	0.597	102	11	0.719	14.86***
Access to market	89	-	0.328	64	3	0.268	7.02
Improved genotype	94	-	0.326	81	7	0.456	28.06***

*** show significance at 1%

[a] Number of households considering the constraint important

[b] Number of households ranking the constraint first

[c] Rank index calculated as used by (Kosgey *et al.*, 2008)

Discussion

Household Characteristics

In the present study, a household was used as a unit of analysis. A household is also recognized as a distinct economic and social unit in South Omo zone where stock management and crop production activities are being organized by the pastoral and agro-pastoral tribes (Strecker, 1976; Ayalew, 1995). A household is described as 'dele' in Hamer society ('house' or 'homestead'). In its wider social sense it means 'family', 'the people of one homestead', 'lineage' under the authority of the male head (donza). The objective manifestations of a 'dele' are the houses (Appendix Figure B4) of the wives and mothers, a goat enclosure and a cattle kraal (Strecker, 1976).

The average family size of the studied districts was lower compared to other pastoral and agro-pastoral areas in Ethiopia (Tefera *et al.*, 2007; PCDP, 2008). This could be due to the external and historical hazards (tribal conflicts) that affected the household compositions in South Omo zone (Strecker, 1976; Ayalew, 1995). The pastoral districts in South Omo compared to other pastoral areas in the country are also underdeveloped and have the lowest literacy rate (PCDP, 2008). The pastoral tribes, however, have extended traditions and livestock keeping experiences that are all developed through generations (Strecker, 1976; Mekuria *et al.*, 2008).

Sale of livestock and livestock products in Hamer district and sale of livestock and crops in Bena-Tsemay district are the main source of income for households studied. In Hamer district, in addition to rain-fed agriculture, pastoral households practice cultivation in large flood plains of Woyto and Omo rivers. Therefore, livestock production and cultivation are the basis for economic culture for the pastoral and agro-pastoral ethnic groups in both districts (Ayalew, 1995; Turton, 1995). However, the higher percentage of households ranking goats as the first income source in Hamer than Bena-Tsemay district may indicate a higher economic dependence of pastoral households in Hamer district on goats than the agro-pastorals in Bena-Tsemay district. In the pastoral/ extensive systems, the greater role of goats in income generation compared with the crop dominated smallholder system has been reported (Kosgey *et al.*, 2008).

In actual circumstances, however, the pastoral system of southern Ethiopia traditionally has been based on cattle husbandry for wealth storage and milk production, and on small ruminants for quick cash income (Desta and Coppock, 2000). For the Hamer tribe ownership of cattle is also the sign of competence, and cattle are the highest goal to which a man can aspire (Strecker, 1976). Therefore, it will not be overemphasized to describe goats, to the pastorals in South Omo Zone, are next to cattle and in addition to their biological and cultural roles, goats are a means to acquire more cattle, means to upgrade wealth and social status of the households.

Ownership, herd composition and trend of goat production

In the present study, ownership of goats per household was 66.7±54.2 heads (range 6 to 348) in Hamer and 41.8±31.2 (range 2 to 143) in Bena-Tsemay. Otte and Chilonda (2002) reported mean goat herd sizes of 1.3 to 128.1 for pastoral systems in Sub-Saharan Africa. The pastoral/extensive systems usually have large number of goats (females constituting the largest proportion) compared to smallholder systems in tropical Africa (Otte and Chilonda, 2002; Kosgey *et al.*, 2008).

The higher decline in goat numbers reported by households in Hamer district than Bena-Tsemay could be associated with the higher diseases prevalence (Mekuria and Asmare, 2010) and drought occurrences in Hamer district than Bena-Tsemay (Admasu *et al.*, 2010). The fact that larger goat herds in Hamer than Bena-Tsemay district may also explain the difference since a decline in goat numbers could be seen as a result of decline in herd sizes among the wealthy (those with large flocks) as reported for cattle (Desta and Coppock, 2000). Overall, there was a decline in number of goats at the household level in southwestern pastoral and agro-pastoral districts as was reported for other pastoral system in Ethiopia (Desta and Coppock, 2000; PCDP, 2008).

Purposes of keeping goats

The multiple roles of sheep and goats in rural regions with arid and semiarid climates have been well described (Bosman *et al.*, 1997; Peacock, 2005). The present study revealed that in pastoral and agro-pastoral areas of southwestern Ethiopia, next to the economic importance of goats, a powerful cultural and religious tie exists with goat production as was also reported for cattle in the area (Strecker, 1976; Gustaf and Silvester, 2008). Studies indicate that grains/cereals are the primary source of food for the households in pastoral and agro-pastoral districts of South Omo (Strecker, 1976; Admasu *et al.*, 2010). This could be one reason for the households least ranking of goats as a source of meat, milk and blood. However, the significantly higher ($P<0.05$) percentage of ranking households in Hamer district indicates the greater role of goats as a source of meat, milk and blood for Hamer pastoral households than agro-pastoral households in Bena-Tsemay. It has been reported that, in marginal rural regions with arid or semi-arid climates, goats have greater role in the households strategy to achieve food security (Peacock, 2008).

Source of genotypes and perception on traits

All goats in the studied districts are indigenous genotypes which are generally recognized according to the areas where they occur. It has been reported that 99.8% of Ethiopian goats are indigenous genotypes (CSA, 2012). Names given to indigenous goat types of the country also reflect mainly their geographical location or ethnic affiliation (Tesfaye, 2004). Even though recent characterization works are lacking, broad physical descriptions of the goats in southern Ethiopia have been given (FARM-Africa, 1996) and the goats are also generally considered as a separate indigenous goat genetic entity (Tesfaye, 2004). However, the varying environments and sources of origin for the goats in the present study as stated by the pastoral and agro-pastoral households may have varying effect on the morphological characteristics and production performances of goat populations within south western Ethiopia. Tesfaye (2004) also reported that there is reasonable variation among Ethiopian goat populations and therefore, within breed selection could be conducted to improve the breeds and lines with different characters could be established to conserve the genetic diversity in the future.

The pastoral households' low rating for growth performance traits was mainly due to the smaller body size and poor body conformation of their goats. However, the households indicated that within their goat genotypes there is considerable variation in productive traits such as twining, meat and milk production potential. Environmental variations or the dissimilarity in source of goats within/between the districts could be the factors for the variability in performances within the existing goat genotypes. The potential use of this variability, however, needs to be investigated. Holst (1999) reported that the desire to increase livestock performance through selection begins with the individual farmer when he realizes that there is variation within his flock or between flocks in his region. Reports also indicate that the adaptation and welfare of extensively farmed livestock can be further improved through within breed selection (Simm *et al.*, 1996). Kosgey *et al.* (2006) also indicated that there is great scope for conservation, genetic improvement and utilization of the indigenous small ruminants in east Africa, which makes village-based breeding programs more attractive.

The households rated highly for the adaptability traits (drought tolerance and resistance to endemic diseases) and they indicated that their goats are not inferior to other goats in their vicinity including the Borana goats with respect to reproductive and adaptation traits. There are also indications that goats in south western Ethiopia are known to live in areas where trypanosomiasis is endemic (FARM-Africa, 1996), various tick borne diseases are rampant (Mekuria *et al.*, 2008) and recurrent droughts are prevalent (Admasu *et al.*, 2010). It has also been reported that disease resistance including litter size, fleece type and the ability to store body fat, some aspects of behavior, especially maternal and grazing behavior are among the traits conferring better adaptation of animals in extensive conditions (Simm *et al.*, 1996). Hence, there have been opportunities for natural selection for the traits to these environments and, thus, an understanding of the adaptive traits and their inclusion in the breeding goal is an important consideration for the effectiveness of a genetic improvement programs involving introduction of improved goat breeds other than local goats for extensive systems (Simm *et al.*, 1996).

A better understanding of the relationships between production traits and adaptation traits is critical for the development of appropriate, sustainable breeding programs (Simm *et al.*, 1996; Bett *et al.*, 2011). Moreover, it has been reported that in the developing countries, a breeding program involving improved, indigenous breeds and their crosses need to be evaluated in relation to socio-economic value, fiscal constraints, religious rituals, responsiveness to indigenous knowledge and the traditional skills of the producer (Kosgey *et al.*, 2006; Shrestha and Fahmy, 2007). Bett *et al.* (2009) also stated that in animal breeding the best animal or breed is the one fitting the breeding objectives and the farm environment.

Breed preferences and selection criteria

The preference of the majority of households for dual purpose goats indicates that meat and milk are important for the pastoral and agro-pastoral households in the study districts. Since goat milk is mostly used for the households nutrition, the greater preference for milk type goats in Hamer district may indicate the greater role of goat milk for the nutrition of households in the more pastoral Hamer than Bena-Tsemay districts. On the other hand, the households in Bena-Tsemay district are relatively more diversified due to favorable environment for crop and cattle production (Admasu *et al.*, 2010). Therefore, for the households in Bena-Tsemay district goat milk is less important, especially for those in the upper part of the district. The high demand for meat type and improved goat breeds in Bena-Tsemay district indicates the relatively higher economic role of goats in the district compared to Hamer district since greater proportion of households in Bena-Tsemay district raise goats for income source than food (meat, milk and blood) compared to the Hamer district though the economic role of goats outweigh the other roles of goats (source of food or social functions) in both districts.

The study showed that the majority of households (>90%) have their own bucks for breeding. In the pastoral/extensive system, usually higher percentage of farmers raise their own males for breeding purpose compared with the smallholder (Kosgey *et al.*, 2008). However, 50 to 60% of the households in the present study also borrow or share bucks from their neighbors unlike in north Kenya where pastoral/extensive farmers tend to purchase than borrow when males were not reared (Kosgey *et al.*, 2008). This is because the pastoral and agro-pastoral tribes in South Omo zone have a cultural tradition of stock sharing (male or female) through bond friendship which is considered as a means to minimize risk and accumulate wealth (Strecker, 1976). Therefore, it is uncommon for a pastoralist to refuse if another asks for an animal (buck/doe in this case) to rear on a share-basis or for a loan for a certain period for breeding.

The pastoral and agro-pastoral households consider growth and reproductive performances of the individual and its relatives when selecting animals for replacement. This was in agreement with the practices of pastoral communities in north Kenya (Mbuku *et al.*, 2006). The greater proportion of households practicing selection (buck and doe) in Hamer district than Bena-Tsemay may have been associated with the greater flock size of goats in Hamer district than Bena-Tsemay. Use of body size and performance characteristics by the households as criteria for buck and doe selection observed in the current study is similar with other reports (Kosgey et *al.*, 2008; Kebede *et al.*, 2012). It has been reported that livestock farmers in general rely more on morphological selection criteria (subjective selection) than production selection criteria (objective selection) (Tabbaa and Al-Atiyat, 2009). However, selection criteria might differ with breed, herd size, production system and marketing opportunity available in their area (Tabbaa and Al-Atiyat, 2009; Ilatsia *et al.*, 2012; Kebede *et al.*, 2012).

The household preference for brown or red coat colors with black or brown spots/stripes was due to the higher market value for the goats and because of the households assertion that colored goats reproduce better than the dominantly black or white. With respect to market, for example, dried and unprocessed goat skins are used to make traditional leather garments for pastoral girls or women in South Omo zone (FARM-Africa, 1996; Gustaff and Silvester, 2008). According to the households studied, white goat skin is not preferred for traditional leather garments over brown or red. White coat color is also less preferred by some pastoral households because they consider it as an invitation to predators and thieves when goats graze away from the homesteads. The assertion that colored goats reproduce better than the dominantly white or black, however, was not consistent for the black color (Ebozoje and Ikeobi, 1998). On the other hand, it has been reported that pastoral communities in north Kenya use coat color of the animals as the most important identification system within and without their flocks, in addition to branding and ear notching (Mbuku *et al.*, 2006).

Feed resources and grazing management

The present study showed that rangeland is the major feed source for the households and availability of grazing was dependent on the rainfall in the study districts. Similar feed sources and grazing pattern and stock management/movement exists in Borana rangelands of south Ethiopia (Tolera and Abebe, 2007). However, a decrease in rangeland and change in vegetation composition due to frequent droughts, overgrazing, and expansion of cultivation is posing a serious threat to livestock production in South Omo rangelands (Carr, 1998; Admasu *et al.*, 2010).

Availability and quality of grazing and browse resources in the pastoral areas of Ethiopia vary with altitude, rainfall, soil type and cropping intensity and the pastoral zones are characterized by dense thorn bush with a low carrying capacity (Mengistu, 1985). Moreover, it has been reported that poor management of rangelands, inappropriate grazing management, rangeland fires and droughts limit the availability of fodder to ruminants in the country (Angasa, 2002; Benin *et al.*, 2004; Gemedo *et al.*, 2006).

Nardone *et al.* (2010) reported that although, the effects of global warming will not be adverse everywhere, a relevant increase of drought is expected across the world affecting forage and crop production. Similarly in East African rangelands, the rapid decrease in forage quality in the dry season, increasing populations, conflicts between wildlife and cattle and the growth of agriculture all are crucial factors determining livestock production and pastoral land use patterns (Hary *et al.*, 1996; Thornton *et al.*, 2003).

The development of improved grazing and feeding schemes, which reduce the pressure on the natural vegetation, especially during the vegetation period have been suggested and studies to quantify animal feed intake on the natural pastures and at the homesteads should be combined with further vegetation studies to better appraise the actual grazing pressure against the carrying capacity of the fragile pastures in arid environments (Schlecht *et al.*, 2009).

Strategies to alleviate dry season feed shortage

Mobility

The present study indicated that mobility is the main strategy of households in times of feed shortage. Similar strategies have been used by pastoralists in the southern and eastern rangelands of Ethiopia (Tefera *et al.*, 2007; Tolera and Abebe, 2007; PCDP, 2008). However, it has been reported that tribal conflicts as a consequence to competition for water and grazing and the infestation of the forage abundant forests in Omo and Woyto River basins with Tsetse flies are limiting the movement of livestock in south western Ethiopia (Strecker, 1976; Ayalew, 1995; Turton, 1995).

The future settlement of pastoral households and irrigation projects due to increase in demographic pressures from the highlands and the resulting changes in the socio-economic environment may be of potential threats to the pastorals since reduced mobility of herds introduces a severe constraint on animal productivity, with repercussions on the welfare of pastoral communities (Hary and Schwartz, 2002) unless some adaptive systems followed (Walker and Janssen, 2002).

To sustain the pastoral production systems in south western Ethiopia, the current condition of communal rangeland should be improved through rangeland rehabilitation, conservation and proper management. Among others, resting of the communal grazing areas, proper grazing management, strengthening of privately owned enclosures as well as establishment of community based enclosures in some key sites are very essential (Admasu *et al.*, 2010). In the semi-arid region of Tigray, north Ethiopia, rehabilitation of degraded communal grazing lands is implemented through a network of exclosures constructed since the early and late 1990s proved successful and leading to increased grass and browse production in the region (Yayneshet *et al.*, 2009).

Supplementation

The current study described the supplementation practices of the households as a strategies to alleviate dry season feed shortage of animals. In arid areas strategies such as matching livestock numbers with availability of feed resources, use of fodder tree and shrubs, use of feed or urea/molasses blocks or licks, conservation of forages, improvement of crop residues and efficient utilization of agricultural and industrial by-products as sources of feed and encouraging increased intake of animals have been reported (Anderson, 1985; Houtert and Sykes, 1999; Ahmed *et al.*,2001; Rubanza *et al.*, 2007; Salem and Smith, 2008; Yami, 2008).

The present study also showed that greater proportion of households in Bena-Tsemay district fattening goats than Hamer district. This could be associated with the higher feed availability and the proximity of Bena-Tsemay district to major roads, zonal towns and to major markets which may have encouraged the households in the district to perform more fattening activities to have higher prices from sale of their goats. Therefore, it seems feasible to promote improved feeding technologies and/or goat genotypes targeting such areas/households. In north Kenya, smaller percentage of the pastoral/extensive than the smallholder farmers practice improved feeding systems (Kosgey *et al.*, 2008).

Kidding pattern

In the study districts, kidding period of goats also fluctuate in accordance with the rainfall or availability of range resources. However, the higher kid mortality in the hot dry season (December to February) indicates that mating of goats in July to September should be avoided due to the feed shortage or low pasture availability in the kidding period of goats. It has been reported that confining breeding to the long dry season or in the beginning of the main rainy season can be an effective management intervention to reduce mortality rates in pastoral goat flocks in east Africa (Hary and Schwartz, 2002; Kosgey *et al.*, 2008).

Diseases and other constraints

The study described the major goat diseases in the study districts. In Borana, the largest pastoral area in Ethiopia, CCPP and Peste des petite ruminant (PPR) are the most important infectious diseases of goats (Gelagay *et al*., 2007). In north Kenya, high incidences of pneumonia and tick-borne diseases in goats have been reported for pastoral/extensive systems (Kosgey *et al*., 2008). The limited involvement of private veterinarians and the high cost of drugs in Hamer district compared to Bena-Tsemay may be due to the inaccessibility or remoteness of some administrative sub-units in the district as reported for the Mursi tribe in South Omo (Turton, 1995).

The households ranked the major constraints for goat production as animal diseases, shortage of grazing resources and water in their order of importance, drought occurrence being the major factor for the later two. Admasu *et al.* (2010) generally reported drought, shortage of feed and water and health problem as the major constraints for livestock production in the districts.

Experiment 2

Results

Feed composition

Nutritive values of grass hay and meal concentrate used in this study were presented in Table 23.

Feed intake

Feed intake of Woyto-Guji goats after 90 days of feeding period was presented in Table 24. There is a significant effect of meal concentrate supplementation on intakes of hay, total dry matter (TDMI), energy and protein. Concentrate supplementation reduced grass hay intake. However, TDMI as g/day, %BW and g/kgBW$^{0.75}$/day and feed per gain significantly increased with meal concentrate supplementation compared with the control. Consequently, energy intake for T_2 goats (4.7 MJ/day) was 44% and 27% higher than that of the control (T_0) and T_1 goats, respectively. Similarly, protein intake for T_2 goats (73 g CP/ day) was 3 and 1.5 fold higher than that of T_0 and T_1, respectively.

Table 23 Chemical composition (%DM) of the experimental feeds

Item	Grass hay	Concentrate
Dry matter	89.2	89.3
Organic matter	89.3	88.0
Crude protein	6.9	18.5
Neutral detergent fiber	73.1	31.3
Acid detergent fiber	44.9	9.4
Acid detergent lignin	5.6	0.7
Ash	10.7	11.9
Hemicelluloses	28.2	21.9
Cellulose	39.3	8.7
Calcium	0.616	2.38
Phosphorus	0.011	0.076
Gross energy, MJ/kg DM	15.6	15.4
[1] Metabolisable energy, MJ/ kg DM	8.58	9.54

1 According to Ethiopian feed composition data base for mature Rhodes grass hay (SLP, 2011); Concentrate ME estimated by Alema Koudijs Feed PLC, Debrezeit, Ethiopia.

Table 24 Feed intake of Woyto-Guji goats before the mating period

Intake parameters	Treatments			P-value
	T_0	T_1	T_2	
Concentrate, DM g/day	-	169.9±0.1 ^{b}	326.4±3.0 ^{a}	<0.0001
Grass hay, DM g/day	380.5±41.6 ^{a}	242.3±41.2 ^{b}	182.3±39.4 ^{c}	<0.0001
Total DM (TDMI)				
g/day	380.5±41.6 ^{b}	412.2±41.3 ^{b}	508.7±40.4 ^{a}	<0.0001
%BW	2.5±0.32 ^{b}	2.6±0.37 ^{ab}	2.9±0.40 ^{a}	<0.0186
g/kgBW$^{0.75}$	50.5±5.77 ^{b}	50.5±6.64 ^{b}	59.1±6.95 ^{a}	<0.0006
Energy, MJ ME/day	3.3±0.23 ^{c}	3.7±0.22 ^{b}	4.7±0.24 ^{a}	<0.0001
Total protein, g/day	26.2^{c}±7.6	48.1^{b}±7.7	73.0±11.5 ^{a}	<0.0001
Feed per gain (TDMI/ ADG)	140.9 ±130.4 ^{a}	12.3 ±2.3 ^{b}	9.3 ±2.2 ^{b}	<0.0079

$^{a,b,\,c}$ Values on the same row with different superscripts differ significantly

Growth rate

Body weight change and growth rate pattern of Woyto-Guji goats during the 90 days feeding period are shown in Table 25 and Figure 7, respectively. Though, initial weights of animals between treatments were similar but their final weights significantly varied among the treatments. ADG significantly increased with meal concentrate supplementation compared with the control.

Table 25 Body weight changes of Woyto-Guji goats before the mating period

Parameters	Treatments*			P-Value
	T_0	T_1	T_2	
Initial average BW (kg)	14.7±1.7	15.0±1.5	15.2±1.9	0.6675
Final average BW (kg)	15.0±1.5 [c]	18.1±1.7 [b]	20.2±2.3 [a]	<0.0001
Total weight gain (kg)	0.26±0.3 [c]	3.0±0.5 [b]	4.9±1.1 [a]	<0.0001
Average daily gain (g/day)	2.7±4.0 [c]	33.5±5.2 [b]	54.7±11.9[a]	<0.0001

[a,b, c] Values on the same row with different superscripts differ significantly

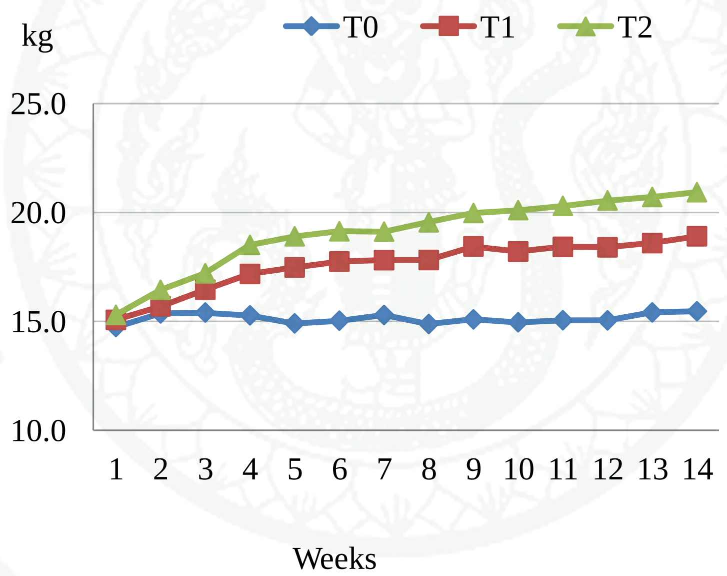

Figure 7 Growth rate of Woyto-Guji goats before the mating period

Cost and income variables

The cost and income variables and profit calculated from daily feed intake and average daily gain values were presented on Table 26. The result indicates that goats supplemented with 200 (T_1) and 400 g (T_2) concentrate had a net return of 5 and 7

Birr per day per goat, respectively. In contrast, the net return from goats without supplementation was negative.

Table 26 Effect of concentrate supplementation on the variable costs, income and profit (Birr/goat/day) (value in October 2011)

	Treatments[1]		
	T_0	T_1	T_2
Variable costs			
- grass hay	0.7398	0.4711	0.3548
- concentrate	-	0.3795	0.7292
- total	0.7398	0.8507	1.0841
Income			
- ADG (kg/head/day)	0.003	0.034	0.055
- Meat price (Birr/kg)	150	150	150
Value	0.45	5.10	8.25
Profit	-0.2898	5.066	7.1659

[1] Variable costs in this study did not include labor

Body condition and BW changes

The BCS and BW changes of pregnant goats since the start of feeding was shown in Figure 8 and 9, respectively. Mean BCS of the treatment groups differed significantly at mating and parturition periods, however, with no significant difference in BCS at the start of feeding and at 90 days of pregnancy. Body weight of the supplemented goats, however, was significantly higher than the control throughout the experimental period.

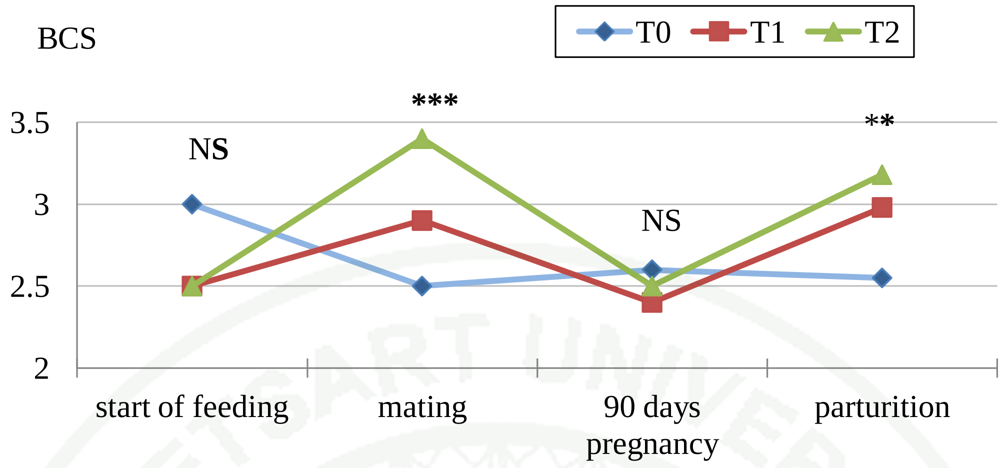

Figure 8 Body condition score (at 5-point scale) of pregnant goats during the experimental period. **P < 0.05; ***P < 0.001; NS= not significant.

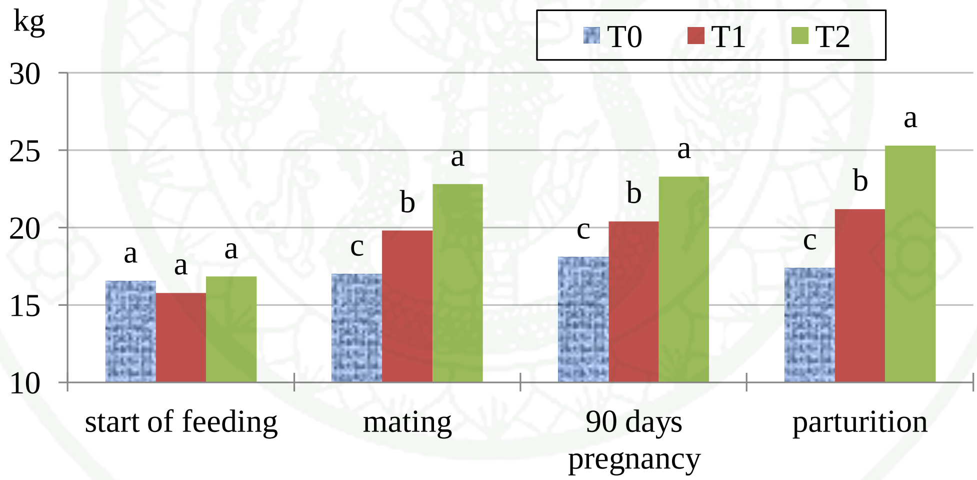

Figure 9 Body weight changes of pregnant goats during the experimental period. The columns within each parameter with different superscripts (a-c) are statistically significant (P < 0.05).

Mating and kidding days

Figure 10 shows the mean variation in mating and kidding days between the treatment groups. The supplemented groups mated and kidded earlier (within 4 and 3 days since the first mating and kidding goats) compared to the control (mated and kidded within 12 and 10 days since the first mating and kidding goats).

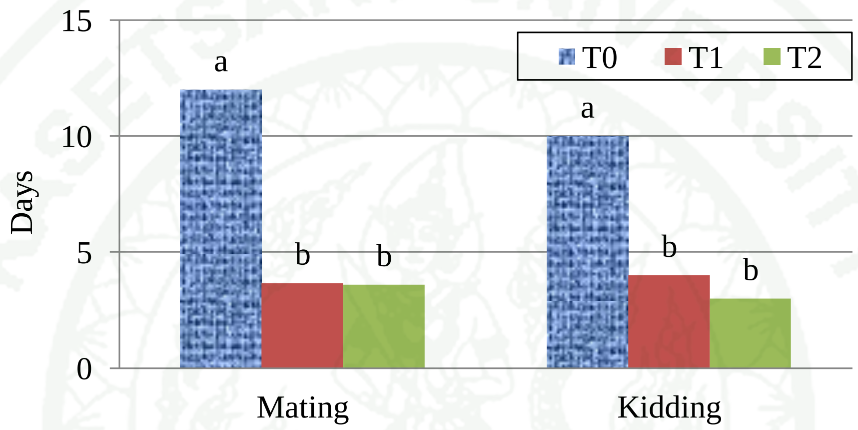

Figure 10 Mean variation in mating and kidding days (Day 0 = first mated and first kidded goats of all animals). The columns within each parameter with different superscripts (a, b) are statistically significant: ($P < 0.05$).

Ovarian activity

Figure 11−13 shows serum progesterone (P4) profile of goats before mating. The proportion of does showing oestrus was presented on Table 27. There was variation in P4 concentration among the treatment groups before mating. The goats in 400 g/day (T_2) concentrate supplemented (no. 46, 51, 53, 64 and 79) showed lowest (<1ng/ml) and a rising (>1 ng/ml) P4 concentration starting day 7, 3, 17, 21 and 17, respectively. In T_1 (200 g/day concentrate supplementation) 3 goats (no. 47, 49 and 50) showed lowest (<1ng/ml) and rising P4 concentration at days 17, 21 and 21, respectively. Similar P4 pattern was observed in the control group. However, in the control the magnitude of P4 remain high until day 7, 13 and 7 for goat no. 57, 60 and

61, respectively and afterwards declined constantly. In the follow up observation, with buck introduction, the proportion of goats in oestrus increased significantly with meal concentrate supplementation (P<0.05).

Pregnancy and kidding rates

Data on reproductive activities of does since the time of oestrus was presented on Table 27. Supplementation with meal concentrate significantly (P < 0.05) increased the proportion of goats in oestrus and goats mated. Accordingly, Pregnancy rate and kidding rates of goats were improved by 17% (T_1), 29% (T_2) and by 71% (T_1), 83% (T_2) over the control, respectively.

Gestation length and litter size

Data on gestation length and other parturition parameters of the does were presented in Table 28. A significant difference (P < 0.05) was observed between the treatment groups in birth weight of kids and post partum weight (PPW) of does. However, there was no significance difference in gestation length and litter size (kids born per doe) between the treatment groups.

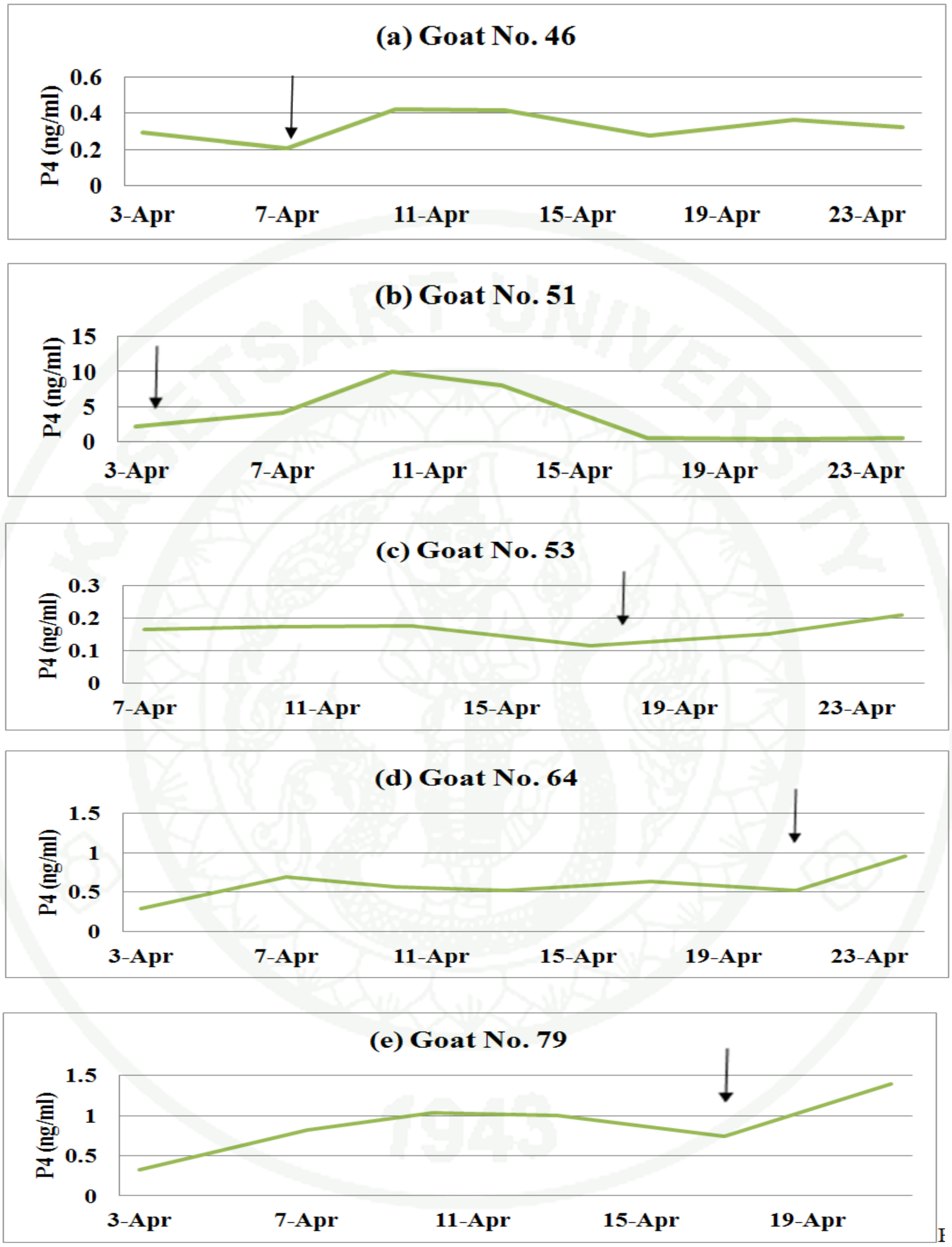

Figure 11 Representative serum progesterone (P4) profile of T_2 goats (a-e) before mating (arrows indicate possible occurrence of oestrous)

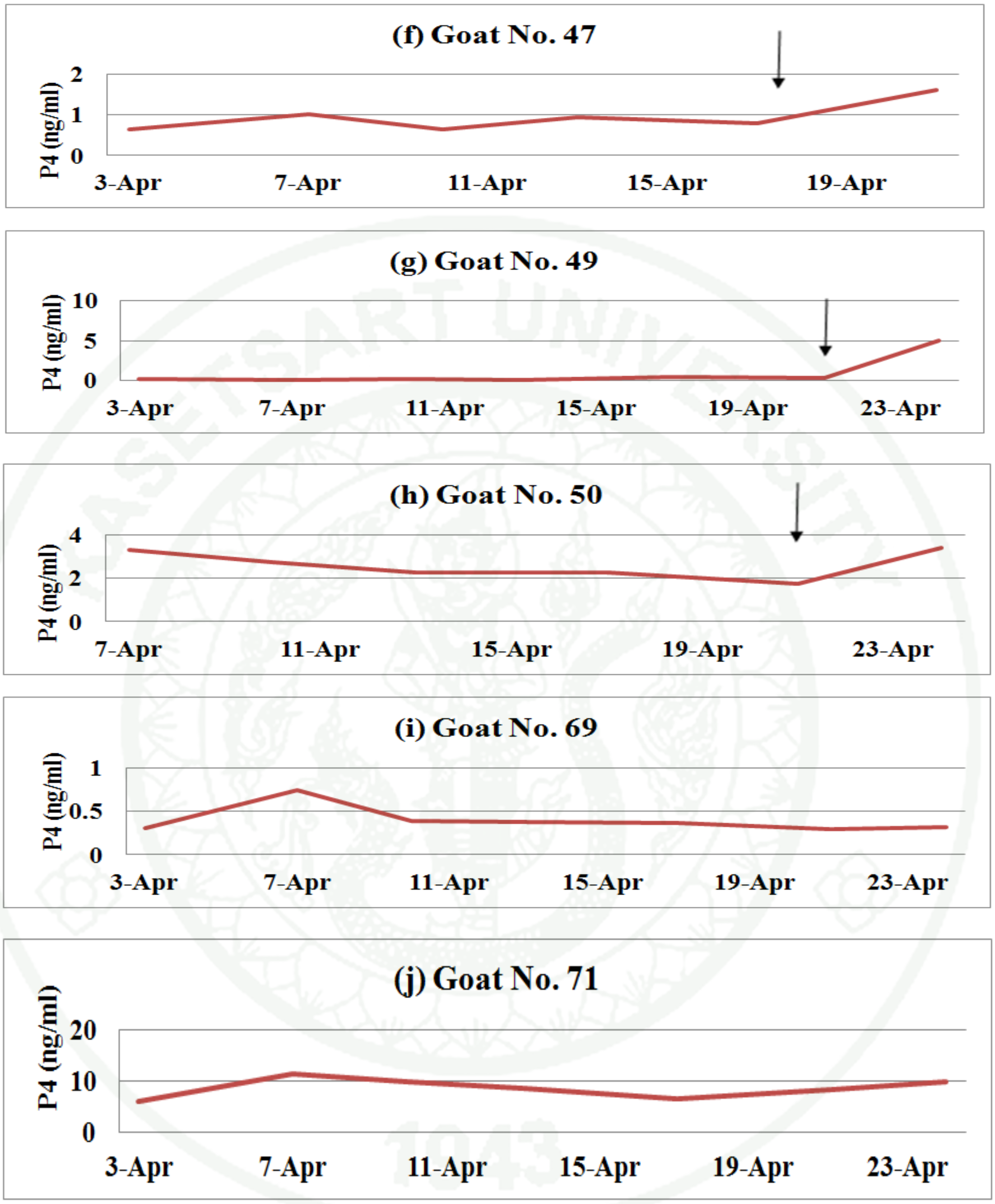

Figure 12 Representative Serum progesterone (P4) profile of T_1 goats (f-j) before mating (arrows indicate possible occurrence of oestrous)

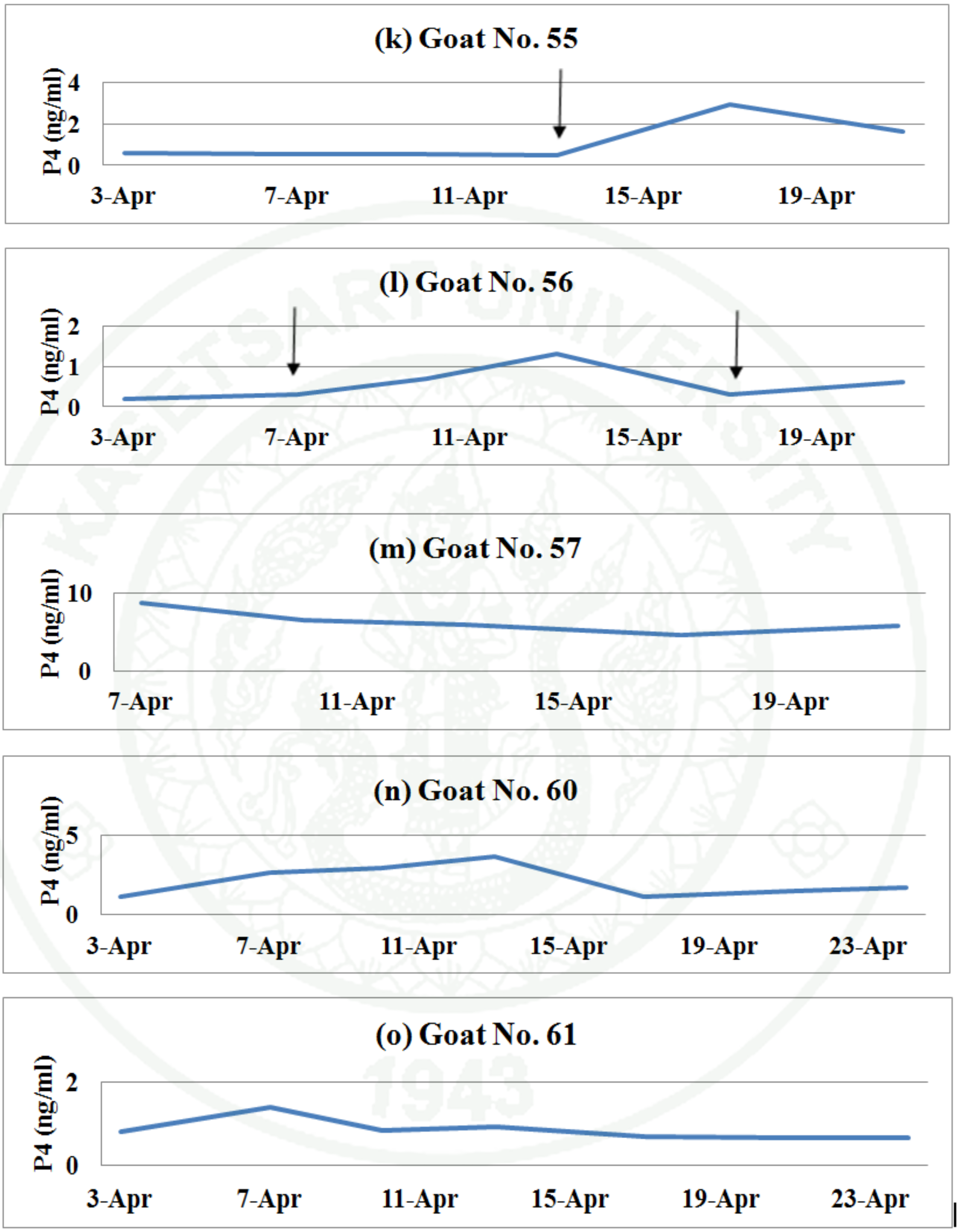

Figure 13 Representative serum progesterone (P4) profile of T_0 goats (k-o) before mating (arrows indicate possible occurrence of oestrous)

Table 27 Reproductive activities of goats during the experimental period

Parameters [1]	Treatments T_0	T_1	T_2	P-value
N	15	15	15	
Goats in oestrous	3	9	14	0.0307
Goats mated	3	9	14	0.0307
Goats anoestrous	12	6	1	0.0082
Goats pregnant	2	7	12	0.0286
Goats aborted	1	1	1	1.0000
Goats kidded	1	6	11	0.0158
Abortion rate	50	14.3	8.3	<0.0001
Pregnancy rate	66.6	77.7	85.7	0.3095
Kidding rate	50	85.7	91.6	0.0013

[1] Observed from 1st service of goats

Table 28 Gestation length and other parturition parameters of goats.

Parameters	Treatments T_0	T_1	T_2	P-value
Gestation length, days	135±0.0	138±2.3	136±1.8	0.1128
Litter size (kids per doe)	1.0	1.0	1.0	NS
Kids birth weight, kg	1.5 ± 0.01^c	1.8 ± 0.07^b	2.1 ± 0.08^a	0.0002
Post partum damweight, kg	17.4 ± 0.64^c	21.2 ± 0.83^b	25.3 ± 0.71^a	<0.0001

[a, b, c] Values on the same row with different superscripts differ significantly

Behavioral characteristics of does and kids at parturition

Does behavioral characteristics at parturition were presented on Table 29. Appendix Figures 17 to 23 describe does and kids behavioral characteristics observed before and during parturition. It was observed that 2 to 3 hours prior to parturition all the does showed restlessness and a lying and standing posture. The average length of labor for does was 8–14 minutes, with no significant difference between the control and concentrate supplemented groups.

Table 29 Does behavioral characteristics at parturition.

Behavioral characteristics	Treatments			Overall	
	T_0	T_1	T_2	Frequency	%
Before parturition (number of does)					
Restlessness	1/1	6/6	11/11	18	100
Vocalization (>20)	0/1	1/6	4/11	5	27.7
Lying and standing	1/1	6/6	11/11	18	100
Kidding period (number of does)					
Morning	1/1	1/6	1/11	3	16.6
Noon	0/1	1/6	1/11	2	11.1
Afternoon	0/1	3/6	8/11	11	61.1
Night	0/1	1/6	1/11	2	11.1
Birth difficulty (number of does)					
No assistance	1/1	5/6	9/11	15	83.3
Minor assistance	0/1	1/6	2/11	3	16.6

The does 61% kidded in the afternoon and 87.5% of them kidded without assistances. Length of labor recorded since first sign of amniotic fluid appearance was 9, 14 and 8 minutes for does in T_0, T_1 and T_2, respectively ($P > 0.05$). All the does except two were observed licking, grooming and suckling their kids without leaving the parturition site. It was observed that such does suckle easily when the kid attempts to suckle.

Data on kid behavioral characteristics at parturition were presented on Table 30. The time taken by the kids for standing and suckling were not significantly affected by meal concentrate supplementation before breeding and end of pregnancy (P > 0.05). However, supplemented groups tended to stand and suckle faster than the non-supplemented/control groups.

Table 30 Kids behavioral characteristics at parturition.

Behavior	Time after birth (minutes)			P-value
	T_0	T_1	T_2	
Latency to attempt to stand	31.5	11.75	14.4	0.172
Latency to successful stand	38.5	40.0	32.6	0.900
Latency to suckling attempt	87.0	43.25	38.0	0.215
Latency to successful suck	99.0	49.0	43.8	0.137
Kids birth weight, kg	1.5^{c}	1.8^{b}	2.1^{a}	0.0002

$^{a, b, c}$ Values on the same row with different superscripts differ significantly (P < 0.05)

Discussion

Feed composition

The CP, NDF, ADF and ADL contents in grass hay were within the range of values reported for mature Rhodes grass in Ethiopian feed composition data base (SLP, 2011). However, the fiber fractions in the grass hay was higher compared to 18 to 20 % ADF or 41 % NDF optimum in rations for dairy goats and 23% ADF for growing goats though the information is not inclusive of all age and physiological groups (Lu *et al.*, 2008). The low CP and high NDF values in the grass hay suggest that the basal ration used was low quality forage (Leng, 1990). However, the current result showed that goats gained weight on low quality forage with supplementation. Improvement in live weight gain of goats on low quality tropical forages with supplementations have been reported (Legesse *et al.*, 2006; Kahindi *et al.*, 2007; Mushi *et al.*, 2009; Safari *et al.*, 2009).

Crude protein content of 185 g/kg DM in the commercial concentrate was higher than 130 g/kg crude protein reported optimum for growing local goats (Atti *et al*., 2004). Gross energy content of the Rhodes grass in the present study was 15.6 MJ/ kg DM which is in the range of 14.2–19.2 MJ/ kg DM reported for forages available in tropical Africa (Richard *et al.*, 1990). The authors also reported energy digestibility range of 35–78 % and total digestible energy content of 6.5–13.9 MJ/kg DM for the same forages. For the present study, average Metabolisable energy value of 8.6 MJ/kg DM was used as given in Ethiopian feed composition data base for Rhodes grass hay of similar maturity (SLP, 2011)

Feed intake

The reduction in hay intake and the apparent increase in TDMI with increasing level of meal concentrate supplement could be due to the substitution effect of the basal diet with the concentrate feed (Kraiem *et al.*, 1997). The significant increase in ADG values in this study with meal concentrate supplementation could be associated with the greater DM and nutrient intake by the supplemented groups as a result of higher energy and protein in the concentrate supplement than the basal feed.

The DMI g/kg $BW^{0.75}$/day values in the present study are lower than Solomon *et al.* (2008b) and Limea *et al.* (2009) which could be due to variation in sex, age, rumination time and metabolic rate of goats (Givens *et al.*, 2000). Hadjigeorgiou *et al.* (2001) reported a wide range of voluntary intakes (42±78 g DM/kg $W^{0.75}$/day) in sheep and fiber producing goats feeding forages differing in their chemical composition. Thus, the genotype of the breeds, maturity and type of forage (Aumont *et al.*, 1995) or source of concentrate (Woods *et al.*, 2003a, 2003b) may have contributed for variation in the feed intakes.

An increase in energy and protein intake of the supplemented groups was mainly due to the greater meal concentrate intake in the supplemented groups. It has been reported that higher nutritive diets result in greater nutrient digestibility (except for ADF), N retention, ruminal NH_3-N concentration, and urinary excretion of purine derivatives in animals fed diets based on grass hay (Cantalapiedra-Hijar *et al.*, 2009).

Growth rate

The significant variation in total and daily weight gain indicates that nutritional supplementation plays an important role in the growth performance of indigenous goats. The observed maximum final BW for female Woyto-Guji goats in the current study was 20.2 kg. FARM-Africa (1996) reported 28.8±5.0 kg body weight for adult female Woyto-Guji goats. In the current study, however, the weight at maturity of the goats was not attained. The significant ($P<0.05$) increase in ADG values in this study with supplementation was associated with greater DM, energy and protein intake of goats.

Even though data on ADG values for female indigenous Ethiopian goats is limited, the ADG values obtained in the current study for growing female Woyto-Guji goat's is comparable to ADG value of 35 to 53 g/day reported for indigenous dairy type (Begait) female goats of Ethiopia under varying legume (vetch) hay supplementation (Berhane and Eik, 2006). In fact, legume supplementation would have some benefit to ADG, their availability and use is limited in semi-arid environments due to the short rainy seasons. Thus, during extended dry periods supplementation of meal concentrate would be suggested.

Cost and income variables

The present study showed that meal concentrate supplementation of 200 and 400 g/day has a positive net return of 5 to 7 Ethiopian Birr/goat/day, respectively, as calculated from the growth trial. Legesse *et al.* (2005) reported a net return of Ethiopian Birr 10.6 per animal with marginal rate of return of 93.9%s from supplementing grazing with concentrates to goats managed extensively. They also stated that combining grazing with concentrate supplementation seems potentially more profitable than either grazing without concentrate supplementation or pen-feeding with no grazing for Somali goats. In addition to improvements in growth performances, the present study also showed an enhancement in pregnancy and kidding rates of goats and low incidence of abortion in goats due to feed supplementation.

Body condition

Supplementation before the breeding season enhanced growth performances of the goats resulting higher BW and BCS at mating and parturition periods. The BCS observed at mating period in the current study was 2.5, 2.9 and 3.4 for goats in T_0, T_1 and T_2 treatment groups, respectively. It has been reported that goats should have a BCS of (on a 5 point scale) 2.5 to 4.0 for healthy reproductive functions (Villaquiran *et al.*, 2004), above 2 to maintain pregnancy (Mellado *et al*., 2004) and 2.5 to 3 for optimal ovulation rate (Iiker *et al.*, 2010). However, body size differences may also contribute for the variation in reproductive activities observed between the treatments groups in the current study.

After the mating period, BW of T_1 and T_2 groups decline at a rate faster than the control (T_0) due to the discontinuation of concentrate. This could be the reason for the lack of significant difference in BCS between the treatment groups at 90 days of pregnancy (Figure 8) even though at this period T_1 and T_2 had higher body weights than the control (T_0) (Figure 9). This indicates that supplementation prior to the breeding period does not sustained body condition of goats throughout pregnancy. However, when supplementation resumed after 90 days of pregnancy, the supplemented goats (T_1 and T_2 groups) regained body weight at a faster rate than the control, having higher BW and BCS at the end of pregnancy and at parturition, but without significance difference in BCS at parturition between the supplemented T_1 and T_2 groups.

Mating and kidding days

Goats in the current experiment were mated at age of 17 months. Goats in the tropics are usually first mated at age of 14 to 17 months in the extensive system (Peacok, 1996) since young breeders are very likely to abort. However, mating at earlier than this age is possible in the intensive systems, where goats have been well fed and are able to develop early. The variation in mating and kidding days observed in the present study is associated with the higher growth rate of goats since faster growth is related with higher BW and enhanced reproductive performance, i.e. earlier attainment of sexual maturity and more intense oestrous activity and earlier lambing or kidding when mated (Dyrmundsson, 1981; Boulanouar *et al*., 1995). Earlier sexual maturity of 19 days has been reported for Moroccan indigenous goats with improved feeding (Chentouf *et al.*, 2011). In the dry tropical Africa, the benefit of early mating and kidding of goats is crucial in terms of ensuring high kid survival and success in post partum reproductive performances of does (Hary, 2002).

Ovarian activity

In the present study, varying pattern of progesterone (P4) concentration was observed in goats within and between treatments. A variation in progesterone profile of small ruminants due to supplementation has been reported (Mekoya *et al.*, 2009). It has been reported that P4 concentration is lowest (<1 ng/ml) with the onset of oestrus. However, after 5 days of onset of oestrus, cells of the ovulating follicle turn into luteal cells and form the corpus luteum which secrete progesterone causing its concentration to increase and remain at high level (>1 ng/ml) during the luteal phase (Fatet *et al.*,2011). In goats, with absence of oestrous and ovulation, a constant low P4 concentration (<1 ng/ml) have been reported (Rondina *et al.*, 2005; Fatet *et al*., 2011). It has been reported that oestrous activity is highly variable in goats and it can be modulated by environmental factors such as photo period and nutrition (Fatet *et al*., 2011). High dietary intake induces an expected improvement in reproductive output in goats since the sustained energetic flow increases oestrous and ovarian activity.

Insufficient nutrition can be a cause for the appearance of prolonged anoestrous and anovulatory periods in goats (Rondina *et al*., 2005).

In the current study, the increase in the proportion of does showing oestrous is associated with the higher BCS of supplemented goats due to higher feed intakes (Bizelis *et al.*, 1990; Mukasa-Mugerwa, 1991; Meza-Herrera *et al.*, 2008). Dietary energy restriction/under nutrition during pre-breeding has been reported to affect negatively the proportion of goats showing estrus (Mani *et al.*, 1996; Kusina *et al.*, 2001). Boland *et al.* (2001) also reported that nutrition can influence reproductive functions in ruminants. However, the relationship between nutrition and reproduction is complex and responses are often quite variable and inconsistent.

Pregnancy and kidding rates

The study showed that first service pregnancy and kidding rate with the highest supplementation of 400 g per day (T_2) was 85.7 and 78.6%, respectively. The increase in first service pregnancy and kidding rates and lower abortion rates in concentrate supplemented groups compared to the control could be due to improvement in body weight and body condition of the goats. The increase in first service pregnancy and kidding rates and lower abortion rates in concentrate supplemented groups compared to the control could be due to improvement in body weight and body condition of the goats. Ocak *et al.* (2006) also observed similar results with respect to pregnancy and kidding rates. In addition, supplementation was reported to sustain pregnancy during the dry season in Begait and Abergelle goats of Ethiopia (Berhane and Eik, 2006). For mid rift valley goats of Ethiopia a conception and kidding rate of 79 and 74% have been reported under natural pasture grazing (Tucho *et al*., 2000).

Gestation length and litter size

In concentrate supplemented groups, a higher kid birth weight and post partum body weight of does was observed which would enhance the survival of kids and performances of the does later in the post partum period. However, the variation in gestation period and kids born per doe (litter size) in the present experiment was not significant between the dietary treatments, although level of nutrition and mating weights were reported to affect gestation period and litter sizes in goats (Amoah *et al.*, 1996; Ali *et al.*, 2009). The goats used in the present study were in their first parity and they are also purchased from pastoral herds where inadequate feed and water supply is common due to a marked seasonal variation in rainfall distribution (Admasu *et al.*, 2010). Thus, despite the concentrate supplement, this may have contributed for the lack of differences in litter size of the goats since it has been reported that parity of the dam (Devendra and Burns, 1983) and reduced growth rate early in life influences litter size in small ruminants (Mellado *et al.*, 2006). A fecundity rate of 83% single, 16% twin and 1% triplet births have also been reported for goats in south western Ethiopia (FARM-Africa, 1996).

Behavioral characteristics at parturition

In the present study an observation was made on does and kids behavioral characteristics at parturition. Aspects of behavior, especially maternal and grazing behavior are among traits conferring better adaptation in goats (Simm *et al.*, 1996). Thus, a better understanding of the relationships between production traits and these adaptation traits will be critical for the development of appropriate, sustainable breeding programs.

In the current study, does showed restlessness, a lying and standing posture and frequent vocalization before parturition. Female goats about to give birth exhibited changes in both physical appearance and behavior (Lickliter, 1985) for instance separation from the herd, increased restlessness, frequent vocalizations, and increased intolerance of conspecifics. The kidding of most of the does in the afternoon observed in the current study is in agreement with Lickliter (1985) and Allan *et al.* (1991). In the present study, length of labor was between 8–14 minutes, with no significant difference between the control and supplemented groups. Major birth difficulty was not observed in any of the treatment groups during parturition. No birth difficulty have been reported in Australian bush goats supplemented with three levels of protein at kidding, with the birth process being completed within mean duration of 13.3 ± 2.5 min (Allan *et al.*, 1991).

The licking and grooming behavior was observed in the does after parturition. It was observed that such does suckle easily when the kid attempts to suckle. Such behavior around birth encouraged a bond between dam and offspring and facilitated survival of the offspring. Behavioral interactions that take place between the mother and young in the very first hours following birth are important for the development of a bond with the mother and the future of the neonate; nevertheless, inadequate maternal communication and care at this stage leads invariably to early death of kids (Nowak, 1996).

In the present study, though there was no significant differences between treatment, kids from concentrate supplemented does tended to stand and suckle quickly compared to the non-supplemented control groups. This will improve kid vigor and could reduce kid post partum mortality which is a major constraint for improving efficiency of small ruminant production system in the tropics (Devendra and Burns, 1983). In the current study, the time taken by kids to make standing attempt since birth was 14–32 minutes and the kids stood successful within 33–40 minutes of birth. Licklitter (1985) reported a 3–25 min after birth for Sannen and Togenberge kids and successfully standing at 5–32 minutes. In Australian bush goats supplemented with one of three levels of protein at kidding, nutritional treatments did not affect time to stand (Allan *et al.*, 1991). The successful suckling time for kids in the current study was 44–99 minutes after parturition. Licklitter (1985) reported that Sannen and Togenberge suckle successfully at 14–85 minutes.

Overall, Woyto-Guji goats showed good mothering ability (grooming, licking and suckling) irrespective of supplementation, even though, optimal feeding strategies during the various stages of pregnancy and at parturition reported to influence birth weight and the quality of maternal behavior in small ruminants (Nowak, 1996). The results also indicate that the establishment of maternal recognition can be impaired by underfeeding during the second half of pregnancy (Poindron *et al.*, 2007a). It has been reported that maternal behavior is also dependent on the developmental stage of the young at birth, the environment into which they are born and genetic differences appear to exist within and between breeds in the degree of grooming behavior (in both intensity and duration) and in the exclusivity of the bond once formed (Simm *et al.*, 1996).

CONCLUSION AND RECOMMENDATIONS

Conclusion

The survey study explored goat management practices and constraints in the pastoral and agro-pastorals districts of South Omo zone. Sale of goats, cattle and sheep, in their order of importance, are the main source of income for households in the studied districts. The households are keeping goats primarily for socio-economic (sale, asset, security) purposes and secondly for socio-cultural functions (rites, ceremony, dowry). The role of goats as a source of meat, milk and blood was ranked third.

All the households owned indigenous goat genotypes and the average goat herd size per a household was 66.7±54.2 in Hamer and 41.8±31.2 in Bena-Tsemay district. A decline in goat population in the last 5–10 years was reported by 71.6 and 44.4% of households in Hamer and Bena-Tsemay districts, respectively. Prevalence of diseases, shortage of grazing and water due to drought are the major constraints. Contagious Caprine Pleuro Pneumonia (CCPP) is the most prevalent disease causing high morbidity and mortality of goats in the districts.

Breeding practice in the study districts is uncontrolled. The households indicated that there is high variability in performance traits within their goat genotypes. They valued highly for adaptation traits of goats such as tolerance to drought and disease resistance above performance traits. The households, 88% in Hamer and 70% in Bena-Tsemay districts prefer dual purpose goat genotypes (meat and milk) over either meat or milk types.

Natural pastures from rangelands are major feed sources for livestock. Higher feed availability is reported in March to April (during the main rainy season). However, availability of feed extends up to October in Bena-Tsemay district due to the higher rainfall in the district. In both districts, the hot dry season (November to

February) is the period of feed scarcity and during which high mortality of goats has been reported.

Mobility is the main strategy for the households to alleviate dry season feed shortage but movement of livestock within the districts was occasionally constrained by ethnic conflicts. Tree lopping is the common practice for supplementation of goats during the dry season. Crop residues and some food left over are also available for supplementing animals especially in the agro-pastoral areas. Greater proportion of households are supplementing salt (22.6 vs. 7.4 %) and practicing fattening of goats (40 vs. 28%) in Bena-Tsemay district compared to Hamer.

In experiment 2, growth and reproductive performances of Woyto-Guji goats was evaluated beginning the end of dry season under various meal concentrate supplementation, 0 (T_0), 200 (T_1) and 400 g/day (T_2). Meal concentrate supplementation significantly increased total dry matter intake (TDMI) of goats. Accordingly, energy and protein intake of the supplemented goats increased significantly compared with the control.

The final BW for female Woyto-Guji goats was 15.0, 18.1 and 20.2 kg and the ADG values were 2.7, 33.5 and 54.7 g/day for T_0, T_1 and T_2 treatment groups, respectively. The higher BW and ADG values in the supplemented groups were associated with the greater DM, energy and protein intake of goats.

In the study, subsequent reproductive performances of Woyto-Guji goats were also investigated. The supplemented groups had higher BW and BCS during mating and parturition periods compared to the control. As a result, the proportion of goats in oestrus and goats mated significantly higher in the supplemented groups than the control. Accordingly, pregnancy rate and kidding rates of goats were also improved by 17% (T_1), 29% (T_2) and by 71% (T_1), 83% (T_2) over the control, respectively.

The birth weights of kids were 1.5, 1.8 and 2.1 kg and the PPW of Woyto-Guji goats were 17.4, 21.2 and 25.3 kg for T_0, T_1 and T_2 treatment groups, respectively.

The average gestation length for the goats was 136 days and litter size (kids born per doe) is one, with no significant difference between the treatment groups. Woyto-Guji goats also showed good mothering ability (grooming, licking and suckling) irrespective of supplementation. The improvement in kids and dams PPW would enhance the survival of the kids and reproductive performances of the goats in the post-partum period.

Recommendations

Based on the findings of the study the following recommendations were made:

1. The study described diseases as the major constraints for goat production in the study districts. Strengthening animal health services by the regional government with the involvement of private veterinarians and other institutions should be the priority in any goat improvement programs in south western Ethiopia.

2. To sustain goat production in the districts efficient utilization of grazing resources through proper rangeland measures is required. Moreover, the efficiency of goat production could be increased by optimizing the breeding season with the availability of feed resources.

3. High mortality of kids during the dry reason could be reduced by concentrating mating of goats in Maech to May. Supplementation of goats end of dry season prior to the mating may also offer benefit in promoting early mating and kidding of goats before the following hot dry season of south western Ethiopia.

4. From the survey result and cost benefit analysis of this study it is feasible to promote supplementary feeding of goats targeting potential areas/households and markets. Further investigations are also required to develop alternative and least cost feeding technologies for goat production using locally available feed resources.

5. According to the households, there is considerable variation within their goat genotypes with respect to productive traits such as meat, milk production and twinning potentials. The potential use of this variability, however, needs to be investigated. A genetic improvement program for goat production in south western Ethiopia involving introduction of improved breeds other than local goats should also considered the adaptability traits such as drought tolerance and resistance to endemic diseases.

6. The greater preference of households for dual purpose goat genotypes indicates that milk and meat are important for the households. Thus, the knowledge obtained from this study would assist in promoting suitable goat genotypes by the regional government, NGOs or other institutions to specific localities in south Omo zone.

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APPENDICES

Appendix A

Tables

Appendix Table A1 ANOVA for initial BW before concentrate feeding

Source	DF	SS	MS	F value	Pr > F
Treatment	2	2.3737778	1.1868889	0.41	0.6675
Error	42	122.1386667	2.9080635		
Corrected Total	44	124.5124444			
R-Square =	0.019065		CV =	11.34684	

Appendix Table A2 ANOVA for final BW after 90 days concentrate feeding

Source	DF	SS	MS	F value	Pr > F
Treatment	2	206.4484444	103.2242222	28.94	<.0001
Error	42	149.8226667	3.5672063		
Corrected Total	44	356.2711111			
R-Square =	0.57947		CV =	10.63726	

Appendix Table A3 ANOVA for total weight gain after 90 days concentrate feeding

Source	DF	SS	MS	F value	Pr > F
Treatment	2	164.348000	82.2740000	166.61	<.0001
Error	42	20.7400000	0.4938095		
Corrected Total	44	185.2880000			
R-Square =	0.888066		CV =	25.77197	

Appendix Table A4 ANOVA for ADG after 90 days concentrate feeding

Source	DF	SS	MS	F value	Pr > F
Treatment	2	20579.44133	10289.72067	166.63	<.0001
Error	42	2593.60667	61.75254		
Corrected Total	44	23173.048			
R-Square =	0.888077		CV =	25.91211	

Appendix Table A5 ANOVA for hay dry matter intake (g/day) of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	309851.9151	154925.9576	93.36	<.0001
Error	42	69698.2107	1659.4812		
Corrected Total	44	379550.1258			
R-Square =	0.816366		CV =	15.17976	

Appendix Table A6 ANOVA for concentrate intake (g/day) of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	799572.6840	399786.3420	132836	<.0001
Error	42	126.4040	3.0096		
Corrected Total	44	799699.0880			
R-Square =	0.999842		CV =	1.048613	

Appendix Table A7 ANOVA for total dry matter intake (g/day) of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	133858.1373	66929.0687	39.68	<.0001
Error	42	70848.6827	1686.8734		
Corrected Total	44	204706.8200			
R-Square =	0.653902		CV =	9.467857	

Appendix Table A8 ANOVA for total dry matter intake (%BW) of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	1.20165333	0.60082667	4.39	0.0186
Error	42	5.74986667	0.13690159		
Corrected Total	44	6.95152000			
R-Square =	0.172862		CV =	13.92032	

Appendix Table A9 ANOVA for total dry matter intake (g/W$^{0.75}$) of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	750.475720	375.237860	8.96	0.0006
Error	42	1759.542960	41.893880		
Corrected Total	44	2510.018680			
R-Square =	0.298992		CV =	12.12678	

Appendix Table A10 ANOVA for feed per gain of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	61748.8595	30874.4298	5.44	0.0079
Error	42	238442.1084	5677.1931		
Corrected Total	44	300190.9679			
R-Square =	0.205699		CV =	201.8179	

Appendix Table A11 ANOVA for BW at mating of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	71.66844444	35.83422222	300.31	<.0001
Error	15	17.73433333	1.18228889		
Corrected Total	17	89.40277778			
R-Square=	0.81636		CV=	5.143748	

Appendix Table A12 ANOVA for initial BW of pregnant goats before 90 days concentrate feeding

Source	DF	SS	MS	F value	Pr > F
Treatment	2	6.84266667	3.42133333	10.36	0.2864
Error	15	37.72233333	2.51482222		
Corrected Total	17	44.565			
R-Square	0.153544		CV=	9.738910	

Appendix Table A13 ANOVA for BW at 90 days pregnancy of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	163.896	81.9480	1510.31	<.0001
Error	15	8.124	0.54160		
Corrected Total	17	172.02			
R-Square=	0.952773		CV	2.841447	

Appendix Table A14 ANOVA for post partum weight (PPW) of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	134.5106667	67.2553333	1190.33	<.0001
Error	15	8.4543333	0.5636222		
Corrected Total	17	142.965			
R-Square=	0.940864		CV=	3.257040	

Appendix Table A15 ANOVA for BCS of pregnant goats before concentrate feeding

Source	DF	SS	MS	F value	Pr > F
Treatment	2	0.44444444	0.22222222	30.33	0.0634
Error	15	1	0.06666667		
Corrected Total	17	1.44444444			
R-Squre=	0.37692		CV=	10.10343	

Appendix Table A16 ANOVA for body condition score (BCS) at mating of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	1.31777778	0.65888889	530.42	<.0001
Error	15	0.185	0.01233333		
Corrected Total	17	1.50277778			
R-Squre=	0.876895		CV=	3.513181	

Appendix Table A17 ANOVA for BCS at 90 days pregnancy of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	0.07111111	0.03555556	00.74	0.4934
Error	15	0.72	0.0480		
Corrected Total	17	0.79111111			
R-Square=	0.089888		CV=	8.842158	

Appendix Table A18 ANOVA for post partum BCS of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	0.72266667	0.36133333	200.66	<.0001
Error	15	0.26233333	0.01748889		
Corrected Total	17	0.985			
R-Square=	0.733672		CV=	4.335920	

Appendix Table A19 ANOVA for variation in mating days of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	175.0173611	87.5086806	15.17	0.0002
Error	15	86.5387500	5.7692500		
Corrected Total	17	261.5561111			
R-Square =	0.669139		CV =	47.77312	

Appendix Table A20 ANOVA for variation in kidding days of goats

Source	DF	SS	MS	F value	Pr > F
Treatment	2	108.2777778	54.13888891	14.50	0.0003
Error	15	56.0	3.7333		
Corrected Total	17	164.2777778			
R-Square =	0.659114		CV =	41.90278	

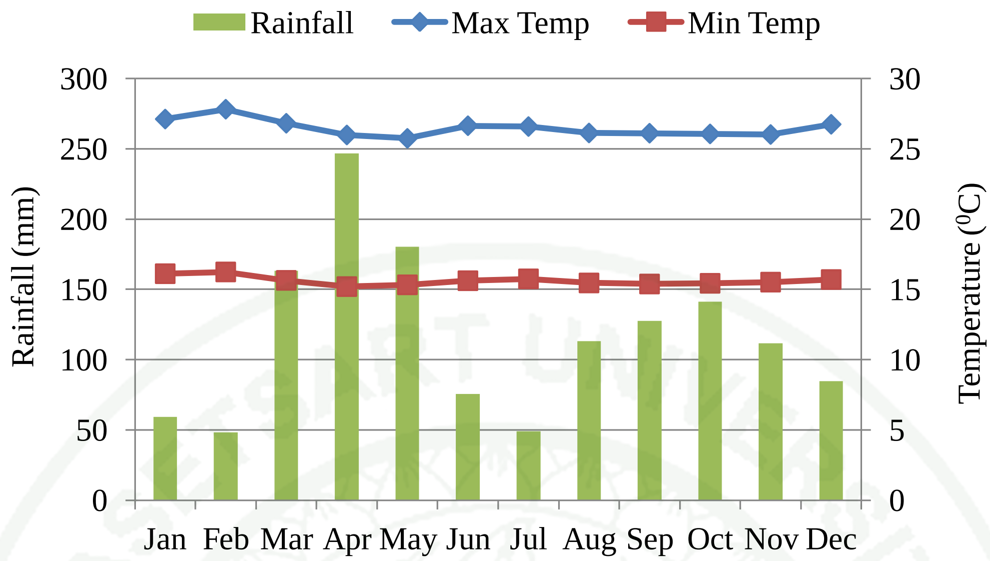
Appendix Table A21 ANOVA for kid's birth weight

Source	DF	SS	MS	F value	Pr > F
Treatment	2	0.72066667	0.36033333	640.09	<.0001
Error	15	0.08433333	0.00562222		
Corrected Total	17	0.805			
R-Square=	0.895238		CV=	3.912077	

Appendix Table A22 ANOVA for gestation length

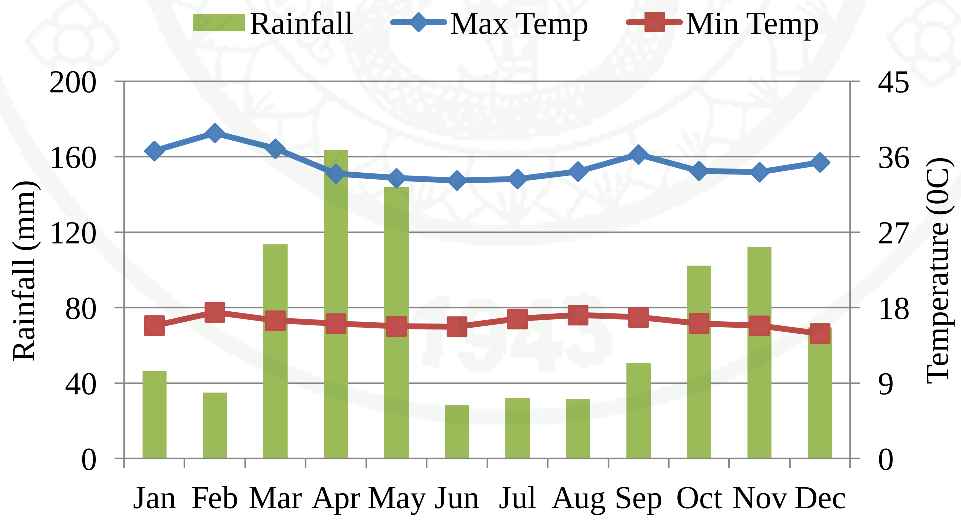
Source	DF	SS	MS	F value	Pr > F
Treatment	2	20.09595960	10.04797980	2.53	0.1128
Error	15	59.51515152	3.96767677		
Corrected Total	17	79.61111			
R-Square=	0.252427		CV=	1.451002	

Appendix B
Figures



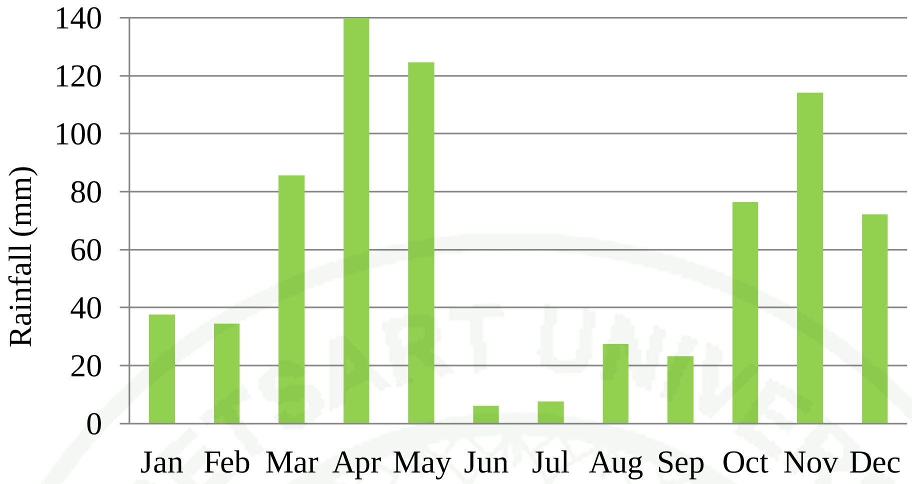
Appendix Figure B1 Monthly average rainfall and temperature (2000–2010) at Keyafer, Bena-Tsemay district

Source: NMA (2011)



Appendix Figure B2 Monthly average rainfall and temperature (2000–2010) at Dimeka, Hamer district

Source: NMA (2011)



Appendix Figure B3 Monthly average rainfall (2000 –2010) at Turmi, Hamer district

Source: NMA (2011)

Appendix Figure B4 A pastoral home and goat herds near Dimeka, Hamer district

Appendix Figure B5 Goats herd in Alduba, Bena-Tsemay district

Appendix Figure B6 Goat sale at Keyafer, Bena-Tsemay district

Appendix Figure B7 Pastoral groups in Hamer district

Appendix Figure B8 Group discussion with pastorals at Asile, Hamer district

Appendix Figure B9 Group discussion with pastoral groups at W/baynu, Hamer district

Appendix Figure B10 Female Woyto-Guji goats used in the experiment

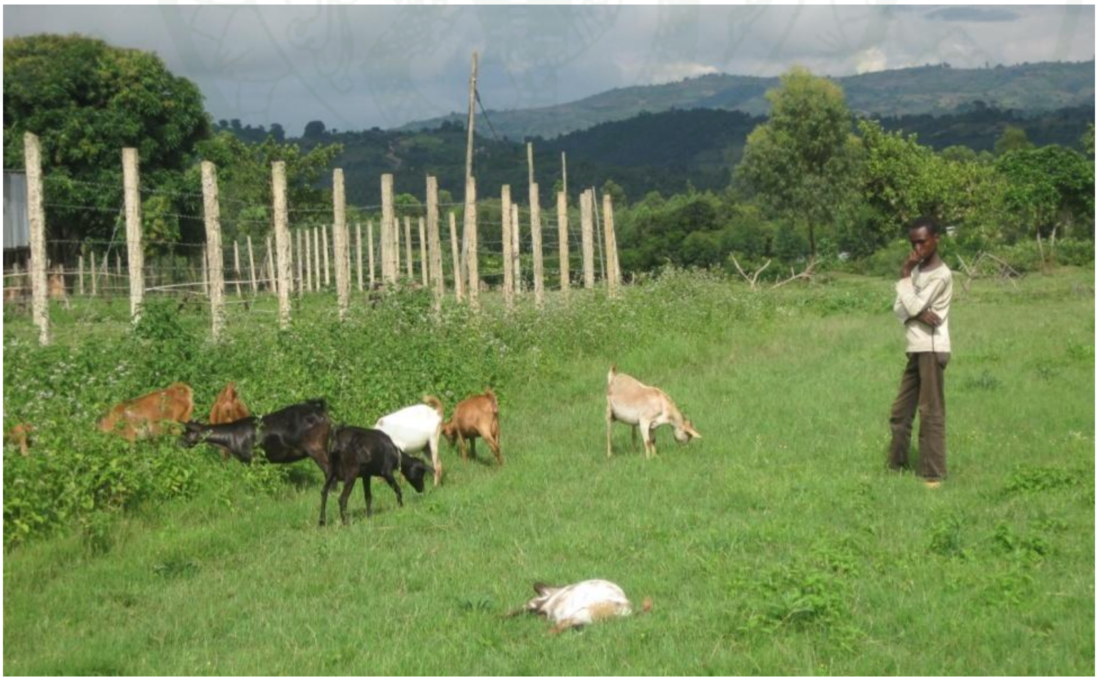
Appendix Figure B11 Feeding grass hay during the experiment

Appendix Figure B12 Feeding concentrate during the experiment

Appendix Figure B13 Feed measurement during the experiment

Appendix Figure B14 Body weight measurement during the experiment

Appendix Figure B15 Observation of goat in oestrous



Appendix Figure B16 Observation of goats in parturition

Appendix Figure B17 Blood collection for progesterone analysis

Appendix Figure B18 Bleating before parturition

Appendix Figure B19 Isolation and appearance of amniotic fluid

Appendix Figure B20 Standing attempt by the kid while doe licking

Appendix Figure B21 Kid's suckling attempt

Appendix Figure B22 A doe leaving her kid immediately after parturition

Appendix Figure B23 The doe in right held in a rope, non-suckling and non-attentive toward her kid

Appendix C

Household survey Questionnaire

Appendix C Household survey Questionnaire

Enumerator Name ____________________ Date _____________

General Information

1. Name of study district _____________________
2. Name of Kebele (lowest administrative sub-unit) _____________________
3. Village name_____________________
4. Interviewee No. _____________
5. Name of the interviewee ___________________________
6. Ethnic group of the interviewee
   a) Hamer
   b) Erbore
   c) Bena
   d) Tsemay
   e) Ari
   f) Braile
7. Sex of the interviewee
   a) Male [ ]
   b) Female [ ]
8. Position in the household
   a) Household head [ ]
   b) Spouse of head [ ]
9. Family size

Children by age	Number of household members
Females <15	
Males <15	
Adults	
Females 15–65	

Males 15–65	
Female >65	
Male >65	
Total	

10. Education level of parents and children

Education level	Mother	Father	Number of children (> 7 years)
No school			
Grade 1–3			
Grade 4–6			
Above grade 6			

11. Source of Income

Source	Description	Rank
Livestock sale		
Sale of livestock products		
Honey sale		
Crops sale		
Petty trading		
Others		

12. Which type of livestock is the best income source for family?

Livestock type	Rank	Remark

Production system

13. Number of livestock kept by households

Animal Type	Number
Cattle	
Goats	
Sheep	
Ox	
Camel	
Donkeys	
Chicken	
Honey bee hives	

14. How long have you been keeping goats?
15. How many Goat breeds/types exist in your locality?
16. What is/are the name for your goat breed (s)? Where is the source for your breed(s)?
17. What type of goat you are rearing?
    a) Meat
    b) Milk
    c) Meat and milk
18. Do you think that your goats are more productive than any other goat breeds in your or other localities?
    a) Yes [ ]
    b) No [ ]
19. If yes, better than which breeds____

    ____
20. If no, which breeds are superior to yours?______________________________

    ____
21. How do you express the positive or poor side of your goats relative to other breeds? (multiple answers is possible)

Positive aspects	Poor sides
High disease resistance [ ]	Low disease resistance [ ]
High drought tolerance [ ]	Low drought tolerance [ ]
good conformation and growth [ ]	poor conformation and growth[ ]
high reproductive potential [ ]	low reproductive potential [ ]
For their quality skin [ ]	poor quality skin [ ]
others (specify) [ ]	others (specify) [ ]

22. How was the trend of goat production and productivity in the last 5 to 10 years?

a) Decreasing
b) Increasing
c) No change

If any changes, what are the reasons for these changes?_________________

23. Flock composition

Group	No	Ownership status			
		Private	Family	Produced	Purchase
Bucks >1 year					
Non-castrated					
Castrated					
Does >1 year					
Pregnant					
Lactating					
Non-pregnant					
Buck kids					
6 month- 1 year					
Non-					

castrated					
Castrated					
Does kids					
6 month –1 year					
< 6 months					
Male					
Female					

24. Purpose of keeping goats

Purpose	Rank
1. Yield attributes (Meat, milk, blood, skin)	
2. Socio-economic (cash, asset, security)	
3. Socio-cultural (rites, ceremony, dowry)	

25. The major source of feed for goats

Type	Season		Remark
	Dry	Wet	
Rangeland (Natural grazing)			
Crop residue			
Others, specify			

26. Grazing management of goats (multiple answers is possible)

Grazing type	Dry season			Wet season		
	Kids	Does	Bucks	Kids	Does	Bucks
Communal grazing						

Private grazing						
Un herded, kept around homestead						
Herded in Enclosure						
Herded in Riverside						
Other (specify)						

27. How many grazing sites do you have?
    a) 1 to 2
    b) 3 to 5
    c) >5
28. How much is the distance for grazing sites?
    d) 1 to 5
    e) 5 to 10
    f) 10 to 20
    g) >20
29. How much is the time spent by goats on grazing per day? _____
30. Do goats graze as mixed flock with sheep?
    a) Yes [ ]
    b) No [ ]

    Reason ________________________________

31. Do goats graze as mixed flock with cattle?
    a) Yes [ ]
    b) No [ ]

32. In which months do you encounter shortage or surplus of grazing for your Goats?

Quantity	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG
Shortage												
Surplus												

33. What are your strategies to alleviate dry season feed shortage?
34. Do you practice feed conservation practices such as hay making?
    a) Yes [ ]
    b) No [ ]
35. Do you supplement feed during drought or shortage of grazing?
    a) Yes [ ]
    b) No [ ]
36. Do you supplement salt for goats?
    c) Yes [ ]
    d) No [ ]
37. Do you practice fattening?
    e) Yes [ ]
    f) No [ ]
38. What is the source of water in your locality?
39. Distance to nearest watering point for adult goats during dry season
    a) < 1 km [ ]
    b) 1-5 km [ ]
    c) 6-10 km [ ]
    d) > 10 km [ ]

40. Frequency of watering for adults goats during the dry season
    a) Freely available [ ]
    b) Once a day [ ]
    c) Once in 2 days [ ]
    d) Once in 3 days [ ]
    e) Other (specify) [ ]

Health

41. Major diseases and physiological disorder

Major disease	Local name	goats Classes affected	Season of occurrence	Typical symptom

42. Do you have access to veterinary service?
    a) Yes
    b) No
43. If yes, which one is the accessible service for you? (multiple answers is possible)
    a) Government [ ]
    b) Private veterinarian [ ]
    c) Shop or market [ ]
    d) Other specify [ ]
44. How far is the nearest veterinary centre?____km.
45. How is the cost for medicine?
    a) Low
    b) Moderate
    c) High
46. How is the cost for veterinary service?
    a) Low
    b) Moderate
    c) High

Breeding

47. Do you select the best breeding Buck?
    a) Yes [ ]
    b) No [ ]
48. What is your criteria for choice of buck(s) ? (multiple answers is possible)
    a) Size [ ]

b) Color [ ]

c) Horns [ ]

d) Character [ ]

e) Availability [ ]

f) Other (specify) [ ] ______________________

49. Color choice for buck selection with reason

____

50. Buck colors not preferred with reason

____

51. Breeding/mating system

a) Controlled [ ]

b) Uncontrolled [ ]

52. Source of buck(s) within the last 12 months (multiple answers is possible)

a) Own buck (bred) [ ]

b) Own buck (bought) [ ]

c) Buck donated [ ]

d) Buck borrowed [ ]

e) Neighbor's buck [ ]

f) Communal buck [ ]

g) Unknown buck [ ]

53. Do you select the best replacement female goat from your flock?

a) Yes [ ]

b) No [ ]

54. If yes, what are the main criteria's used to get the best replacement female goat?

a) Fast kidding interval [ ]

b) Body size or conformation [ ]

c) Prolificacy of their parents [ ]

d) Twining ability and maternity [ ]

e) Other reasons [ ]

55. Kidding rate
    a) Twice/year [ ]
    b) Once/year [ ]
    c) Two-times/three year [ ]
    d) Not permanent [ ]
56. Number of kids at birth
    a) One at a time [ ]
    b) Twins [ ]
    c) Triplets [ ]
    d) Above triplet [ ]
57. When is the major breeding/mating season?
    a) Dry
    b) Meher (short rain)
    c) Belg (main rain)
    d) Belg and Meher
    e) All year round

58. If mating is seasonal what are the reasons (multiple answers is possible)
    a) Availability of feed [ ]
    b) Convenient day temperature [ ]
    c) To meet with highest birth and service time [ ]
    d) Other [ ]
59. How is the prevalence of abortion in does?
    a) High [ ]
    b) occasional [ ]
    c) low [ ]
60. When is the season of high abortion in goats?
    a) Dry
    b) Meher (short rain)
    c) Belg (main rain)
    d) Belg and Meher
61. What do you think are reason for the prevalence of abortion?

62. Which season or month of the year the highest births of kids observed

a) Dry

b) Meher (short rain)

c) Belg (main rain)

d) Belg and Meher

63. Major constraints of goat production in the area

Constraint type	Give explanation	Rank
Animal diseases		
Shortage of grazing		
Water shortage		
Market problem		
Drought		
Other (specify)		

64. What solutions you suggest to alleviate the major constraints?

Constraints	Suggested Solutions
Animal diseases	
Shortage of grazing	
Water shortage	
Market problem	
Drought	
Other (specify)	

65. Which improved goat breeds you prefer to be supplied for expansion of your goat production?

a) Meat

b) Milk

c) Meat and milk

Thank you very much for your cooperation.

CURRICULUM VITAE

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	1991	Alemaya University of Agriculture	B.Sc. (Animal Science)
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PUBLICATIONS

Berhanu T, Thiengtham J, Tudsri S, Abebe G, Tera A and Prasanpanich S 2012: Purposes of keeping goats, breed preferences and selection criteria in pastoral and agro-pastoral districts of South Omo Zone. Livestock Research for Rural Development. Volume 24, Article #213. http://www.lrrd.org

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