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**MAJOR FEED RESOURCES AND EFFECT OF FLUSHING ON
PRODUCTION AND REPRODUCTIVE PERFORMANCE OF ARSI
BALE EWES IN ARSI ZONE, OROMIA REGIONAL STATE,
ETHIOPIA**

PhD Dissertation

By

ABAYNESH JARSO MOJO

**April, 2024
Bishoftu, Ethiopia**

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PRODUCTION AND REPRODUCTIVE PERFORMANCE OF ARSI
BALE EWES IN ARSI ZONE, OROMIA REGIONAL STATE,
ETHIOPIA**

**A Dissertation Submitted to the Department of Animal Production Studies
College of Veterinary Medicine and Agriculture
ADDIS ABABA UNIVERSITY**

**In Partial Fulfillment of the Requirement for the Degree of DOCTOR OF
PHYLOSOPHY IN ANIMAL PRODUCTION STUDIES**

**By
Abaynesh Jarso Mojo**

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Reproductive Performance of Arsi Bale Ewes in Arsi Zone, Oromia
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STATEMENT OF THE AUTHOR

First, I declare that this dissertation is my bonafide work and that all sources of material used for this dissertation have been duly acknowledged. This dissertation has been submitted in partial fulfillment of the requirements for a PhD degree at Addis Ababa University, College of Veterinary Medicine and Agriculture is deposited in the University/College library to be made available to borrowers under the rules of the library. I solemnly declare that this dissertation is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this dissertation are allowed without special permission, provided that accurate acknowledgement of the source is made. Requests for permission for extended quotation from or copy of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however permission must be obtained from the author.

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BIOGRAPHICAL SKETCH

The author, Abaynesh Jarso was born on October 20, 1983 E.C, in East Showa Zone, Ada'a Woreda, Koftu Kebele, Oromia Regional State. She attended her Elementary Education in Bole Primary School, High School at Bishoftu Secondary School and Preparatory School at Bishoftu Preparatory School. After completion of preparatory school, she joined Mizan Tepi University in 2002 E.C academic year and graduated with BSc. degree in Animal Science in June 2004 E.C

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LIST OF ABBREVIATION

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
CP	Crude Protein
CSA	Central Statistics Agency
DM	Dry Mater
DOMD	Dry Organic Matter Digestibility
FAO	Food and Agriculture Organization
IVOMD	<i>In Vitro</i> Organic Matter Digestibility
ME	Metabolizable Energy
NDF	Neutral Detergent Fibers
NP	Natural Pasture
PI	Parturition Interval
TDN	Total Digestible Nutrient

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ABSTRACT

The aim of this study was to assess the major feed resources and effect of flushing on production and reproductive performance of Arsi Bale ewes in Arsi Zone. For survey part, two districts, Tiyo and Digelunatiyo from Arsi zone were purposively selected based on sheep population, and three Peasant Associations (PAs) from each districts were selected randomly. A total of 200 HHs were taken. Feed sample of natural pasture and barley straw was collected from ten (10) randomly selected HHs from each PAs. Feed samples collected were mixed, dried, packed individually and taken to Holeta Agricultural Research Center for laboratory analysis of Dry Matter, Crude Protein, Ash, Neutral Detergent Fiber, Acid Detergent Fiber, Acid Detergent Lignin, In Vitro Dry Matter Digestibility, In Vitro Organic Matter Digestibility and Metabolizable Energy. On the other hand, effect of flushing on production and reproductive performances of Arsi Bale ewes was also tested. A feeding trial was conducted using 24 Arsi Bale ewes. The ewes were purchased from the Sagure market of Arsi Zone at their 7 to 8 months of age. The treatments are T₁ (hay+350 g of barley grain), T₂ (hay+287.5 g of barley grain), T₃ (hay+225 g of barley grain) and T₄ (the control diet). All ewes, except in the control diet were supplemented for three weeks prior to mating and four weeks after mating. Two mature rams of Arsi Bale breed were purchased for mating. After three weeks of the feeding period, the rams were set free in the flock for 35 days. Reproductive performances of ewes were assessed by taking records on Conception Rate, Lambing Rate, Abortion Rate, Litter Size and Pre Weaning Lambs Mortality Rate; and Production characteristic was assessed by taking records on lambs birth and weaning weight (at three months of age) and body weight of dam before and after flushing.

For survey part, collected data were stored in Microsoft Excel spread sheet. Data analyses were carried out by using SPSS version 2019, software. Chemical composition of both feed types was subjected to analysis of variance using a GLM procedure of statistical analysis system (SAS) version 9.1 (SAS, 2002). The Pearson Chi-Square was used to determine mean differences at ($p < 0.05$) for qualitative variables. Data on production and reproductive was analyzed using R 4.2.2, 2023soft ware. Tukey HSD test was employed for separation of treatment means differences at ($p < 0.05$).

The results of the field survey in the present study revealed that natural pasture contributes the largest proportion (53%) in Tiyo and (55%) in Digelunatiyo of sheep feed which is followed by crop residue (30%) and (33%) in Tiyo and Digelunatiyo, respectively. On the other hand 16 % in Tiyo and 10% in Digelunatiyo use both natural pasture and crop residues. The overall mean of DM, Ash, CP, NDF, ADF, ADL, IVDMD, IVOMD and ME content of natural grasses respectively were 89.5%, 5.4%, 20.1%, 68.5%, 37.1%, 5.0%, 55.8%, 43.8% and 7.4 MJ/kg DM. The corresponding values for barley straw were also 90.9%, 5.6%, 5.4%, 70.7%, 54.05%, 9.6% and 8.25MJ/kg.

In terms of reproductive and production characteristics, the conception rate of ewe was 83% for T₁ and 100% for T₂, T₃ and T₄ and revealed as there were no significant differences ($p>0.05$) among the treatments that ewes fed, while lambing rate was 120%, 100% and 83.3% and 66.7% for T₁, T₂, T₃ and T₄, respectively and there is a significant difference ($p<0.05$) between treatment groups. There was a significant differences ($p<0.05$) on the litter size from ewe under T₁ and T₂ and where all ewe in the first two treatment group gave twin births. Lamb mortality rate was high under T₃ and T₄ than the first two treatment group. In terms of production characteristic, the average body weight (BW) of dam before flushing was 21.5kg, 22.6kg, 22kg and 22.2kg for T₁, T₂, T₃ and T₄, respectively and the corresponding results for average dam BW after flushing was 25kg, 23.8kg, 23.2kg and 22.5kg. On the other hand, the birth weight of lambs was 2.3 kg, 2.1 kg, 2. 3 kg and 1.8 kg for T₁, T₂, T₃ and T₄, respectively and the average weaning weight (three months of age) of lambs was 11.3 kg, 10.3 kg, 9.9 kg T₁, T₂and T₃, respectively. There was a significant difference ($p<0.05$) on average weaning birth and weight of lambs. From the above results, it was concluded that, natural pasture and crop residue (mainly barley straw) are the main sheep feed in the studied areas, and good production and reproductive performances were seen under T₁ and T₂, so flushing ewes with 350g (T₁) and 287.5g (T₂) barley grain are recommended. Conducting other research by different types of feed like concentrate at different feeding rate is recommended and also flushing ewes after first parity is recommended.

Keywords: *Arsi-Bale ewes, Barley grain, Flushing, Natural grass hay, Nutritional quality, , Reproductive performance*

1. INTRODUCTION

1.1. Background

Sheep are the second most important species of livestock in Ethiopia that are dominantly found in the crop-livestock production system and contribute about 63% of the net cash income derived from the livestock production. Sheep are among the major economically important livestock species in Ethiopia playing an important role in the livelihood of resource-poor farmers. They are an integral part of livestock keeping in Sub-Saharan Africa that are mainly kept for immediate cash sources, milk, meat, wool, manure and saving or risk distribution (Bayissa *et al.*, 2022).

About 38 million sheep are estimated to be found in Ethiopia, out of which about 70.62% are females, and about 29.38% are males (CSA, 2020). The proportion of sheep kept for mutton is significantly higher for males. Moreover, the data reveals that female sheep are primarily kept for breeding purposes. Among the sheep flock, two years and older are at about 51.25% of the total sheep and from this about 46.95% are kept for breeding purpose, about 3.13% for mutton and 0.23% for wool production CSA (2020). Despite of their large number and contributions, efforts made so far to improve the productivity of indigenous sheep were very little (Shashei and Mengistu, 2019).

Sheep feed resources in Ethiopia are mainly grazing on communal natural pasture, crop stubble, fallow grazing, road side grazing, crop residues, browses, improved forages and non-conventional feeds like food leftovers, weeds, crop tillers and fillers. The contribution and quality of these feed resources is; however, depends up on agro-ecology, types of crops produced, and accessibility and production system. Small ruminant feed resources in Ethiopia are mainly grazing on communal natural pasture, crop residue, road side grazing, browses and non-conventional feeds (household's food leftovers and weeds) and improved forages. Most of the sheep feeds are derived from natural pasture and crop residues (Getachew *et al.*, 2017).

Despite the continued expansion of croplands into the grasslands and the resultant decline in size of grazing areas, native pastures remain the major contributors of livestock feed in the densely populated highlands of Ethiopia (Endale, 2015). Natural pastures mostly suffer from seasonally spells of dry periods during which they drop in quality, which is characterized by high fiber content, low digestibility, and low in nitrogen, very low protein and energy content (Assefu, 2012).

Crop residues are among the most widely available, low-cost feeds for ruminants in the majority of developing countries. It supply roughly 50-80% of the total resources of ruminant livestock feed in the mixed cereal-dominated crop and livestock production system that varies with agro ecology, crop variety and production potential (Shashie and Mengistu, 2019).

Mixed crop livestock production practice is common production system of Ethiopia across different agro-ecological conditions which depends on indigenous breed of small ruminant with low level of production and productivity (Solomon *et al.*, 2010). In these systems, the use of crop residues is important for various uses that include soil mulching and livestock feeding. In mixed crop-livestock farming systems farmers typically use crop residues for livestock feed. In the Ethiopian highlands where crop-livestock systems are prevalent, the contribution of straw to the total dry matter fed to live stock ranges from 10% to 70% (Matawork and Mitiku, 2017).

Barley (*Hordeum vulgare*) is a major food crop in the highland areas of Ethiopia with associated production of one metric ton of the grain accompanied by 1.2 metric tons of straw. It is one of the major cereal crops that are largely produced in the central and southeast mid and high-altitude areas of Ethiopia (Abu, 2022). Barley is largely produced in the central and southeast mid and high-altitude areas of Ethiopia. Its production in 2022/23 was 2.4 million metric tons (MT) (Abu, 2022). Globally, European Union, Russian Federation, Ukrian, Turkey and Canada are the top five largest world barley producers where, European Union produces the greatest quantities of barley with an estimated production of nearly 60 million tons followed by Russian Federations with a production of about 20 million tons according to Untied State of Agricultural Institute estimate in 2014. Barley is the fifth most

important crop in terms of area coverage after Teff, corn, wheat, and sorghum. Barley grain is used for human food, animal feed, and malt production in Ethiopia. Ethiopia is the second largest barley producer in Africa (Samuel, 2016).

Barley straw is among the dominant farm animal feeds in the highlands of Ethiopia particularly in barley-based farming, where crop and livestock production are well integrated. It is utilized as livestock feed as collected and used for stall feeding of livestock mostly during the dry season. Ruminant animals can utilize barley straw since the ruminal microbes have the ability to ferment the cell walls (Mulugeta *et al.*, 2021).

Inadequate nutrition is one of the factors that generally affect livestock productivity in the tropical countries (Aberra, 2011). Feeding of sheep is one of the most important factors that influence the fertility, and a high level of feeding of energy feed stuff may increase ovulation. This results in a higher lambing percentage by increasing the number of twin births. This procedure is known as flushing. Nutrition is one of the most significant influences on the ovulation rate of sheep, short periods of improved nutrition before and during mating increase the proportion of ewes bearing twins (Never, 2022).

Ewes should not be allowed to become excessively fat but should make daily gains from weaning to breeding. If pasture production is inadequate, ewes may be confined and fed high-quality hay and a small amount of grain if necessary. The amount grain offered depends on the condition or fat covering of the ewes and quality of the forage. If ewes are in a fair to good condition, 0.5 - 0.75 lb (225 - 350 g) daily grain is usually sufficient (David, 2020). The findings of Kiflay *et al.* (2019), suggested that the increase in energy and protein availability improved ewes' reproductive efficiency.

Increasing energy and protein availability improves ewes' reproductive efficiency. Farmers rely on commercial concentrate to supplement livestock productivity (Asfaw, 2022).

Supplementation of low-quality feed resources with grains can be employed to enhance the energy and/or protein status of low-quality feeds (Seyoum and Fekede, 2008). A long ago it was postulated that the ovaries of ewes fed on a high plane of nutrition would contain more follicles, than would the ovaries of ewes fed a low plane of nutrition and that, a given quantity of gonadotrophin would cause greater ovarian stimulation.

Flushing is a temporary but purposeful increase in the level of nutrition around breeding time. This is done to boost ovulation, conception, and embryo implantation rates. Flushing may also increase the proportion of females that exhibit estrus. It can also increase lambing and kidding rates by 10-20 percent. Flushing brings ewes/does into good body condition prior to breeding. This practice also improves embryonic survival rate (Tesfa, 2022).

To flush ewes, producers should supplement the breeding flock with good quality hay, fresh pasture, or grain for two to three weeks before and two to four weeks after breeding. Special feeding usually begins around 2 weeks prior to breeding and continues at least 2 to 4 weeks into the breeding season. This ensures good embryo attachment to the uterus wall, reducing early embryonic death. Because most spontaneous fetal deaths (early embryonic deaths or EEDs) occur in the first month of gestation and are probably due to poor maternal nutrition, flushing for four weeks post-breeding is recommended, especially in a flock with a low BCS. During flushing, producers should focus on increasing the amount of energy feed to ewes and does (Asfaw *et al.*, 2023).

1.2. Statement of the Problem

Arsi Zone is known by having a huge sheep population of about 1.66 million heads (CSA, 2015). The main sheep feed in the study area was not identified before. In addition, there has been no adequate information about nutritional composition of common sheep feed around area. Arsi Zone is characterized by a cereal dominated farming system in which bread wheat and barley are the major crops (Tamrat *et al.*, 2019), but supplemental effect of barely grain based flushing on reproductive and production performances of Arsi Bale highland ewe was not seen before.

1.3.Objectives

General objective

- To assess the major feed resource and to evaluate effect of flushing on production and reproductive performances of Arsi Bale ewes.

Specific objectives

- To assess the major feed types in the study area,
- To evaluate the nutritional quality of the common feed types assessed; and,
- To see effect of barley flushing on production and reproductive performances of Arsi Bale ewes.

1.4. Research Question

1. What are the most common sheep feeds around the study area?
2. What is the nutritional composition of the common feeds around the study area?
3. Can flushing ewes with barley grain influence their reproductive and production performances?

1.5. Scope of study

The study was focus on the ewes which did not give birth before and Flushing was done with barley grain with minimum, average and maximum daily requirement of ewes.

1.6. Significance of study

The present study is significant because it assessed common sheep feed types and evaluate the nutritional composition of common sheep feeds around the study area. In addition, effect of supplementing barley on production and reproductive performances of Arsi Bale ewes was also seen. This study will contribute to the existing literature by checking nutritional composition of the most common sheep feeds in study and by testing the effect of flushing on reproductive and production performances of ewes.

2. LITERATURE REVIEW

2.1. Feeds for Sheep and Their Feeding

Nutrition plays a major role in the overall productivity, health, and well-being of the sheep flock. Because feed costs account for approximately two-thirds of the total cost of production on most sheep farms, it is important that producers consider nutrition management a top priority. Nutrient requirements of sheep vary with differences in age, body weight, and stage of production. The five major categories of nutrients required by sheep are: 1) water; 2) energy; 3) protein; 4) vitamins; and 5) minerals. During the grazing season, sheep can meet their nutrient requirements from pasture and a salt and mineral supplement (Mulugeta *et al.*, 2021).

2.1.1. Natural pasture and browse

Natural pastures, supply the bulk of sheep and goat feed, are composed of indigenous forage species and are subject to severe overgrazing. Grazing occurs on permanent grazing areas, fallow land and on land following harvest. Both fallow land and crop stubble provide poor grazing for a very short period just after harvest. The availability and quality of native pasture varies with altitude, rainfall, soil type and cropping intensity. Average pasture yield for the highland areas is estimated to be 4 tons/ha. In many areas, natural pastures are invaded by species of low palatability. The wearing out and/or loss of teeth induced by unpalatable and tough vegetation is a problem that reduces the grazing ability of sheep and goats at an early grazing and browsing comprise the feed supply in pastoral areas. The higher rainfall areas of the pastoral zone are characterized by dense thorn bush of low carrying capacity (Alemu and Merkel, 2008).

Permanent pasture should be the predominant source of nutrition for the sheep flock. Intensive sheep production systems where the sheep are housed and fed harvested feeds are not as profitable as more extensive production systems where they harvest their own feed. When enough forage is available, sheep can meet their nutrient requirements from forage alone along with a supplemental source of salt and minerals. Clover should be over seeded on permanent pastures in the winter to improve the quantity and quality of forage produced

during the grazing season (Aberra, 2011). Sheep prefer to graze leafy, vegetative growth that is 2 to 6 inches tall rather than stemmy, more mature forages. Pasture growth is not distributed evenly throughout the year. Approximately 60% of the annual dry matter (DM) production of most species of cool season grasses occurs in the spring. When pastures are not stocked heavily enough to utilize the spring flush of growth, sheep graze and re-graze certain areas while other areas are left to mature and go to seed (Aberra, 2011).

The total area of grazing and browsing in the country is 62,280 million hectares out of this, 12% is in the farming areas and the rest is around the pastoral areas estimated that 80-85% of the livestock feed in Ethiopia comes from natural pasture. Natural pastures mostly suffer from seasonally spells of dry periods during which they drop in quality, which is characterized by high fiber content, low digestibility, low in nitrogen, very low protein, and energy content (Assefu, 2012). The yield as well as quality of pasture is very low due to poor management and over stocking (Abate, 2008). In general, grazing land productivity is declining at a higher rate because of temperature stress and scarcity of rainfall, which is favored by deforestation that denies humid environment to the area. In addition to this, the transfers of grazing lands to cultivation for cropping and poor grazing land management are some of the reasons for DM reductions from grazing lands (Admasu, 2008). Natural pastures would be adequate for live weight maintenance and weight gain during wet seasons but would not support maintenance for the rest of the year.

2.1.1.1. Pasture productivity and grazing management

Most pasturelands in the Ethiopian highlands have suffered encroachment of crop production because of the growing human population. The demands for high food led to expansion of arable lands that resulted in shrinkage of land available for grazing and browsing. Consequently, livestock are forced to concentrate on very limited pastureland that deteriorates and becomes unproductive in the long run. Overgrazing is not really a function of how many animals are on a pasture, but how long they remain there. In grazing management, time is the most important factor to consider in establishing a grazing system for sustained forage production. Generally, properly managed burning, manuring/fertilization, chemicals, hand

weeding and plowing reduce weed population and stimulate desirable species. Grazing of pasture by animals has an impact on the photosynthetic area of the plant, species composition and the soil type. Moderate grazing of grasses results in quick replacement of removed shoots, which promotes compensatory photosynthesis, and increases production of green biomass. Biomass production over time varies and therefore causes seasonal variation in forage availability. Likewise, grazing pressure varies across time because of differences in forage production among spatially separated plant communities. Under heavy grazing pressure, plants may not compensate sufficiently for the biomass removed by grazing animals. Hence, net primary production, which is the difference between non-grazed and grazed biomass production, is a useful tool to establish the defoliation level of plant vegetation (Gezahegn *et al.*, 2016).

Different grazing management treatments cause diverse changes in plant growth and these changes affect the quantity of the aboveground biomass produced on pasturelands. The timing and severity of grazing determine whether detrimental or beneficial effects might occur. Repeated heavy grazing removes a great amount of the photosynthetic leaf area and causes long-term reductions in the total biomass and organic reserves. Both early grazing and late grazing reduce herbage biomass of pasturelands. In contrast, grazing that is synchronized with grass growth stages is beneficial to plant growth mechanisms and ecosystem processes and stimulates greater herbage production (Gezahegn *et al.*, 2016).

2.1.2. Factors Affecting Forage Nutritive Value

Forage testing is necessary because forage quality varies considerably due to several factors, including differences in forage genotype, maturity, season, and management. An understanding of factors affecting forage quality will help producers anticipate and plan for changes in forage quality. When forage quality is low, forage alone may not support desired rates of animal performance. In such cases, it is necessary to provide livestock with supplements for protein and energy. Animal performance, whether growth or milk production, depends upon the animal's potential for production, as well as on how much DM the animal eats and the nutritive value of the DM that the animal consumes. Therefore, the two forage-related factors that determine animal performance are forage intake and forage nutritive value.

Collectively, these factors determine the quality of the forage. When forage is fed without restriction as the sole feed, forage quality can be an excellent predictor of animal performance (Harris *et al.*, 2022).

Forage nutritive value is primarily determined by concentrations of crude protein (CP) and “available “energy in the forage. For many years total digestible nutrients (TDN) have been used as an overall measure of available energy in forages. In the past 20 years, however, measurements of digestible forage, metabolizable forage, and net energy of forage have increasingly been used. However, TDN is still an acceptable and easily understood measure of nutritive value, particularly for beef cattle. Forage quality is affected most by variations in forage genotype, maturity, season, and management (Harris *et al.*, 2022).

2.1.2.1. Genotype

Legumes generally have a higher quality than grasses. Legumes have higher CP concentrations and a higher intake by livestock due to a higher percentage of rapidly digestible leaves. However, TDN concentrations of legumes and cool-season grasses are similar. Generalizations about quality of grasses are risky, but temperate or cool-season grasses, such as rye and ryegrass, often have higher quality than tropical or warm-season grasses, such as Bermuda grass and Bahia grass. However, there is much variation in forage quality within and among grass genera (Harris *et al.*, 2022).

2.1.2.2. Maturity

Maturity stage at harvest is the most important factor determining forage quality of a given species. Forage quality declines with advancing maturity. As plants mature and become more fibrous, forage intake drops dramatically. Typical DM digestibility and intake values for cool-season grass hays harvested at different stages of maturity. Numerous studies have shown similar effects in many different species. Intake potential decreases and NDF concentration increases as plants age, this is because NDF is more difficult to digest than the non-fiber components of forage. Also, the rate at which fiber is digested slows as plants mature. Therefore, digestion slows dramatically as forage becomes more mature

2.1.2.3. Season

A “summer slump” was observed in that gains of grazing cattle were less during the summer than in spring and fall. Summer re growth may have lower quality because high temperature increases lignin deposition, and high rainfall increases growth rates and maturation of the forage. Spring harvests are made generally after short re growth periods, while summer harvests are made after long re growth periods because of heavy summer rainfall that delays harvests. Therefore, the quality of Bermuda grass hay is highest when harvested in the spring or early summer (Harris *et al.*, 2022).

2.1.2.4. Temperature

Plants grown at high temperatures generally produce lower quality forage than plants grown under cooler temperatures, and cool-season species grow most during the cooler months of the year. However, forage of any species tends to be lower in quality if produced in a warm region rather than a cool region. For example, in one study annual ryegrass grown at temperatures of 50° to 59°F produced forage made up of 59% leaf material, but only 36% leaf matter when grown at 68° to 77°F (Ball *et al.*, 2001).

2.1.2.5. Management

Pre-harvest management for a maximum quality of hay or silage involves weed control and frequent cutting. Some producers harvest every four or five weeks throughout the season, making either hay or silage, depending on rainfall. In post-harvest management the quality of hay or silage will never increase during harvesting and storage, but rather a decrease in quality can be minimized by careful management. Post-harvest management requires avoiding rain damage, as well as proper curing of hay with natural pasture productivity and grazing management (Gezahegn *et al.*, 2016).

Most pasturelands in the Ethiopian highlands have suffered encroachment of crop production because of the growing human population. The demands for high food led to expansion of arable lands that resulted in shrinkage of land available for grazing and browsing.

Consequently, livestock are forced to concentrate on very limited pastureland that deteriorates and becomes unproductive in the long run. Overgrazing is not really a function of how many animals are on a pasture, but how long they remain there. In grazing management, time is the most important factor to consider in establishing a grazing system for sustained forage production. Generally, properly managed burning, manuring/fertilization, chemicals, hand weeding and plowing reduce weed population and stimulate desirable species. Grazing of pasture by animals has an impact on the photosynthetic area of the plant, species composition and the soil type. Moderate grazing of grasses results in quick replacement of removed shoots, which promotes compensatory photosynthesis, and increases production of green biomass. Biomass production over time varies and therefore causes seasonal variation in forage availability. Likewise, grazing pressure varies across time because of differences in forage production among spatially separated plant communities. Under heavy grazing pressure, plants may not compensate sufficiently for the biomass removed by grazing animals. Hence, net primary production, which is the difference between non-grazed and grazed biomass production, is a useful tool to establish the defoliation level of plant vegetation (Gezahegn *et al.*, 2016).

Different grazing management treatments cause diverse changes in plant growth and these changes affect the quantity of the aboveground biomass produced on pasturelands. The timing and severity of grazing determine whether detrimental or beneficial effects might occur. Repeated heavy grazing removes a great amount of the photosynthetic leaf area and causes long-term reductions in the total biomass and organic reserves. Both early grazing and late grazing reduce herbage biomass of pasturelands. In contrast, grazing that is synchronized with grass growth stages is beneficial to plant growth mechanisms and ecosystem processes and stimulates greater herbage production (Gezahegn *et al.*, 2016).

2.1.3. Crop residues

Crop residues are the fibrous parts of the plant that remain after the harvest of crop for human consumption. Amongst crop varieties, the cereal crops produce large quantities of stem and leaf besides crop harvest, which become part of livestock diet for conversion into economic products. These residues are used to their best advantage through proper storage so that the

livestock have an adequate supply throughout the lean season where the fodder is scarce. The various sources of crop residues are as shown in the Table below (Bhandari, 2019).

Mixed crop-livestock farming systems are the backbone of farmers' livelihoods in developing countries. In these systems, the use of crop residues is important for various uses that include soil mulching and livestock feeding. In cereal-based crop-livestock systems, residues include stover and straw from cereal crops after harvesting the grain. The retention of such residual biomass in crop fields has the potential to improve soil quality by reducing surface runoff, enhancing soil moisture, improving soil structure, and potentially suppressing weed growth. However, mixed crop-livestock farming systems typically use crop residues for livestock feed. This often becomes increasingly important due to the expansion of cropland, low productivity of natural pasture and prevailing livestock feed scarcity (Abednego *et al.*, 2019).

Crop residues are fibrous materials that are by-products of crop cultivation. Crop residues have low CP content in the range of 3 - 13% of the DM. This is a basic limitation in residues such as straw and bagasse with CP contents around the border-line level of 6 - 7% required to create an appropriate rumen environment that promotes DM digestibility and intake. Most residues are deficient in fermentable energy and minerals. Crop residues have low palatability and digestibility that leads to poor intake, particularly when fed as the sole roughage. The availability of crop residues is closely related to the farming system, the type of crop produced and the intensity of cultivation. Teff, wheat, and barley straws are the major residues available in the highlands. Pulse crop residues like chickpeas, haricot beans and lentils are also important. Residues of maize and sorghum form the bulk in the lowlands. The common practice in utilizing crop residues is feeding in the long dry form (Alemu, 2008).

2.1.3.1. Factors affecting quality and quantity of crop residues

The quantity of available crop residues is affected by all the factors that normally affect the yield of a crop. Animals' selective grazing habit is another factor, which leads to utilizing only certain parts or specific fractions of crop residues. Trampling contributes to the loss of edible material during grazing. Collecting the residues and processing it (e.g. milling)

increases the amount of residue ingested by the animal, but is associated with reduced animal performance because animals are forced to eat lower quality material. A number of factors affect the quality of residues, including: 1. Leaching of nutrients and damage by rain can severely reduce the nutritional value of crop residues. 2. Mode of harvesting has been shown to affect quality of residues significantly. 3 Cultivar plays a great role. 4 Plant density and crop yield, where low crop harvest produces higher quality residues because nutrients were not translocated from the stem and leaf to the grain (Abate, 2008). Beside these factors, the technical means to improve intake as well as quality include supplementation with additives, such as spraying residues with molasses or feeding a rumen stimulating lick such as urea molasses brick (Alemu, 2008).

2.1.3.2. Barley Straw

Barley is a major food crop in the highland areas of Ethiopia. The annual main season area covered by barley crop is 0.92 million hectare, making up 13% of the total area in the country. The pressure on the barley-livestock farming system is increasing due to the increase in human and livestock populations, income, and rate of urbanization. Barley straw is a key resource in mixed crop-livestock systems in the country. Barley straw has a better nutritive value compared to wheat straw with an average of 90.9% DM, 3.8% CP and 6 MJ metabolizable energy/kg of DM (Heuze, 2021). However, it is rich in lignocellulose and poor in calcium and phosphorus. Ruminant animals can utilize barley straw since the ruminal microbes able to ferment cell walls (Tilahun *et al.*, 2021).

In addition to grain production, barley provides a quantitatively important amount of straw for livestock feeding. Cereal straws induce low feed intake, digestibility and animal performance. The low nutritive value of cereal straws is attributed to their high content of structural carbohydrates and high level of lignification. Compared to wheat (*Triticum*) and teff (*Eragrostis tef*) barley (*Hordeum vulgare*) straws are higher in CP and *in-vitro* DM digestibility. The DM components of barley straw contain about 40-45, 30-50, and 6-12% of cellulose, hemicellulose, and lignin, respectively (Mulugeta, 2022).

The feeding value of barley straw is influenced by genetic makeup, environment, and their interaction. The chemical composition of barley straw can be affected by location; cultivars, agronomic practices, post-harvest management, and storage condition. Barley straw has DM, CP, NDF, TDN, P, Ca, K, Mg and Ash content of 93.1%, 4.4%, 77.3%, 38.8%, 0.24%, 0.45%, 1.44%, 0.16% and 7.2% respectively (Alemu, 2008).

2.1.4. Hay

Hay is grass, legumes, or other herbaceous plants that have been cut, dried, for use as animal feed, particularly for ruminants such as cattle, horses, goats, and sheep. Average quality hays should be fed during gestation, leaving the higher quality hay (hay which has a bright green color and a sweet, fresh odor) to be fed during lactation. Because protein requirements of the ewe increase dramatically after lambing, less protein supplementation from concentrate feeds is required when higher quality hay is used. Second-cutting, mixed grass-clover hay may be more economical to feed to the ewe flock than alfalfa hay. This is especially true if alfalfa hay must be purchased from off farm. Alfalfa hay is an excellent feed for sheep and is best used during lactation when ewes require more protein to promote higher levels of milk production. Many producers have fed alfalfa hay to gestating ewes with good results. However, some producers feeding alfalfa hay to gestating ewes have experienced problems with vaginal prolapses, late term abortions, and milk fever (Steven, 2009).

2.1.5. Grain as sheep feed

When additional energy and protein are required, corn and soybean meal commonly form the basis of the grain portion of the diet. However, when justified by supply or price, other grains may replace all or part of the corn and soybean meal. Barley can be used effectively as a source of supplemental energy in ewes' diets (Endale, 2015).

Research conducted at Montana State University compared barley, soybean meal, barley plus blood meal, barley plus feather meal or control no supplement as supplements for gestating ewes grazing dormant native range. Non-supplemented ewes lost more weight than ewes fed supplements. Ewes fed barley alone had intermediate weight gains, and ewes fed soybean meal, barley plus meal or barley plus blood meal had the highest weight gains. No differences

were noted in subsequent reproductive performance, indicating that the economic advantage lies with the low-cost supplementation program (Greg, 2013). Barley has Total Digestible Nutrient, Net Energy for growth, Crude Protein, Neutral Detergent Fiber and Acid Detergent Fiber of 86%, 1.45%, 13.5%, 18.1% and 5.8% respectively.

In terms of mineral and vitamin content, all cereal grains are low in Ca and relatively high in P, necessitating the use of supplemental Ca in high-grain diets for lambs, especially males. Barley's P content is like corn and sorghum but lower than wheat or oats. Barley is higher in K than other feed grains. Barley is higher in vitamins A and E than other major cereal grains (Greg, 2013).

2.1.6. Supplemental Feeds for Sheep

Alternative feed resources refer to those local feeds, which could replace partially or totally conventional feedstuffs either forages or concentrate feeds without reducing livestock performance but should reduce the feeding cost. In low input systems of the Mediterranean Region, alternative feed resources can be native pastures or rangelands, crop residues mainly straw and stubbles or locally available agro-industrial by-products (olive cake, molasses, tomato pulp). In comparison to the use of conventional feed particularly concentrates, the option of using alternative feed resources is more economic, more ecological as it integrates the animal to its environment and can improve soil and water conservation in the case of shrubs. In addition, and under low rainfall areas, this option is more sustainable than grains cropping or purchasing (Endale, 2015).

2.1.6.1. Urea and salt

Urea is not a protein supplement, but a source of nonprotein Nitrogen (NPN) for protein synthesis by rumen bacteria. It should be used only in conjunction with high-energy feeds such as corn. Salt and mineral supplementation is required on a free choice, year-round basis. Failure to supplement salt and minerals results in a low fertility, weak lambs at birth, lowered milk production, impaired immunity, and numerous metabolic disorders. A variety of salt and

mineral supplements specifically formulated for sheep are commercially available. These supplements range from trace mineralized salt (TMS) fortified with selenium to complete mineral mixes containing all of the macro and micro minerals required by sheep (Endale, 2015).

2.1.6.2. Vitamins

Sheep require a diet rich in fat-soluble vitamins (A, D, and E). Sheep require vitamins B as well, but they are generated in substantial amounts in the rumen and do not need to be supplemented. All of the fat-soluble vitamins are abundant in high-quality legume hay and green pasture. Poor quality hay and winter range are likely to be deficient in vitamin A, but fat reserves are generally sufficient to see the ewes through the winter. Vitamin A deficiency in sheep can be remedied by feeding high-quality alfalfa hay (Purushotam, 2022).

2.1.6.3. Mineral requirement of ewes

Although required in small quantities, minerals are very important to the living organism. They form part of the structure of the skeletal system and play a role in most body processes. Plants obtain their minerals from the soil. The mineral composition of a feedstuff largely depends on the mineral composition of the soil. Mineral composition of plants is affected by plant species and stage of growth. Young, leafy materials generally have a good supply of all the essential minerals, particularly calcium. Cereal grains have a satisfactory amount of P and K but are poor sources of Ca (Alemu, 2008).

There are two types of minerals: macro minerals those required at 0.1% or more in the diet, and micro minerals that required at very small amounts (parts per million). Ca, P, Na, K, Cl, S, and Mg are macro minerals whereas Fe, Cu, Co, Mn, Zn, I, Se, and others are micro minerals. Mineral deficiencies can lead to decreased growth and reproduction. There are some areas of Ethiopia deficient in one or more minerals, e.g., Cu in the Rift Valley region (Alemu, 2008).

Six major minerals and seven minor minerals are recognized as being important to sheep production. However, only two -Ca and Na are needed as additional supplements during drought feeding. Calcium is deficient when diets consist mainly of cereal grains. To prevent Ca deficiency, add 1.5% by weight of ration of finely ground agricultural limestone (calcium carbonate) to cereal grain (Alan, 2019). According to the reports of David (2014) who observed in treating of ewes with Zn increased the proportion of lambs survival rate and had heavier lambs than non-treated one (Alan *et al.*, 2019).

2.1.6.4. Water

Animal feeds contain variable quantities of water. In the wet season, or in humid areas, sheep and goats may eat forage composed of 70-80% water and may need little or no drinking water. However, most feeds in the tropics have low moisture content and thus drinking water is essential for animals. Coarse, fibrous feeds need to be accompanied by adequate drinking water for proper digestion. The feed needs to absorb water in the rumen for it to be effectively digested by ruminal micro-organisms. The amount of water an animal needs depends on the species, breed, climate, type of feed eaten, the type and level of production desired (milk, growth, etc.). Tropical breeds kept in arid and semi-arid areas may only need to drink once every 2-4 days in the dry season. They have better ability to reduce water loss through urine and feces than temperate breeds that may need twice as much water in the same environment (Alemu, 2008).

Sheep must have a free-choice supply of clean, fresh water. If adequate fresh water is available and convenient, a lactating ewe will consume approximately 2 to 3 gallons a day. Frozen water supplies, muddy conditions where sheep must drink, and long distances to water reduce water intake and have a negative impact on production. Heated water bowls should be used during the winter to encourage adequate consumption of water by lactating ewes and lambs. Water bowls should be checked and cleaned daily (Steven, 2009).

All sheep require a steady supply of clean, fresh water. Sheep consume more water in the summer when they are fed dry feed and during the late gestation and lactation stages of

production, during the winter or when eating succulent feeds or pasture, they consume less water (Alemu, 2023).

2.1.6.5. Energy

The most prevalent dietary shortfall in ewes is a lack of energy. Forages are the main and, in some cases, the only, source of energy. When energy requirements are high (flushing, late gestation, breastfeeding), concentrate feeds such as barley, wheat, oats, and corn can be used to supplement energy. A lack of energy can impair the pace of conception, lambing, and milk production. It may also have a detrimental impact on wool output. Energy deprivation is associated with increased parasite susceptibility and is also the principal cause of pregnancy toxemia (ketosis) in late pregnancy. In developing animals, a lack of energy can cause weight loss or even death in extreme circumstances. Excessive energy use might also hinder productivity. Over-conditioned (fat) ewes are reproductively less efficient and have more lambing difficulties. Excess energy intake is most likely to occur in ewes grazing highly productive pastures after weaning their lambs (Alemu, 2023).

2.1.6.6. Protein

The quantity of protein fed to sheep is more essential than the quality or type of the protein. Too much protein is costly and inefficient as an energy source. Diets should fulfill but not exceed the animal's nutritional needs. Legume hays (12-20% CP) satisfy the needs of adult ewes. Oily foods, such as soybean meals or cottonseed meals, are also great sources of supplemental protein. Protein insufficiency causes lower feed intake, poorer feed utilization, lower growth rate, lower milk output, and lower wool production. These symptoms are evident only in severe deficiency cases and are often associated with an energy deficiency (Alemu, 2023).

2.2. Small Ruminant Production System in Ethiopia

Describing the production system in a holistic manner is a pre-requisite to design and implement a breeding program and feeding strategy that can address production performance, trait preferences and breeding objectives of smallholder farmers. To this extent, many studies

were undertaken to describe the small ruminant production systems in Ethiopia since the mid-1980s (Alubel, 2015; Tsigabu *et al.*, 2015; Netsanet *et al.*, 2016) following the adoption of farming system research approach by the then EARO (Ethiopian Agricultural Research Organization) and now EIAR (Ethiopian Institute of Agricultural Research). Based on the level of the small ruminant production, their contribution to the community and the type of crop production enterprises, there are two major small ruminant production systems in Ethiopia: mixed crop-livestock and pastoral and agro-pastoral that can be distinguished mainly through the three production factors: land, labor and capital (Oumer and Kefyalew, 2018).

Sheep production systems are one of the major parts of the livestock production system in Ethiopia (Adane and Getachew, 2017). They are classified using criteria that included a level of integration with crop production and contribution to livelihood, level of input and intensity of production, agro-ecology, length of the growing period, and relation to land and type of commodity to be produced (Getachew *et al.*, 2017). Based on the above classification criteria, the sheep production system practiced in the country is Highland sheep-barley system, mixed crop-livestock system, pastoral and agro-pastoral production system, ranching, and Urban and peri-urban sheep production system (Anteneh and Yadav, 2017).

Commonly, in the country, they are three major sheep production system such as highland sheep - barley system, mixed crop-livestock system, and pastoral and agro-pastoral production systems and two minor production systems (not currently practiced widely) such as ranching and urban and peri-urban (landless) sheep production system are described (Anteneh and Yadav, 2017).

2.2.1. Mixed crop - livestock systems

These systems are based on cropping associated with livestock husbandry. This system is generally found in areas where the altitude ranges between 1500 and 3000 m.a.s.l. The area has adequate rainfall and moderate temperature and is thus suitable for grain production. The integration of crops and livestock is high in most areas. The integration is lower in the

perennial crop-livestock system (coffee growing areas) in southern Ethiopia where animals are of minor importance. Livestock in general and small ruminants in particular play an important role in food security and food self-sufficiency. In the crop-based mixed production system, livestock are the main cash source for the purchase of agricultural inputs. Livestock are used as a savings and insurance mechanism. Cattle are the dominant livestock species and are kept mainly for draft power. Sheep and goats are kept to meet small and immediate cash needs. Sheep are more dominant than goats in this production system. The major commodity is meat, while milk is a subsidiary product in some areas. Skin of hair ('Gishe') goats in the extreme highland areas has a local niche market for making saddles. Coarse wool is also produced from Menz sheep and other sheep in the central and north central highlands. The wool is usually used for the local carpet-making industry (Kosgey, 2008).

Land-holding per household is 2 - 3 hectares with some areas having much smaller holdings of less than 2 ha. The major feed resources are natural pasture and crop residues. In some areas, one-fifth to one-third of the holding is used for grazing. In most of the areas, however, livestock generally depend on grazing communal land that is dwindling in size and productivity. Sheep and goats in this system experience year-round nutritional stress due to increases in cultivated land area. This results in very high grazing pressure and subsequent shortage of feed. This area is also characterized by excessive soil erosion and soil nutrient depletion because of intensive cropping and overgrazing. The system of sheep and goat production for the most part is a low input/low output system except in some cases of concentrate supplementation and use of anthelmintics for fattening sheep and goats. There is a need to intensify production because of the high population density in these areas. Potential for intensive small ruminant production through finishing activities and stratification of production exists (Solomon *et al.*, 2008). In mixed farming systems of the highlands, sheep mostly depend on grazing fallow lands, natural pasture, and crop residues with no extra supplement and receive minimum health care. In humid, sub-humid, and highland agro-ecological zones, sheep are kept by small holders and in central Ethiopia (Asfaw, 2022).

2.2.2. Highland sheep-barley system

This production system prevails in the high-altitude areas (above 3000 m.a.s.l.) where the major crops grown are barley and pulses such as faba beans, lentils, etc. Sheep are the dominant livestock species. The main feed resource-base includes wasteland grazing, stubble and sometimes straw. Sheep flock sizes range from 30 to several hundred head. Although sheep are reared mainly for meat but skins and coarse wool production for the cottage industry of the central highlands are subsidiary products (Solomon *et al.*, 2008).

Temperature is the main factor determining productivity in the highland sheep - barley production system. At times, night temperatures fall below 0°C and frosty nights are common, particularly between October and January. Cropping intensity in these areas is generally low. Sheep are the dominant livestock species. The main feed resource-base includes wasteland grazing, stubble and sometimes straw. Sheep flock sizes range from 30 to several hundred head (Solomon *et al.*, 2008).

2.3. Reproductive and Production Performances of sheep

Reproductive performance is a prerequisite for any successful livestock production programme where farm resources are severely limited, as it is often the case in SSA, reproduction failure is the first sign of decreased productivity. Reproductive traits are difficult to measure and are strongly influenced by management decisions, but are also of paramount economic importance. Flock reproductive rate also affects selection intensity and consequently the rate of genetic improvement in all traits under selection. Reproductive rate can be influenced by conception rate, litter size, weaning mortality and interval between parturitions (Asfaw, 2022).

The traditional free roaming management system allows year-round breeding, with minimal purchased inputs. This creates a good environment for bucks and rams to service does or ewes any time, which is not a case in a controlled system under on station. On the contrary, uncontrolled breeding is complicated by diseases transmission and inbreeding when the bucks

and rams are small in number. Poor reproductive performances of Ethiopian sheep and goats can be associated with genetic factors, poor management, seasonal fluctuations in feed resources and diseases. Season had a significant effect on most reproductive traits including fertility, lambing rate and weaning rate. Age at first mating (puberty) affects reproductive efficiency. The age at which puberty is attained is determined largely by genotype and environmental factors like nutrition, season and climate (Getahun, 2008; Girma, 2008). In most sheep and goat breeds, achieving 40-70% of the mature BW is satisfactory for attainment of puberty. There are large variations in mean age at puberty between and within breeds, resulting from the genotype and post weaning nutrition.

2.3.1. Age at first lambing

Age at first Lambing can be recorded easily in a farmer's stock. There is a big variation among production system and breeds for this trait (12-24 months). These variations could be due to genetic and environmental differences (Girma, 2008). Solomon *et al.* (2002) reported that the age at first lambing of Horro ewes was at 64.6-85% of their mature BW.

The number and availability of breeding males in the flock determines the speed of genetic improvement of the flock. Age at first lambing ranged between 16.5 months in mixed farming systems of sub-Sahara African countries. The age at first lambing of African sheep seems to have wide variation and might be attributed to breed, husbandry and management practices. Poor nutrition and disease delayed the age at first lambing through limiting early animal growth. Age at first lambing (AFL) is predisposed by genetic and nutrition, disease and parasite infestation factors resulting in wide variability within and between breeds and among different production system. Better management and planned nutrition for earlier maturity and thus for earlier age at puberty could help to shorten the age at first lambing (Eyayu, 2020).

2.3.2. Lambing interval

Lambing interval refers to the number of days between successive parturitions. Reproductive efficiency is related to the length of parturition interval; i.e. ewe with long lambing interval has lower reproductive efficiency. To attain this, PI should not exceed 8 months (245 days). Though PI of the traditionally managed sheep was influenced by various factors including previous litter type, parity and lambing season (Tibebu *et al.*, 2015).

Lambing or kidding interval is the interval between two parturitions that determines reproductive efficiency in small ruminant production. At least three times kidding or lambing is expected per two years under normal circumstances 9.16 month for Washera sheep 8.04 months (Belete, 2009). The PI for most Ethiopian indigenous sheep under traditional management was between 7 and 10 months. These differences referred to in breed difference, season, sex of lamb, type of birth (single, twin), parity and management practice. Ethiopian sheep had the range of 7 to 12 months reported for Sub-Saharan African sheep (Eyayu, 2020). Parturition interval (LI) for Arsi bale sheep under traditional management conditions is 7.8 month. (Dibissa 2000)

Lambing interval varied according to the feed availability, management and mothering ability and breed of sheep across parts of the country and the world too. As the report shown by Assen and Aklilu (2012), lambing interval was 196.5 days, for Ethiopian native sheep and 247.7±49 days for native Bangladesh sheep (Anwar and Yayneshet, 2011).

2.3.3. Litter size

Litter size is a combination of ovulation rate and embryo survival, number of lambs born per parturition. There is a positive relationship between litter size and age and litter size and parity (Getahun, 2008). Twins born ewes tended to produce more and heavier lambs than did those born single. Peak prolificacy generally achieved between 4 and 8 years of age. Litter size is significantly affected by year of lambing, parity and weight of ewes at mating (Solomon *et al.*, 2002; Birhanu *et al.*, 2009).

2.3.4. Birth weight and pre-weaning growth performances

Birth weight of animals is one of the most important factors influencing the pre-weaning growth of the young and has a positive correlation between birth weight and subsequent live BW development. Birth type and sex are sources of variation in lamb pre-weaning growth rate. Kids or lambs which are heavier at birth are usually singles or are those produced by ewes or does with larger body sizes and good feeding conditions. The indication is that lambs heavier at birth have larger adult weight and higher growth capacity (Mengistu *et al.*, 2009).

2.3.5. Weaning (90-Days) Weight and Pre-Weaning Average Daily Gain (ADG) of Sheep

Weaning weight is a trait of great economic importance in meat sheep production since it has influence on growth rate and survival (Mengistu *et al.*, 2009). Different values of weaning weight were reported by different authors. Thus, weaning weight and post-weaning growth rate of lambs is as important as the pre-weaning growth performances, mainly when the objective is producing meat through lamb and kid production. Seasonal variation in growth rate is observed in tropics because feed supply varies remarkably. Because of weaning shock, lower growth rate was observed at weaning time (Mengistu *et al.*, 2009). Significant effect of season on post-weaning weight was reported on lamb's growth (Markos, 2006) while there was non-significant effect of sex and birth type. Other studies found the significant influence of type of birth and sex (Markos, 2006) on post-weaning growth rate. The Birth weight, weaning weight and average daily gain of Arsi Bale sheep breed is 2.89 kg, 12.23 kg, and 102.01 kg under traditional management conditions.

2.3.6. Survival rate of sheep

Reproductive losses during pre-weaning period due to poor milking ability of dam, poor management and pneumonia are very high. As assessed from literature results compiled in Table 8, lamb losses before one year of age vary from 6.4 % to 45%. This could be a major influencing factor of productivity of a flock). Lamb mortality rate varies from one flock to another depending mostly on management level (Solomon *et al.*, 2002). Slow growth rate

associated with mortality has been limiting factors for profitability of the indigenous sheep breeds. More than half of the causes of mortality were similar and attributed to pneumonia as reported from the study on Horro and Menz sheep of Ethiopian highlands (Mukasa *et al.*, 2002; Markos, 2006).

Significant effect of season, flock size and sex of animals on survival was reported (Gemedu *et al.*, 2002) for Horro sheep. The same author reported that coughing (23.8%) and diarrhea (23.5%) are among the major clinical signs for mortality of sheep. Belete (2009) reported similar events for Keffa goats and Bonga sheep of southwestern Ethiopia. The mortality rate was higher for lambs born in dry season, compared to those born in the wet season. There is a paucity of information on genetic variability for growth rate and mortality in indigenous sheep breeds of Ethiopia. Pre-weaning mortality of Arsi bale sheep under traditional management conditions is 28.4%.

2.4. Breeding and Flushing

To avoid loss of body condition or issues during lambing, proper feeding is essential. In females, poor nutrition may result in irregular cycles, decreased ovulation, fragile offspring, pregnancy toxemia, or diminished twinning. Poor nutrition in males may lower sperm quantity and quality. A multi-hormonal influence determines fertility, which includes not only sex and gonadotropic hormones, but also "metabolic" hormones (Abadjieva *et al.*, 2011).

A malfunction in any of the components of this hormone complex has a direct impact on reproduction. They also note that recent scientific research validates reproduction's tight reliance on energy sources and metabolic state, as well as their signaling pathways. They both have a big importance for good fertility (Hafez, 2011). The amount of grain provided to ewes right before conception is also critical. Experiments have indicated that if a sheep is provided a substantial amount of nutrients at that moment, she is likely to lose more eggs than usual. This increases the number of twin births, resulting in a greater lambing percentage. Mineral and vitamin supplements must be given special consideration. Most researchers have reported that the absolute effects of body condition score (BCS) and live weight have a greater impact on sheep reproduction efficiency than their variations, implying the importance of breed and

interactions with nutritional and physiological conditions and their impact on reproduction efficiency (Purushotam, 2022).

The practice of increasing nutrient intake and condition prior to and during breeding is called flushing. Its purpose is to increase the rate of ovulation and, hence, lambing rate. Flushing is especially beneficial for thin ewes that have not recovered from previous lactation stress. (Shad *et al.*, 2011).

Flushing is a feeding management technique commonly used to increase litter size or defined as temporary, but purposeful elevation in the plane of nutrition prior to and a few weeks after mating (Hamito, 2010). The main purpose is to bring ewes/does into good body condition prior to breeding. This practice will increase ovulation rate (number of ova released), increase conception, and improve embryo survival and consequently increase multiple births. Other added advantages of flushing include decreased percentage of barren ewes and reduced percentage of stillbirths (Never, 2022).

Flushing prior to the beginning of the breeding season positively affects body condition score (BCS) and improves reproductive performance of sheep. Supplemental fats improve ovarian follicle development and corpus luteum activity and are important precursors for the synthesis of reproductive hormones such as steroids and prostaglandins (Ali *et al.*, 2009). In most cases energy feeds like maize, barley, and wheat, can be fed at a rate of 250 to 300 g daily, flushing with high protein feeds is advantageous when sheep or goats are on a protein deficient diet, such as low protein pasture (Hamito, 2010).

2.4.1. Effects of Flushing on Production and Reproductive Performance of Sheep

The biochemical and physiological process by which an organism consumes food to sustain its existence is referred to as nutrition. Ingestion, absorption, assimilation, biosynthesis, catabolism, and elimination are all part of the process. Dietary nutrients stimulate the programming and expression of metabolic pathways that allow animals to reach their genetic reproductive potential. The biological process by which new individual organisms' "offspring" are formed from their "parent" or parents is known as reproduction. The enormous

discrepancy between potential output and lambs produced indicates that sheep reproduction is an exceedingly inefficient operation. If all of the prospective eggs in ewe's ovaries matured, she could produce around 40,000 lambs, but a ram generates 10,000 million sperm every day. A herd of sheep, on the other hand, only produces five to ten lambs throughout her lifetime. Much of this waste between potential and actual lambs is unavoidable. To fertilize an egg, just one sperm is required; yet, millions of sperm must be put in the ewe's vagina to achieve fertilization. Despite the significant amounts of waste found in all sheep breeds, the variation in lambing performances suggests that farmers may impact the reproductive performance of their sheep through management. Water, energy, protein, vitamins, and minerals are the five fundamental nutritional classes. A lack of any vitamin might impair performance or production (Tesfa, 2022).

Special attention must be paid to mineral and vitamin supplements (Petrovic *et al.*, 2012). Flushing is understood as the rapid increase in ovulation rate of ewes receiving a nutrient supplementation before mating showed important interactions between reproduction and level of nutrition. Positive energy balance occurs when the nutrient requirement of an animal is less than the nutrient intake resulting in the storage of the excess nutrients. It is also associated with increased BW and ovulation rate (Never, 2022).

Tatek *et al.*,(2004) noted that flushing has also been informed to increase the body condition and weights of ewes/does not only at mating (static effects), but also during their post-partum period, responses to flushing. Generally, Flushing is a well-managed flock's nutrition and reproduction program to ensure that female sheep gain an appropriate amount of weight before being mated. It is utilized to increase the conception rate of the flock and ensures that more ewes that are mated conceive (Tesfa, 2022).

The practice of flushing is predicated on the understanding that there's distinct relationship between nutrition and reproduction and their interaction has far fetching implications for reproductive competency in goats and sheep. Hence getting the proper nutrition at the proper time is important for the reproductive successes that drive profitable production of sheep and goats (Allaoui *et al.*, 2018). Viability of goats and sheep enterprise are dependent on a need to

produce a high percentage of lamb/kid crops, that pull through weaning while developing satisfactory replacement animals.

The period from weaning to breeding of ewes is critical if a high twinning rate is desired. Ewes should not be allowed to become excessively fat but should make daily gains from weaning to breeding. The rate of gain depends on the desired weight, but should be ~60%–70% of projected mature weight at breeding and 80%–90% of projected mature weight at lambing, with a body condition score of 2.5–3/5. If pasture production is inadequate, ewes may be confined and fed high-quality hay and a small amount of grain if necessary. After mating, ewes can be maintained on pasture, thus allowing feed to be conserved for other times of the year. Good quality pasture for this period allows the ewes to enter the winter-feeding period in good condition. When pasture is unavailable, an appropriate ration should be formulated (David, 2020).

During the last 6–8 weeks of pregnancy, growth of the fetus is rapid. This is a critical period nutritionally, particularly for ewes carrying more than one fetus. Beginning 6–8 weeks before lambing, the plane of nutrition should be increased gradually and continued without interruption until after lambing. The amount offered depends on the condition or fat covering of the ewes and quality of the forage. If ewes are in fair to good condition, 0.5–0.75 lb (225–350 g) daily is usually sufficient. The roughage content of the ration should provide all the protein required for all nonlactating ewes. If necessary, the ewes may be classified according to age, condition, and number of fetuses and divided into groups for different treatment (David, 2020).

The gonadotrophic hormone, luteinizing hormone, is needed for the maturation and release of oocytes, and flushing may improve ovulation rate by this effect. High plane of nutrition promotes a greater production of insulin which increases the uptake of glucose leads to increase in the growth of oocytes. A high level of hepatic steroid metabolizing enzymes (SME) is associated with an increased clearance rate of steroids, and a decrease in steroids is associated with an increase in gonadotropins and thus an increase in ovulation. The gonadotrophic hormone and LH are needed for maturation and release of oocytes. A low

plane of nutrition reduces the frequency of LH. Increased intake of nutrients, particularly protein, effectively increases levels of hepatic steroid metabolizing enzymes SME (Shad *et al.*, 2011).

2.4.1.1. Flushing effect on body weight of dam and lambs

Live body weight plays an important role in determining several characteristics of the farm animals, especially the ones having economic importance. Since body measurement parameters vary with breed and environment, breed specific models need to be developed. The BW evaluation is commonly used to monitor the nutritional status and growth of animals. Karikari and Blasu, (2009), stated that the live BW increases through nutritional flushing. Ilker *et al.* (2010) stated that BW and body condition score (BCS) were significantly affecting the pregnancy rates and suggested the necessity of using higher energy feeding in small ruminants with lower BW and BCS before breeding season (Acero *et al.*, 2008).

Different diets and their compositions have been used for flushing with different consequences that affect reproductive performance. The results from the flushing research were based on differences in the flushing diet (Mourad *et al.*, 2012), and the duration of flushing. Supplementation with conventional concentrates is economically unsuitable, so more cost-effective and sustainable alternative feeding strategies need to be developed. Flushing ration along with both energizing and protein sources improve sheep and goats' sexual behavior. Garcia (2012) suggested that availability of energy has a key influence on reproductive performance, due to sensitivity of the reproductive axis to the adequacy of nutrition and stores of metabolic reserves. This high-level of flushing concentrated feed induced energy to mate and conceive higher than of those does flush with low level of concentrated feed and none supplemented. Energy and protein deficiencies can result in embryonic loss, decreased fetal growth, depressed placental growth, fetal mummification, and the birth of weak young (Rejean, 2015).

Flushing may be maintained during pregnancy, but it increases fetal growth and survival and affects birth weight (Liker *et al.*, 2010). Weight changes in pregnant dams often indicate

prenatal development of the fetus, as evidenced by the significant correlation between offspring birth weight and maternal weight. Flushing ewes before breeding resulted in a significant increase in the average daily gain of lambs before weaning (Never, 2022).

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2.4.1.2. Flushing effect on ovulation and conception rates

Flushing, or giving supplementary feed to ewes before breeding, has been shown to enhance ovulation rate and embryo survival in sheep (Never, 2022). Feed supplementation before or during mating has a positive effect on fertility and ovulation rate and ovulation rates immediately (Karikari and Blasu, 2009). The maternal nutrition through its effect on body condition is one of the factors that strongly influences ovulation rate (Never, 2022). Prior to mating, enhancing ewes/does nutritional status with high-quality feed resources ensures that they gain weight and improve their physical condition, which improves estrus activity, ovulation, and conception rates. Protein or energy-based supplemental feeding (flushing) during mating usually improves reproductive performance by increasing the expression of ewe estrus, conception, fecundity and twin proportions. In the ewe, short-term nutritional supplementation stimulates folliculogenesis and increases ovulation rate

2.4.1.3. Flushing effect on lambing rate and litter size

Restriction of dietary energy intake pre-mating resulted in less BW gain, delay oestrus following synchronization and reduced litter size. Hafez *et al.* (2011) found that twinning rate was significantly lower with the low energy treatment than high level, but the medium level

achieved satisfactory results in estrus incidence, conception rate, lambing and twinning rates. Acero *et al.* (2008) found that the twinning rate was significantly lower for the low energy treatment than for the others and recommend the medium level to achieve satisfactory results in terms of estrus, conception rate, fecundity and twinning rates. Magda *et al.* (2015) had shown that feed supplementation during the mating period improved ovulation and pregnancy rates in low yielding sheep. Nutritional requirement during pregnancy is essential to support placental and foetal development, which is vital for lamb survival. The lower pregnancy rates observed in underfed ewes could be mediated through this alteration in the signal of maternal recognition of pregnancy (Never, 2022).

2.4.2. Flushing with high energy feeds and post breeding flushing

As mentioned, most producers flush by using one-half to one pound of grain per animal per day. Typical grains include corn, barley, oats, wheat and Milo. If wheat is used, it should not constitute more than 50% of the grain ration or it will form a poorly digestible mass in the rumen. Oil seed crops (whole cottonseed or sunflowers) could also be used but are probably cost prohibitive (Shad *et al.*, 2011).

Body Condition Scoring at breeding should be between 3.0 and 3.5 on a scale from 1 to 5. It takes three weeks on an increased plane of nutrition to increase a BCS by a half-score, so animals with BCSs below 3.0 may need to be flushed for three weeks before breeding. In addition to increasing the number of follicles released and reducing EEDs, elevated energy is believed to increase the number of embryos that implant in the uterus (Shad *et al.*, 2011).

2.5. Factors Affecting Reproductive and Production Performances of Ewes

Breed selection can greatly influence reproductive performance, particularly prolificacy and age at first lambing. The characteristics and performance of sheep breeds around the world vary enormously. For example, terminal sire breeds such as Suffolk, Hampshire, and Texel are often used to obtain rapid growth and muscling. Traditionally, these breeds are only moderately to lowly prolific and so are not preferred in the ewe flock except to produce

replacement terminal sire rams. Maternal breeds should be fertile and prolific, of easy lambing with good maternal instincts have high milk production and longevity, and be suitable both for the environment and for some management systems. The ewes may fail to be bred, or be bred but fail to become pregnant. In addition, the ewe may not maintain the pregnancy or may have decreased prolificacy. **Ewes may not be bred** because of the following: the ewe may already be pregnant, it may be an ovulatory season, which is longer in ewe lambs, the ewe lamb may be prepubertal, influenced by growth (nutrition) and breed, ewes may be too thin, lactating, or recently weaned, ewe lambs that are overfed post pubertal may not cycle. In addition, Ewes may not conceive or maintain pregnancy because of the following: The **synchronization program is not correct**; eg, rams are joined too early with the ewes before they are in estrus, there is pathology of the reproductive tract, early **embryonic death** occurs, which can be due to a variety of disorders. Examples, **selenium** deficiency, specific causes of abortion (such as border **disease**, toxoplasmosis), stress, heat shock in early pregnancy, or high levels of soluble protein in the feed, leading to high urea nitrogen levels in the blood. Reasons for poor prolificacy in ewes that become pregnant include insufficient energy at breeding when in poor body condition (low body condition score), very young or very old age, anovulatory? or transition season, insufficient dose of, early embryonic death and genetics (Tesfa, 2022).

3. MATERIALS AND METHODS

3.1. Description of Study Area

The **survey** was conducted in Tiyo and Digelunatiyo districts of Arsi Zone, Oromia Region, Ethiopia. **Tiyo district:** - is located at about 167 km south east of Addis Ababa and at the foot slopes of **Mount Chilalo** in the eastern side. It is found at 6° 59' to 8° 49' N latitude and 38° 41' to 40° 44' E longitude with altitude from below 2300 to 3200 meters above sea level and classified under **cool temperate agro-climatic** zone.

Digelunatiyo: - is located 192 km from the capital Addis Ababa in the southeast. Its altitude ranges from 2500 to 3560 meters above sea level and classified under **cool agro-climatic zone** and **Mount Boraluku** is the highest point found in it.

Flushing of ewes was conducted in Bishoftu town Oromia Region. The town is at 45 km South East of Addis Ababa. The area is located at 9°N latitude and 40°E longitude and altitude of 1850 m.a.s.l. with annual rain fall of 866 mm of which 84% is in the long rainy season from June to September. The annual average temperature ranges from 12.3 to 27.7°C with an overall average of 18.7°C.

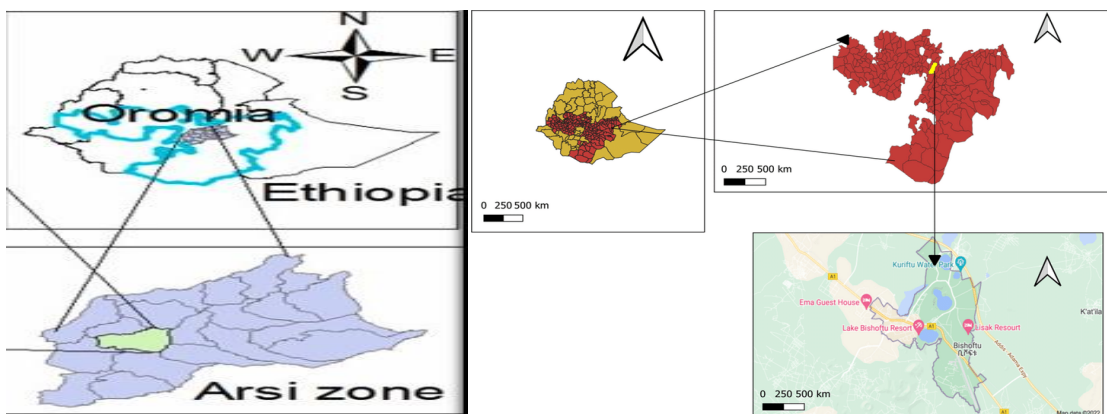


Fig. 1 Map of study area. a. Arsi Zone (left)

b. Bishoftu town (right)

3.2. Survey on Sheep Feed Resources and Feeding System in the Study Area

Two districts namely, Tiyo and Digelunatiyo were purposively selected based on sheep population from Arsi Zone. Three Peasant Associations (PAs) from each district, namely Doshu, Burka Chilalo and Bilalo from Tiyo district and Sagure Mole, Sagure 01 and Ashebekawolkite from Digelunatiyo were randomly selected from the list provided by District Offices. A total of 100 sheep owners were selected from each district.

Table 1: Determination of Sample Size in Study districts

Districts	Total HHs	Sampling Interval	Sample HHs
Tiyo	123,106	1,231	100
Digelunatiyo	201,435	2,014	100
Total	324,541	3,245	200

Source: Population Size by Sex, Region, Zone and Wereda: July 2021.

The assessments were conducted using questionnaires. The questionnaires were prepared and pretested before the actual data collection started. The data collected were includes the socio-economic characters of households, purpose of keeping sheep, the common sheep feed around study area and sheep feeding and production system.

3.3. Sample collection and Laboratory Analysis of Sampled Feeds

The major feed resources of farmers' high priority regarding their relative abundance and importance as sheep feed based on information obtained during interview were sampled for quality test. Natural pasture and barley straw were the main sheep feed mentioned by respondent in both study district. Sample of Natural pasture and barley straw were collected in October 2022 (at onset of the data collection) from both districts.

During the sampling period, natural pasture were cut at 5cm above the ground and sample of barley straw was collected from heap of barley straw of individual farmer. Representative samples of both were collected forms sixty (60) households (30 from each district).

To determine nutritional quality (chemical composition) of natural pasture and barley straw, in the study area, feed samples collected from 60 (sixty) households were combined, dried properly, packed individually and taken to Holeta Agricultural research center nutrition laboratory, for laboratory test. Total ash, dry mater (DM) and crude protein (CP), neutral detergent fibers (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), *in vitro* dry matter digestibility (IVDMD), *invitro* organic matter digestibility (IVOMD) and metabolizable energy (ME) of both feed types (natural pasture and barley straw) were tested.

The dry samples were ground in Willey mill to pass through 1 mm mesh sieve size and packed in air tight plastic containers until analysis for chemical composition at Holeta Research Center's, Animal Nutrition Laboratory. The samples were analyzed in % DM basis separately for both districts. "The DM and ash contents were determined by oven drying at 1050^C overnight and igniting in a muffle furnace at 500^{OC} for 6 hours, respectively" and crude protein (CP) were calculated as N * 6.25 (AOAC, 1995). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to Van Soest *et al.*, (1991). In vitro dry matter digestibility (IVDMD) and In vitro organic matter digestibility (IVOMD) was determined by Tilley and Terry method as modified by (Van Soest and Robertson, 1985). Metabolizable energy of a given feed was estimated from IVDOMD employing the following formulae: ME (MJ kg-1 DM) = 0.15*IVDOMD

3.4.Body Condition Scoring of Ewes

Body condition scoring (BCS) is a means of evaluating an animal based upon muscle and external fat cover. BCS is a simple procedure that producers can use to make management decisions regarding the health of their animals and the quality and quantity of feed needed to optimize performance. Important times to condition score animals include pre-breeding, mid-gestation, early lactation, weaning, and before sale. Scoring sheep and goats is done using a BCS ranging from 1.0 to 5.0. An animal of BCS 1.0 is extremely thin with no fat reserves and a BCS of 5.0 is a very over conditioned (obese) animal. In most cases, healthy sheep and goats should have a BCS of 2.0 to 3.5 Girma (2007). So based on this, ewe which were not extremely fat or not extremely thin but average body condition were selected for flushing.

3.5.Experimental Feed Storage

The basal diet (natural pasture hay) sufficient for all ewes up to the end of feeding period was purchased from Arsi Zone and transported to experimental site and stored at appropriate place before the onset of flushing (Fig. 2). The barley grain (experimental diet) was also purchased from the nearby market and stored until flushing was started.



Fig. 2.Natural pasture hay used as basal diet

3.6.Management of Experimental Animals

Twenty-four (24) Arsi Bale highland ewe at their 7 to 8 month and 2 mature rams (for mating) was purchased from the Sagure market. The age of the ewe was determined by dentition (Appendix.1) and information from the owner. Ewes those have related or similar BW were selected during purchasing to reduce error occur due to BW variation. In addition, non-pregnant ewes (after checking by traditional system) and only those animals, which did not give birth before were selected to remove the unwanted effect of reproductive disorder on the study. House, feeding and watering trough with adequate feed was prepared before purchasing (Appendix.2)

All sheep were quarantined for 15 days at the experimental site in until they are adapted to new environment. The animals were vaccinated against ovine pasteurellosis, sheep pox and anthrax, with 1 ml of ovine pasteurellosis vaccine subcutaneously for one sheep, 1 ml of

diluted vaccine injected subcutaneously on the inner face of the thigh for one sheep, 1 ml of diluted vaccine injected subcutaneously, respectively. In addition, all sheep were also vaccinated with 200 µg of Ivermectin per kg of BW subcutaneously for external parasites like tick and mange. Ewes were weighed before start of flushing. After they are collected from market, ewes were put on the weighing balance appropriately and their weight was recorded (Appendix.8left), then after they are divided randomly into 4 treatment groups of T₁, T₂, T₃ and T₄ with 6 ewes under each treatment. In addition, all ewes under all treatment groups were weighed soon after end of flushing, to see effect of flushing on their BW (Appendix 8 right)

Flushing was done by T₁: natural pasture hay plus 350 g of barley grain/head/day, T₂: natural pasture hay plus 287.5 g of barley grain/head/day, T₃: natural pasture hay plus 225 g of barley grain/head/day and T₄ as control group without flushing ration, based on David (2020), which say if ewes are in fair to good condition, 0.5–0.75 lb (225–350 g) daily grain is usually sufficient for flushing.

Based on above recommendation, flushing was carried out with minimum grain requirement of 0.5lb (225g), maximum requirement of 0.75lb (350g) and 0.625lb (287.5g) was taken as an average. The difference between treatments group was 62.5g of barley grain between (T₁ and T₂) and (T₂ and T₃), and 125g between (T₁ and T₃).

Natural pasture hay as basal diet and barley grain as experimental diet was used for experiment. In addition, minerals (one spoon Ca and one spoon of Zn per ewe was provided by mixing it with feed), salt and clean tap water was provided for all groups equally.

Table 2: Experimental layout

Treatment	Basal diet	Supplement	Replications
T₁	Natural pasture hay <i>ad libitum</i>	350 g of barley grain	6
T₂	Natural pasture hay <i>ad libitum</i>	287.5 g of barley grain	6
T₃	Natural pasture hay <i>ad libitum</i>	225 g of barley grain	6
T₄	Natural pasture hay <i>ad libitum</i>	0	6

All experimental ewes were identified by number written on their body and on the wall in front of each animal. Ewe under experiment was flushed for three weeks before breeding and four weeks after breeding and there were on natural pasture hay only during mating period.

3.7. Determining Production and Reproduction Performance of Sheep

After three weeks of flushing, on 21st day, the ewes were allowed for mating. For mating purpose, two mature Arsi Bale breed rams were purchased from the same market and set in the flock for 35 days (two estrous cycles). After all ewes were conceived, flushing was continued for four weeks.

Various reproductive parameters such as conception rate (ewe conceived/ewe mated) and lambing rate (number of lambs born alive/ewe conceived), abortion rate (ewe abort/ewe conceived) and litter size (single, twin or triplet) and production performance like BW of dam before and after flushing, birth weight and weaning weight of lambs were also recorded. Lambs were weighed soon after birth (to see their birth weight and weaning weight was taken at their three months of age).

The reproductive performances of ewes were calculated as follow:

1. Conception rate = $\text{Number of ewes conceived} / \text{Number of ewes mated} * 100$
2. Lambing rate = $\text{Number of lambs born alive} / \text{number of ewes conceived} * 100$
3. Abortion rate = $\text{Number of ewe aborted} / \text{number of ewes conceived} * 100$
4. Pre weaning lamb mortality rate = $\text{Number of lambs dying before weaning} / \text{total lambs born alive} * 100$ (Menzie, 2006).

3.8. Statistical Analysis

For the survey part, appropriate data was collected from individual farmers and stored in Microsoft Excel spread sheet. Data analyses were carried out by using SPSS version 2019, software. Descriptive statistics such as mean and percentage were used to present the results.

Chemical composition of both feed types: natural pasture hay and barley straw subjected to analysis of variance using a General Linear Model procedure of statistical analysis system (SAS) version 9.1 (SAS, 2002). The Pearson Chi-Square was used to determine mean differences at $P \leq 0.05$.

Data on production and reproductive was analyzed using R 4.2.2 software. Tukey HSD test was employed for separation of treatment means differences at $p < 0.05$.

The statistical model used in nutritional composition part can be expressed as:

$$Y_{ij} = \mu + l_i + e_{ij}$$

Where Y_{ij} is the response variable, (nutritional composition of feed)

μ = is the overall

l_i = Fixed effect of the i^{th} location/districts ($i = \text{Tiyo, Digelunatiyo}$)

e_{ij} = is the random residual error

The statistical model used for production and reproductive performance can be expressed as:

$$Y_{ij} = \mu + t_i + e_{ij}$$

Where, Y_i is the response variable (reproductive performance of ewe)

μ = is the overall mean,

t_i = is the treatment effect,

e_{ij} = error term

4. RESULTS

4.1. Purpose of Keeping and Sheep Holding Characteristic in the Study Districts

According to the respondents, sheep were kept for different purpose, represented in Table 3. All the respondents (100%) in Digelunatiyo and majority (67%) in Tiyo used sheep as source of cash income, while the remaining (33%) in Tiyo rear to slaughter during different festival and holydays. There is a significance difference ($p < 0.05$) between the study districts on purpose of sheep keeping. On the other hand, large number (61%) in Tiyo and (64%) in Digelunatiyo of the HH interviewed have 11-12 sheep in number and (20%) in Tiyo and (31%) in Digelunatiyo have <10 sheep. The remaining (19%) in Tiyo and (5%) in Digelunatiyo have >20 head of sheep. Significance ($p < 0.05$) differences were seen on average number of sheep per HH between the study districts.

Table 3: Mean sheep holding and purpose of keeping in Tiyo and Digelunatiyo Districts of Arsi Zone

Parameters	Districts			Sig.	
	Tiyo	Digelunatiyo	Overall		
Number of sheep per HH	N	N	N	(%)	0.01
<10	20	31	51	25.50	
11-20	61	64	125	62.50	
>20	19	5	24	12	
Total	100	100	200	100	
Purpose of keeping	N	N	N	(%)	0.00
Use as source of cash income	67	100	167	83.50	
To be slaughtered	33	0	33	16.50	
Sign of wealth	0	0	0		
Total	100	100	200 (%)	100	

HH= households; N= sample size, Sig.= significance level

4.2. Sheep Feed Sources in the Study Districts

The major feed sources for sheep in the two districts are summarized below in Fig. 3. Natural pasture, crop residue (mainly barley straw) and other feed resource are mentioned by HHs, of which natural pasture and crop residue are the main sheep feed in both districts of the study. According to their responses, natural pasture contributes the largest proportion of 53% in Tiyo and 55% in Digelunatiyo which is followed by crop residue of 30% and 33%, respectively of the districts. The number of HHs use both natural pasture and crop residues are 16% in Tiyo and 10% in Digelunatiyo. of which very few (1% and 2%), respectively use other feed resources like, *Atella* and food left over as sheep feed. No farmers under interview prepare hay for their sheep and there was no improved forage introduced in both districts.

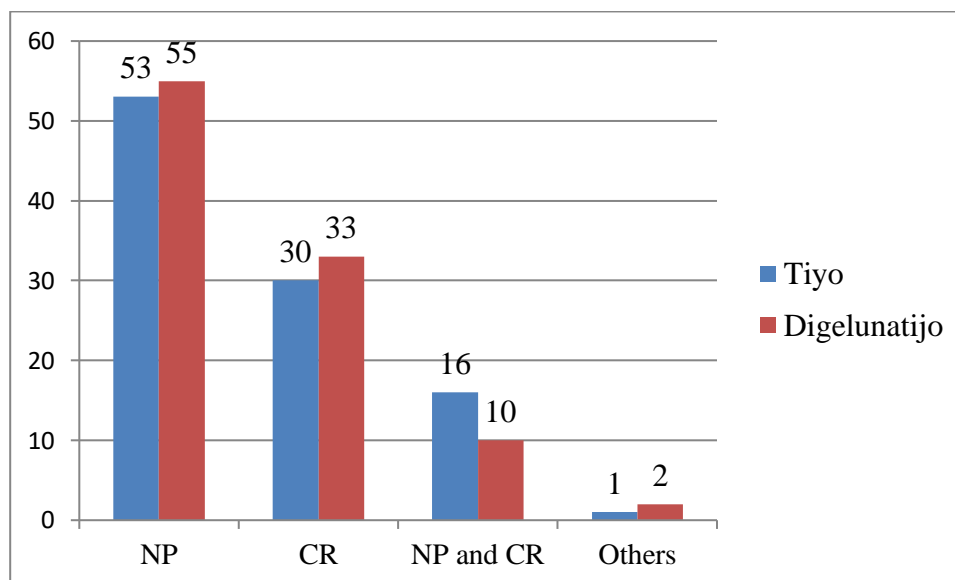


Fig 3. Major feed sources for sheep in the study area (NP= Natural Pasture, CR= Crop residue)

4.3. Common Sheep Farming and feeding Systems in the Study Districts

Mixed crop-livestock production system is the dominant farming system in the study areas. Significant numbers in Tiyo (98%) and Digelunatiyo (99%) of the HHs interviewed were follow the mixed livestock and crop production systems and only very few of them (2% and 1%, respectively) in Tiyo and Digelunatiyo follow crop production only. Sheep production

system, mostly 68% in Tiyo and 72% in Digelunatiyo, is extensive production (Free grazing) which is followed by semi intensive (Free grazing plus cut and carry System) of 29% and 21% in Tiyo and Digelunatiyo, respectively. Numbers of farmers that follow the intensive sheep production system in the area were very few and were 3% in Tiyo and 7% in Digelunatiyo. Overall, the presents study results showed that there were no significant differences ($p>0.05$) between the two districts on sheep farming and feeding system (Table 4).

Table 4: Sheep production and farming systems in the study districts

Parameters	Districts			Sig.	
	Tiyo	Digelunatiyo	Total		
Production system	N	N	N	%	0.22
Extensive	68	72	140	70	
Semi intensive	29	21	50	25	
Intensive	3	7	10	5	
Total	100	100	200	100	0.25
Farming system	N	N	N	Total	
Mixed farming	98	99	197	98.50	
Crop production	2	1	3	1.50	
Total	100	100	200	100	

N= sample size, Sig.: significance

4.4. Nutritional Quality of Natural Pasture and Barley Straw

Beside feed evaluation in terms of biomass yield, determination of the potential of forages is important in estimating its nutritive values. Chemical composition is one of the approaches used by researchers to determine nutritive values of feeds. Table 5 shows nutrient content of natural pasture and barley straw (which are the main sheep feed resource) in Tiyo and Digelunatiyo districts.

Table 5: Chemical composition of natural pasture and barley straw in the Tiyo and Digelunatijo districts

District	Chemical composition of natural pasture								
	DM%	Ash%	CP%	NDF%	ADF%	ADL%	IVDMD%	IVOMD%	ME (MJ/kg DM)
Tiyo	88.90	6.10 ^a	21	67.40	37.80	5.20	56.60	45.90 ^a	7.30
Digelunatijo	90.20	4.60 ^b	19.3	69.70	36.50	4.80	55.00	41.60 ^b	7.50
Average	89.50	5.40	17.7	68.50	37.10	5.0	55.80	43.80	7.40

District	Chemical composition of barley straw							
	DM%	Ash%	CP%	NDF%	ADF%	ADL%	ME (MJ/kg DM)	
Tiyo	90.90	5.40	6.50 ^a	71.00	50.30 ^b	10.00	8.60	
Digelunatijo	90.90	5.80	4.20 ^b	70.30	57.80 ^a	9.10	7.90	
Average	90.90	5.60	5.4	70.70	54.05	9.60	8.25	

Means with different letter in the same column are significantly P<0.05) different; ADF: acid detergent fiber; ADL: acid detergent lignin; CP: crude protein; DM: dry matter; NDF: neutral detergent fiber; IVDMD: In vitro dry matter digestibility; IVOMD: In vitro organic matter digestibility; ME:metabolizable energy.

The nutritional composition of natural pasture (NP) in the present study was presented in Table 5. The results revealed that the **DM** content was 86.9% and 90.2%, respectively in Tiyo and Digelunatiyo districts and showed a non-significant difference ($p>0.05$). The **ash** contents were also 6.1% and 4.6%, respectively in the districts and showed a significant difference ($p<0.05$) in between. The **CP** contents were 21.0% in Tiyo and 19.3% in Digelunatiyo districts and the **NDF** contents were also 67.4% and 69.7%, respectively with no significance ($P>0.05$) differences in between. The **ADF** content of the was 37.8% in Tiyo and 36.5% in Digelunatiyo and were not showed significance difference ($p>0.05$), and the **ADL** content in Tiyo and Digelunatiyo districts were 4.4% and 5.2%, respectively and was not showed a significant ($p>0.05$) difference. The **ME** content is 7.3 and 7.5 (MJ/kg DM), respectively in districts revealed a non-significant differences ($p>0.05\%$). In terms of **IVOMD** of the NP in the study districts were significantly different ($p<0.05$) with the values of 45.9% 41.6%, respectively in Tiyo and Digelunatiyo, and the values for **IVDMD** were 55% in Tijo and 56.6% in Digelunatiyo.

Barley straws were the main crop residue produced by farmers in Arsi Zone. The chemical composition of barley straw is presented in Table 5 above. The **DM** content (90.9%) in Tiyo and Digelunatiyo districts was not significantly different ($P>0.05$). Similarly, the Ash contents (5.4% and 5.8%), respectively in Tiyo and Digelunatiyo didn't show a significance ($P>0.05\%$) difference. Besides, the **NDF** contents was 71% and 70.3%, respectively for the districts and were not different ($P>0.05$). However, the **CP** content was 6.5% and 4.2%, respectively for districts and were showed significance differences ($P<0.05$) in between.

The **ADF** contents (50.3% and 57.8%), respectively in two districts weredifferent ($p<0.05\%$) and had a (**ADL**) lignincontents of 10% and 9.1%, respectively in the districts and there were no differences ($P<0.05$). I the present study, the **ME** content of barley straw was 8.6 MJ/kg DM in Tiyo and 7.9 kJ/kg DM in Digelunatiyo districts with no significance differences ($p>0.05$)

4.5. Effect of Flushing on Reproductive and Production Performances of Ewes

4.5.1. Effect of Flushing on Conception rate

Conception rate was calculated as number of ewes conceived per number of ewes mated *100. The conception rate of ewe in the current study was 83.3% for T₁ and 100% for T₂, T₃ and T₄ (Table 6). Out of twenty-four (24) ewes under four treatment groups, twenty-three (23) of them were conceived (Table 6). So, the total conception rate was 95.8%, and there are no significant differences ($P>0.05$) among the treatments.

Table 6: Effect of flushing on conception, lambing and abortion rates of Arsi Bale ewes

Treatments	Parameters				
	Number of Ewes mated	Conception rate	Number of Ewes gave birth	Abortion rate	Lambing rates
T ₁	6	5 (83.3)	3 (50)	2 (40)	6 (120)
T ₂	6	6 (100)	3 (50)	3 (50)	6 (100)
T ₃	6	6 (100)	5 (83.3)	1 (16.7)	5 (83.3)
T ₄	6	6 (100)	4 (66.7)	2 (33.3)	4 (66.7)
Total	24	23 (95.8)	15 (62.5)	8 (33.3)	21 (91.3)
Sig.		0.413	0.55	0.67	0.076

N: number; Sig= significance level; T₁= natural pasture hay+350 g barley grain; T₂= natural pasture hay+287.5 g barley grain; T₃= natural pasture hay+225 g barley grain and T₄= natural pasture hay only

4.5.2. Effect of Flushing on Lambing rate

The result on lambing rate is presented in Table 6 above. As observed from the results, the lambing rates of ewes under treatment groups were 120%, 100%, 83.3% and 67.7% for T₁, T₂, T₃ and T₄, respectively and there were a significant differences ($P<0.05$) between treatment groups. Lambing rate was high in T₁ and T₂. All lambing ewes under T₁ and T₂ gave twin birth, but in opposite twin birth not seen on ewes that fed treatment diets of T₃ and T₄. The number of ewes gave birth were three (3) under T₁ and under T₂ and five (5) and (4) under T₃ and T₄, respectively, but the number of lambs born alive was (6) under the first two

treatment groups and (5 lambs) and (4 lambs) under T₃ and T₄, respectively. All ewes under the first two treatment group were giving twin birth, but under T₃ and T₄ there is no twin birth at all.

4.5.3. Effect of Flushing on Abortion rate

Abortion rate was 40%, 50%, 16.6% and 33.3% in T₁, T₂, T₃ and T₄, respectively and a significant ($p>0.05$) difference was not seen among the treatments. Abortion was slightly higher in T₁ and T₂ and occurred at the 3rd to 4th months of pregnancy. All ewes under the treatments were served at ten months of their age and it was their first parity, so, their uterus may be unable to accommodate the fetus and increase risk of abortion.

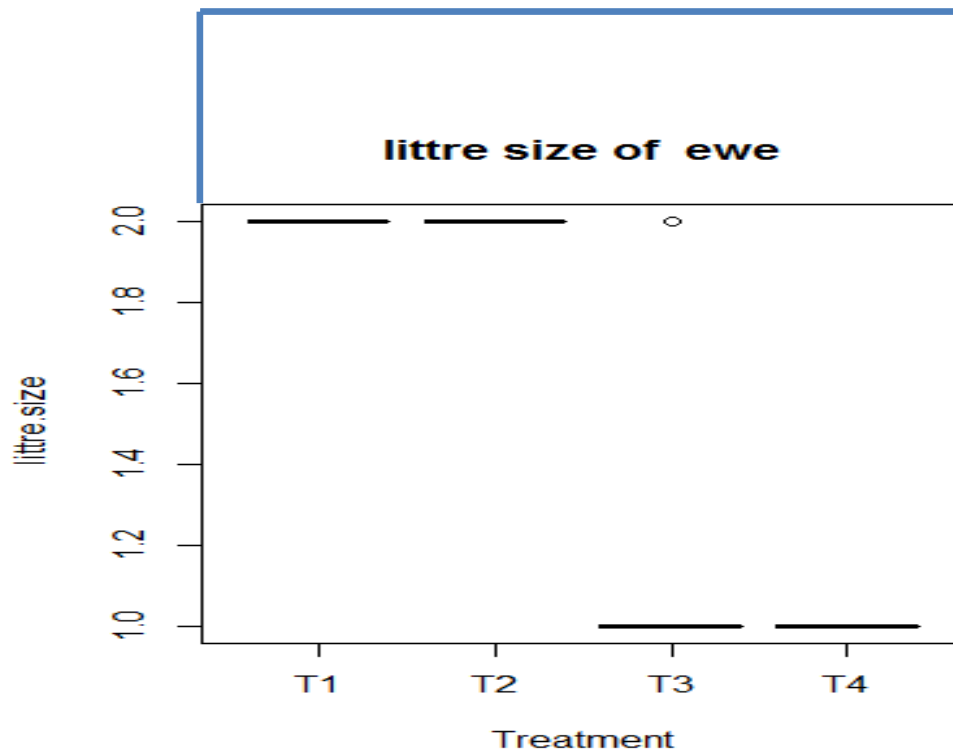


Fig.4. Effect of flushing on litter size (T₁= natural pasture hay+350 g barley grain; T₂= natural pasture hay+287.5 g barley grain; T₃= natural pasture hay+2250 g barley grain and T₄= natural pasture hay only)

4.5.4. Effects of Nutritional Flushing on Litter Size

Measurement of the litter size of Arsi Bale ewes is presented in (Fig. 4above). There is a significant differences ($p<0.05$) on litter size among treatment groups. The twin birth in T_1 and T_2 was an indication of increased ovulation rate in these two treatment groups due to flushing. The occurrence of higher twin birth might be correlated with higher BW gain in ewes that was observed in T_1 and T_2 due to the increased level of barley grain supplementation.

4.5.5. Pre-Weaning Lambs Mortality rate

As it is shown in (Fig.5), out of 21 lambs born alive from four treatment groups, 12 lambs die during the pre-weaning period and only 9 lambs (4 lambs from T_1 , 4 lambs from T_2 and 1 lamb from T_3) weaned. Lambs' mortality rate was (9.5%) in T_1 and T_2 and it was (19%) in T_3 and T_4 . Out of the four lambs born under T_4 (control group) all of them die during and after birth. Lambs' mortality before weaning was high in all treatment groups, especially it was higher in T_3 and T_4 (control group) (Fig.5). One reason for death of lambs was, majority of the ewes were rejecting their lambs and did not let the new born to suckle.

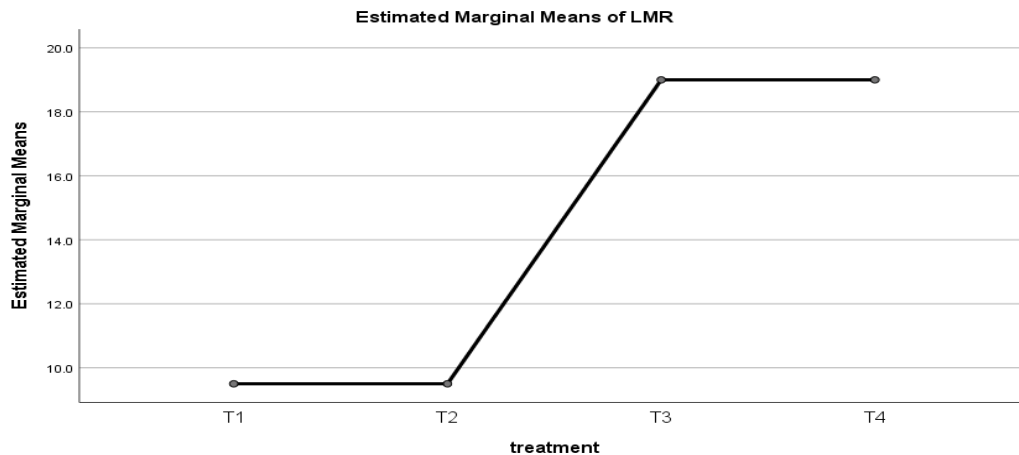


Fig.5. Lambs mortality rate under all treatment groups (LMR= lamb mortality rate) (T_1 = natural pasture hay+350 g barley grain; T_2 = natural pasture hay+287.5 g barley grain; T_3 = natural pasture hay+2250 g barley grain and T_4 = natural pasture hay only)

4.5.6. Effect of flushing on body weight of the dam and lambs

The mean BW of Arsi Bale ewes measured before and after flushing is shown in Table 7. The current results show ewes under all treatment groups have related ($P>0.05$) BW before flushing. However, after a while flushing, the mean BW of dam under T₁, flushed by hay+350 g of barley grain per day, showed a significant difference ($p<0.05$) than ewes under the remaining three treatment diets.

The effect of nutritional flushing on lambs birth weight is presented in (Table 7). The birth weights of lambs under T₁, T₂ and T₃ were not significantly ($p>0.05$) different; however, a significance differences ($p<0.05$) were seen between T₁ and T₄ in that the average birth weight of lamb under T₁ is higher (2.3 kg) than that of T₄ (1.8 kg), which could be an indicator to the higher nutritional supplementation (flushing) under T₁.

Weaning weight of lambs is indicated in table 7 below. The average weaning weight of lambs was 11.3, 10.29 and 9.9 kg for T₁, T₂ and T₃ respectively. Significance difference ($p<0.05$) was seen between T₁ and T₃. Similar with birth weight, lamb weaning weight was higher under T₁ than T₂ and T₃ which is a clear indication of flushing effect on weaning weight.

Table 7: Average body weight of dams before and after flushing and lambs birth and weaning weight

Parameters	Treatment				Sig.
	T ₁	T ₂	T ₃	T ₄	
Dams weight before flushing (kg)	21.5±0.45	22.6±0.49	22.0±0.89	22.2±.1.17	0.17
Dams weight after flushing (kg)	25.0±0.54 ^a	23.8±.52 ^{ab}	23.2±.68 ^{ab}	22.5±.81 ^b	0.00
Lambs weight at birth (kg)	2.3±0.16 ^a	2.1±0.10 ^{ab}	2.03±0.18 ^{ab}	1.8±0.34 ^b	0.01
Lambs weight at weaning (kg)	11.3±.88 ^a	10.29±.51	9.9 ^b	-	0.09

Mean values with different superscripts within a row differ significantly at $P<0.05$; Sig. = significance level; T₁= natural pasture hay+350 g barley grain; T₂= natural pasture hay+287.5 g barley grain; T₃= natural pasture hay+225 g barley grain and T₄= natural pasture hay only. CV= coefficient of variation

5. DISCUSSION

5.1. Purpose of Sheep Keeping and Flock Size in the Study Areas

In the present findings, majorities of the HHS' interviewed were use sheep as source of cash income while, a few of them rear to slaughter during festivals and holydays. This finding agreed with reports Endale, (2015) and Dhaba *et al.*, (2012) that showed 100% and 93% of the respondents keep small ruminants as source of cash income in Meta Robi District, West Shewa Zone, Oromia Regional State, Ethiopia and in Ilu Abba Bora Zone of Oromia Regional State, Ethiopia respectively. Additionally, in agreement with the current of Belete (2009) and Getahun (2008) also show that (94%), (91%) and (66.4%) of house hold use small ruminant as source of cash income in Goma District of Jimma Zone, Southern Ethiopia and Metema District of North Gondar Zone respectively.

5.2. Feed Resources for Sheep in Study Area

In the current study, shortage of feed is the major problem raised by all the respondents in both districts. All respondents in the districts mention as they face scarcity of feed during the dry season. This result is similar with finding of (Adugna and Aster, 2007; Fetsumet *al.*, 2009; Firew and Getnet, 2010) which were done in southern Ethiopia, Wombera, Bullen, and Guba Woredas and Amhara regional state respectively. Many authors described the seasonal feed shortages, both in quality and quantity, and the associated reduction in livestock productivity in different parts of the country (Tsedeke, 2007, Getahun, 2008; Admasu, 2008). Result of Melese and Tesfaye (2017) also show that majority of (62.5%) hhs in Bench-Maji Zone; South western Ethiopia report Feed problem during dry season.

Natural pasture and barley straw were the main sheep feed sources in the study districts. In agreement with the present findings, results of Endale (2015), also indicate that, the major feed resources in West Shoa of Meta-Robi district were natural pasture grazing (58.9%), crop residues of wheat straw, barley straw, *Atella* (by product from traditional brew) and crop aftermath. Similarly, result of Melese and Tesfaye (2017) also indicates that natural pasture and crop residues are the primary source of feed to animals in Benchi-Maji Zone, South

western Ethiopia. Lemma *et al.* (2002); Mengistu (2003); Zewdu *et al.*,(2012), and Andualem *et al.*, (2015) explained the feed resources in most part of Ethiopia was comprised of all these.

5.3.Common Sheep Farming System in the Study Area

Significant number of hhs in both districts followed a mixed crop- livestock farming system. Mixed crop-livestock production system is the dominant farming system in the study areas. This result agreed with the work of Kiflay *et al.* (2019), who reported that mixed crop-livestock production system is the dominant farming system in selected zone of Tigray region. Similarly, report of Afras (2019) also indicates that, a mixed crop-livestock production system dominant farming system in Esera District, Dawuro Zone, Southern Ethiopia.

On the other hand, extensive sheep production system is the dominant production system in both districts of study. The current result was agreed with the reports of Matawork and Mitiku (2017) in the central highland of Ethiopia where sheep depend mostly on grazing of fallow land, over grazed NP and crop residue with no extra supplements and receive minimum health care.

5.4.Nutritional Quality of Natural Pasture and Barley Straw around the Study Area

The **DM** content of the natural pasture in study area was in agreement (Tesfaye, 2022). who reported DM content of natural pasture ranging from 92.9 to 94.1% in northern Gondar Zone. Zewdie (2010) and Tamene *et al.* (2022) also reported natural pasture DM content was 91 % and 92.4% in central Rift Valley of Ethiopia and in Haru district, Ethiopia. However, the DM content of natural pasture of the present is higher than the result of Gashu *et al.* (2017) and Andualem *et al.*, (2015) who reported DM values ranging from 90 to 91% and 18.7 to 69.6% in chire district, southern Ethiopia and Essera District Southern Ethiopia, respectively.

The **ash** content of natural pasture showed a significantly difference ($p < 0.05$) between two districts. The variation in ash contents of natural pastures between districts may be due to the nature of the soil and age of the forage. This value is in agreement with finding of Alemu (2023),who reported the ash content of natural pasture was 6.9% in East Gojjam Zone,

Amhara Region, but lower than that of Tamene (2022) and Habtamu *et al.* (2013) which was 6.9 to 12.7 and 12.5% to 16.7% in Haru District, Ethiopia and semi-arid range lands of Ethiopia respectively.

The CP content of native grasses in the present study is higher than the minimum level of 7% for animals in the tropics. This result is higher than the finding of Alemu *et al.*, (2023), who report natural grass CP contents of 7.24% in East Gojjam Zone, Amhara Region. But Andualem *et al.*, (2015) reported natural grass CP content of 3.67–14.25% in Essera District Southern Ethiopia. According to Van Soest *et al.*, (1994), feed with CP level less than 7% inhibit voluntary feed intake and declines the activity of microbial action, resulting in lower digestibility of roughages. While result of Tamene *et al.*, (2023) indicate the CP content of Natural pasture varies from 9.1 to 12% medium and low agroecological zones in the mixed farming system of Haru District, Ethiopia.

Crude protein content of natural pasture was high in both study districts. This might be due to Mixture of grass with legume species; in addition as sample is collected from private grazing land, there may some management like manuring and weeding. In addition grass grow in cold (high land) area have high nutritional composition than those grow in low land. Fresh grass Crude Protein (CP) levels can range from 16% to 28% and is dependent on factors such as the species present, growth stage of the grass crop, soil health and fertility and the climatic conditions (Bilatu *et al.*, 2012).

The NDF content of Natural Pasture was high with no differences between the districts. Similar with current study, result of Tamene *et al.*, (2022) indicate that, the mean NDF contents of natural grass ranged from 61.8% to 74.5% in the medium and low agroecological zones in the mixed farming system of Haru District, Ethiopia. Current result is related with finding of Alemu (2023), which indicate the NDF of natural pasture was 65.97% in East Gojjam Zone, Amhara Region. Roughage feeds with NDF contents of less than 45%, 45–65%, and more than 65%, respectively, were classified as high, medium, and low-quality feeds. The NDF content reported in both districts of this study were more than 65% and can be categorized as low in quality (Singh and Oosting, 1992).

Besides, the **ADF** content of the NP revealed a no ($P>0.05$) difference between the districts. The current result is lower than result of Alemu (2023) and Tamene *et al.*, (2022) which indicate 49.8%, 47-52% in East Gojjam Zone, Amhara Region and in the medium and low agroecological zones in the mixed farming system of Haru District respectively. Feeds low in ADF constitutes more digestible nutrient as ADF is negatively correlated with feed digestibility of nutrients (Minson , 1990).

The **ADL** content of the natural pasture in the study districts were lower than that of 7.94% reported by Alemu *et al.*,(2023), while higher than that of Andualem *et al.*, (2015) which is 1.02 to 2.53% in in East Gojjam Zone, Amhara Region and in Essera District Southern Ethiopia. Lignin is completely indigestible and forms lignin-cellulose/hemicelluloses complexes due to physical encrustation of the plant fiber and making it unavailable to microbial enzymes (McDonald *et al.*, 1995). It is a well-established fact that lignin concentration of forages is negatively correlated with digestibility.

The **energy** content of natural pasture was 7.3 MJ/kg DM in Tiyo and 7.5 MJ/kg DM in Digelunatiyo with no significance difference ($p>0.05$) between the districts. Feed stuffs containing more than 12.0 MJ/kg of DM of metabolizable energy are classified as high energy feed and feed stuffs containing less than 9.0 MJ/kg of DM of metabolizable energy are classified as low energy feeds, So natural pasture in both districts are classified as low energy feeds (Minson , 1990).

Barley straws were the main crop residue produced by farmer in area of study. The **DM** content of barley straw was equal in both Tiyo and Digelunatiyo districts. The current report was in agreement with that of Tamene *et al.* (2022), Zewdie (2010) and Alemu (2023), who reported the DM content of crop residues, was 90%, 93.6%, and 92.3% respectively, in Haru District, Highlands And Central Rift Valley of Ethiopia and East Gojjam respectively. Result of Dirsha *et al.*, (2018) and Kassahun *et al.*, (2016) also show that the DM of barley straw was 93.4% and 93% in Gurage zone, southern Ethiopia and Horro and Guduru Districts, Western Ethiopia respectively, which was higher than the current result.

The **NDF** content of barley straw was high in both study districts and showed no significance difference ($P>0.05$). The current result is lower than finding if Alemu (2023) which show the

NDF content of barley straw was 75.0% in East Gojam. But it was higher than that of Dirsha *et al.*, (2018) and Kassahun *et al.*, (2016), which was 48.94% in Gurage zone, southern Ethiopia and 68.77% in Horro and Guduru Districts, Western Ethiopia respectively. The NDF content of roughage feeds with less than 45% is categorized as a high-quality feed and 45–65% as medium quality feed (Singh and Oosting, 1992). Based on these categories, the NDF content of barley straw in this study was high. The NDF content of feeds above 55% was reported to limit the DM intake of ruminants (Van Soest, 1982).

The **Ash** content of barley straw in the current result was lower than result of Tamene *et al.*, (2022) and Dirsha *et al.*, (2018) and Zewdie (2010) which indicate the ash content of the barley straw was 10.5%, 9.02% and 8.5% in the medium and low agroecological zones of Haru District, Ethiopia, Gurage zone, southern Ethiopia and Central Rift Valley Of Ethiopia respectively. But it was equivalent with result of Alemu (2023) and Kassahun *et al.*, (2016) which show the ash content of barley straw was 5.5%, and 5.8% in East Gojam and Horro and Guduru Districts Western Ethiopia respectively.

The **CP** content of barley straw showed a significant differences ($p < 0.05$) and was higher than the findings of Dirsha *et al.*, (2018), Gashu *et al.*, (2017), Zewdie (2010) and Kassahun (2016) who reported 2.63%, 4.1%, 3.55% and 4.08% in Gurage zone, southern Ethiopia, in Chire District, Southern Ethiopia, in the Highlands and Central Rift Valley of Ethiopia, and Horro and Guduru Districts Western Ethiopia respectively. However, it was related with the findings of Tamene *et al.* (2022) and Alemu (2023) who reported a 4.86% and 5.5% in the medium and low agroecological zones of Haru District and east Gojam respectively. The value of CP content of barley straw found in the present study is below the minimum level required of 7% for normal rumen microbial physiology (Van Soest, 1982).

When compared to the findings of Gashu *et al.*, (2017) and Kassahun *et al.*, (2016) which indicate ADF content of Barley straw was 49.5 % and 36.97% in Bale highlands of Ethiopia, Chire District, Southern Ethiopia and Horro and Guduru Districts Western Ethiopia respectively, the present study had the highest ADF content. But, the current study was in agreement finding of Dirsha *et al.*, (2018) and Zewdie (2010) which were 50.2% and 52.84% in Gurage Zone Southern Ethiopia and Highlands and Central Rift valley of Ethiopia

respectively. While, result of Alemu (2023) show that the ADF content of barley straw was 63.03% in East Gojjam which was higher than current result.

Barley straw in the study areas had **lignin** contents which were almost equivalent to 10.4% and 10.5% reported by Alemu (2023) in East Gojjam and Dirsha (2018) in Gurage zone southern Ethiopia. However, the lignin content of barley straw in the current study was greater than report of Seyoum and Fekede (2008) and Kassahun *et al.*, (2016) which was 6.3% and 6.6% in West Shewa Zone of Oromiya, and Horro and Guduru Districts, Western Ethiopia. Result of Zewdie (2010) indicate than the ADL content of barley straw was 12.14% In Highlands and Central Rift Valley of Ethiopia, which was higher than current findings.

The energy contents of barley straw in this study below 9.08% which was reported by Kassahun *et al.*, (2016) in Horro and Guduru Districts, Western Ethiopia. But in agreement with current result, finding of Zewdie (2010), show that the ME content of barley straw was 7.89MJ/kg DM in the Highlands and Central Rift Valley of Ethiopia.

According to Minson (1990), the lowest energy density at which sheep does not lose weight is between 8 and 10 MJ/kg DM. in the current study the average ME of barley straw (8.25 MJ/kg DM) was lower when compared with 10 MJ/kg DM

5.5.Reproductive Characteristics

The **conception rate** of ewe in the current study was 83.3% for T₁ and 100% for T₂, T₃ and T₄ and there was no significance difference ($P > 0.05$) on conception rate among all treatment groups. The result obtained in current study agree with the result of Huseyin *et al.* (2006) and Bahaa (2019), which stated the conception rates of 88.33% and 100% for Akkaraman and Abou-Delik ewes, when ewe are flushed with 250g - 700g barley grain/ animal/day and concentrate feed mixture (43% yellow corn, 22% cotton seed meal, 20% wheat bran, 12% rice bran 1.5% limestone, 1% sodium chloride and 0.5% minerals mixture) at the rate of 250 g/head/day respectively. However, the present results were higher than that of Ahmad *et al.* (2022) who reported the conception rate of Ossimi ewes were 70% and 80% and when ewes are flushed with 500 gm of corn/ewe/day and 500 gm of soybean/ewe/day. Similarly, Shafiullah *et al.*, (2022) and Asfaw (2022) also report that, the conception rate of Marwari

ewes supplemented with concentrate mixture and Doyogena ewes supplemented with ensen leaf and concentrate/day was 81.81% and 60 to 83.3%, when ewes are flushed, which is lower than current result.

Lambing rate was higher in T₁ and T₂ than T₃ and T₄. All ewes under the first two treatment groups were giving twin births, but under T₃ and T₄ there was no twin birth at all. This may be an indication of the effect of flushing on lambing rate. The result of Asfaw (2022) also indicates that the lambing rate of Doyogena ewes was 66.7%-100% and lambing rates of flushed groups were significantly higher than that of the control group. The present study results agree with the findings of Bahaa (2019) whose report the lambing rate of 100% and 88.89% in flushed and non-flushed group of Abou-Delik ewes. The finding of Ahmad *et al.*, (2022) also indicates that lambing rate of Ossimi ewes was 70% and 80% for flushed and control group respectively.

Abortion was slightly higher in T₁ and T₂, and occurred at the 3rd to 4th months of pregnancy. According to Abassa (1995), abortions mostly occur at the last stage of pregnancy in sheep. Very high rates of abortion and stillbirth were found among twin or triplet bearers and when primiparous (young animal) and immature females were bred. Ewe lambs bred between four and eight months of age not only suffered from higher abortions and stillbirths (55%) than adult ewes (14.6%), but also lost 89% of their progenies before one year of age. In the case of Arsi-Bale sheep breed, age at first lambing was 12.7 months (Tsedeke, 2007) and the present study results might be due to flushing the ewes too early. Twin birth was seen in T₁ and T₂, the twin birth in the T₁ and T₂ was an indication of increased ovulation rate in these two treatment groups due to flushing. Result of Asfaw (2022) also indicated flushing increased litter size of Doyogena ewes in Doyogena district, southern Ethiopia. Mortality before weaning was high in all treatment groups, especially it was higher in T₃ and T₄ (control group). Decrease in lamb's mortality under T₁ and T₂ might be an indication of effect of high supplementation in first treatment group.

5.6. Production Characteristics

The current results showed that ewes under all treatment groups have a related BW before onset of flushing, but significance difference was seen on ewe body weight after flushing. The average body weight of ewe flushed with 350g of barley grain/head/ day was 21.5kg at the begging of flushing and 25kg after flushing, while it was 22.2kg before flushing and 22.5kg after flushing for ewe under control group. Ewes flushed with 350g of barley grain/head/ day was 3.2kg heavier after flushing than control group.

The birth weights of lambs under T₁ was higher (2.3 kg) than control group T₄ (1.8 kg) which indicated a flushing could improve birth weight of lambs. The current results were lower than result of Asfaw (2022) who indicated that lambs' birth weights were in the range of 2.73 kg - 3.39 kg, and high body weight was obtained from flushed ewe. Finding of Bahaa (2019) also show that, the average weaning weight of lambs was 2.91kg, which is higher than current result. But current result was higher than that of Ahmed (2022) and Shashie *et al.*, (2021) which indicates average birth weight of lambs was 1.76kg and 1.95kg when ewe are flushed with corn and soy bean respectively.

The average weaning weight of lambs was 11.3Kg for T₁, 9.9 kg for T₃. Significance (P<0.05) difference was seen between this two treatment groups. Similar with birth weight, lamb weaning weight was higher under T₁ than T₂ and T₃ which is a clear indication of flushing effect on weaning weight. But current result is lower than finding of Bahaa (2019) which show average weaning weight of lamb was 16.89kg.

6. CONCLUSION AND RECOMMENDATIONS

The results indicated that the major feed resources in the study areas were natural pasture and crop residues. The majority of the households interviewed were follow a mixed crop-livestock farming system and the extensive sheep production system is the common sheep production system in the districts. Natural pasture in the study areas had CP content above the critical level (7% CP) that required for maintenance, optimum rumen function and feed intake. The barley straw was also found to have low contents of CP which is an important nutrition for animals. It also has a significant quantity of NDF and ADL which might influence the feed intake and animal performances.

Flushing ewes with barley grain brought an improvement on some of the reproductive and production performances of Arsi Bale ewes. Lambing rate was high from ewes that flushed on 350 g and 287.5 g of barely grain per day with supplemental pasture hay than ewes that fed 225 g barely grain and ewes that only on pasture hay. Even though, the conception rate was not different between ewes flushed and non-flushed, the abortion rate was slightly higher in ewes that flushed with 350 and 287.5 g of barely grain, because, all conceived ewes under these treatments were carried twin.. Even if abortion rate is high under T₁ and T₂, lambing rate was very high, which was an indication of increase in ovulation rate. Flushing ewes with of 350g and 287.5 g of barley, improve **lambing rate, litter size, BW of dam after flushing, lamb birth** and **weaning weights** and also **reduce lams mortality before weaning**.

From the above results and conclusions, the following recommendations are forwarded for improving sheep production in the study area.

1. Flushing ewes with 287.5 g and 350 g is recommended, because, ewe under first two treatment group were more productive than control group.
2. Reduction of abortion rate by applying flushing after the first parity when their reproductive organs mature enough to accommodate all fetuses without difficulties is recommended.

3. Provision of strong extension services and training on cultivation of improved forage, feed conservation in the form of hay and silage from natural pasture, specially to overcome feed shortage during the dry season is necessary.
4. Conducting different research, with different types of feed and different feeding level is recommended

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8. APPENDICES

8.1. Appendix Table

Table1: Effect of location on nutritional composition of natural pasture

Nutritional composition (%)	Location		
	Tiyo	Digelunatiyo	SL
Dry Matter	88.90	90.20	Ns
Ash	6.10	4.60	***
Crude Protein	21	19.30	Ns
Neutral Detergent Fiber	67.40	69.70	Ns
Acid Detergent Fiber	37.8	36.50	Ns
Acid Detergent Lignin	5.20	4.80	Ns
IVDMD	56.6	55.0	Ns
IVOMD	45.90	41.60	***
Metabolizable Energy (MJ/kg DM)	7.30	7.5	Ns

IVDMD= Invitro Dry Matter Digestibility IVOMD=Invitro Organic Matter Digestibility SL= significance level

Table2: Effect of location on nutritional composition of barley straw

Nutritional composition (%)	Location		
	Tiyo	Digelunatiyo	SL
Dry Matter	90.90	90.90	Ns
Ash	5.40	5.80	Ns
Crude Protein	6.50	4.20	***
Neutral Detergent Fiber	71.00	70.30	Ns
Acid Detergent Fiber	50.30	57.80	***
Acid Detergent Lignin	10.00	9.10	Ns
Metabolizable Energy (MJ/kg DM)	8.6	7.90	Ns

SL= Significance Level

Table 3: Effect of flushing on reproductive parameters of ewes

Treatment	Parameters				
	Conception rate	Lamping rate	Abortion rate	Litre size	Lamb mortality rate
T1	83.3	120	40	2	9.5
T2	100	100	50	2	9.5
T3	100	83.3	16.7	1	19
T4	100	66.7	33.3	1	19
SL	Ns	***	Ns	***	***

Table 4: Effect of flushing on production parameters of ewes

Treatment	Parameters			
	Dam body weight before flushing (Kg)	Dam body weight after flushing (Kg)	Lamb birth weight (Kg)	Lambs weaning weight (Kg)
T1	21.5	25.0	2.3	11.3
T2	22.6	23.8	2.1	10.29
T3	22.0	23.2	2.03	9.90
T4	22.2	22.5	1.8	--
SL	Ns	***	***	***

8.2. Appendix Figures



Fig1: Identifying ewes by dentition



Fig 2: Feeding troughs for ewes



Fig3: weighing balance



Fig 4: Vaccinating ewes



Fig 5: Ewes eating hay



Fig. 6. Providing mineral for ewes



Fig 7: Ewes identified by number



Fig 8: Weighing ewes before flushing (a) after flushing (b)



Fig 9: While taking weaning weight (left) and birth weight (right)



Fig.10. Ewes with their new born



Fig.11. Ewes drinking water

8.3. Questionnaire

Major Feed Resources and Effect of Flushing on Production and Reproductive Performance
of Arsi Bale Ewes in Arsi Zone, Oromia Regional State, Ethiopia

The information obtained from this interview questionnaire will be used only for academic Purpose and the personal information will be kept confidential. I, therefore, kindly request you to feel free in answering the questionnaire.

Thank You

Name of the Enumerator -----Signature -----

Date-----

1. Personal information

1.1 Date of interview -----

1.2. Zone -----

1.4. Districts -----

1.5. Kebele-----

1.6. farmers ID -----

1.7. Sex of HH -----

1.8. Age (yrs) of HH -----

1.9. How many family members do you have?

1.10. Educational status of the household

Gender	Educational status				
House hold head	Illiterate	Read and write	Primary school	Secondary school	Diploma and above
Male					
female					

2. Agriculture

2.1. What type of agriculture you practice and rank? a. Livestock production b. Crop Production b Crop production andLivestock production 03 livestock

2.2. Number of sheep they have _____

2.3. Which type of Feed is available in the area?forage_____ crop residue_____ concentrate_____ industrial by product_____ other_____

2.4. Purpose of keeping sheep; A) cash B)tobe slaughtered C) wealth D) other specify_____

2.6. which type of sheep production system?

A) Extensive_____ B) Semi intensive_____C) Intensive _____

8.4.List of Publications

1. Abaynesh Jarso, Gebeyehu Goshu and Etalem Tesfaye. 2023. Assessment of Major Sheep Forage Types, Feeding System, and Nutritional Quality Assessment, Arsi Zone, Oromia Region, Ethiopia. *Asian Journal of Advances in Agricultural Research*, Volume 23, Issue 2, Pages :44-54,
2. Abaynesh Jarso, Gebeyehu Goshu and Etalem Tesfaye. 2023. Effect of Flushing on Production and Reproductive Performances of Arsi Bale Highland Ewe. *International Journal of Advanced Multidisciplinary Research*, Volume 10, Issue 12, Pages: 36-45



Assessment of Major Sheep Forage Types, Feeding System, and Nutritional Quality Assessment, Arsi Zone, Oromia Region, Ethiopia

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Authors' contributions

This work was carried out in collaboration between all authors. Author AJ designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors GG and ET managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The aim of this study was to assess the major sheep feed types, feeding system and its nutritional quality evaluation in Arsi Zone, Oromia Region, Ethiopia. A total of 100 households (hh) were taken from each district. For laboratory work, feed samples were collected from ten randomly selected farmers from each peasant association and nutrition composition like Dry matter, crude protein, Ash, Neutral detergent fiber, Acid detergent fiber, Acid detergent lignin, *In vitro* dry matter digestibility, Digestibility of organic dry matter were tested and Metabolizable Energy was calculated. The field survey data were analyzed using SPSS and SAS software used for nutritional composition test.

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The Pearson Chi-Square and Tukey HSD test was used to determine mean differences at ($p < .05$). The results of the field survey revealed that, the major feed resources available in both districts comprised of natural pasture (82%) followed by crop residue (25%) and Free grazing is the common feeding system in both districts. The overall mean of, Dry matter, Ash, crude protein, Neutral detergent fiber, Acid detergent fiber, Acid detergent lignin, *In vitro* dry matter digestibility, Digestibility of organic dry mater and Metabolizable Energy content of natural grasses were 89.5%, 5.9%, 68.5%, 68.5%, 37.1%, 4.9%, 55.5%, 43.8% and 7.4 KJ/kgDM, respectively. The corresponding values for barley straw were also 90.9%, 5.4%, 5.4%, 70.7%, 54.8%, 9.6% and 8.2 KJ/kgDM for Dry matter, Ash, Crude protein, Neutral detergent fiber, Acid detergent fiber, Acid detergent lignin and Metabolizable energy respectively. Significant ($p < .05$.) difference was seen on Ash and Digestibility of organic dry mater content in natural pasture between two districts and there was no significant difference on other composition It was concluded that, natural pasture and barley straw are the main sheep feed in area. Further studies are needed to see other feed resource and test nutritional composition.

Keywords: Barley straw; feeding system; natural grass; nutritional quality; sheep.

1. INTRODUCTION

"The domestic sheep (*Ovis aries*) is a very widespread ruminant species, a *Pleistocene* mammal, raised primarily for its meat, milk, wool, and hides" [1].

Ethiopia has the largest livestock population in Africa with estimated number of 64 million cattle, 40 million sheep, 51 million goats, 8 million camels and 49 million chickens" [2]. A study of [3] indicated that "the livestock sector in Ethiopia contributes about 47% to the Agricultural Gross Domestic Product (AGDP), including monetary values and the non-marketed services (traction and manure)". "At the household (hh) level, livestock plays a significant role as sources of food and family income for smallholder farmers and pastoralists. Small ruminants are among the major economically important livestock species in Ethiopia playing an important role in the livelihood of resource-poor farmers. They are the integral part of livestock keeping in Sub-Saharan Africa (SSA) that are mainly kept for immediate cash sources, milk, meat, wool, manure and saving or risk distribution. Among the small ruminant, sheep are the second most important species of livestock in Ethiopia that are dominantly found in the crop-livestock production system and contribute up to 63% of the net cash income derived from the livestock production" [4-9].

"Different sheep production systems are performed worldwide according to availability of grass lands, pastures and other feed resources, production specialization of the farm (milk, meat, wool or combination of these yields), consumer

demands and financial conditions of the sheep farmers" [10].

"Mixed crop livestock production practice is a common production system of Ethiopia in different agro ecological conditions which depends on indigenous breeds of small ruminants with low levels of production and productivity. Feed is among the major factor that determines the production potential of animals. In mixed farming system, use of crop residues is mainly important for livestock feeding and soil mulching. In the Ethiopian highlands where crop-livestock systems are prevalent, the contribution of straw to the total dry matter (DM) fed to livestock ranges from 10% to 70%" [4].

"Small ruminant feed resources in Ethiopia are mainly grazing on communal natural pasture, crop stubble, fallow grazing, road side grazing, crop residues, browses, and non-conventional feeds (hh food leftovers, weeds, crop tillers and fillers), improved forages and crop residues. The contribution and quality of these feed resources is however, depends up on agro-ecology, types of crop produced, accessibility and production system. Crop residue supply roughly 50-80% of the total resources of ruminant livestock feed in the mixed cereal-dominated crop and livestock production system that varies with agro ecology, crop variety and production potential. Barley is a major food crop in the highland areas of Ethiopia with associated production of 1 metric ton of the grain is accompanied by 1.2 metric tons of straw. Ruminant animals have the ability to utilize barley straw since the ruminal microbes have the ability to ferment the cell walls" [11].

Arsi zone is known by having a huge sheep population of 1.66 million heads Asmare *et al.*, (2010), and main feed source of the natural pasture and crop residue of barley straw. However, the nutritional composition of available feeds in the study district has not yet been investigated. Therefore, the aim of this study was to assess the major sheep feed types, feeding system and evaluation of nutritional quality of the common feed assessed.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted in Tiyo and Digelunatijo districts Fig.1. Tiyo is a district in central Ethiopia, located in Arsi Zone of Oromia Region at about 175 kilometers south east of Addis Ababa. Asella is the town found at 6°59' to 8°49' N latitude and 38°41' to 40°44' E longitude at altitude ranges of 2500 to 3000 meters above sea level (m.a.s.l). It has a subtropical highland climate of the warmest month of the year in April with an average temperature of 16.6°C and the coldest in December (13.5°C). The average temperature of Digelunatijo is 15.1°C and is a district in Sagure town of Arsi Zone.

2.2 Survey on Sheep Feed and Feeding System in the Study Area

The two districts, Tiyo and Digelunatijo, were purposively selected from Arsi Zone based on sheep population potential. Three Peasant Associations (PAs) (Dosha, Burka Chilalo and Bilalo) from Tiyo; and Saguremole, Sagure 01 and AshebekaWalkite from Digelunatijo districts were randomly selected. A total of 100 hhs respondents were selected from each district. The sample sizes were determined by using the formula recommended by [12]) for formal survey studies as follows:

$$N = 0.25/SE^2 = 100$$

Where, N=sample size; SE= standard error, assuming the standard error of 5% at a precision level of 0.05 and the confidence interval of 95%.

The assessments were conducted using structured questionnaire. The questionnaires were pretested before the actual data collection started. The data collected were includes the socio-economic characters of the hh, the common sheep feed types and the feeding system were assessed.

2.3 Laboratory Analysis of Sampled Feed

The major feed resources of farmers' high priority regarding their relative abundance and importance as sheep feed based on information obtained during the interview were sampled for quality test. Representative samples of natural pasture and barley straw were collected in October 2022 from both districts. To determine the nutritional quality (chemical composition) of common feeds in the study areas, samples of natural pasture and barley straw were collected from 60 randomly selected farmers (10 from each PA), combined, dried properly under shade, packed individually and sent to Holeta Agricultural Research Center's laboratory to test dry mater (DM), crude protein (CP), total ash, neutral detergent fibers (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), *in vitro* DM digestibility (IVDMD), Digestible Organic Matter in Dry Matter (DOMDM) and metabolizable energy (ME) of natural pasture and barley straw were tested.

2.4 Statistical Analysis

Data analyses were carried out using SPSS software for the survey work. Descriptive statistics of mean and percentage were used to present the results. Chemical compositions data for both feed types were subjected to analysis of variance using a General Linear Model procedure of statistical analysis system (SAS) version 9.1 (SAS, 2002). The Pearson's chi square and Tukey was used to determine mean differences at P<0.05. Agro ecology was considered as predictor variables and natural pasture and barley straw nutritive values and DM yield were considered as response variables.

The statistical model used in the survey part can be expressed as:

$$Y_i = X_i\beta + \epsilon_i$$

Where, Y_i is the decision vector, X_i is a vector of explanatory variables derived from hh surveys at β of corresponding regression coefficient and ϵ_i is the error term.

The statistical model used for nutritional quality was:

$$Y_{ijk} = \mu + e_{ijk}$$

Where Y is the response variable, μ is the overall mean, e_{ijk} is the random residual error assumed to be normally and independently distributed.

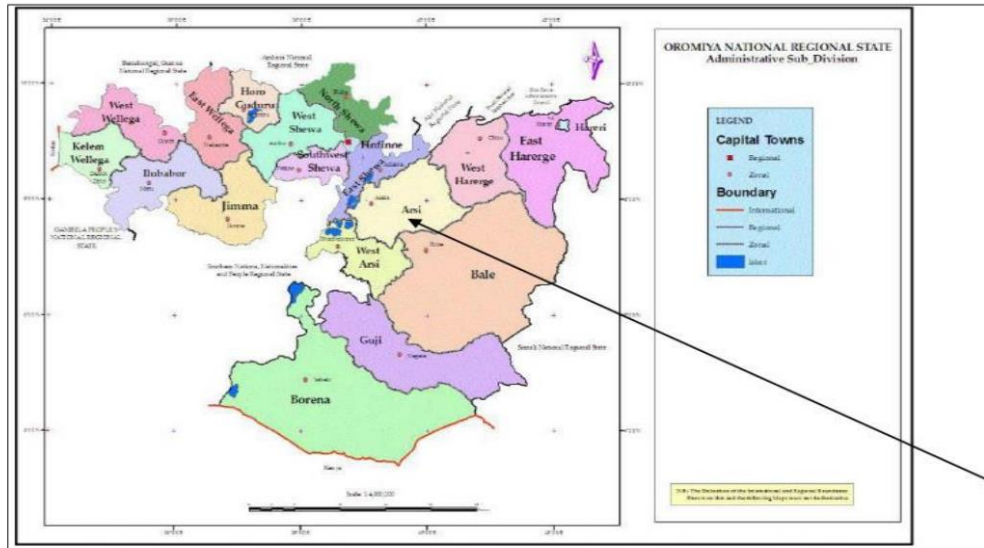


Fig. 1. Map of the study area
(Source: BFED, 2008)

3. RESULTS AND DISCUSSION

3.1 Common Sheep Breed, Purpose of Keeping Sheep and Sheep Holding Characteristic in Sampled Households in the Study Districts

According to the respondents, sheep were kept for different purpose Table 1. All the respondents 100% in Digelunatijo and majority 67% in Tiyo used sheep as source of cash income, while the remaining 33% in Tiyo rear to slaughter during different festivals and holydays. There is a significance ($P < .05$), difference between the study districts on purpose of sheep keeping. On the other hand, large number 61% in Tiyo and 64% in Digelunatijo of the hh interviewed have 11-12 sheep in number and 20% in Tiyo and 31% in Digelunatijo have <10 sheep. The remaining 19% in Tiyo and 5% in Digelunatijo have >20 head of sheep. Significance ($P < .05$) differences were seen on average number of sheep per hh between the study districts. As it is indicated in Table 1, all hhs interviewed were rear Arsi Bale Sheep breed.

Large number 61% in Tiyo and 64% in Digelunatijo of the hh interviewed have 11-12 sheep in number and 20% in Tiyo and 31% in Digelunatijo have <10 sheep. The remaining 9% in Tiyo and 5% in Digelunatijo have >20 head of sheep. In the present findings, majority of the hhs' interviewed used sheep as source of cash income while a few of them rear to slaughter

during festivals and holydays. This finding is in agreement with different reports [13] and [14] that showed 78.9% of the respondents keep small ruminants for home consumption while 80% and 93% of the hhs responded sheep for income generation that conducted in Meta-Robi and Ilu-Abba-Bora areas, Ethiopia, respectively. Additionally, in agreement with the current study [15] reported farmers that rear sheep mainly for income source 66.4% and both meat and cash 30.4% and for home consumption only 3.2% that was in western Harerghe.

3.2 Feed Resources and Sheep Feeding System

The major feed sources for sheep in the two districts are summarized below in Fig. 2. Natural pasture, crop residue (mainly barley straw), crop aftermath and others are the major feed sources in both the study areas. Among these feed resources, natural pasture contributes the largest proportion 53% in Tiyo and 55% in Digelunatijo which is followed by crop residue 30% and 33% in Tiyo and digelunatijo, respectively. Number of hhs use both natural pasture and crop residues are 16% in Tiyo and 10% in Digelunatijo, respectively. Only very few of hhs 1% in Tiyo and 2% use other feed resource like Atella and food left over. No farmers under interview prepared hay for their sheep and also there was no improved forage introduced in both the study sites.

Table 1. Mean sheep holding and purpose of keeping sheep in sampled households of the districts

Parameters	Districts		X ²	Sig.
	Tiyo	Digelunatijo		
Sheep breed	N	N	N	%
Arsi Bale	100	100	200	100
Other	0	0	0	0
Total	100	100	200	100
Number of sheep per hh	N	N	N	
<10	20	31	51	25.50
11-20	61	64	125	62.50
>20	19	5	24	12
Total	100	100	200	100
Purpose of keeping	N	N	N	
Use as sources of cash income	67	100	167 (%)	83.50
To be slaughtered	33	0	33 (%)	16.50
Sign of wealth	0	0	0	
Total	100	100	200 (%)	100

Hh= households; N= sample size, Sig.= significance level

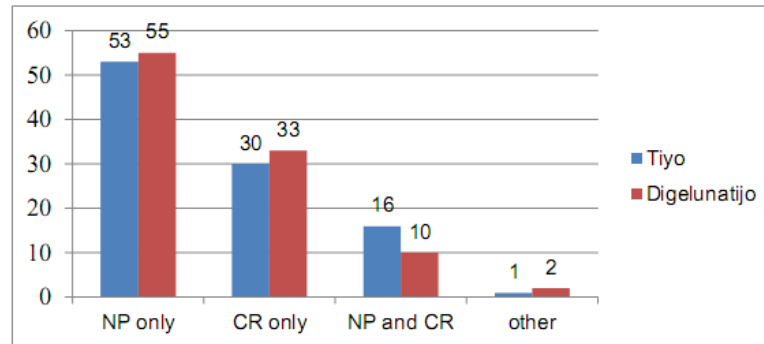


Fig. 2. The major feed resources for sheep in the study area NP= Natural Pasture, CR= Crop residue

In the present study, shortage of feed is the major problem raised by all the respondents in both districts. All respondents in both districts mention as they face scarcity of feed during the dry season. This result is similar with the reports of different researchers [5]; [16]; [17]; and [18]) which were done in other parts of the country. Many authors described the seasonal feed shortages, both in quality and quantity, and the associated reduction in livestock productivity in different areas [19]; [20]; and [21].

Natural pasture and barley straw were the main sheep feed sources in the study districts. Results of [13] also indicate that, the major feed resources in West Shoa of Meta-Robi district were natural pasture grazing 58.9%, crop residues of wheat straw, barley straw, Atella and crop aftermath. Similarly, ([22];[23]; and [24] explain the feed resources in most highlands of Ethiopia was comprised of all these. The results of [25] also indicated that natural pasture, crop residue, crop aftermath, hay, *atella* (by product from traditional brew) and concentrates (soybean meal and molasses) are the major feed sources in selected district of Tigray region. Significant number of hhs 75% in Tiyo and 84% in Digelunatijo, use free grazing system and 23% and 9% in Tiyo and Digelunatijo respectively use semi grazing and indoor feeding system and the remaining 2% in Tiyo and 7% in Digelunatijo use indoor feeding system.

3.3 Common Sheep production and Farming Systems in the Study Districts

Sheep production system is mostly 68% in Tiyo and 82% in Digelunatijo is the traditional

production system (free grazing only) which is followed by partially modern (free grazing plus concentrate supplementation) 29% and 22% in Tiyo and Digelunatijo, respectively). Number of farmers follow modern (install feeding only) sheep production system in the area is very few 3% in Tiyo and 7% in Digelunatijo. There is no significance ($P > .05$), between the two districts on sheep farming system (Table 2).

Mixed crop-livestock production system is the dominant farming system in the study areas. Significant numbers 98.5% of the interviewed hhs were follow mixed crop-livestock production systems and only very few of them 1.5% were follow crop production only. This result was in agreement with the work of [25], who reported that mixed crop-livestock production system is the dominant farming system in the different selected zone of Tigray region. On the other hand, [26] reported in the highland part of Ethiopia where the most dominant production systems were crop production only. Traditional sheep production system is the dominant production system in both districts of the present study. According to [27] in central highland of Ethiopia, sheep depend mostly on grazing of fallow land, over grazed natural pasture and crop residue with no extra supplements and receive minimum health care which go hand in hand with this study.

Large number 75% in Tiyo and 84% in Digelunatijo use free grazing system followed by semi grazing 23% and 9% and indoor feeding 2% and 7% system in Tiyo and digelunatijo respectively. Similarly, reports of [13] which was done in West Shoa Zone showed that majority of the hhs let their animal to free grazing. [6] also

reported that the feeding system practiced in Ilu-Aba-Bora Zone was predominantly free-grazing system. In Jeldu district, about 94.5%, 4.4% and 1.1% of the respondents practiced let to graze, cut and carry and tethering, respectively [28].

Significant number of hhs75% in Tiyo and 84% in Digelunatiyo, respectively use free grazing system and the remaining of them were use semi grazing and indoor feeding system (Fig.3).

3.4 Nutritional Quality of Natural Pasture and Barley Straw

Beside feed evaluation in terms of biomass yield, determination of the potential of forages is important in estimating its nutritive values. Chemical composition is one of the approaches used by researchers to determine nutritive values of feeds. Table 3 shows nutrient content of natural pasture in Tiyo and Digelunatiyo district.

3.4.1 Chemical composition and nutritive values of natural pasture

Natural pasture was reported as the most important source of feed in the study area and results were presented in Table 3. The present results revealed that the mean DM content of the

natural pasture was 86.9% in Tiyo and 90.2% in Digelunatiyo districts and revealed a non-significant differences ($P > .05$). The ash content were also 6.1% and 4.6%, respectively for Tiyo and Digelunatiyo districts and showed a significant differences ($P < .05$). The CP contents were 21.0% and 14.3% in Tiyo and Digelunatiyo districts, respectively; and the mean NDF contents were 67.4% and 69.7% in Tiyo and Digelunatiyo, respectively with no ($P > .05$). differences between the districts. The ADF content of the natural pasture was 37.8% and 36.5% in Tiyo and Digelunatiyo districts, respectively and were not showed a difference ($P < .05$)between the districts. The ADL content of the natural pasture in Tiyo and Digelunatiyo districts were 4.4% and 5.2%, respectively and was not different ($P > .05$).

The ME content of feed is 7.3 and 7.5 (kJ/kg DM) in Tiyo and Digelunatiyo districts, respectively revealed a non-significant ($P > .05$), differences between the districts. The two districts were significantly different ($P < .05$)in terms of IVOMD with composition of 45.9% in Tiyo and 41.6% in Digelunatiyo districts. The mean IVDMD of the natural pasture was 55% in Tiyo and 56.6% in Digelunatiyo districts (Table 3).

Table 2. Sheep production and farming systems in the study area

Production system	Tiyo	Digelunatiyo	Total	X ²	Sig.
	N	N	N		
Traditional	68	72	140	70	3.00 0.25
Partially modern	29	21	50	25	
Modern	3	7	10	5	
Total	100	100	200	100	
Farming system	N	N	N	Total	
Mixed farming system	98	99	197	98.50	
Crop production only	2	1	3	1.50	
Total	100	100	200	100	

N= sample size, Sig.: significance

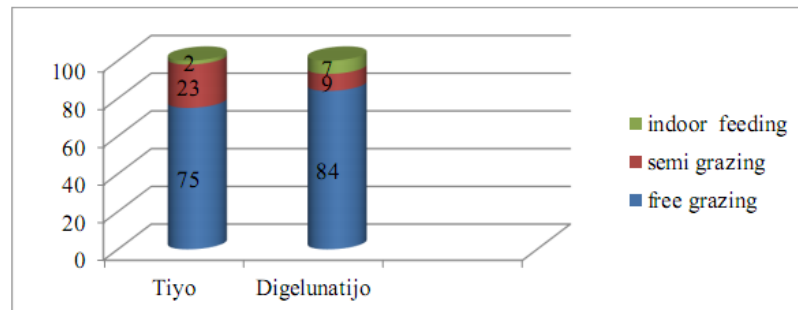


Fig. 3. Common sheep feeding system in the study areas

Table 3. Chemical composition of natural pasture and barley straw in the two districts

District	Chemical composition of natural pasture								
	DM%	Ash%	CP%	NDF%	ADF%	ADL%	IVDMD%	IVOMD%	ME (KJ/kg DM)
Tiyo	88.90	6.10 ^b	21 ^a	67.40	37.80	5.20	56.60	45.90 ^b	7.30
Digelu/Tiyo	90.20	4.60 ^a	14.30 ^b	69.70	36.50	4.80	55.00	41.60 ^a	7.50
Average	89.50	5.90	68.50	68.50	37.10	4.90	55.50	43.50	7.40
CV (%)	4.60	10.90	7	4.40	2.40	2.40	4	1.30	12.30
District	Chemical composition of barley straw							ME (KJ/kg DM)	
	DM%	Ash%	CP%	NDF%	ADF%	ADL%			
Tiyo	90.90	5.40	6.50 ^a	71.00	50.30 ^a	10.00	8.60		
Digelunatiyo	90.90	5.80	4.20 ^b	70.30	57.80 ^b	9.10	7.90		
Average	90.90	5.40	5.36	70.70	54.80	9.60	8.20		
CV (%)	2.60	15.70	7.90	4.30	6.90	17.60	9.90		

Means with different letters in the same column are significantly $P < 0.05$ different: DM: dry matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; ADL: acid detergent lignin; IVDMD: In vitro dry matter digestibility; IVOMD: In vitro organic matter digestibility; ME: metabolizable energy, CV: coefficient of variation;

Natural pasture was reported as the most important source of feed in the study area. The results revealed that the mean DM content of the natural pasture was 86.9% in Tiyo and 90.2% in Digelunatiyo. This result is in agreement with [29] who reported DM content of natural pasture ranging from 92.9 to 94.1% in northern Gondar Zone also reported natural pasture DM content ranging from 91 to 92.4% in the central Rift Valley of Ethiopia and in Haru district, Ethiopia respectively. However, the DM content of natural pasture of the present is higher than the result of [30] and [31] who reported DM values ranging from 35.17% to 44.97% in Chire district, southern Ethiopia and Essera District Southern Ethiopia, respectively.

The ash content of natural pasture in the present study districts showed a significant ($P < 0.05$) differences. These results are not in agreement with that of [32] and who reported the ash content of natural pasture was ranged from 12.5%–16.7%. The CP content of native grasses in the present study is higher than the minimum level of 7% for animals in the tropics [33]. This result is contrary to finding of [30], who report natural grass CP contents of 10 to 9.62% in Gasera and Ginnir, respectively, and [31] and [34] who reported natural grass CP content of 3.67–4.25 % and 8.38 % in Essera District Southern Ethiopia and southern Ethiopia, respectively. According to [33], feed with CP level less than 7% inhibit voluntary feed intake and declines the activity of microbial action, resulting in lower digestibility of roughages.

The mean NDF contents of natural grass were 67.4% and 69.7% in Tiyo and Digelunatiyo, respectively with no ($P > .05$) differences between the districts. The NDF content reported in both districts of this study were more than 65% and can be categorized as medium in quality [35]. Besides, the ADF content of the natural pasture was 37.8% in Tiyo and 36.5% in Digelunatiyo districts, respectively and it revealed a non-significant ($P > .05$) differences between the districts. The ADL content of the natural pasture in the study districts were 4.4% and 5.2%, respectively for Tiyo and Digelunatiyo. Lignin is completely indigestible and forms lignin-cellulose/hemicelluloses complexes (due to physical encrustation of the plant fiber and making it unavailable to microbial enzymes. However, the lignin contents of feeds in this study were lower than the maximum level of 7% that limits the DM intake and performances of animals.

3.4.2 Chemical composition and nutritive values of barley straw

Barley straws were the main crop residue used in both district in study area. The chemical composition of barley straw is presented in Table 3 above. The dry matter (DM) content of barley straw in the districts Tiyo and Digelunatiyo was not different ($P > .05$) and 90.9%. The Ash content of barley straw was 5.4% in Tiyo and 5.4% in Digelunatiyo and did not showed ($P > .05$) differences between the districts. Similarly, the

NDF contents of 71% and 70.3%, respectively for the districts Tiyo and Digelunatio also showed no differences ($P > .05$). However, the CP content of barley straw was 6.5% and 4.2%, respectively for Tiyo and Digelunatio districts and were showed a significant ($P < .05$), differences in between. In the current study, barley straw had ADF contents of 50.3% in Tiyo and 57.8 in Digelunatio districts and there was a significance ($P < .05$), differences in ADF contents of crop residues between the districts. The crop residues in the study areas had lignin contents of 10% and 9.1% in Tiyo and Digelunatio, respectively and there is no significance ($P < .05$), difference on lignin content of barley straw between the two districts. The ME content of barley straw is 8.6 kJ/kg DM in Tiyo and 7.9 kJ/kg DM in Digelunatio districts with no differences ($P > .05$).

The DM content of barley straw was 90.9% in Tiyo and 90.9% in Digelunatio districts and showed no significant ($P > 0.05$) differences between the districts. The DM content of barley straw in the current study is lower than that of the national average value of 91.9% that reported by [24]. However, the current report was in agreement with that of [36] and [37] who reported the DM content of crop residues higher than 90% and 93.6% respectively. The NDF content of barley straw was 71% in Tiyo and 70.3% in Digelunatio districts and showed no difference ($P > .05$).

The NDF content of roughage feeds with less than 45% is categorized as a high quality feed and 45–65% as medium quality feed [35]. Based on these categories, the NDF content of barley straw in this study was high. NDF content of feeds above 55% was reported to limit the DM intake of ruminants [33]. Similar with the current result, Solomon *et al.* (2010), reported for a study in Sinana sub-district of Bale highland that all the crop residues had higher (70%) NDF content. The CP content of barley straw in the present study districts showed significance ($P < 0.05$) difference and was higher than the findings of [38], who reported 2.63% CP in barley straw. However, it was similar with the findings of [36], who reported 4.86% CP of barley straw. The value of CP content of barley straw found in the present study is below the minimum level required for normal rumen microbial physiology [33]. In the current study, barley straw had the highest ADF contents of 50.3% in Tiyo and 57.8 in Digelunatio Districts.

The crop residues in the study areas had lignin contents 10% and 9.1% in Tiyo and Digelunatio, respectively. Which were almost equivalent to 10.4% [39] in East Gojjam. However, the lignin content of barley in the current study was greater than the lignin content of the barley straw in the Tanqua-Abergelle region, which ranged from 5.6 to 6.6% [40] in North west of Ethiopia. According to [41], lignin is the single most important factor in limiting feed intake, the rate of organic matter fermentation, the number of microbial cells produced per unit of fermented organic matter, and the proportion of propionate to acetate in the products of fermentation. The energy content of barley straw was 8.6 MJ/kg DM in Tiyo and 7.9 MJ/kgDM in Digelunatio with no significance difference ($P > 0.05$) between the districts. The energy contents of barley straw in this study were within the range reported by [8] in West Shewa zone of Ethiopia.

4. CONCLUSION AND RECOMMENDATION

The results indicated that the major feed resources in the study areas were natural pasture, crop residues and crop aftermath. Most of hhs interviewed were use free grazing which is followed by semi-grazing feeding system. Number of hhs that practice indoor feeding system were very few. Natural pasture in the study areas were composed of a huge DM yield and the CP content of natural pasture was found to be above the critical level (7% CP) that required for maintenance, optimum rumen function and feed intake. The structural constituents (NDF, ADF and ADL) were optimum and natural pasture in both districts was categorized as medium in quality. The barley straw was also found to have low contents of CP which is an important nutrition for animals. It also has significant quantities of NDF which might influence the feed intake and animal performances. So, improving qualities of barley straw in order to maximize feed intake is important. Studies should be conducted on identification and contribution of important natural grass and other feed for sheep feeding during different seasons in the area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Effect of Flushing on Production and Reproductive Performances of Arsi Bale Highland Ewe

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Abstract

The objective of this study was to evaluate the effect of flushing on production and reproductive performances of Arsi Bale highland ewe. 24 Arsi ewes were used for trail. The treatments are T₁ (hay+350 g of barley grain), T₂ (hay+287.5 g of barley grain), T₃ (hay+225 g of barley grain) and T₄ (only natural pasture hay). All ewes, except in the control diet were supplemented with barley grain for 3 weeks prior and 4 weeks after breeding. Reproductive performances of ewes like conception rate, lambing rate, litter size, abortion rate, and dam weight before and after flushing, lamb birth and weaning weight and lambs mortality were assessed. All collected and analyzed using SAS and R software and Tukey test was used to separate mean differences at 5% significance level. Conception rate of ewe was 83% for T₁ and 100% for T₂, T₃ and T₄ and revealed as there is no significant differences (P>0.05), while lambing rate was 120% in T₁, 100% in T₂ and 83.3 and 66.7 for T₃ and T₄, respectively and there is significant (P<0.05) difference between treatment groups. The birth weight of lambs was 2.3 kg, 2.1 kg, 2.03 kg and 1.8 kg for T₁, T₂, T₃ and T₄, respectively and the average weaning weight of lambs was 11.3 kg, 10.3 kg, 9.9 kg and 9.0 kg for T₁, T₂, T₃ and T₄, respectively.

Keywords

Barley grain,
Hay,
Flushing,
Production,
Reproductive

Introduction

Small ruminant significantly contribute to agrarian economy and plays a vital role in livelihood, security of marginal and landless farmers especially in arid, semiarid and hilly regions of the country by providing a household

nutrition and contribute to the family income through meat, wool/fiber, skin, milk and manure with little or no feed supplementation (Shad *et al.*, 2011). The primary determinant factor of fertility and fecundity in ewe depends on ovulation rate. Female sheep gains weight and fat reserves in the first 3-4 weeks prior to mating and are more likely

to conceive and have twins or triplets that have got flushing than those in poorer condition (Shad *et al.*, 2011).

Nearly 40 years ago it was postulated that the ovaries of ewes fed on a high plane of nutrition would contain more follicles, than would the ovaries of ewes fed a low plane of nutrition and that, a given quantity of gonadotrophin would cause greater ovarian stimulation. Ewes fed a sub-maintenance diet, administration of PMSG (Pregnant Mare Serum Gonadotropin.) increased the number of follicles present, suggesting that nutritional effects on ovarian activity in ewes were related to the concentration of gonadotrophin presence in the blood reaching the ovary (Downing, 1991).

Nutrition is one of the most significant influences on the ovulation rate of sheep. Short periods of improved nutrition before and during mating increase the proportion of ewes bearing twins, this practice has been termed 'flushing' and described thus "The practice of 'flushing' consists of giving ewes which are in fairly poor condition an improved diet for a few weeks before mating so that they are in rapidly rising condition when they meet the ram" (Downing, 1991).

The period from weaning to breeding of ewes is critical if a high twinning rate is desired. Ewes should not be allowed to become excessively fat but should make daily gains from weaning to breeding. If pasture production is inadequate, ewes may be confined and fed high-quality hay and a small amount of grain if necessary.

Beginning 6–8 weeks before lambing, the plane of nutrition should be increased gradually and continued without interruption until after lambing. The amount offered depends on the condition or fat covering of the ewes and quality of the forage. If ewes are in fair to good condition, 0.5–0.75 lb (225–350 g) daily grain is usually sufficient (David.G. 2020).

Barley is one of the major cereal crops that are largely produced in the central and south east mid and high altitude areas of Ethiopia. Barley is used primarily as an energy and protein sources in

sheep diets and it does not require processing when used in sheep diets. Expressed on a dry matter basis, barley has 7.5-18% protein and a total digestible nutrient (TDN) value of 80-84%. Arsi zone is characterized by a cereal dominated farming system in which bread wheat and barley are the major crops (Bedada *et al.*, 2014). So, the aim of this study is to evaluate the supplemental effect of barely grain based flushing on reproductive and productive performances of Arsi Bale highland ewe.

Materials and Methods

Description of the study area

The study was conduct in Bishoftu town Oromia Regional state (Fig. 1). The town is at 45 km South East of Addis Ababa. The area is located at 9°N latitude and 40°E longitude and altitude of 1850 meters above sea level with annual rain fall of 866 mm of which 84% is in the long rainy season from June to September. The annual average temperature ranges from 12.3 to 27.7°C with an overall average of 18.7°C. The soil and climate are similar to those in many highland areas in Ethiopia. Cattle, small ruminant, poultry and equines are the major livestock species kept in the area and the smallholder dairy production with fast growing.

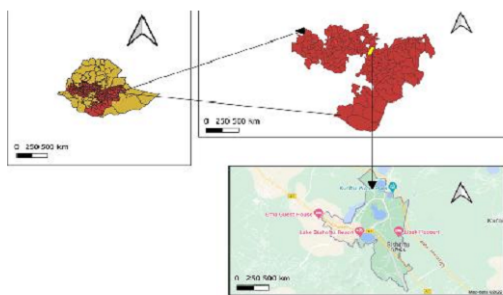


Fig. 1: Map of Bishoftu town

Characteristic and Distribution of Arsi Bale Sheep Breed

Arsi Bale sheep breed are among the potential breeds of Ethiopia reared in the mixed crop and

livestock production system of Ethiopia. They are long fat-tailed and hairy. Arsi Bale breed is distributed in wet, cool and warmer highlands (2000–3300m); sub moist lowlands and mainly found in Arsi, Bale, East Shoa, West Hararghezones and some districts in Borana zones, Hadya, Gurage, Kembata and Sidama zones (Berhanu and Oli, 2020).

Experimental Feed Storage

The basal diet (natural pasture hay) sufficient for all ewes up to the end of feeding was purchased from Arsi zone and taken and stored in appropriate place at experimental site (Fig. 2). The barley grain (experimental diet) was also purchased from the nearby market and stored until flushing was started.



Fig. 2: Natural pasture hay used as basal diet

Management of Experimental Animals

Twenty four (24) Arsi Bale highland non pregnant ewes (after checking by traditional system) at

their 7 to 8 month and 2 mature rams (for mating) were purchased from the Sagure market. The age of the ewe was determined by dentition. Only those animals, which did not gave birth before were selected to remove the unwanted effect of reproductive disorder in the study. All the sheep were quarantined for 15 days at the experimental site in until they are adopted to new environment. The animals were vaccinated against ovine pasteurellosis, sheep pox and anthrax, with 1 ml of ovine pasteurellosis vaccine subcutaneously for one Sheep, 1 ml of diluted vaccine injected subcutaneously on the inner face of the thigh for one sheep, *1 ml of diluted vaccine injected subcutaneously*, respectively. In addition all sheep were de-wormed against external parasites like tick and mange. Soon after flushing, the sheep were weighted (Fig.3) and divided randomly into 4 groups of T₁, T₂, T₃ and T₄ and 6 ewes in each treatment.



Fig: 3: Weighing of ewes before (left) and after (right) flushing

Flushing was done by T₁: natural pasture hay plus 350 g of barley grain/head/day (maximum), T₂: natural pasture hay plus 287.5 g of barley grain/head/day, T₃: natural pasture hay plus 225 g of barley grain/head/day and T₄ as control group without flushing ration, based on David (2020), which say if ewes are in fair to good condition, 0.5–0.75 lb (225–350 g) daily grain is usually sufficient for flushing. And there was 6 ewe under each treatment groups, totally 24 ewe was included under study.

Natural pasture hay as basal diet and barley grain as experimental diet was used for experiment. In addition, minerals (one spoon calcium and one spoon of zinc per sheep was provided by mixing it with feed), salt and clean tap water was provided for all groups equally. All experimental ewes were identified by number written on their skin and on the wall in front of each animal (fig.4). Ewe under experiment was flushed for three weeks before breeding and four weeks after breeding.



Fig 4. Ewe identified by number given (left) Ewe eating barley during flushing (right)

Determining production and reproduction performance of sheep

After three weeks of flushing, on 21th day, the ewes were allowed for mating. Various reproductive parameters such as conception rate (ewe conceived/Ewe mated) and lambing rate (number of lambs born alive/ewe conceived), abortion rate (ewe abort/ewe conceived) and litter size (single, twin or triplet) and production performance like BW of dam before and after flushing, birth weight and weaning weight of lambs were also studied. Lambs were weighed soon after birth (Fig. 5 left) to see their birth weight and weaning weight was taken at their three months of age (Fig. 5 right).



Fig 5. Weighing of lambs at birth (left) Weighing of lambs at weaning age (right)

The reproductive performances of ewe were calculated as follow:

1. Conception rate = $\frac{\text{Number of ewe conceived}}{\text{Number of ewe mated}} * 100$
2. Lambing rate = $\frac{\text{Number of lamb born alive}}{\text{number of ewe conceived}} * 100$
3. Abortion rate = $\frac{\text{Number of ewe aborted}}{\text{number of ewe conceived}} * 100$
4. Pre weaning lamb mortality rate = $\frac{\text{Number of lambs dying before weaning}}{\text{total lambs born alive}} * 100$ (Menzies, 2006)

Data was analyzed using the General Linear Models procedure of SAS and software. Turkey's honest significant test was employed for separation of treatment means.

The statistical model for the production and reproductive performances was

$$Y_{ijk} = \mu + t_i + e_{ij}$$

Where, Y_{ijk} is the response variable (reproductive performance of ewe)

μ = is the overall mean,

t_i = is the treatment effect,

e_{ij} = error term

Result

Effect of Flushing on Reproductive and Production Performances of Ewes

Effect of Flushing on Conception rate:

Conception rate was calculated as number of ewe conceived per number of ewe mated *100. The conception rate of ewe in the current study was 83.3% for T₁ and 100% for T₂, T₃ and T₄ (Table1). Out of twenty four (24) ewes under four

treatment groups twenty three (23) of them was conceived (Table1). So, the total conception rate was 95.8%. And there is no significant differences ($P>0.05$) among the treatments.

Effect of Flushing on Lambing rate

Results on lambing rate is presented in (Table 1) below. As observed from the results, the lambing rates of ewes under treatment groups were 120%, 100%, 83.3% and 67.7% for T₁, T₂, T₃ and T₄, respectively and there is significant ($P<0.05$) differences between treatment groups. Lambing rate was high in T₁ and T₂. All lambing ewes under T₁ and T₂ gave twin birth, but in opposite twin birth could not seen under T₃ and T₄ fed ewes. The number of ewes gave birth were three (3) under T₁ and under T₂ and five (5) and (4) under T₃ and T₄, respectively, but the number of lambs born alive was (6) under the first two treatment groups and (5 lambs) and (4 lambs) under T₃ and T₄ respectively. All ewes under first two treatment group was give twin birth, but under T₃ and T₄ there is no twin birth at all. This is a clear indication as flushing increase ovulation rate of ewes.

Table 1: Effect of flushing on conception, lambing and abortion rates

Treatments	Parameters				
	Number of Ewes mated	Conception rate, N (%)	Number of Ewes gave birth, N (%)	Abortion rate, N (%)	Lambing rates, N (%)
T ₁	6	5 (83.3)	3 (50)	2 (40)	6 (120)
T ₂	6	6 (100)	3 (50)	3 (50)	6 (100)
T ₃	6	6 (100)	5 (83.3)	1 (16.7)	5 (83.3)
T ₄	6	6 (100)	4 (66.7)	2 (33.3)	4 (66.7)
Total	24	23 (95.8)	15 (62.5)	8 (33.3)	21
Sig.		0.413	0.55	0.67	0.076
CV		8	27	46	6

N: number; Sig= significance level; T₁= natural pasture hay+350 g barley grain; T₂= natural pasture hay+287.5 g barley grain; T₃= natural pasture hay+225 g barley grain and T₄= natural pasture hay only, CV= Coefficient of Variation

Effect of Flushing on Abortion rate

Abortion rate were 40%, 50%, 16.6% and 33.3% in T₁, T₂, T₃ and T₄, respectively and a significant (P>0.05) difference was not seen among the treatments. Abortion was slightly higher in T₁ and T₂, and occurred at the 3rd to 4th months of pregnancy. All ewes under the treatments were served at ten months of their age and it was their first parity, so, their uterus may be unable to accommodate the fetus and increase risk of abortion.

Effects of Nutritional Flushing on Litter Size

Measurement of the litter size of Arsi Bale ewes is presented in (Fig. 6). There is a significant (P<0.05) differences on litter size among treatment groups. The ewes under T₁ and T₂ gave twin birth; however, ewes under T₃ and T₄ (control group) did not gave a twin births (Fig.6). The twin birth in the T₁ and T₂ was an indication of increased ovulation rate in these two treatment groups due to flushing. The occurrence of higher twin birth might be correlated with higher BW gain in ewes that was observed in T₁ and T₂ due to the increased level of barley grain supplementation.

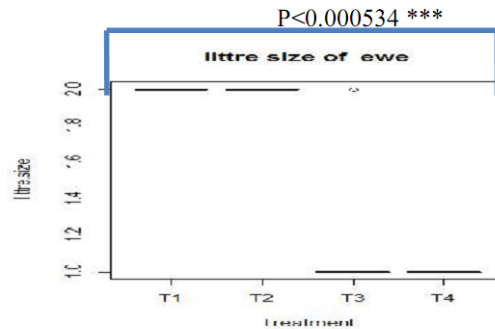


Fig. 6: Effect of flushing on litter size (T₁= natural pasture hay+350 g barley grain; T₂= natural pasture hay+287.5 g barley grain; T₃= natural pasture hay+2250 g barley grain and T₄= natural pasture hay only)

Pre weaning Lambs mortality

As it is shown in (Fig.7), out of 21 lambs born alive from four treatment groups, 12 lambs were died during the pre weaning period and only 9 lambs (4 lambs from T₁, 4 lambs from T₂ and 1 lamb from T₃) were weaned. Lambs mortality rate was (4.8%) in T₁ and T₂ and it was (19%) in T₃ and T₄. Out of the four lambs born under T₄ (control group) all of them were died during and

after birth. Lambs mortality before weaning was high in all treatment groups, especially it was higher in T₃ and T₄ (control group) (Fig.7). One reason for death of lambs was, majority of ewes were reject their lambs and not let the new born to suckle. On the other hand increase in lamb's mortality under T₃ and T₄ (control group) might be an indication of effect of flushing on lambs' mortality.

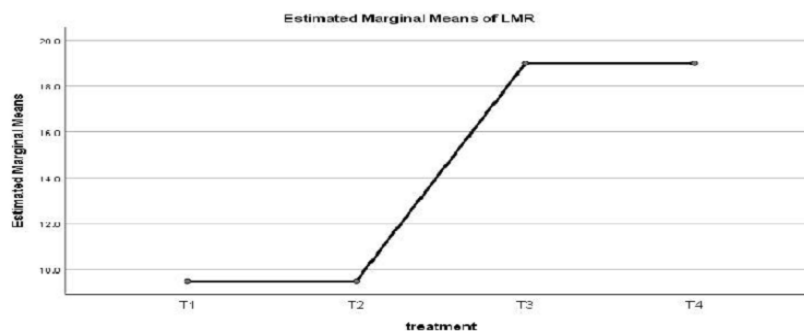


Fig. 7: Lamb mortality rate under all treatment groups (LMR= lamb mortality rate) (T₁= natural pasture hay+350 g barley grain; T₂= natural pasture hay+287.5 g barley grain; T₃= natural pasture hay+2250 g barley grain and T₄= natural pasture hay only)

Effect of Flushing on Body Weight of Dam and Lamb

The mean BW of Arsi- bale highland ewe measured before and after flushing is shown in Table 2. The current results show ewes under all treatment groups have related body weight before flushing. Significance (P>0.05) difference was not seen on body weight of dam before flushing. This confirmed that the animals allocated to four treatment groups have a similar BW on the onset of the study, while after flushing, the mean BW of dam under T₁ flushed by hay+350 g of barley grain per day showed a significant difference

(P<0.05) than ewes under the remaining three treatment diets.

The effect of nutritional flushing on lamb birth weight is presented in (Table 2). The birth weights of lambs under T₁,T₂ and T₃ were not significantly (P>0.05) different; however, a significance (P<0.05) differences were seen between T₁ and T₄ in that the average birth weight of lamb under T₁ is higher (2.3 kg) than that of T₄ (1.8 kg), which could be an indicator to the higher nutritional supplementation (flushing) under T₁.

Table 2: Average body weight of dam before and after flushing

Parameters	Treatment				CV	Sig.
	T ₁	T ₂	T ₃	T ₄		
Dam weight before flushing (kg)	21.5±0.45	22.6±0.49	22.0±0.89	22.2±.1.1	3.70	0.17
Dam weight after flushing (kg)	25.0±0.54 ^a	23.8±.52 ^{ab}	23.2±.68 ^{ab}	22.5±.81 ^b	2.80	0.00
Lamb weight at birth (kg)	2.3±0.16 ^a	2.1±0.10 ^{ab}	2.03±0.18 ^{ab}	1.8±0.34 ^b	32.70	0.01
Lamb weight at weaning (kg)	11.3±.88	10.29±.51	9.9±.14	9.00	23.20	0.09

Different superscripts within a row differ at P<0.05; Sig. = significance level; T₁= natural pasture hay+350 g barley grain; T₂= natural pasture hay+287.5 g barley grain; T₃= natural pasture hay+225 g barley grain and T₄= natural pasture hay only.CV= coefficient of Variation

Discussion

Effect of Flushing on Conception rate:

Significance difference was not seen on conception rate among all treatment groups. The result obtained in current study is in agreement with the result of Huseyin *et al* (2006) and Bahaa (2019), which stated the conception rates of 83.33% and 100% for Akkaraman and Abou-Delik ewes, respectively. However, the present study results were higher than that of Ahmad *et al* (2022), Abdulkareem *et al* (2014) who reported the conception rate of Blackhead Somale and Awassi ewes, respectively was 70% and 66.6%.

Effect of Nutritional Flushing on Lambing rate:

Lambing rate was high in T₁ and T₂ than T₃ and T₄. All ewes under first two treatment group was give twin birth, but under T₃ and T₄ there is no twin birth at all. The result of Asfaw (2022) were, also indicate that the lambing rate of Doyogena ewe was 66.7%-100% and lambing rates of flushed groups were significantly higher than those of control group. The present study results were in agreement with the findings of Bahaa (2019) who reported the lambing rate of 100% when ewes were treated with flushing ration of 300 g of barley grain/head/day. In contrast, Sabra and Hassan (2010) reported a lower lambing rate of 80% than the present study when ewes treated with 500 g Sesbania (*Sesbania grandiflora*) dried forage.

Effect of Flushing on Abortion rate:

Abortion was slightly higher in T₁ and T₂, and occurred at the 3rd to 4th months of pregnancy. According to Abassa (1995), abortions mostly occur at the last stage of pregnancy in sheep. Very high rates of abortion and stillbirth were found among twin or triplet bearers and when primiparous (young animal) and immature females were bred. Ewe lambs bred between four and eight months of age not only suffered from higher abortions and stillbirths (55%) than adult ewes (14.6%), but also lost 89% of their

progenies before one year of age. In the case of Arsi-Bale sheep breed, age at first lambing was 12.7 month (Tsedeke, 2007) and the present study results might be due to flushing the ewes too early.

Effects of Nutritional Flushing on Litter Size:

Twin birth was seen in T₁ and T₂, the twin birth in the T₁ and T₂ was an indication of increased ovulation rate in these two treatment groups due to flushing. Result of Asfaw (2022), also indicate as nutritional flushing increase litter size of Doyogena ewe in Doyogena district, southern Ethiopia.

Pre weaning Lambs mortality

Pre-weaning growth rate is from birth to 30 days of age. Lambs mortality before weaning was high in all treatment groups, especially it was higher in T₃ and T₄ (control group). Flushing should always practice before breeding so that it can increase the lamb weaning rate (Nanjing, 2023). Pre weaning lamb mortality can be also affected by parity. Lambs from second and third parity dams grew better than first and fifth parities (Tibbo, 2006; Taye *et al.*, 2009).

Effect of Flushing on body weight of dam and lamb:

The current results show ewes under all treatment groups have similar body weight before flushing, while after flushing, the mean BW of dam under T₁ was higher than other treatment groups. On the other hand, the birth weights of lambs under T₁ was higher (2.3kg) than control group T₄ (1.8kg), which indicate flushing can improve birth weight of lambs. The current result is lower than result of Asfaw (2022) indicating lamb birth weight is 2.73-2.93kg.

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I, the Corresponding Author, declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

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Statements & Declarations

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