SOMALI REGION PASTORAL AND AGRO-PASTORAL RESEARCH INSTITUTE (SoRPARI)

3rd PROCEEDINGS OF 2022/23, SoRPARI's RESEARCH REPORT

VOLUME ONE



January, 2024

Jigjiga-Ethiopia

Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI)

3rd Proceedings of 2022/23 (Volume One), SoRPARI research report

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3rd Proceedings of 2022/23 (Volume One), SoRPARI research report, Jigjiga Ethiopia

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ISBN 978-99990-0-417-6

Year, 2016 E.C

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ACKNOWLEDGEMENTS

The authors would like to thank the Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI) for funding the research work and preparation of these annual research report proceedings. The Authors also express their gratitude to Mr. Mohammed Sharif for organizing this event and for establishing Technical Advisory Committee (TAC), which contributed to the preparation of this proceeding. Moreover, the respective research centers and staff members are cordially acknowledged for supporting, hosting and executing these research works. All authors of the references cited in each manuscript are duly acknowledged.

Preface

Realizing the key role that it plays in the national economy; the Ethiopian government has given due emphasis to the agricultural sector development. The Agricultural and Rural Development Policy and Strategy of the country which was designed nearly a decade and half ago, has highly emphasized the important role of agriculture as a means of ensuring rapid economic growth, enhancing benefits to the people, eliminating food aid dependency, and promoting the development of a market-oriented economy. Guided by this national policy and strategy, different consecutive national plans, programs and projects focusing on the development of the agriculture sector has been implemented and is being implemented throughout the country. In addition to this, our country is designed 10 years strategic plan of which agriculture sector is once recognized as backbone for the national economy. It is believed that, in achieving and implementing these and other national plan, the role of research is expected than ever as it did in the previous plans and research component is added in these national plans.

The aim of the research component is to adapt or generate agricultural technologies, undertake pre-extension demonstration of proven technologies, produce source technologies that would serve as a base for large scale technology multiplication and enhance capacity of the research systems to improve technology supply. Being one of the implementing institutions, the Somali Region Pastoral and Agro-Pastoral Research Institute (SoRPARI) is conducting various technology adaptation and generation, research report proceedings, source technology multiplication and capacity building activities.

SoRPARI is therefore working on generating/adapting technologies suited to the agro-ecologies of the region and demonstrating them in close collaboration with farmer research and extension offices. SoRPARI also supplies source technologies by multiplying them in the mandate areas on farmer's field, to address problems related to seed shortage and the like. As part of disseminating generating information and technologies, SoRPARI have prepared this proceeding where more than 19 research works and technologies from Livestock & Forage, Rangeland & Forestry, Socio-economic & Gender research directorates and center as part of its implemented projects of 2022/23 plan. Demonstration of generated or introduced technologies and their multiplication needs serious attention from the stakeholders working in the agricultural system.

Mohammed Sharif (MSc.)

Director General of SoRPARI

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LIVESTOCK AND FORAGE RESEARCH DIRECTORATE

LIVESTOCK AND FORAGE RESEARCH DIRECTORATE

Phytochemical Analysis and Antimicrobial Activity of *Dodonaea Viscosa* against Selected Bacteria in Jigjiga City Administration, Somali Regional State, Ethiopia

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ABSTRACT

This study aimed to document and preserve the traditional knowledge of medicinal plants used for the treatment of human and livestock ailments in the Somali region of Ethiopia. In addition, Phytochemical analysis and antimicrobial and anthelminthic efficacy of Dodonaea viscosa and Vernonia Mogadoxensis were also evaluated. The result indicated the presence of alkaloids, tannins, flavonoids, terpenoids, and phenolics in D. viscosa and tannins, flavonoids, terpenoids, and saponins in Vernonia Mogadoxensis. The methanolic extract of D. viscosa showed significant antimicrobial activity against Salmonella typhi, streptococcus pyogens, Staphylococcus aureus and Pseudomonas aeruginosa. The study demonstrated the potential of medicinal plants as a rich source of different types of drugs. The information generated can serve as baseline information for future pharmacological and phytochemical studies to develop alternative antimicrobial drugs.

Keywords: *Antimicrobial, Bacteria, Ethiopia, Dedonia viscosa, Phytochemical, Somali region*

INTRODUCTION

It is estimated that more than 75% of the world's population relies on medicinal plants for treatment of various ailments. Africa is a continent greatly endowed with an abundance of medicinal plants, which indigenous people are familiar with and have used over time (Ramamurthy *et al*., 2013). Africa has as much as three hundred thousand medicinal plants (Sofowora, 1996). Wherein, around 80% of the population uses traditional medicinal plants for the treatment of various diseases, and ethno-botanical surveys have shown that traditional medicines have been deemed effective against those diseases, which are a great concern to most of the sub-Saharan African nations (World Health Organization, 2002). Due to the high cost of modern drugs, inaccessibility and paucity of modern health institutions as well as their cultural acceptability,

about 80% of the population and 90% of livestock in Ethiopia still depend on traditional medicinal plants to combat a number of diseases (Demir, 2020). Most importantly, the majority of rural and/or urban slum inhabiting populations primarily rely on traditional medicines to treat malaria. Similarly, the indigenous people of different localities of the country have been shown to have developed their own specific knowledge of plant resource utilization, management and conservation (Temeche & Asnakew, 2020).

In spite of the fact that Ethiopia is a country with great variety of cultures and diversity of medicinal plants, the alarming population growth with increasing demand and consumption is distracting medicinal plants resources from their natural habitat. Wherein, deforestation and agricultural encroachment aggravate the loss of medicinal plants from their habitat and consequent loss of globally significant plant species (Alebie & Mehamed, 2016). Furthermore, documentation of medicinal plants knowledge is incomplete as the result of limited inventory of medicinal plants traditionally used by local people (Alebie & Mehamed, 2016). The indigenous people of Somali region have been widely used medicinal plants for upholding their primary healthcare system. However, ethnobotanical study conducted to explore traditional medicinal plants and to document the indigenous knowledge of the people is virtually patchy (Alebie & Mehamed, 2016).

Therefore, the aim of this study is to fill the gap and enrich the limited inventory of medicinal plants thereby documenting and preserving traditional medicinal plants and the associated knowledge used for treatment of human and livestock ailments. In fact, plants produce a diverse range of bioactive molecules making them a rich source of different types of medicines. Higher plants as sources of medicinal compounds have continued to play a dominant role in the maintenance of human health since ancient times. Over 50% of all modern clinical drugs are of natural product origin and natural products play an important role in drug development programs in the pharmaceutical industry (Ramamurthy et al., 2013).

Nowadays multiple drug resistance has developed due to the indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of infectious disease (Nwankwo & Ukaegbu-Obi, 2014). In addition to this problem, antibiotics are sometimes associated with adverse effects on the host including hypersensitivity, immune-suppression and allergic reactions. This situation forced scientists to search for new antimicrobial substances. Given the alarming incidence of antibiotic resistance in bacteria of medical importance, there is a constant need for new and effective therapeutic agents. Therefore, there is a need to develop alternative antimicrobial drugs

for the treatment of infectious diseases from medicinal plants (Boominathan and Ramamurthy, 2009). *D. viscosa*, a medicinal plant commonly used for skin diseases in Ethiopia was subjected to a systematic dermato-toxicity study. To this effect, the dermato-toxicity of an 80% methanol extract of the leaf was investigated in animals following standard procedures for irritation, sensitization, acute toxicity and repeated toxicity tests (Kefale *et al.*, 2010). *D. viscosa* is not associated with any toxicologically relevant effects and the data could provide satisfactory preclinical evidence of safety to launch a clinical trial on a standardized formulation of the plant extracts (Kefale *et al.*, 2010).

Against this background information and appreciating the knowledge of medicinal plants an effect has been made in this study to determine phytochemical analysis of *Dodonaea viscosa* and *Vernonia Mogadoxensis* and to evaluate the potential antimicrobial activity of *Dodonaea viscosa* against selected bacterial. The study also pertains to inculcate the subject about the utilization of natural flora as therapeutic agents. The information generated enhances the ethnobotanical knowledge of the region and provides recommendations that would help to combat problems in the conservation and sustainable use of medicinal plants and serve as baseline information for future pharmacological and phytochemical studies.

METHODS AND MATERIALS

Study design

A cross-sectional study was conducted to screen the phytochemical contents of D.viscosa and *Vernonia Mogadoxensis* and to evaluate antimicrobial and anthelminthic efficacy of D.viscosa and *Vernonia Mogadoxensis* respectively.

Method of data collection

Plant Collection and Extraction

Fresh middle, lower and upper strata of plants grown under same environmental and growth conditions that were identified during interview were collected from the selected districts. The plant material was air dried at room temperature to a constant weight and pulverized with pestle and mortar. Fifty grams of the dried plant material were macerated in 500 ml of methanol for one week with through agitation of the solvent regularly. The methanolic extract was filtered through a Whitman filter paper and evaporated to dryness over a regulated hot water bath maintained at 60-70 ◦C to obtain a yield of 9.12 % (w/w). The dried extract was stored in the refrigerator at 4 ◦C

until further use. The extract was re-suspended in distilled water on daily basis during administration to experimental animals.

Preliminary phytochemical Screening

The presence of major phytochemicals (secondary metabolites) such as alkaloids, flavonoids, saponins, tannins, terpenoids, glycosides, phenol and steroid were evaluated in the crude *D. Viscosa* and *Vernonia Mogadoxensis* using standard testing methods with little modification (Jones and Kinghorn, 2012; Onwukaeme *et al*., 2007; Njoku and Obi, 2009; Ugochukwu *et al*., 2013; Geetha and Geetha, 2014; Mohammed *et al.*, 2016).

Test for alkaloids (Wagner's test)

Ten milligrams of the crude extract were dissolved in 1ml of distilled water. Then three drops of Wagner's reagent (i.e., a solution prepared by dissolving 2 gm of Iodine and 6 gm of potassium iodide in 100ml of distill water) was added. Finally, presence of alkaloids was confirmed by the formation of reddish-brown colored solution.

Test for Terpenoids

About 250 mg of crude extract was dissolved in 2ml of chloroform. Then 3ml of concentrated sulfuric acid was carefully added that form a layer. A reddish-brown coloration of interface indicates the presences of terpenoids.

Test for Flavonoids (Alkaline Reagent or NaOH test)

About 300mg of the crude extract was dissolved into 2ml of distilled water. To this solution, three drops of 20% sodium hydroxide solution was added that produce an intense yellow color. Then upon addition of three drops of 20% hydrochloric acid turned to colorless indicated the presence of flavonoids. Likewise, lead acetate test was performed but what used in place of 20% sodium hydroxide and 20% hydrochloric acid was 3 drops of 10% lead acetate and formation of yellow precipitate indicates the presence of flavonoids.

Test for Saponins

About 0.5mg of crude extracts was dissolved in 20 ml of distilled water. Then after vigorous shaking in graduated cylinder for 15 minute the formation of foam to length of 1cm was observed. This was taken as an indicative for the presence of saponins and steroids.

Test for Glycoside

About 100mg of the extract was dissolved in 1 ml of distilled water. Then three drops of 20% sodium hydroxide solution were added. Hence, formation of yellow color proves the presence of glycosides.

Test for Steroids

About 250mg of the extract was placed in a test tube and dissolved by 2 ml of acetic anhydride. Then 4 drops of chloroform were added. Following this, two drops of concentrated sulphuric acid was added at the side of the test tube. Finally, development of a brownish ring at the interface of the two liquids and the appearance of violet color in the supernatant layer was used to confirm the presence of steroids.

Test for Phenols and Tannins

Lead acetate test: Ten mg of extract was taken and 0.5 ml of 1% lead acetate solution was added. Finally, development of precipitate indicates the presence of tannins and phenolic compounds. Ferric chloride test: Five mg of extract was taken and 0.5 ml of 5% ferric chloride was added and hence the development of dark bluish or black color confirms the presence of tannins.

Test for Anthraquinone

About 0.5 gm of the extract was kept in dry test tube and 5 ml of chloroform was added and shaken for 5 minutes. Then extract was filtered and the filtrate was shaken with equal volume of 10% ammonia solution. The presence of a pink violet or red color in the lower layer confirmed the presence of anthraquinone.

Antimicrobial Activity Analysis of D. Viscosa

The following organisms were employed for this study as test organisms: *Salmonella typhi*, *Staphylococcus aureus*, *Streptococcus pyogenes*, and *Pseudomonas aeruginosa*. The test microbial pathogen cultures were obtained from the stock cultures in Jigjiga Veterinary Laboratory Diagnostic Center, maintained in specific agar medium. All the extracts were tested using agar diffusion method described by (Collin and Lyne 1970). The above-mentioned bacteria were inoculated into nutrient agar medium. The well of 8 mm diameter was punched in culture medium using sterile cock borer. Different extracts were administrated to fullness in each well. Culture plates were incubated at 37 °C for 24 hours in the bacteria. The bioactivity was

determined by taking the diameter of inhibition zones in mm. Solvents used for extraction served as control.

RESULTS AND DISCUSSION

Extract yield and qualitative phytochemical composition

Qualitative phytochemical analyses for alkaloids, carbohydrates, tannins, phenols, saponins, proteins, volatile oils, flavonoids and steroids were screened in methanolic extracts of *D. viscosa* and *Vernonia Mogadoxensis.* The phytochemical screening of the crude extract of *D.viscosa* indicated the presence of alkaloids, tannins, flavonoids, terpenoids, reducing sugars and phenolics, but shown absence of saponin(Table 1). This result is in agreement with the results of scientific study conducted in different areas Kefale *et al*., 2010; Khurram *et al*., 2009; Ramamurthy *et al*., 2013). In addition, the phytochemical analysis of *Vernonia Mogadoxensis* extracted revealed the presence of tannins, flavonoids, terpenoids, reducing sugars and Saponin and absence of phenolics and alkaloids.

Table 1: Phytochemical composition of the methanolic extracts of the selected plants

Phytochemical	**Method**	**Result**	
		Dadonia Viscosa	**Gagabood**
Tannins	Ferric chloride test	+ve	+ve
Saponins	Foam test	_-ve	+ve
Phenolics	Ferric chloride test	+ve	-ve
Terpenoids	Salkowski's test	+ve	+ve
Flavonoids	Alkaline reagent test	+ve	+ve
Alkaloids	Wagner’s test	+ve	-ve
Reducing sugars	Fehling's test	+ve	+ve

Antimicrobial Activity Analysis of D. Viscosa

The methanolic extract showed maximum activity against Salmonella typhi, Staphylococcus aureus and Pseudomonas aeruginosa. These data revealed that the leaf of Dodonaea viscosa showed significant antimicrobial activity, and this agrees with similar report by different scientific reports (Esmaeel & Al-jobori, 2011; Khurram et al., 2009; Mothana et al., 2010; Ramamurthy et al., 2013). It can be stated that the inhibition zone increases with increase in drug concentrations and hence exhibit concentration dependent activity.

Table 2: Antimicrobial efficacy of *Dodonaea viscosa* on selected bacterial isolates.

SN	Bacterial Species	Inhibition zone in mm	
		Root	**Leaves**
1.	Salmonella Typhi	6	19
2.	Staphylococcus aureus	5	23
3.	Streptococcus pyogenes	8	17
4.	Pseudomonas aurogonosa	7	14

CONCLUSION AND RECOMMENDATIONS

The study aimed to document and preserve traditional medicinal plants used for human and livestock diseases and evaluated the phytochemical composition, antimicrobial activity of D. viscosa against bacterial strains, and anthelminthic activity of Vernonia Mogadoxensis against nematode parasites. The phytochemical analysis of both plants signifies their richness in different secondary metabolites. D. viscosa demonstrated inhibition against Salmonella typhi, Staphylococcus aureus, and Pseudomonas aeruginosa, while Vernonia Mogadoxensis showed potential anthelmintic activity against nematodes. The results suggest that these plants could be studied further for possible alternative natural remedies to synthetic drugs. Isolation and identification of active compounds in these plants can lead to the development of new natural drugs. Comprehensive ethnobotanical surveys are also recommended to gain further knowledge of their traditional use.

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Identification and Screening of Toxicity Effect of Major Poisonous Plants on Camel in Selected Districts of Fafan and Jarar Zones, SRS, Ethiopia

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ABSTRACT

This study aimed to screen the phytochemical contents and identify acute and sub-acute toxicity effect of the major poisonous plants affecting camels. Participatory methods were used to identify the major poisonous plants affecting camels in selected areas. Phytochemical analysis was performed on the plant extracts to evaluate their potential pharmacological uses. Acute oral toxicity was assessed in rats with dose levels of 300 mg/Kg BW and 2000 mg/Kg BW for 14 days. Sub-acute oral toxicity was also performed at dose levels of 250 mg/Kg BW, 500 mg/Kg BW, and 1000 mg/Kg BW for 28 days, followed by hematological and biochemical trait analyses. In the participatory study, Lantana Camara, Solanum Incanum, Coppers Tormentosa, Euphorbia Nubica, and Adenium obesum were identified as the most frequently occurring toxic plants in descending order. Phytochemical analysis revealed the presence of terpenoids and alkaloids in the four studied plant extracts. Acute oral toxicity tests showed that L. Camara extract caused mortality and significant behavioral changes in rats, but S. Incanum extract caused no mortality. Sub-acute oral toxicity tests revealed significant changes in body and organ weights of mice administered with L. Camara extract. Significant elevation in AST, ALT, serum urea, and LDH was observed in mice administered with L. Camara and S. Incanum extract compared to the control group. The results suggest that L. Camara and S. Incanum are toxic plants that are harmful to camels. It is recommended that herders avoid grazing their camels in areas where these plants grow abundantly.

Keywords: *Phytochemical, Participatory, Lantana Camara, Solenum Incanum, plant poisoning*

INTRODUCTION

There are about 35 million camels in the world, of which 89 % are one-humped (*Camelus dromedarius*) camels (FAO, 2020). East African countries like Somalia, Sudan, Ethiopia, Kenya, Djibouti and Eretria are homeland by having proportionally higher number of camels (one humped) than the rest part of the world (CSA, 2011). Ethiopia has 8.1 million camels distributed mainly in lowland areas of the Somali, Afar and Oromiya Regional States (CSA, 2020).

The subsistence of pastoralists living in lowland areas of Ethiopia depends on one humped camel (*Camelus dromedaries*). Camels are well-adapted to living in arid and semi-arid areas where other animal species struggle to survive and crop production is not feasible (Awoke and

Moham, 2015). Due to their exceptional performance in the limited browse and water conditions of eastern Ethiopia, pastoralists heavily rely on camels for their livelihood (Tadesse *et al.*, 2015). In this area the primary purpose that camels are reared is because of their milk product indeed during the dry season when milk from other animals is scarce (Seifu, 2007).

Ethiopia is a country with varied climatic conditions and temperature varies from 10°C to 45°C (Azage *et al*., 2017). This varied climatic condition enables the country to have diverse flora and fauna that are unique of which 12% are endemic(Azage *et al*., 2017). Despite there are plants that played a central part in combating many aliments in human and livestock in many indigenous communities, in the world including Africa, there are also number of problematic toxic plants. Plants add a touch of color and fragrance to our daily lives. They also inject an element of anger in our lives and they cannot move to escape their predators. So, all plants have other means of protecting themselves from the herbivores. Some plants have physical such as thorns. But others contain some toxic. Chemical defenses of plants against consumption by herbivores are determined by non-nutrient compounds such as fiber, lignin, cellulose, toxicants or essential oils and other volatile substances. Some volatile substances are overtly toxic others are merely unpleasant (Samtiya *et al.*, 2020).

Even though plants have vital nutritious and providing the normal atmospheric oxygen, it will cause life threatening if it is toxic (Walelign *et al*., 2016). A variety of poisonous plants have caused extensive losses to the livestock industry in many parts of the world mainly east Africa including Ethiopia and they are still significant problems in numerous areas (Gurmesa and Abdeta, 2019).

Plant poisoning is due to either accidental ingestion of material eaten along with grass or willful consumption of poisonous plants when pasture is dry while most of the poisonous plants remain green and attractive for hungry and thirsty animals (Walelign *et al.*, 2016). It is also more likely to occur in animals which have been moved from one part of the country to another (Walelign *et al*., 2016). New importations are unfamiliar with the strange ingestion of their fresh surrounding since acclimatization in herbivores animals induces a sense of discrimination between edible and non-edible parts (Gurmesa and Abdeta, 2019). Even though animals are selective about what they eat, there are instances (for example, herbicide applications) that may change palatability or increase toxicity of some plants. If weeds are embedded in hay cubes, animals may not be able to avoid ingestion of the weeds (Bailey *et al*., 2019). Plant poisoning occurs when animals consume

these plants in large amount in a short period or graze over a prolonged period of time. Animals under nutritional stress may be less able to detoxify plant toxins and may suffer relatively greater harm from the metabolic effects of the toxins (Desta, 2019). Thus, proper observation of grazing animals, good grazing management with prior knowledge of poisonous plants in the rangelands, and strategic supplemental feeding may help to mitigate the problem (Walelign *et al*., 2016).

Despite the variation in the effect poisonous plants, the common clinical signs and symptoms include chronic illness and debilitation, decreased weight gain, abortion, abdominal discomfort, salivation, congenital defects, photosensitization and finally death (Fikadu, 2018). These symptoms have been attributed to the toxic principle in such plants, which range from nitrates, oxalate, fluoroacetate, selenium etc. (Getahun and Beze, 2019). Currently rapidly diagnosing of a plant poisoning is often extremely difficult. In many cases initial clinical signs are nonspecific (such as diarrhea) and post-mortem lesions may be absent (Getahun and Beze, 2019). However, diagnosis of plant poisoning of livestock depends on the history, clinical syndrome observed, post-mortem lesions, evidence that plants have been grazed, and remains of toxic plants in the gastrointestinal tract (Ugwah-oguejiofor and Ogbonna, 2019).

In addition, specialized veterinary toxicology laboratories may provide testing for plant toxins and should be consulted. Thus, the best way to support a diagnosis of a plant poisoning is to confirm the presence of a toxic plant in the animal's environment, and to confirm that the plant has been ingested (Varga and Puschner, 2012). Awareness of poisonous plants growing in a certain geographical region and their associated clinical signs are instrumental in making a diagnosis and initiate treatment (Gurmesa and Abdeta, 2019). It is important to establish an accurate diagnosis in order to provide adequate treatment to affected animals, carefully and accurately assess the potential for the transfer of toxins into edible products and prevent further exposures (Fikadu, 2018).

In Ethiopia, to this date, most of the available information about poisonous plants is case reports. Thus, it is virgin (neglected) area for interested researchers to fill available gaps regarding paucity of information on the effects of poisonous plants on livestock particularly on camels (Walelign *et al.*, 2016). The objective of this study was to identify, document and screen different poisonous plants and their toxic effects on livestock in selected districts of Fafan Zone and Jarar zone, SRS of Ethiopia.

MATERIALS AND METHODS

Study area

The study was conducted in selected two districts of Fafan zone and one district from Jarar zone of Somali Region (SRS), Ethiopia. Fafan zone is situated in the northern part of SRS. The total land coverage of the zone is 40, 861 km^2, of which the rangeland extends over 36, 629 km^2. About 52.6%, 31% and 7% of the landscape of the zone can be categorized as flat to gentle slopes, hills and steep slope, respectively. Fafan zone comprises pastoralism, Agro-pastoralism and sedentary production systems. Agro-pastoralism (95%) is the dominant production system in the zone (Feyera *et al.*, 2017). The zone geographically lies between 8 ° 44′ N to 11 ° 00′ N latitude and 40 ° 22′ E to 44° 00′ E longitude. The altitude of the zone ranges from 500 to 1650 m above sea level. The mean minimum and maximum temperature ranges from 16 to 20 °C and 28–38 °C, respectively (NAPA, 2007). The rainfall distribution in the Fafan zone is very erratic with a mean annual rainfall of 600 to 700 mm (Feyera *et al.*, 2017).

Study design and Sampling Procedure

A cross-sectional study comprising Participatory epidemiological study and acute and sub-acute toxicity study of selected toxic plants was employed to collect phytotoxicity information of selected poisonous plants that were assumed to have toxic effect on camel in the selected area. Phytotoxicity information were collected from elders and animal health practitioners in the selected area through interview and FGD from July, 2022 to May, 2023. For the study Three districts, two districts (Gursum and Babile) from Fafan zone and one district (Birkot) from Jarar zone were purposively selected based on the fundamental criteria for their selection i.e., the representation of different vegetation types, production systems, and the accessibility of adequate numbers of elder pastoralists for interviewing and access to transportation. For the participatory epidemiology, 6 independent groups were used whereby each group composed of 8 respondents. Explicitly, 2 groups were interviewed per district (Catley *et al.*, 2012; FAO, 2000). During sampling any voluntary animal owners specifically elders with age of ≥ 50 years old and animal health practitioners with indigenous knowledge on plants and plant poisoning on livestock were selected as a key informant that was later formed as FGD members in order to inquire their indigenous knowledge for identifying the local name, the toxicity, and toxic effect of browsing plant. Other people present nearby with good camel herding experience and rich indigenous knowledge related to camel diseases and health care were also invited to join the discussion by

the research team. These key informants were sampled using purposive snowball sampling technique. This approach aids in acquiring the desired quality and quantity of information on traditional animal health care systems (Feyera *et al.*, 2017).

Methods of data collection

Participatory Study

A multidisciplinary team were formed, and the team consisted of local pastoralists, district agricultural experts, pharmacist, Veterinarians and rangeland experts. The study was conducted during the rainy season when most of the browsing plant species regenerate and flower. Both primary and secondary data were collected. The primary source of data was obtained using semi–structured interviews guided by a checklist, simple ranking and pairwise ranking. Specifically, semi-structured interviews were used to gather qualitative data on predetermined topics using open-ended questions. The topics included the common livestock species kept, number of animals, purpose of camel keeping; constraints of livestock production, major toxic plants affecting camels in the locality and other relevant information.

Then the informant groups were asked to rank and compare the frequency of occurrence of common poisonous plants on camel using 100 piles of stones. The item with the highest score was ranked number one. Lastly, a comparison and a slightly more complex method of ranking in which each item is compared individually with all the other items one-by-one were done by informants. This pair wise ranking method was used to understand the relative importance of different poisonous plants. In this study, the key informants were asked to compare individual toxic plant identified during semi-structured interview with other toxic plant one by one. The names of toxic plants were written vertically (y-axis) and horizontally (x-axis) on a piece of colored A4 papers. For each pair of toxic plant (x, y), participants were asked which was more important. Probing questions such as why a participant felt a chosen toxic plant was more important than another was asked. toxic plants were ranked first to fifth according to the score they got during pair-wise ranking. This activity was conducted with six informant groups (three groups form each district) in the selected districts

Phytotoxicity Analysis

Plant Collection and Extraction

Fresh middle, lower and upper strata of plants grown under same environmental and growth conditions that were identified during interview were collected from the selected districts. The plant material was air dried at room temperature to a constant weight and pulverized with pestle and mortar. Fifty grams of the dried plant material were macerated in 500 ml of methanol for one week with through agitation of the solvent regularly. The methanolic extract was filtered through a Whitman filter paper and evaporated to dryness over a regulated hot water bath maintained at 60-70 ◦C to obtain a yield of 9.12 % (w/w). The dried extract was stored in the refrigerator at 4 ◦C until further use. The extract was re-suspended in distilled water on daily basis during administration to experimental animals.

Experimental animals

Male and female rats weighing about 150-165 gram and the mice (20-30 gram) were obtained from Haramaya University Central Laboratory. The animals were acclimatized for 2 weeks before the commencement of the study. Standard commercial chow and water were provided for the animals. Housing conditions were maintained at 25 ◦C at 12 hours day/night cycles. The care and handling of the animals were according to the established public health guidelines in Guide for Care and Use of Laboratory Animals (2011).

Preliminary phytochemical tests

The plant extract was subjected to qualitative analyses using the methods described by Trease and Evans (1983), El-Olemmy *et al*. (1994), and Harbone (1993). The presence of alkaloids, glycosides, tannins, saponins, terpenoids, flavonoids, saponins glycosides, cardiac glycosides, anthraquinones and steroids was tested.

Acute and sub-acute toxicity studies

Acute toxicity test

The oral acute toxicity study of the methanolic extract of the sampled plants were carried out in accordance with the Organization for Economic Development (OECD) guideline no. 425 (Organization for Economic Development, 2001). Fifteen (15) healthy Wistar rats were randomly assigned into three groups (1, 2, and 3), individually weighed, and marked for easy identification. five female rats were used for each dose level in the study. An animal was picked at a time, weighed and dosed with the equivalent volume of extract dissolved in distilled water.

The extract was administered orally using gastric feeding tube. Rats in group 1 were orally administered with 10 ml/Kg BW of distilled water and served as the control.

The rats in groups 2 and 3 were orally administered 300 mg/Kg BW and 2000 mg/Kg BW, respectively, of the methanolic extract of *L. Camara* and *S. Incanum.* Each rat was observed after dosing for the first 5 min for signs of regurgitation and kept in a metallic cage. Each was then observed every 15 min in the first 4 hours after dosing, every 30 min for 6 hours and daily for 48 hours for behavioral signs of toxicity (changes in skin, hair, eyes, mucous membranes, and respiratory, circulatory, autonomic and central nervous systems, motor activity, convulsion, tremors, salivation, diarrhea, lethargy, or sleep) according to the specifications of the OECD (2001). The animals were monitored for a total of 14 days for the long-term possible lethal outcome. The body weights of the rats were measured on days 1, 7, and 14.

Sub-acute toxicity test

According to OECD guideline 407, sub-acute oral toxicity study was carried out. Twelve experimental mice for each plant extract (6 male and 6 female) were randomly allotted four groups in this study. The control group mice (Group I) received distilled water (10 ml/Kg BW) orally, once daily, for 28 days. Mice in experimental groups II, III, and IV received 250 mg/Kg BW, 500 mg/Kg BW, and 1000 mg/Kg BW in distilled water, respectively, of the methanolic extract of *L. Camara and S. Incanum* orally once daily for 28 days. The body weights of the animals were measured weekly using an electronic balance (Mettler PM 4600, Germany) and recorded. The animals were observed daily for any physiological and behavioral changes. On day 29, the mice were weighed and sacrificed. Blood samples were collected via cardiac puncture for biochemical and hematological analyses. The heart, liver, lungs, kidneys, spleens, were excised, weighed.

Assessment of Hematological and Serum Biochemical Parameters

The samples for hematology were put in bottles containing anticoagulant, ethylene diamine tetra-acetic acid (EDTA). Hematological analyses were performed using an automated hematology analyzer (Mytaic 22, Germany). Parameters analyzed include total and differential leukocyte (WBC), erythrocyte (RBC), Hemoglobin (Hgb), Hematocrit (HCT) and platelet count (PLT). Blood for biochemical analysis were gently placed in plain bottles to avoid hemolysis of the blood cells. Blood serum was obtained by centrifugation of the blood sample. Biochemical studies were carried out using standard methods for aspartate aminotransferase (AST), alanine

aminotransferase (ALT), total and conjugated bilirubin, total protein, albumin, urea and creatinine.

Statistical Analysis

Phytotoxicity data was analyzed both quantitatively using analytical tools and excel spreadsheet 2010. Phytotoxicity data was entered into Excel spreadsheet and summarized using descriptive statistics. The results of the experimental study were expressed as the mean ± Standard deviation. The results were analyzed using Stata software version 14. Comparison in all the groups was made using one-way analysis of variance (ANOVA) followed by Dunnett's post hoc test. Differences was considered significant at $p \leq 0.05$.

RESULTS

Participatory Epidemiological Study results

Simple Ranking of Major Poisonous Plants on Camels

In simple ranking, informants in Gursum, Babile and Birkot districts ranked *Lantana Camara, Solanum Incanum, Coppers Tormentosa, Euphorbia Nubica* and *Adenium obesum* in descending order as the most frequently occurring toxic plants on camel in their localities (Table 1). They have their own local names for each plant as *Barkakati* (Lantana Camara), *Kiriir* (Solanum Incanum), *Gamoor* (Coppers Tormentosa), *Irgin* (Euphorbia Nubica) and *Dun-dhurwaa* (Adenium obesum).

Table 1: Simple ranking of the common poisonous plants of camel according their frequency and occurrence by the informants in Gursum, Babile and Birkot districts.

Species	N[a]	Score	Rank
Lantana Camera (*Barkakati)*	6	29	1
Solanum Incanum (*Kiriir*)	6	25.5	2
Coppers Tormentosa (*Gamoor*)	6	19.5	3
Euphorbia Nubica (*Irgin*)	6	14	4
Adenium obesum (*Dun-dhurwaa*)	6	12	5

Pairwise Ranking of Major Poisonous Plants of Camels in the Studied Areas

After simple ranking for frequency of occurrence, informants conducted pair-wise ranking of the five selected toxic plants mainly based on occurrence and mortality rates, loss of production and

impact on the camel keepers' livelihood. Accordingly, Lantana Camara, Solanum Incanum, Coppers Tormentosa, Euphorbia Nubica and Adenium obesum in descending order as the most frequently occurring toxic plants on camels in their localities. Kendall's coefficient of concordance (W) for informant groups for the toxic plants indicated strong agreement in ($W = 0.94$; $p = <0.001$) districts (Table 2).

Table 2: **Pair-wise ranking of major poisonous plants on camel diseases by informants in Gursum, Babile and Birkot District**

Poisonous plants	**Lantana Camera**	**Solanum Incanum**	**Coppers Tormentosa**	**Euphorbia Nubica**	**Adenium obesum**	**Over all Rank**
Lantana Camera	X	Lantana Camera	Lantana Camera	Lantana Camera	Lantana Camera	4
Solanum Incanum		X	Solanum Incanum	Solanum Incanum	Solanum Incanum	3
Coppers Tormentosa			X	Coppers Tormentosa	Coppers Tormentosa	2
Euphorbia Nubica				X	Euphorbia Nubica	1
Adenium obesum					X	0
N[a]						**6**
W[b]						**0.94**
P						**<0.001**

[a] Number of informant groups [b] Kendall's Coefficient of Concordance

Phytotoxicity Results

Extract Yield and Qualitative Phytochemical Composition

Qualitative phytochemical screening revealed the presence of terpenoids, tannins, saponins, flavonoids, reducing sugars and alkaloids in *L. camara, S. incanum.* This study also revealed the absence of Saponins and reducing sugars from C*oppers tormentosa and Euphorbia Nubica* (Table 3).

Table 3: Qualitative phytochemical composition of the methanolic extracts of the selected plants

Phytochemical	**Method**	**Result**			
		L. Camara	**Solanum Incanum**	**Euphorbia Nubica**	**Coppers Tormentosa**
Tannins	Ferric chloride test	+ve	+ve	+ve	-ve
Saponins	Foam test	+ve	+ve	-ve	-ve

Phenolics	Ferric chloride test	+ve	-ve	+ve	+ve
Terpenoids	Salkowski's test	+ve	+ve	+ve	+ve
Flavonoids	Alkaline reagent test	+ve	+ve	+ve	+ve
Alkaloids	Wagner’s test	+ve	+ve	+ve	+ve
Reducing sugars	Fehling's test	+ve	+ve	-ve	-ve

Acute Oral Toxicity of Lantana Camara And Solanum Incanum

Only mortality regarding *Lantana Camara* was observed throughout the 14-day acute oral toxicity study period. Also, the general conditions of the extract-treated animals changed, the behavioral changes observed where respiratory change, skin and fur change, convulsion, sedation but this general behavioral change was dose related only dose of extract ≥ 2000mg/kg BW caused these changes (Table 4). In addition, body weights of *Lantana Camara* extract treated rats changed significantly across the 14-day acute oral toxicity study period (P>0.05; Table 5). The LD50 of the methanolic extract of *Lantana Camara* was ≥ 2000 mg/Kg BW. However, *S. Incanum* extract caused no mortality. Insignificant (p = 0.06) body weight change to rat caused by *S. Incanum* during acute toxicity study period was observed.

Table 4: Acute oral toxicity effects of the Methanolic extract of *L. Camara and S. Incanum* in Wistar rats

Observation	***Lantana Camara***			***Solanum Incanum***		
	Control (10 ml/Kg BW distilled water)	**300 mg/Kg BW of extract**	**2000 mg/Kg BW of extract**	**Control (10 ml/Kg BW distilled water)**	**300 mg/Kg BW of extract**	**2000 mg/Kg BW of extract**
Respiratory changes	-	-	+	-	-	+
Circulatory changes	-	-	+	-	-	-
Gripping strength	+	+	+	+	+	+
signs of aggression	-	-	-	-	-	-
Skin and fur changes	-	-	+	-	-	+
Response to sound	+	+	+	+	+	+
Salivation	-	-	+	-	-	+
Urinary incontinence	-	-	-	-	-	+
Defecation	+	+	+	+	+	+
Diarrhea	-	-	+	-	-	-
Sedation	-	-	+	-	-	+
Convulsions	-	-	-	-	-	+
Mortality	-	-	+	-	-	-
Post mortem changes	-	-	+	-	-	-

Table 5: Effect of the methanolic extract of *L. Camara and S. Incanum* body weights of Wistar rats

Treatment group	***Lantana Camara***				***Solanum Incanum***			
	Initial weight	**7th Day**	**14th Day**	**P-value**	**Initial weight**	**7th Day**	**14th Day**	**P-value**
Control (10 ml/Kg BW)	163.1±0.74	164.35 ±0.49	164.±0.41	-	163.04±0.56	164.14 ±0.53	164.07±0.60	-
300 mg/Kg BW extract	160.03±0.57	161.15±0.99	161.5±0.77	0.7	162.04±0.04	162.05±0.99	161.5±0.77	0.9
2000 mg/Kg BW extract	163.97±0.72	162.75±1.20	160.9±0.72	0.04	163.04±0.04	162.05±0.99	161.5±0.77	0.06

All values are expressed as mean ± standard deviation of three animal groups.

Sub-Acute Oral Toxicity Lantana Camara and Solanum Incanum

Effects of the methanolic extract of l. Camara and s. Incanum on body weights and relative organ weights of swiss albino mice

Effects of the methanolic extract of *L. camara* on body weights and relative organ weights of Swiss albino mice were dose-related extract having dose of ≥1000 mg/kg has significant effect compared with the control. Significant changes in mean body weights of female treated with methanolic extract of *L. camara* were observed compared with the control throughout the 28-day study period (P>0.05; Table 6). But males shown no significant body weight loss after being treated with methanolic extract of *L. camara*. Moreover, significant differences in relative organ weight were observed in mice treated with the of *L. camara.* (Table 7). *S. incanum* extract caused no body and organ weight change to the Swiss albino mice.

Table 6: **Effects of the methanolic f extract of *L. camara* and *S. Incanum* on body weights of Swiss albino mice**

Extract	Day	Sex	Control	250mg/kg Bwt	P - Value	500mg/kg Bwt	P- Value	1000mg/kg Bwt	P - Value
L. camara	Before	F	**28.67±1.00**	**23.33±0.58**	**0.09**	**23.50±0.48**	**0.09**	**23.73±0.65**	**0.09**
		M	**24.00±1.00**	**28.5±0.50**	**0.11**	**27.5±0.53**	**0.11**	**26.5±0.50**	**0.11**
	After	F	**28.15±1.32**	**22.15±0.30**	**0.06**	**22.35±0.50**	**0.14**	**22.17±0.60**	**0.02**
		M	**25.42±1.37**	**28.00±1.29**	**0.12**	**29.00±0.49**	**0.16**	**29.30±0.59**	**0.19**
S. Incanum	Before	F	**28.54±1.84**	**24.87±2.92**	**0.09**	**24.79±2.05**	**0.08**	**24.61±2.14**	**0.06**
		M	**23.99±1.72**	**28.38±1.63**	**0.11**	**24.28±1.61**	**0.99**	**27.60±0.82**	**0.08**
	After	F	**28.59±3.06**	**24.19±3.64**	**0.83**	**25.65±0.73**	**1.00**	**23.11±2.33**	**0.48**
		M	**26.26±1.98**	**30.84±3.07**	**0.12**	**25.17±3.94**	**0.94**	**26.58±2.79**	**1.00**

Table 7: Effect of the methanolic extract of *L. camara and S. Incanum* on relative organ weights of experimental mice

Extract	Organ Weight (grams)	Sex	Control	250mg/kg	P value	500mg/kg	P value	1000mg/kg	P value
L. Camara	Liver	M	**5.72±1.06**	**5.13±0.61**	**0.001**	**4.90±0.53**	**0.03**	**4.26±0.48**	0.02
		F	**5.88±0.33**	**5.51±0.20**	**0.82**	**4.89±0.86**	**1.00**	**4.67±0.78**	**0.04**
	Kidney	M	**1.56±0.13**	**1.48±0.11**	**0.82**	**1.39±0.20**	**0.31**	**1.60±0.15**	**0.96**
		F	**1.24±0.12**	**1.41±0.10**	**0.63**	**1.35±0.14**	**0.98**	**1.28±0.14**	**0.01**
	Heart	M	**0.51±0.06**	**0.50±0.02**	**1.00**	**0.50±0.08**	**1.00**	**0.49±0.08**	**0.23**
		F	**0.55±0.09**	**0.56±0.06**	**1.00**	**0.54±0.08**	**1.00**	**0.52±0.15**	**0.04**
	Spleen	M	**0.84±0.15**	**0.73±0.14**	**0.81**	**1.00±0.33**	**0.42**	**0.99±0.35**	**1.00**
		F	**0.94±0.07**	**0.83±0.32**	**0.90**	**1.02±0.15**	**1.00**	**0.85±0.18**	**0.05**
S. Incanum	Liver	M	**5.72±1.06**	**5.13±0.61**	**0.56**	**4.50±0.53**	**0.43**	**5.26±0.48**	**0.73**
		F	**5.88±0.33**	**5.51±0.20**	**0.82**	**5.89±0.86**	**1.00**	**5.87±0.78**	**1.00**
	Kidney	M	**1.56±0.13**	**1.48±0.11**	**0.82**	**1.39±0.20**	**0.31**	**1.60±0.15**	**0.96**
		F	**1.24±0.12**	**1.41±0.10**	**0.63**	**1.35±0.14**	**0.98**	**1.48±0.14**	**0.19**
	Heart	M	**0.51±0.06**	**0.50±0.02**	**1.00**	**0.50±0.08**	**1.00**	**0.59±0.08**	**0.23**
		F	**0.55±0.09**	**0.56±0.06**	**1.00**	**0.54±0.08**	**1.00**	**0.62±0.15**	**0.69**
	Spleen	M	**0.84±0.15**	**0.73±0.14**	**0.81**	**1.00±0.33**	**0.42**	**0.99±0.35**	**1.00**
		F	**0.94±0.07**	**0.83±0.32**	**0.90**	**1.02±0.15**	**1.00**	**0.85±0.18**	**0.56**

Effect of Methanolic Extract of L. Camara and S. Incanum on Hematological and Biochemical Parameters of The Experimental Mice

The effects of the methanolic extract of *L. camara* and *S. incanum* at the studied dose levels on hematological parameters of mice following a 28-day subacute oral toxicity study are presented in Table 8. No significant differences among the RBC, Hematocrit, and Hemoglobin, respectively, were observed in experimental mice administered with 250 mg/Kg BW, 500 mg/Kg BW, and 1000 mg/Kg BW of the methanolic extract *S. Incanum* and *L. Camara* compared with those of the control group mice (P>0.05; Table 8). However, mice that received *L. camara* and *S. Incanum* plant extract posted significantly higher WBC and platelet counts than those recorded in the negative control group mice (P<0.05; Table 8).

Table 8: Effect of the methanolic extract of *L. camara and S. Incanum* on Hematological parameters of experimental mice following Sub-Acute toxicity study

Treatment	**Sex**	**RBC (10^6/uL)**	**WBC (10^3/uL)**	**Platelets (10^3/uL)**	**Hematocrit (%)**	**Hemoglobin (g/dL)**
Control	F	8.39±3.60	5.96±2.25	312±226.66	**35.74±14.39**	**12.66±5.11**
	M	9.52±0.96	12.06±3.72	326±122.75	**40.34±3.48**	**15.28±0.99**
Lantana	F	10.34±0.54	12.05±4.27	792±203.66	**42.82±2.98**	**14.10±1.83**
extract	M	11.25±0.56	13±6.35	847±138.20	**43.10±4.83**	**14.04±2.41**
S. Incanum	F	8.36±3.54	11.14±3.18	315±253.14	**42.82±2.98**	**14.10±1.83**
	M	9.25±0.56	12.93±4.51	347±154.31	**43.10±4.83**	**14.04±2.41**
P value		0.06	0.02	<0.001	0.07	0.52

All Values are expressed as mean± standard deviation, n= 10 mice (5 female and 5 male); RBC: Red blood cells; WBC: White blood cells.

A number of biological parameters, including ALT, AST, serum urea, creatinine, and LDH, were measured and analyzed as a biological response to *Lantana Camara* and *S. incanum* extract as a possible toxicity effect. The results are shown in Table 9. When *Lantana Camara* and *S. incanum* extract was administered to Swiss alpino mice, a significant elevation in AST, ALT, serum urea, and LDH concentration was observed as compared to the control group (Table 9).

Table 9: Effect of the methanolic extract of L. camara and S. Incanum on biochemical parameters of Swiss albino mice following sub-Acute toxicity study

Treatment	**AST (U/ml)**	**ALT (U/ml)**	**Serum urea (mg/dl)**	**Creatinine (mg/dl)**	**LDH (U/L)**
Control	40.24 ± 0.58	31.12 ± 0.40	25.3 ± 1.03	0.66 ± 0.05	98.44 ± 0.41
Lantana extract	45.2 ± 0.22	46.04[a] ±0.75	30.06 ± 0.12	0.76 ± 0.07	115.62 ± 1.28
S. Incanum extract	44.3 ± 0.32	42.25 ±0.64	27.12 ± 0.31	0.69 ± 0.14	112.36 ± 1.43
P-value	0.00	0.00	0.019	0.026	0.00

All Values are expressed as mean± standard deviation, ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; LDH: Lactate dehydrogenase

DISCUSSION

In this study a pair-wise ranking conducted of five selected toxic plants mainly based on occurrence and mortality rates, loss of production and impact on the camel keepers' livelihood, indicated *Lantana Camara, Solanum Incanum, Coppers Tormentosa, Euphorbia Nubica and Adenium obesum* in descending order as the most frequently occurring toxic plants on camels in their localities. Kendall's coefficient of concordance (W) for informant groups for the toxic plants indicated strong agreement in (W = 0.94; p = <0.001). this result is in line with a study conducted by different researchers in different areas of the country (Walelign, Mekuriaw and Sodo, 2016; Fikadu, 2018; Desta, 2019; Getahun and Beze, 2019; Gurmesa and Abdeta, 2019; Gebeyew *et al.,* 2020).

This could be that most of the poisonous plants are known by the pastoralists. In the present study, various phytochemical compounds like alkaloid, terpenoid and others was detected in the plant extracts of *L. Camara, E.Nubica, C. Tormentossa and S. incanum*. This result is in comparable to different researches (Pariyani *et al.*, 2015; Altemimi *et al.*, 2017; Sahle and Okbatinsae, 2017; Gebeyew *et al.*, 2020; Mansoori *et al.*, 2020; Sbhatu and Abraha, 2020). Acute toxicity test assesses the adverse effects that occur within a short time after administration of a single dose of a test substance. This testing is performed principally in rodents and is usually done early in the development of a new chemical or product to provide information on its potential toxicity (Kipkore *et al.*, 2014). In the 14-day acute toxicity study, the methanolic extract of *L. Camara* elicited significant clinical signs of toxicity or death at LD50 equal or greater than 2000 mg/Kg BW. thus, LD5 less than considered safe as previously demonstrated. This finding is comparable to previous scholarly reports (Sharma *et al.*, 2007; Asadu *et al.*, 2015; Zamrodah, 2016; Kumar *et al.*, 2018; Pingale, 2020).

An adverse change in body weight is a key indicator of the toxicological effects of extracts or drugs (Ugwah-oguejiofor and Ogbonna, 2019). In this study, the methanolic extract of *L.Camara* produced significant changes in relative liver, kidney, heart, and spleen weights, indicating its toxicity. This could be due to that the animals experience constipation immediately after consuming *lantana* extract, and they stop eating after about two hours (Shyamkumar *et al*., 2021). However, *S.incanum* caused insignificant body weights and organ weight changes. This result is comparable to the previously scholarly results (Sharma *et al.*, 2007; Asadu *et al.*, 2015; Zamrodah, 2016; Kumar *et al.*, 2018; Pingale, 2020).

One of the most sensitive targets of toxic compounds is the hematopoietic system, and it serves as an important index of physiological and pathological response to toxic insults. The hematological parameters such as RBC, WBC, HB, hematocrit, and MCV of the extract-treated mice and those of the control group were comparable, depicting the extract's safety. A nonsignificant increase in red blood cells and hemoglobin shows that the extract did not induce anemia. Moreover, there was change in WBC and Platelet count, which is known to rise in response to toxic environments. This result is in comparison with other result (Asadu *et al.*, 2015; Kumar *et al.*, 2018; Pingale, 2020).

The liver is the body's major organ for detoxification, and its damage may result from the accumulation of toxic compounds due to inefficient metabolism and excretion. This damage is usually assessed by determining serum transaminases (ALT and AST) and total protein in serum samples. In our study, there were significant alterations in the levels of alanine aminotransferase, aspartate aminotransferase, and total protein, which are indicators of liver dysfunction. In addition, the urea levels in female mice and creatinine levels in male mice, which received 1000 mg/Kg BW of the methanolic extracts of *L. Camara* and *S. incanum,* implying a possible impaired kidney function. This result is in comparable with other scholarly results (Asadu *et al.*, 2015; Kumar *et al.*, 2018; Pingale, 2020).

CONCLUSION AND RECOMMENDATIONS

In conclusion, this study identified the major poisonous plants on camels, evaluated the qualitative phytochemical composition, and investigated the acute and sub-acute toxicity of the methanolic extract of *L. Camara* and *S. Incanum*. The results showed that these plants are relatively non-toxic when administered orally for a short period with a dose less than 2000mg/kg, while sub-acute ingestion at a dose of ≥1000 mg/Kg BW induced reduced the body and vital organs weight and hepatotoxicity in experimental mice. Based on the findings, it is recommended that further research should focus on identifying the mechanism of toxicity. Moreover, pharmacological value appraisal of *L. Camara* and *S. Incanum* with larger doses and using other routes of administration other than oral may give more reliable results. The findings of this study also suggest the need for improved management practices and control measures to minimize the exposure of camels to toxic plants such as *Lantana Camara* and *Solanum Incanum*.

It is recommended that herders avoid grazing their camels in areas where these plants grow abundantly.

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Participatory Epidemiological Study of Reportable Livestock Diseases and Evaluation of Veterinary Vaccines in Selected Districts of Fafan Zone, Somali Region, Ethiopia

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ABSTRACT

Participatory epidemiology and questionnaire based cross-sectional survey was carried out from September 2022 to June 2023 in purposefully selected two districts of Fafan Zone, Somali Region, Ethiopia. with the aim of assessing the occurrence of reportable livestock diseases and evaluating the associated risk factors in veterinary vaccine failures in the study area. A total of 4 focus group discussions (FGDs) (2 FGDs in each district) comprising all animal species holders of consisting 12 – 15 individuals of both sexes were hired for each FGD. Thus, a total of 54 FGDs participants were included. proportional piling, ranking and scoring techniques were used while FGDs undertaken. For veterinary vaccines evaluation survey part, a total of 45 (25 from Awbare and 20 from Harshin district) respondents were involved. Thus, an overall total of 99 participants were recruited in the current study. By using SPSS ver.23, iterative, participatory and statistical analysis had employed for analyzing of the collected data. Results of participatory survey part has shown that PPR, SGP and CCPP were among the top ranked diseases from small ruminants. While, CBPP, LSD and FMD were uppermost ranked diseases in cattle. Similarly, anthrax and trypanosomiasis were reported as the top two most frequently occurring camel diseases in the study area. Moreover, our findings revealed that the incidence of CCPP, CBPP, LSD, PPR, trypanosomiasis and camel mange was higher in the wet season while the utmost occurrence of SGP, anthrax and FMD is confirmed in dry season. Furthermore, the present study discovered that there is occurrence of animal diseases following post vaccinations. This was happened because of different factors including use of improper animal vaccination schedule, difficulty in differentiating diseased and health animals before vaccination is commenced, use of spoiled veterinary vaccines and poor veterinary vaccination coverage. Hence, our findings warrant appropriate prevention and control measures of livestock diseases and effective ways of veterinary vaccine handling and practices in the study area.

***Key words**: Livestock Diseases, Participatory, vaccines, Ethiopia, Fafan Zone, Somali Region*

INTRODUCTION

In Ethiopia, pastoralist areas cover sixty percent (60%) of the total landmass, and inhabited more than 10 million of people in seven regional states. The pastoralist areas are divided into around 42 and 122 political administrative zones and districts respectively (pastoral forum 200). Currently, the pastoral areas are to be considered as the potential areas, which contributed for earning of national economy. The majority of these areas are engaged in extensive livestock herding, which forms the backbone of national economy. The Ethiopian pastoralist groups

managed some 40% of the national cattle herd one quarter of the sheep three quarter of the goats and nearly all the camels. The Somali regional state (SRS) of Ethiopia is considered as one of the high livestock resource potential areas in the country. Livestock rearing or pastoralism is the dominant and indispensable practice followed by little mixed farming in the higher altitude and valley areas of the region (Little, 2001).

Somali Regional state (SRS) is divided in to eleven administrative zones and 93 woredas with an area of an estimated 315,100 square kilometers, the region constitutes nearly one third of the total area of the country. It is located in the southeastern part of Ethiopia and is bordered by Oromia Regional State in the west, Kenya in the south by Somali in the east & south east, in the north by the Afar Region state & in the northeast by Djibouti. The total population of the Somali Region was estimated 4.5 million (CSA, 2007). The region is classified as arid & semiarid Agro-ecological zones and the altitude varies from 300-2000 meter above sea level with an average annual rainfall of 300-800mm. The low annual rainfall & its uneven distribution combined with recurrent drought makes water & pasture the most important element that determines people's lifestyle. The livestock resource base of the region is considered amongst the largest in the country.

Based on the industrial project service (IPS) 2000 census, the total livestock population of the region is estimated at 23.6 million. However, this huge number of resources is not benefiting the region in proportion to its size and potential. One of the main causes of this mismatch between population size and production output from livestock in the region is undoubtedly: the widespread occurrences of multitude of infectious diseases which drastically reduce the production of the animals through morbidity, mortality, market restriction and; limited gene pools for stock upgrading. Animal diseases are wide spread in all ecological zones of the region. The main livestock diseases prevalent in the region are thought to be Poxes affecting different species, PPR, CBPP, CCPP, Pasteurellosis, anthrax, blackleg, Trypanosomiasis, and internal and external parasites. Despite, the wide spread of animal disease in almost all ecological zones of the region, the actual distribution or prevalence of the economically important diseases in each ecological zones of the region is not yet, well established. In situation when, the distribution and prevalence of the diseases that hinder the livestock production and productivity is not well studied, it's very difficult to control livestock diseases and to improve the livelihood of the region through improving livestock production and productivity.

On the other hand, vaccines are key component of livestock disease prevention and control worldwide. Vaccines have a major role in protecting animal health and public health, reducing animal suffering, enabling efficient production of food animals, and greatly reducing the need for antibiotics to treat food and companion animals (Abdella *et al.*, 2016). Good-quality veterinary vaccines are essential for the maintenance of animal health. They are an important means of control for many animal diseases, and crucial components of many national disease-control or eradication programs (Bayise *et al.*, 2011). To ensure these qualities, Vaccines are supplied with specific instructions such as dose rate, storage and administration procedures, any side effects that may potentially occur, withdrawal periods, and the expiry date of the product. These instructions are very important and must be understood and followed to ensure that the product does what it is supposed to do (Bolajoko, 2015).

However, these important activities can be seriously compromised by poor vaccine storage, handling and transport (BoLFR, 2015). Proper supplies are essential for the safe transport of vaccines and proper packing should be maintained before transporting (CSA, 2011). During transportation, refrigerated and frozen vaccines must maintain their optimal temperature values to preserve their potency. Means of transport used must maintain the potency of the vaccine as it is (CSA, 2014/2015). The loss of vaccine effectiveness due to cold chain exposures to adverse conditions is cumulative, permanent and irreversible (Dejemu 2004). Vaccine wastage results in increased costs (to replace the wasted vaccines, human services and specialized transportation). With the globalization of the vaccine manufacturing industry, and intermittent global vaccine shortages, it is not always possible to quickly obtain additional quantities of vaccines to replace vaccine that is wasted (Ellis, 1994).

Awareness of vaccine transport, storage and handling issues is greater in humane medicine than in veterinary medicine because of the risk of epidemic diseases such as polio, influenza, and smallpox (Catley *et al.*, 2002). By reviewing research on human vaccine protocol, veterinary professionals can learn a great deal about proper vaccine handling (ESAP, 2009). In Ethiopia including Somali Region there are problems related to vaccine efficacy and continuous outbreaks in vaccinated animals (Fasanella, 2011). This might be due to improper production or storage and handling of the vaccines. In view of these challenges, through participatory epidemiological tools this research project was aimed to investigate the occurrence of reportable priority livestock

diseases and assess the associated risk factors of their occurrence in the study area. Furthermore, the current project was emphasized to assess the factors affecting veterinary vaccines failures and occurrence of diseases following post vaccination in the study area. Consequently, this survey provided baseline information about the overall functional status of veterinary vaccines used and designing of the control and prevention strategies against the identified major livestock diseases.

MATERIAL AND METHODS

Description of the study area

As it is true for all participatory appraisals, both the survey localities and sample for this project was selected purposively. Such circumstances among others preclude formal randomized studies. Thus, based on their geographical location, proximity to livestock markets, potentiality for livestock production and socioeconomics characterization, two districts of Fafan zone, namely Awbare and Harshin was purposively selected for this project with a future intention of expanding to other districts. Fafan zone is situated in the eastern part of Ethiopia about 630km east of Addis Ababa. The altitude of Fafan zone ranges from 500 to 1650 meter above sea level and is located between 90 20' north latitude and 450 56' east longitudes. The climate of the Fafan zone is semi-arid type which is characterized by high temperature. The area receives a precipitation ranging from 300 to 600 mm per annum and an average daily temperature of 16°C to 20°C (Keskes *et al.*, 2013). The annual rainfall in the area ranges from 600mmto 700mm.linelihhood of the zone is based on the livestock production. The estimated livestock population of the zone includes 558,229 cattle, 807,519 sheep, 712,699 goats 126,911 camels and 22,894 poultry (CSA, 2021).

Study Design

Participatory epidemiological and questionnaire based cross-sectional survey was carried out from September 2022 to June 2023 in purposefully selected two districts of Fafan Zone, Somali Region, Ethiopia. To do so, the project made use of participatory epidemiological tools including informal interviews (**s**emi-structured questionnaires and focus group discussions) visualization techniques (seasonal disease calendars and proportional pilling); scoring and ranking methods for the occurrence of reportable priority livestock diseases. Moreover, to measure the importance

that people place on each of them and to know and prioritize economically important livestock diseases in the target areas, simple and pair-wise ranking techniques were employed. Besides these, by using semi-structured questionnaire assessment of factors affecting veterinary vaccine failures in the study area was employed.

Sample size determination and sampling techniques

Convenient and purposive sampling techniques were employed to select study areas and study participants, respectively. Awbare and Harshin district were conveniently selected from the nine districts of Fafan zone, Somali region, Ethiopia based on their accessibility. A total of 4 key informant groups (2 groups from each district), each comprising of 12 – 15 members, were established and handled in the study area. Key informants were purposefully selected based their indigenous knowledge and experiences of livestock herding. The study was conducted in 4 kebeles (2 from each district) which were selected based on their accessibility and livestock population. The total number of key informants selected from two districts were 54 and their group composition was made to include different community members. Due to absence and non-functionality of existing vet clinics and animal health posts and of course small study population of field veterinary professionals the entire population were included. Moreover, convenient sampling technique was used to identify pastoralists/Agro-pastoralists (potential respondents) who have had better awareness and understanding for the veterinary vaccines given to the animals and occurrence of disease conditions following post-vaccinations in their localities. Onwards these, a total of 45 (25 from Awbare district and 20 from Harshin district) respondents were involved in the evaluation of veterinary vaccine failure. Thus, a total of 99 participants were recruited in this research study.

Data Collection Methods

Participatory Epidemiological Methods

A participatory epidemiological appraisal was used to gain a rapid overview of the range of important reportable *livestock* diseases and to document a measure of the importance that people place on each of them, accordingly. Accordingly, different participatory tools like informal interviews (Semi-structured questionnaires and group discussions); visualization techniques (seasonal disease calendar and proportional pilling) ranking and scoring methods were

employed. Once the respondents and the appraisal team have constructed a list of livestock diseases for a particular species. Finally based on frequency of occurrence, animal herders' livelihood impact and seasonal distribution in the study area, simple and pairwise ranking (prioritization of livestock diseases) were employed.

Questionnaire Method

Semi-structured questionnaire which was firstly prepared in English and later translated to regional working language (Somali) was used as a data collection tool for this particular cross-sectional survey of assessing the causes of veterinary vaccine failures in the study area. The questionnaire was comprised of items regarding respondents' sex, age, and levels of education, and practice with respect to handling, storage and utilization of veterinary vaccines in the study areas.

Data Organization and Analysis

By using SPSS ver.23, Iterative, Participatory and Statistical Analysis had employed for analyzing of information and gathered data from the study. Agreement among the scores of informant groups was assessed using Kendall coefficient of concordance (W) (Siegel and castellan, 1994). In all the analyses, confidence interval level of 95% and $P \leq 0.05$ was deemed to be statistically significant.

RESULTS AND DISCUSSION

Participatory Epidemiological Study Result

Focus Group Discussion

Participatory epidemiology (PE) tools like proportional piling, seasonal calendar, ranking and scoring methods were used as described by (Catley, 2006; Jost *et al*., 2007 and Ameri *et al*., 2009) to collect data during the 4 FGDs sessions conducted in the study areas (Table 1). Common major livestock diseases in animals were raised by species affected and according to their importance. The FGD participants were then asked to list important livestock diseases in their localities of which contributing poor livestock production and greatest socio-economic losses. Doing so, informant groups in each district were discussed amongst themselves and came up with a list of different viral, bacterial and parasitic diseases in sheep, goats, cattle and camels with their local vernacular names (Tables.2 and 3).

Table 1. FGD's Conducted in the Study area

Names of Districts	**Awbare**		**Harshin**		# Overall FGDs
Names of Kebeles	Shed der	Lafaissa	Farah liban	Lan qeyrta	
No. FGDs in each kebeles	1	1	1	1	
# FGDs in each district	2		2		4

Table 2. Identified Major Livestock Diseases and Syndromes with their Local Vernacular Names in Awbare District

S/N	**Diseases and Syndromes**	**Local Vernacular Names (Somali)**	Species affected
1	Sheep and Goat pox	Furuqa adhiga	Sheep and goats
2	Pest des Petitis ruminants	Qalwa dumiye	Sheep and goats
3	Listeriosis/Circling Disease	Shimbir	Sheep and goats
4	Small ruminant brucellosis	Dhiciska adhiga	Sheep and goats
5	Contagious Caprine Pleuropneumonia (CCPP)	Sam babka riyaha	Goats
6	Ovine pasteurellosis	Cuna barar	Sheep
7	GIT Parasites	Caal	Sheep and goats
8	Diarrhea	Xaar	Sheep and goats
9	Contagious Bovine Pleuro Pneumonia (CBPP)	Sambabka lo'da	Cattle
10	Anthrax	Kud	Cattle
11	Foot and Mouth Diseases (FMD)	Cabeeb	Cattle
12	Lumpy Skin Disease	Buur	Cattle
13	GIT Parasites	Goryaan calooleed	Cattle
14	Heart water/Cowdriosis	Wadno biyood	Cattle
15	Mastitis	Candho barar	Cattle
16	Camel Pox	Furuqa geela	Camels
17	Camel Mange	Candhada geela	Camels
18	Anthrax	Kud	Camels
19	Pneumonia	Eebo	Camels
20	Camel Brucellosis	Dhiciska geela	Camels
21	Camel Pasteurellosis	Cuna bararka geela	Camels
22	Hemorrhagic Septicemias	Gariir	Camels

Table 3. Identified Major Livestock Diseases and Syndromes with their Local Vernacular Names in Harshin District

S/N	**Diseases and Syndromes**	**Local Vernacular Names (Somali)**	Species affected
1	Sheep and Goat pox	Furuqa adhiga	Sheep and goats
2	Pest des Petitis ruminants	Qalwa dumiye	Sheep and goats
3	Foot rot	Raaf dillaac	Sheep and goats
4	Small ruminant brucellosis	Dhiciska adhiga	Sheep and goats
5	CCPP	Sambabka riyaha	Goats
6	Ovine Pasteurellosis	Cuna barar	Sheep
7	GIT Parasites	Caal	Sheep and goats
8	Bloat	Dibiro	Sheep and goats
9	Tick paralysis	Qalal	Sheep and goats
10	CBPP	Sambabka lo'da	Cattle
11	Anthrax	Kud	Cattle
12	FMD	Cabeeb	Cattle
13	Lumpy Skin Disease	Buur	Cattle
14	GIT Parasites	Goryaan cajoled	Cattle
15	Ecto-parasites	Jini	Cattle
16	Tick borne diseases	Kaadi dhiig	Cattle
17	Mastitis	Candho barar	Cattle
18	Pneumonia	Oof	Camels
19	Trypanosomiasis	Dhukaan	Camels
20	Camel Pox	Furuqa geela	Camels
21	Camel Mange	Cadhada/Baagta geela	Camels
22	Anthrax	Kud	Camels
23	Camel Brucellosis	Dhiciska geela	Camels
24	Camel Pasteurellosis	Cuno bararka geela	Camels

Proportional Piling

Proportional piling technique was used to allow FGD participants for ranking of livestock diseases occurrence in relation to its important in the target species in their localities. To do so,

firstly circles were drawn on the flip chart representing sick animals from sheep, goats, cattle and camels separately with different diseases. Participants were given 50 counters (stones) to divide among the circles according to the relative importance of each disease in the target species. Time was given to discus and debate as well as to divide the counter by consensus. Then when they all agree with their results, counters were counted and registered on the flip chart where simple and pair-wise ranking was employed later on, accordingly (Figure 1).

Figure 1. Proportional Piling Performance by the Informant groups in Awbare district



Major Livestock Diseases in the Study Area

Frequency of sheep and goat diseases occurrence

In simple ranking, informants in Awbare district ranked pest des petitis ruminants (PPR) "*Qalwo dumiye*", sheep and goat pox (SGP) "*Geed caanood*" and contagious caprine pleuropneumonia (CCPP) "*Sam babka riyaha*" or gastro-intestinal parasites (GIT) parasites "*Caal*" followed by listeriosis (Circling disease) "*Shimbir*", Pasteurellosis "*Cune barar*" and brucellosis "*Dhiciska adhiga*" in descending order as the most frequently occurring sheep and goat diseases in their localities. The corresponding rank by informants in Harshin district was almost similar with that of Awbare district as PPR, SGP, Pasteurellosis, CCPP, GIT, foot rot, brucellosis and tick paralysis in descending order. Unlike in Awbare, in Harshin district some diseases are locally named as *Xaaraami* (PPR), and "*Furuqa adhiga"* (SGP). PPR and SGP were ranked in 1st and 2nd most frequently occurring diseases in sheep and gouts from all informant groups in both districts, Foot rot, bloat and tick paralysis was reported only by the informant groups in Harshin

district while listeriosis and diarrhea were solitary to informant groups of Awbare district. Kendall's coefficient of concordance (W) for informant groups for the occurrence of sheep and goat diseases indicated statistically non-significant strong agreement in both districts, Awbare (W = 0.86; p > 0.05) and Harshin (W = 0.89; p > 0.05) (Table 4).

Table 4. Simple ranking of major sheep and goat diseases by informants in the Study Area

Disease	**N[a]**	**Median score**	**Rank**	**N[a]**	**Median score**	**Rank**
PPR	2	12.5	1	2	10.0	1
SGP	2	10.0	2	2	9.0	2
Listeriosis	2	4.5	4	-	-	-
Ovine Pasteurellosis	2	4.5	4	2	7.0	3
Brucellosis	2	3.5	5	2	4.5	7
CCPP	2	6.5	3	2	6.5	4
GIT-Parasite	2	6.5	3	2	6.0	5
Diarrhea	2	2.0	6	-	-	-
Foot rot	-	-	-	2	5.0	6
Bloat	-	-	-	2	1.0	8
Tick paralysis	-	-	-	2	1.0	8
W[b]		0.86		0.89		
P		0.095		0.072		

[a]Number of informant groups

[b]Kendall's Coefficient of Concordance

Frequency of cattle diseases occurrence

Based on the result of simple ranking, informants in Awbare district ranked contagious bovine pleuropneumonia (CBPP) "*Sam babka lo'da*", lumpy skin diseases (LSD) "*buur buur*", anthrax "Kud", foot and mouth disease (FMD "*Cabeeb*", gastro-intestinal tract (GIT) parasites "*Caal*" ecto-parasites infestation "*Dulin*", Cowdriosis and mastitis "*Candho xanuun*" in descending order as the most frequently occurring cattle diseases in their localities. The corresponding list of major cattle diseases by informants in Harshin district was almost similar with that of Awbare district however by rank they were quite different as ecto-parasites infestation "*Dulin*", foot and

mouth disease (FMD "*Cabeeb*" contagious bovine pleuropneumonia (CBPP) "*Sam babka lo'da*", lumpy skin diseases (LSD) "*buur buur*", gastro-intestinal tract (GIT) parasites "*Caal*" and anthrax in descending order. In this survey, Cowdriosis and bovine mastitis was reported only by the informant groups in Awbare district. Similar to small ruminants' diseases, slightly, strong agreement was noted between the informant groups in both of the districts (W = 0.96 & 0.74). However, it was not statistically significant (p > 0.05) (Table 5).

Table 5. Simple ranking of major cattle diseases by informants in the Study Area

Disease	N[a]	Median score	Rank	N[a]	Median score	Rank
LSD	2	10.0	2	2	8.0	4
CBPP	2	12.0	1	2	8.5	3
Anthrax	2	7.0	3	2	5.0	6
GIT parasites	2	5.0	5	2	6.0	5
Cowdriosis	2	3.0	7	-	-	-
FMD	2	6.0	4	2	11.0	2
Mastitis	2	2.5	8	-	-	-
Ectoparasites	2	4.5	6	2	11.5	1
W		0.96		0.74		
P		0.062		0.191		

[a]Number of informant groups
[b]Kendall's Coefficient of Concordance

Frequency of camel diseases occurrence

The results of simple ranking for major camel diseases occurrence, informants in Awbare district ranked camel pox "*Furuqa geela*", anthrax "*Kud*", pneumonia "*Oof*", camel brucellosis "*Dhiciska geela*", trypanosomiasis/camel mange "Dhukaan/Baagta geela" camel pasteurellosis "Cune bararka geela" and hemorrhagic septicemia "*Gariir*" in descending order as the most frequently occurring camel diseases in their localities. The equivalent list of major camel diseases by informants in Harshin district was almost similar with those in Awbare district. Nevertheless, informants in Harshin district ranked camel pasteurellosis, trypanosomiasis, camel mange, pneumonia, anthrax, camel pox and camel brucellosis in descending order as the most

frequently occurring camel diseases in their areas. Similar to small ruminants and cattle diseases, strong and slightly agreement was noted between the informant groups in Awbare and Harshin districts (W = 0.96 and 0.74) respectively. However, again this was not statistically significant (p > 0.05) (Table 6).

Table 6. Simple ranking of major camel diseases by informants in the Study Area

Disease	N[a]	Median score	Rank	N[a]	Median score	Rank
Pneumonia	2	7.5	3	2	6.0	4
Anthrax	2	10.5	2	2	5.5	5
Camel pox	2	11.0	1	2	5.0	6
Camel brucellosis	2	6.5	4	2	3.5	7
Trypanosomiasis	2	5.0	5	2	10.0	2
Camel mange	2	5.0	5	2	9.5	3
Camel Pasteurellosis	2	2.5	6	2	10.5	1
W[b]		0.92		0.71		
P		0.076		0.199		

[a]Number of informant groups
[b]Kendall's Coefficient of Concordance

Pair-wise Ranking

Considering Lafaissa and Laanqeyrta kebeles of Awbare and Harshin district, respectively as the representativeness' of the study area the final top five diseases selected during simple ranking were subjected to pair wise ranking. During the pair wise ranking the data collection team recorder sketched a 5 × 5 grid on a flip chart paper by using local vernacular names of the five diseases. This was important as writing down the scientific names of the diseases alienates participants who cannot recognize from the discussions. FGD participants were then allowed to compare each disease against the others in each species one-by-one. The criteria for comparison of livestock diseases were in their frequency of occurrence, animal herders' livelihood impact and seasonal distribution in the study area. Subsequently, the total score (0 – 4) for each disease in a group was noted. and sequentially ranked from 1 to 5. On these regards, the result of pair-wise ranking revealed that pastoralists from the two districts ranked PPR, SGP and CCPP as the

top three highest ranking diseases in small ruminants. This result is compatible to the previous report of Ibrahim *et al*., (2022) who reported that PPR, SGP and CCPP were among the top five diseases of small ruminants in Adadle district of Shabelle zone, Somali region, Ethiopia. Moreover, gastro intestinal parasites were reported as the fourth important small ruminants' disease by informants in both districts. This result may be evidenced by the previous report of Giles *et al*., (2022) who confirmed that in Somali region increased deaths of pastoralist herds including sheep and goats were associated with gastrointestinal diseases. However, brucellosis and pasteurellosis were reported separately as the fifth important shoat diseases from Awbare and Harshin district, respectively (Tables 7).

Table 7. Pair-wise Ranking of Major Shoat Diseases by Informants in in the Study Area

Awbare district							
Diseases	PPR	SGP	CCPP	GIT-Parasites	Brucellosis	Score	Rank
PPR	**X**	PPR	PPR	PPR	PPR	4	1
SGP		**X**	CCPP	SGP	SGP	2	3
CCPP			**X**	CCPP	CCPP	3	2
GIT-Parasites				**X**	GIT-Parasites	1	4
Brucellosis					**X**	0	5
Harshin district							
Diseases	PPR	SGP	Pasteurella	CCPP	GIT-Parasites	Score	Rank
PPR	**X**	SGP	PPR	PPR	PPR	3	2
SGP		**X**	SGP	SGP	SGP	4	1
Pasteurellosis			**X**	CCPP	GIT-Parasite	0	5
CCPP				**X**	CCPP	2	3
GIT-Parasites					**X**	1	4

Regarding to the cattle diseases, pairwise ranking in both districts revealed that CBPP, LSD and FMD in descending order were the top three most frequently occurring diseases in the study area. Our finding is in agreement with that of Gizaw *et al*., (2021) who reported that most frequently reported diseases from Somali region were CBPP and LSD. Despite, the prevalence of FMD is highest in intensive production systems, somewhat lower in mixed farming systems, and lower in pastoral systems; Giles *et al*., (2022) reported that increased numbers of abortions in cows from

Somali region was appreciably caused by FMD. Furthermore, outside Somali region recently Oyda *et al*., (2020) reported LSD and FMD as among the top five most frequently occurring cattle diseases in Boloso sore and Bensa districts of southern nations, nationalities and peoples' (SNNP) regional state. Additionally, in the present study gastro intestinal and ecto (including hard ticks, mites, lice and fleas) parasites were ranked distinctly as the fourth important cattle diseases by the informant groups of Awbare and Harshin district, respectively. This result is in agreement with the findings of Teshome *et al*., (2023) who reported a higher prevalence of gastro-intestinal parasites in cattle from Moyale district. Nevertheless, it is in disagreement with previous report of Gizaw *et al*., (2021) who reported gastro-intestinal parasites as the least priority diseases from Somali region. Anthrax was reported as the least most frequently occurring cattle disease from Awbare district and not reported at all by the informant groups in Harshin district (Table 8). Again, the present study is in promise with that of Gizaw *et al*., (2021) who described that anthrax was not included in the most frequently reported cattle diseases from Somali region. Nevertheless, in contrary to the current finding recently Tesfaye *et al*. (2023) reported anthrax as one of the top three diseases in cattle from north Shewa zone of Oromia, Ethiopia. The different in disease ranking between the two studies might be due to the Agro ecological differences of the study areas.

Table 8. Pair-wise Ranking of Major Cattle Diseases by Informants in the Study Area

Awbare district							
Diseases	CBPP	LSD	Anthrax	FMD	GIT-Parasite	Score	Rank
CBPP	X	LSD	CBPP	FMD	CBPP	2	3
LSD		X	LSD	LSD	LSD	4	1
Anthrax			X	FMD	GIT-Parasite	0	5
FMD				X	FMD	3	2
GIT-Parasite					X	1	4
Harshin district							
Diseases	LSD	CBPP	Ectoparasite	FMD	GIT-Parasite	Score	Rank
LSD	X	CBPP	LSD	FMD	LSD	2	3
CBPP		X	CBPP	CBPP	CBPP	4	1
Ecto-parasite			X	FMD	Ecto-parasite	1	4
FMD				X	FMD	3	2
GIT-Parasite					X	0	5

Based on the result of pairwise ranking for the incidence of camel diseases, anthrax and trypanosomiasis were reported as two of diseases among the top three most frequently occurring camel diseases in the study area. The current study also identified camel mange and camel pox as the first and third most frequently occurring camel diseases from Harshin and Awbare district, respectively. This result is aligned with the finding of Negash *et al*., (2020) who reported trypanosomiasis, camel mange and camel pox as among the top five most frequently occurring camel diseases in selected areas of Afar regional state, Ethiopia. However, camel brucellosis and camel pasteurellosis were ranked separately as the fourth important camel diseases by the informant groups in the study area. This could be evidenced by the recent report of Waktole *et el*., (2022) who confirmed the highest prevalence of camel brucellosis in camels' dromedaries from in and around Dire Dawa town, Eastern Ethiopia. Pneumonia in camels was reported as the least most frequently occurring camel disease syndrome from both districts. Moreover, (Table 9).

Table 9. Pair-wise Ranking of Major Camel Diseases by Informants in the Study Area

Awbare district							
Diseases	C.pox	Anthrax	Pneum.	CB	Tryp.	Score	Rank
Camel pox	X	Anthrax	C.pox.	C.pox	Tryp.	2	3
Anthrax		X	Anthrax	Anthrax	Anthrax	4	1
Pneumonia			X	CB	Tryp.	0	5
Camel Brucellosis				X	Tryp.	1	4
Trypanosomiasis					X	3	2
Harshin district							
Diseases	CP	Tryp.	CM	Pneum.	Anthrax	Score	Rank
Camel Pasteurellosis	X	Tryp.	CM	CP	Anthrax	1	4
Trypanosomiasis		X	CM.	Tryp.	Tryp.	3	2
Camel mange			X	CM	CM	4	1
Pneumonia				X	Anthrax	0	5
Anthrax					X	2	3

Seasonal Calendar

To describe the seasonal variation in prevalence/importance of major livestock diseases in the study area. The seasons are roughly divided into two periods, namely wet (March - August) and Dry (September – February) season. To construct seasonal calendar identified major diseases in shoat, cattle and camels along the y-axis and the two seasons in relation to their kebeles on the top of flip chart of the diagram were labeled respectively. Doing so, in this scenario 100 stones were given for each of the 4 FGD's that were established in the study areas and asked to show the relative occurrence of diseases in sheep, goats, camels and cattle in each season, accordingly. When placing of the objects for diseases occurrence against the season was complete, the group was requested to thoroughly check the scores and if they want, rearrange the scores until they were contented with the result. Based on similar scoring method, more items were added one by one to the seasonal calendar and scored by the informant groups. A completed seasonal calendar comprised two seasons along the x-axis of the diagram and response in disease incidence regarding to the seasons of the year along the y-axis of the diagram. Following this, a summarized seasonal calendar of the top ranked shoat, cattle and camel diseases in Awbare and

Harshin districts is shown in Table 10. Statistically significant agreement was evident among the informants' groups concerning the seasonal occurrence of all of the summarized diseases between wet (W= 0.82; p = 0.000) and dry (W = 0.64; p = 0.006) season. Informants in both districts agreed that the incidence of CCPP, CBPP, LSD, PPR, trypanosomiasis and camel mange is higher in the wet season (March-Aug) while the utmost occurrence of SGP, anthrax and FMD is in the dry season (Sept -Feb). (Tables 10).

Table 10. Summarized Seasonal Calendar for Major Shoat, Cattle and Camel Diseases in the Study Area

	Wet (Mar -Aug)			Dry (Sept -Feb)		
Disease	**N[a]**	**Median score**	**Rank**	**N[a]**	**Median score**	**Rank**
PPR	4	13.25	3	4	4.25	8
SGP	4	5.5	8	4	22.75	1
CCPP	4	15.5	1	4	6,75	6
CBPP	4	14.75	2	4	7.75	4
LSD	4	13.25	3	4	5.25	7
FMD	4	6.0	7	4	19.8	3
Camel mange	2	7.75	5	2	2.5	10
Trypanosomiasis	4	12.25	4	4	7.25	5
Anthrax	4	5.5	8	4	20.75	2
Camel pox	2	6.25	6	2	3.0	9
W[b]		0.82		0.64		
P		0.000		0.006		

[a]Number of informant groups
[b]Kendall's Coefficient of Concordance

Assessment of Usable Veterinary Vaccines

Socio-demographic characteristics of respondents

A total of 25 veterinary professionals (15 from Awbare district and 10 from Harshin district) and 40 herders (20 herders from each district) were participated in the current study. The overall

mean age of respondents was 39 years. Majority of respondents were male (73.8%) and highest proportions (30.0%) were between 30 to 50 years age groups. Around 67.7% were married as at the time of the study. Regarding to educational level, 16.9% and 21.5% were primary and religious school graduates, respectively. However, the percentage of illiterate respondents were also relatively high (18.5%). Moreover, while 7.7% and 12.3% and 10.8% were community animal health workers (CAHWs), animal health technicians (AHT) and animal health assistants (AHA) respectively. Only 3.1% and 4.6% of the respondents were bachelor of veterinary science (BVSc) and doctor of veterinary medicine (DVM) holders (Table 11).

Table 11. Socio-demographic features of respondents

Variables	Category	Frequency	Percent (%)
Sex	Male	48	73.8
	Female	17	26.2
Age	< 30	24	25.3
	30 - 50	36	37.9
	>50	29	30.5
Marital status	Single	21	32.3
	Married	44	67.7
Level of education	Illiterate	12	18.5
	Primary	11	16.9
	Secondary	3	4.6
	CAHWs	5	7.7
	AHT	8	12.3
	AHA	7	10.8
	BVSc	2	3.1
	DVM	3	4.6
	Religious school	14	21.9

Common Veterinary Vaccines Used in the Study Area

Available livestock veterinary vaccines with their corresponding ways of storage that were accessible in the study area are listed in Table 12. As indicated in the all most all vaccines were kept at room temperature.

Table 12: Veterinary Vaccines Available in The Study Area.

Vaccines	Type	Recommended Way of storage
PPR	Live	-20^0C
SGP	Live	-20^oC
Ovine pasteurellosis	Killed	$+4^0$C
CCPP	Inactivated	$+4^0$C
CBPP	Inactivated	$+4^0$C
LSD	Live attenuated	-20^0C
FMD	Inactivated	$+4^0$C
Blackleg	Killed	$+4^0$C
Bovine Pasteurellosis	Killed	$+4\ ^0$C
Anthrax	Live	$+4\ ^0$C to -20^0C

Means of Transportation, Storage and Utilization of Veterinary Vaccines

The current study revealed that veterinary vaccines are purchased from NVI by the regional government and transported in cold ice box to the districts for vaccination campaign programs when in need. However, a bulk storing of veterinary vaccines in the district level is not more visible since there is no availability of vaccine storage facilities. But for killed vaccines and diluents are stored at room temperature when it comes. Absence of electric power service was common problem in the study area. 90% (45/50) of the interviewed animal health staffs who were involved in the veterinary services at district level were described that delayed and inadequate storage facilities of veterinary vaccines in the study area could be the main cause of loss of vaccine effectiveness. Furthermore, 96% of the respondents were described that lack of means for transportation to distribute veterinary vaccines from districts to kebeles and sub-kebeles is a great problem and more challenge full in great success of veterinary vaccine programs. All most all of the interviewed respondents (100%) were described that they didn't receive any type of training on vaccine handling and storage protocol. regarding to the schedule of veterinary vaccination in the study area, 80% of the respondents said that on request is the way for vaccination to be undertaken in the district. While the remaining 20% said that when disease outbreak begins the regional government may implement the vaccine campaign, accordingly (Table 13).

Table 13. Access, transportation and handling of veterinary vaccines

Variables	Category	Frequency	Percent (%)
Access to veterinary vaccines in the right time	Yes	5	10
	No	45	90
Transportation facilities for district veterinary vaccine	Yes	2	4
	No	48	96
Training on vaccine handling	Yes	0	0
	No	50	100
Ways for Vaccination campaign Programs	Periodically	0	0
	When disease outbreaks	5	20
	On request	20	80

Occurrence of livestock diseases following vaccination

76% and 80% of animal health staffs and animal herders were responded that there is occurrence of animal diseases following post vaccination programs, respectively. Moreover, around 53.8%, 26.1% and 80% of the respondents in the current study were claimed that this condition could resulted from different factors including use of improper animal vaccination schedule, difficulty in exclusion of already diseased animals before the animal vaccination is commenced and use of spoiled veterinary vaccine, respectively. Furthermore, 73.8% of the respondents for this particular survey were described poor coverage of veterinary vaccination programs as an additional reason for the occurrence of livestock diseases following post vaccination in the study areas (Table 14).

Table 14. Probable factors related with livestock disease occurrence after vaccination.

Variables	Category	Frequency	Percent
Post-vaccination disease occurrence (Veterinary staffs)	Yes	19	76
	No	6	24
Post-vaccination disease occurrence (Animal herders)	Yes	32	80
	No	8	20
Reasons for post-vaccination disease occurrence	Improper animal vaccination schedule	35	53.8
	In exclusion of already diseased animals	17	26.1
	Use of spoiled vaccine	52	80
	Poor coverage of veterinary vaccination programs	48	73.8

CONCLUSION AND RECOMMENDATIONS

The participatory epidemiological (PE) part of the present study revealed that there was a strong level of agreement among key informant groups in ranking the diseases by their frequency of occurrence, animal herders' livelihood impact and seasonal distribution in the study area. Moreover, statistically significant agreement was observed among informant groups for the incidence of diseases between wet season (March-Aug) and dry season (Sept -Feb). of course, this could be evidence that livestock herders in the study area have a good perception about animal diseases occurring in their localities. Besides, this study confirmed that livestock herders have similar and equal understanding of the epidemiology of diseases and are equally affected by the diseases. Additionally, as part of its core activities the present study identified PPR vaccine, SGP vaccine, blackleg vaccine, CCPP vaccine, CBPP vaccine, pasteurellosis vaccine, Anthrax vaccine and LSD vaccine as available veterinary vaccines in the study areas. However, absence of storage facilities and means of transportations with devoid of training on vaccine handling and procedures to woreda veterinary staffs were likely to affect the efficacy of these vaccines. Furthermore, the present study revealed that there is occurrence of animal diseases following post vaccination programs because of different factors including use of improper animal

vaccination schedule, difficulty in differentiating diseased and health animals before vaccination is commenced use of spoiled veterinary vaccines and poor veterinary vaccination coverage.

Based on the above conclusion, the following recommendations are forwarded:

- Active disease surveillance rather than participatory and retrospective survey of disease records is highly effective in animals' disease prevention and control
- In the medium to long term, health facilities and laboratories need to be better equipped and the number of veterinary staff in the public and private sectors should be increased.
- he regional immunology and epidemiological units should be more alert for the provision of veterinary vaccination programs and give quick response to any notification message of disease outbreak.
- Provision of vocational trainings on vaccine handling and storage to woreda veterinary staffs is highly required.
- Using of purpose-built refrigerators and domestic refrigerators for vet. vaccine storage should be initiated and established in the study area.

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Epidemiological and Therapeutics Studies of Tick Species in Cattle and Small Ruminants in Gursum District, Fafan Zone, Somali Region, Ethiopia

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ABSTRACT

*To overcome the economic and health problems posed by ectoparasite invasion application of chemicals in livestock was deemed appropriate control strategies in place as effective method of ectoparasite control**.** Continuous studies on the responsible factors for the dynamics of tick population with the efficacy status of acaricides against the most abundant and important tick in particular area are necessary to carry out efficient tick control and/or tick burden reduction (Dinka et al, 2014). Therefore**,** this study was conducted from June 2022 to May 2023 in Gursum pastoral community with the objectives identifying common tick species and conduct comparative field efficacy trial of the commonly used acaricides in the area. The standard procedure involved hand dressing and manually spraying each acaricide, relying on repeated applications of frequently insufficient acaricide concentrations without changing the acaricidal product. The result of the clinical trial revealed that the three sheep and cattle study animals injected with ivermectin and analyzed after fifth day were found to still possess ticks around different areas of their body. This was suggestive that the ticks on these animals apparently got resistant and ineffective. While study animals injected with Cypermethrin didn't have ticks on them. This indicated that the level of resistance the ticks had on the two drugs was different. The result clearly showed that not the acaricide but the problem was dilution, preparation and application of acaricides according to major predilection sites of ticks. In order to manage resistance and select an appropriate medication, it is essential to regularly check cattle ticks for the development of resistance against various classes of chemical acaricides.*

Key words: *Acaricide, Animals, Efficacy, Ethiopia, In-vitro evaluation, Ticks, Somali Region*

INTRODUCTION

In Ethiopia, livestock is an important part of the entire farming system. According to various estimations, livestock provides 12-16 % GDP and 30-35 % of agricultural GDP. The livestock sector's contribution to national output is devalued because traction power and dung for fertilizer are not taken to account as valuable inputs. It accounts for 12-16 % live animal, hide, and skin exports. In addition, the sector employs around one-third of the country's rural population.

Therefore, livestock can act as a vehicle for improving the food security and better livelihood, and also contributes significantly to agricultural and rural development (Kleeman *et al*., 2009). Ruminant livestock are a significant source of revenue for rural populations and one of the country's principal export currencies (Getachew, 1995). It carries out multiple functions in the Ethiopian economy like utilization of their dung, income generation of the rural household supplying food, soil fertility management, raw material for industry, fuel, social functions and employment (Tesfaye, 2008).

Small ruminants are the most important sources of income for the agricultural communities and are one of the main earners for foreign currency through skin and meat export. In addition, these are among the most important sources of animal proteins, accounts for 35% of meat and 14% of milk for local consumptions and constitute 92% of the value of semi-processed skin export trade (Kleeman *et al*., 2009). However, their contribution to food production, rural cash income, and manure for soil fertility and export income are far below the expected potential (Getachew, 1995). This may be due to several factors, such as shortage of feed, genetic selection, housing and ectoparasites (Tesfaye, 2008). Ectoparasites cause considerable economic losses to farmers due to loss of animals' productivity, mortality and skin diseases (kumsa *et al*., 2012; Beyecha *et al*., 2014). Ticks and tickborne diseases cause considerable losses to the livestock economy and rank third among the major parasitic problems in Ethiopia after trypanosomes and endo-parasitism.

The most common tick-borne diseases are *Anaplasmosis, Babesiosis*, *Theileriosis* and Heart water disease. Besides these, ticks also cause non-specific symptoms like dermatitis, toxicosis and paralysis [6]. Ticks belong to the phylum Arthropod, class Arachnid, and order Acari. The families of ticks parasitizing livestock are categorized into two: *Ixodidae* (hard ticks) and *Argasidae* (soft ticks) [7]. Ticks that are considered most important to animals' health in Africa comprise of about seven genera and sixteen species [8]. In Ethiopia, there are 47 species of ticks found on livestock, most of them have importance as vector and disease-causing agents, have damaging effect on skin and hide production [9,10]. The main genera of ticks found in Ethiopia are *Ambylomma* (40%), *Boophilus* (21%) and *Heamaphysalis* (0.5%), *Hyalomma* (1.5%) and *Rhipicephalus* (37%) [11, 12]. Studies and reports from different parts of the Ethiopia showed that skin quality deterioration is very evident mainly due to ectoparasites [12, 13]. Ticks, lice,

keds, and mange mites are the major ectoparasites of small ruminants in Ethiopia [14]. The occurrence and spread of skin diseases has been shown to correlate with host factors, poor management, climatic factors, feed scarcity and inadequate veterinary services [15].The leather industry is one of the growing economic sectors in the country, but has lost revenue due to decline in quality and fall in export price [16].

According to reports from tanneries, hide and skin problem due to external parasites causes 35% of sheep and 56% of goat skins to be rejected in Ethiopia [17]. To overcome the economic and health problems posed by ectoparasite invasion in livestock, there is need to put appropriate control strategies in place. The application of chemicals is still the most effective method of ectoparasite control. In Ethiopia, over the past decades ectoparasites are mainly controlled by using variety of acaricides; including organochlorines, organophosphates, carbamates, amidines or synthetic pyrethroids [18,19]. However, with the most widespread, under or over concentration and frequent use of organochlorines and organophosphate compounds, ectoparasites are likely to develop resistance in Ethiopia [18,19]. Therefore, studies on tick dynamics [20] with the efficacy status of acaricides against the most abundant and important ectoparasites in particular areas are necessary to carry out efficient ectoparasite control and burden reduction [21].

In contrast to this huge economic loss caused by ticks, most of the pastoralists in the Somali region neglect ticks as animal health problem, most of them have little knowledge about effect of tick on their small ruminants and none of them know diseases transmitted to domestic animals by ticks [14]. Therefore, research should find ways of identifying and validating the effective therapeutic regimes and adopt an appropriate ectoparasite control strategy to safeguard the livelihood of livestock keeping society. Despite these facts, there is very little systematic research on population dynamics and appropriate control strategies of ticks under pastoral setting in Ethiopia. Moreover, there has not been a specific study conducted on status of tick infestation on small ruminants and comparative acaricidal efficacy test on commonly used acaricides in the study area. In line with this fact, the present work aimed at assessing status of tick infestation in small ruminants, identification of common tick species and comparative field efficacy trial of three commonly used acaricides and adopting effective tick control in the selected sites through participatory approach.

METHODS AND MATERIALS

Study Area

Gursum district is located 9°29‟ 0” N latitude and 42° 60‟ 0” E longitude and has an altitude ranging from 976 to 1369 masl (htpp// population Agro-pastoralist is a dominant production system in Fafan Zone. Farming system of the area includes mixed crop livestock production. The vegetation of the area includes different plants where sorghum, maize, barely, wheat and bean are the most important agricultural crops (SCUK, 2004). mongabay.com/).

Study animals

Small ruminants (sheep and goat) of different age categories of both sexes that are kept under traditional extensive management system will be included in the study. Before clinical examination, the age, sex and body condition of each selected animal was recorded. The age of animals was categorized as young (0-2 years), adult (<2-4 years) and old (above 4 years of old) as per method described by Gatenby [23]. Age determination was made using owner's information and by dentition. Body condition scores was determined following the procedures documented by Steele [24] and ESGPIP [25] for sampled animals as poor, medium, and good classes following 1 up to 5 grading system.

Sample size determination

The desired sample size to assess the status of tick infestation in small ruminants was calculated by considering 95% confidence level, 5% desired absolute precision and as there is no previous research work conducted in the study area, 50% expected prevalence is adopted to determine the sample size using the formula given by Thrusfield [26]. A total of 20 goats in 4 groups and each group belonging to same herd was used for comparative field efficacy experimental trials.

Study design

The investigation employed a combination of epidemiological (cross-sectional and questionnaire survey) and experimental (controlled field trial) study designs. The study was carried out for 11 months from July 2022 to May 2023 using a cross sectional and controlled field experimental study design [26] to assess the prevalence of tick infestation, identify the common tick species and evaluation of comparative efficacy of the commonly utilized acaricides (diazinon, amitraz and ivermectin) in Gursum district.

Questionnaire survey

Semi-structured interview using questionnaires was used as primary sources to collect data from respondents concerning tick infestation problems of small ruminants in their locality. By using the participatory survey, perception of herdsmen on tick invasion, seasonal occurrence and strategies of ectoparasite control was be assessed. For this purpose, checklists was be prepared for an in depth interview of the livestock raisers to explore their traditional perception and knowledge on ectoparasite infestation, period of observation of ectoparasite on their livestock and common types of ectoparasites.

Tick Collection and Identification

The selected small ruminants were examined thoroughly from head to tail including legs for the presence of ticks on the body of the animals. The adult visible female and male ticks were collected from head (eye, ear), scrotum, around the anus, tail, leg and preserved in universal bottles containing 70% alcohol for further identification. The collected ticks from each bottle was placed onto petri-dishes and examined under stereomicroscope to identify to the species level with main identification features which included color, size and shape of mouth parts, scutum, anal groove, festoon, shape of base of capituli, coaxa I and presence of eye punctuation according to Welker *et al*. and Okello-Onen *et al*. [8, 27].

Acaricidal efficacy study and participatory intervention

Based on the output from the participatory survey, personal observation in the field and recommendation from literature, a pilot experimental trial (in the field) using three commonly utilized acaricides (diazinon, amitraz and ivermectin) was done on field population of ticks. The choice of these acaricides was based on their commercial availability and patronage by livestock keepers in the area and recommendation from literature. The field efficacy trial was conducted in goat herds naturally and predominantly infested with ticks under field condition.

Application of chemicals will be as indicated in Table 1. A total of 20 goats in 4 groups and each group belonging to same herd with a mean number of >10 tick counts on different body sites were used for the trials. The acaricides was be applied with more emphasis on tick infested regions of the body. The acaricides' concentration was based on the manufacturer's recommendation for hand spray (1:1000 for diazinon, 1:625 for amitraz) and injection (0.2 mg/kg of body weight). To monitor the number of ticks that attach and drop from animals, sketches was be used to 1oughly locate the positions of ticks on animals. The tickicidal effects of

the acaricides and dynamics of ticks on the animals was be observed every other day and final results will be recorded on Day 3, 5 and 7 post exposures. Anti-parasitic efficacy of each treatment regimen was be calculated using the following equation [28].

AE = [B-T/B]/B*100

Where AE is the antiparasitic efficacy, B is the mean number of surviving ticks in the control, and T is the mean number of surviving ticks in treatment.

Table 1: Application of Acaricides on Experimental animals

GROUPS	**Quantity**	**TREATMENTS**
Group one	5 Animals	Ivermectin (injection) alone
Group Two	5 Animals	Ivermectin (injection) + diazinon (Spray)
Group Three	5 Animals	Ivermectin (injection) + amitarz (Spray)
Group Four	5 Animals	Infested untreated (control group)

Data Analysis

Data obtained was entered and stored in Microsoft Excel word sheet. Data was organized, edited and analyzed using Statistical Package for Social Sciences (SPSS) Version 23. Simple descriptive statistical analysis will be used to analyze prevalence and distribution of tick species. Results generated from the investigation of field trial was expressed using descriptive statistics (mean ± standard error of mean, percentage and graphs). One-way analysis of variance (ANOVA) and the student t-test will be employed for inter-group and intra-group difference analysis. Results was deemed statistically significant if $p \leq 0.05$ at 95% confidence levels.

RESULT

Survey part

The current project covered ten kebeles from two districts, namely, Shabeley and Gursum. From each district 60 respondents were included as participants to get an insight about the areas of focus of our project. The project covered two districts, namely, Shabeley and **Gursum** for the survey part of the study.

Sociodemographic Profile of the Respondents

Majority of the study participants were males 90 (75%), agropastoral individuals (83.3%); possessing large family 80 (66.7%). Agropastoralism was the main livelihood in this area. Majority (58.3%) of the participants were of poor economic status according to the measuring criteria's of the study. In this study majority were leading agropastoral livelihood. More than two-third 90 (75%) of the respondents were small herd owners.

Table 2: Sociodemographic Characteristics of Participants

Variable	Category	Frequency	Percentage %
Sex	Male	90	75
	Female	30	25
Family size	<5	40	33.3
	>5	80	66.7
Occupation	Pastoral	20	16.7
	Agropastoral	80	83.7
Level of education	Illiterate	70	58.3
	Adult education	20	16.6
	Elementary	30	25
Herd size	Small	90	75
	Medium	25	20.8
	Large	5	4.2
Economic status	Poor	70	58.3
	Medium	40	33.3
	Rich	10	8.3
Total		120	

Generally speaking, the existing animal production system was extensive management system.

Table 3: Perception of livestock kept by pastoralists and Agro- pastoralists in the study areas (2 districts)

Sn	Camel	Cattle	Sheep	Goats	donkey
Minimum	4	0	5	4	0
Maximum	30	17	20	30	4
Mean	11.3	6.6z	10.9	11.3	1.4
S-e	1.44	0.69	1.311	1.44	0.44
Percent of respondents	100%	84%	100%	100%	84%

*In both districts many of the camel owners we interviewed came from Jerar and Nogob zones for seasonal karan rain which occur in August and September in every year

Perception of Livestock Owners Frequently Encountered Diseases

When asked about any of the prevalent diseases in their localities, the respondents mentioned ten diseases and the following table indicates the collective score of the severity of the diseases given by the locals.

Table 4: Frequently Encountered Diseases

Disease name	Gursum	Shabeley	Total
Pox	45.4	40.5	85.9
CCPP	31.4	28.2	59.6
Lumpy skin diseases	23.8	19.5	43.3
Heart water	16.6	12.9	29.5
Anthrax	20.7	15.4	36.1
ORF	32.2	29.6	61.8
Trypanosomiasis	34.3	35.2	69.5
Tick borne diseases	12.3	11.2	23.5
camel posterior paralysis	2.7	1.4	4.1
Helminthiasis	40.2	36.5	76.7

Perception of the More Five Diseases More Serious for Their Animals health:

And from these lists of more occurring diseases, the respondents specifically selected five (5) more serious diseases according to their impact on their livestock.

Table 5: Specific Diseases of Health Importance

Disease name	Gursum	**Vaccine availability**
Pox	85.9% respondents	Available
Helminthiasis (summer)	75% respondents	Not Available
Trypanosomiasis	69.5% respondents	Not Available
Orf- virus	61.8 % respondents	Not Available
C.C.P.P	59.6 % respondents	Available

The respondents mentioned that two (Pox virus and C.C.P.P) of the five challenging disease got vaccines while the other three doesn't.

Clinical Trail Findings

After applying and injecting the calculated amount of solutions and acaricides on the animals designed for the trail, the following results were encountered: Among the sheep check-up on day

5/4/2023 G.C, we found 3 sheep injected Ivermectin under skin (neck) got ticks on them, which meant that the ticks apparently got resistant to the Ivermectin.

Table 6: Cattle Injected with Ivermectin Under Skin (neck) were also Possessing Ticks on them**.**

Species of animals	**Number of animal used In each**	**Name of drug or accaricide used**	**Day used test**	**Day test read**	**Result found**
Sheep	3	Ivermectin	1/4/2023	5/4/2023 G.C	Ticks present
Sheep	3	Cypermethrin	1/4/2023	5/4/2023 G.C	No ticks Present
Cattle	3	Ivermectin	1/4/2023	5/4/2023 G.C	Ticks Present
Cattle	3	Cypermethrin	1/4/2023	5/4/2023 G.C	Ticks present on animal but less than before sprayed them
Control group	3 sheep 3 cows	No injection with Ivermectine or sprayed with cypermethrine 10%	1/4/2023	5/4/2023 G.C	Ticks were present as before

Regarding Cypermethrin 10% applications on the animals, the experiment indicated that 3 sheep sprayed with Cypermethrine10% found no ticks present on them. On the other hand, 3 cows sprayed with CYPERMETHRINE 10% were found with some ticks still biting them.

DISCUSSION

There have been reports of tick infestation in several areas of Ethiopia. According to reports from other studies carried out in Ethiopia, such as those by Tefera [12], Abdisa *et al*. [36] in Arsi, Wodajnew *et al*. [36] in Benishangul Gumuz, and Sitotaw *et al*. [38] in Debrezeit, the tick species found in the current study affect the animal species. These studies also reported varying degrees of prevalence in their respective study areas. The variation in environmental factors, such as humidity, which is favorable for the survival and growth of tick developmental stages, and the variation in tick reproduction among study areas may be the cause of the variation in

prevalence. During this study, almost all pastoralists complained of failure of acaricides to kill ticks after being treated and concluded that the acaricide was not effective anymore as it used to be. Even though there was wide use of ivermectin drug as both prophylaxis and anti-parasitic treatment, the study indicated that the efficacy was not significant in either killing the ticks or downgrading its impact.

This was contradictory compared to a study conducted in Mexico [40] that reported relatively lower relative resistance of ticks towards ivermectin. The prolonged or incorrect use of the drug might have led to this resistance in ticks. On the other hand, the study indicated that 3 sheep sprayed with Cypermethrine10% found no ticks present on them. However [39], reported a significant level of resistance against cypermethrin with a highest mean percentage mortality 42.2% at recommended concentrations in cattle farms in Uganda.

In general, the study indicated that the acaricides used gave different responses to the two drugs in both small ruminants and cattle. The result clearly showed that not the acaricide but the problem was dilution, preparation and application of acaricides according to major predilection sites of ticks. This was in agreement with other studies Abunna, *et al* [32] and mentioned the proper use of acaricides as a solution to elevate the problem in its root.

CONCLUSION AND RECOMMENDATIONS

The study emphasized none of the respondents were aware on the proper usage and handling of acaricides and on the development of acaricides resistance by tick and its consequences for the livestock health and production. In general, there are several ways to treat cattle, from dipping to injecting systemic acaricides, but regardless of the method chosen, farmers must be trained in the application techniques in order to get the most out of the treatment. In order to manage resistance and select an appropriate medication, it is essential to regularly check cattle ticks for the development of resistance against various classes of chemical acaricides. It would be beneficial to use vaccinations, synthetic and natural acaricides in combination with educating farmers through extension programs about recommended tick control practices as a means of controlling cattle ticks strategically and/or tactfully. An essential operational and research priority is the integration of currently available options for the management of drug resistance. In light of the aforementioned conclusive remarks, the following recommendations are forwarded: -

- Awareness creation towards proper use of acaricides

- Practicing use of the recommended strength in dips as written on the chemical label by the manufacturer.
- Education of community animal health care workers how to identify and clarify different aspects that could bring improper use of drugs
- Using new drugs to change the course of action of the existing acaricides
- Further studies directed towards understanding the prevalence and extent of resistance of the functional drugs in the region

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Assessment on Pastoralist Indigenous Knowledge and Practices of Camel Mineral Supplementation in Selected Zones of Somali Region, Ethiopia

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ABSTRACT

The study was conducted the selected zones of Somali region in 2022 year with the objective to Assessment on Pastoralist indigenous knowledge and practices of camel mineral supplementation in the selected zones of Somali regional state, Ethiopia. A purposive sampling was used since strictly random sampling procedure was less feasible because less accessible nature of the water wells, soil salt and salt plant species. From each woreda, 20 household heads of dominant camel producers were selected, making a total of 180 households from the nine woreda for the household survey. The required primary data was collected by using household survey with Semi-structured questionnaire, field observation and focus group discussions with camel owner pastoralists. The quantitative data was analyzed by the use of descriptive statistics such as percentage, frequency and interpreted by tabular and graphs while qualitative data were narrated, and explained logically based on the existing condition and literatures. According to this finding, the majority of the respondents supplement mineral water wells for their camels (71.7), followed by salty soil and halophytic plants (15 and 8.9, respectively). The three most significant indicators of a mineral shortage were decreased milk production (63.3), restlessness (52.8), and insufficient rumen fill (51.7). The pastoralist also cited other symptoms of mineral deficiency, such as lack of frothiness in milk, refusal of calves, chewing woody materials, licking urine and soil, drinking litter water, high worm loads, and chewing bones. The respondents perceived that increase milk yield (78.3) and physical changes (79.4) were the most significant signs of sufficient mineral supplementation. According to the respondents the major constraints compromising camel mineral supplementation in the study areas were recurrent drought (41.7), followed by long distance water well location (26.7) and a smaller number of mineral water wells (14.4). Lack of dynamo market problems and drought, are among others. It is recommended that different samples should be collected from mineral water wells, salty soil and halophytic plants for laboratory analysis for different season.

Key Words: *Camel, indigenous knowledge, pastoralists, practice, mineral, Somali region*

INTRODUCTION

The one-humped camel (Camelus dromedaries) is an important livestock species uniquely adapted to hot and arid environments. It produces milk, meat, wool, hair and hides and serves for riding, as a beast of burden and draught animal for agriculture and short-distance transport

(Schwartz and Walsh 1992). The global population of domesticated large camelids (dromedaries and Bactrian) is estimated to be about 28 million (Faye 2015). This number is probably underestimated particularly in the Sahelian countries (Mauritania, Mali, Niger, Chad and Sudan) and Ethiopia. More than 80% of the camel population inhabits Africa with 60% in the Eastern African countries (Sudan, Somalia, Ethiopia and Kenya) which are important exporters of dromedary camels to the Arabian Peninsula and Egypt (Faye 2015). The camel population in Ethiopia is estimated at 4.8 million (Behnke 2010).

Major camel-keeping societies in Ethiopia include Afar, Somali, Oromo (Karayu, Gabra, Boran and Guji groups), Kunama and Irob peoples, among others. The Afar and the Somali peoples are known for their camel-keeping traditions for centuries; the Boran and Guji pastoralists, on the other hand, started camel production recently. Gabra and Somali, who have been keeping camels for centuries, are believed to play instrumental roles in introducing camels to the Borana Plateau (Coppock 1994). Besides, farmers and Agro-pastoral communities in mid-altitude areas who were not traditionally camel keepers recently started adopting camel. In traditional systems the only supplement provided by the herders is a salt. It could be common salt (NaCl) or a particular type of soil dug from a specific location. Camels also forage on salty plants or are watered from salty wells if available. Camels have a higher salt requirement than other livestock (Wilson, 1994).

Supplementation is in the form of mineral salt, or allowing grazing on salty grasses on saline soils for at least 5 days. Many Ethiopian Somalis offer ½ kg table salt per head at 2-month intervals especially during wet season. In general, ruminants in tropical regions do not receive mineral supplements other than ordinary common salt (sodium chloride), but depend on pastures for their mineral needs (McDowell et al., 1995). The observation of MacDowell (1995) that such animals consume a considerable amount of earth was confirmed by the present study. However, the mineral contents in soils are highly variable. Importance of salt for camels is common knowledge among camel herders. In the study area, camels depend on salt plants (halophytes), salty soils (kuru) and sometimes commercial salt supplements for their mineral needs. Most herders (70%) claim to follow a regular deficiency preventive routine. Camels kept in the home-based herd are more frequently supplemented with purchased salt. This is attributed to the fact that they had limited access to distant grazing areas with salt plants. “Salt deficiency symptoms” revealed by the herders included chewing bones, eating soils from anthills, reduced milk yield,

reduced water intake, and increased straying in search of salty plants. Periodic salt supplementation was reportedly done once or twice a year in Somalia (Elmid, 1989) and six to seven times in Kenya (Ayuko, 1985). Mineral provisions are important to accomplish the increasing demands of the lactating cows for productive and reproductive functions. Deficiencies of minerals can be primary and/or secondary sources. Primary deficiencies arise because of insufficient levels of the actual mineral element in the diet and secondary deficiencies arise when the pasture contains something else that reduces the uptake of the mineral element (e.g. pasture with high molybdenum reduces the absorption of copper). However, the most naturally occurring mineral deficiencies in dairy animals are area specific (Garg *et al*., 2004; Kumar, 2015), which are related to the type of soils, climate, mineral composition of soils and plants, soil pH and agronomic practices (McDowell, 2003).

Groundwater composition is closely linked to the geological and structural setting of the hosting aquifer due to physical and chemical characteristics that depend on several factors, such as water–rock interaction processes, residence time, hydrodynamic conditions, and mixing processes (Giovanni Vespasiano, *et al* 2021). The quality of groundwater is determined by the type and concentration of its chemical and biological constituents. In general, the chemistry of groundwater is controlled by the type of geological materials through which the water flows and the amount of time the water is in contact with these materials. For example, precipitation percolating into a limestone aquifer would dissolve the limestone (made of calcium carbonate), and the water (now groundwater) would contain predominantly calcium and bicarbonate ions. Groundwater from aquifers made up of or containing carbonate rock is often referred to as “hard.” Hard water contains calcium and magnesium that react with soap and produce soap scum or react with other anions to produce a solid scale or coating when the water is boiled and evaporated. (Samuel panna and Keith Hackley, 2016).

Therefore, the aim of this work was to identify the different geological location of mineral wells and analyze major cations, anions, and trace elements and mineral concentrations of water. Mineral supplementation is an important management aspect for production and productivity of camels (Simkin 1998). The Somali pastoralist herders appreciate the importance of mineral nutrition in camels and have developed criteria for assessing mineral deficiency. Current mineral supplementation strategies are based on local knowledge of mineral rich forages, water and soils. Research efforts geared towards improving mineral supplementation practices in camels in these

areas should build on the existing local knowledge. Therefore, this study was aimed to investigate the indigenous knowledge and practices of pastoralist community on camel mineral supplementation with great emphasis on the sources of mineral supplementations and challenges that the pastoralist is facing during different seasons in Somali region

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Somali Region, located in east and southeastern Ethiopia between 4° to 11°N latitude and 40° to 48°E longitude. It is the second largest Regional State of the Federal Democratic Republic of Ethiopia, while 80% the topography of the region is dominated by lowland plains, with an altitudinal range of 900 to 1600 meters above sea level. Almost 80% of the region has an arid and semiarid climate; rainfall is extremely variable and low having bi-modal distribution with an average annual rainfall from 200 to 700 mm. The mean annual temperature ranges from 20° to 45°C. Strong wind circulation further causes moisture loss from soil and plants. Vegetation is sparse and mainly composed of grass, bushes and scrub. Natural vegetation contains a high proportion of endemic plants of Ethiopia, that are a large variety of Acacia, Boswellia and Chomiphera species; medicinal plants and gum while incense and myrrh producing plants are abundant. As a result of dry climatic condition and scarce surface water, the proportion of better adapted animal species such as camels and goats are higher compared to other animals in the region

Study Design

The study design was contained three parts; the first part was focused on the survey on pastoralist indigenous knowledge and practices of camel mineral supplementation in Somali region. While the second part was sample collection and laboratory analysis the third part was focused geo-spatial distribution of the common water wells, soil salt and most common salt plant species the area located to map through GIS mapping

Sampling Technique and Sample Size

The study was conducted in eleven zones (Jerar, Nogob, Korahey, , Erred, Nogob, Adhere, Shebelle and Siti zone) of Somali regional state, from each zone one districts was selected based on availability of camel drinking water wells, soil salt licking area and also the potentiality of salt plant species (halophytic plant) and camel potentiality in purposive sampling technique. A purposive sampling was used since strictly random sampling procedure was less feasible because

less accessible nature of the water wells, soil salt and salt plant species. From each woreda, 20 household heads of dominant camel producers were selected, making a total of 180 households from the nine woreda for the household survey. Primary data were collected by using household surveys, field observation and focus group discussions with pastoralists and camel herders, while secondary data were collected from published and unpublished data of district and regional Bureau of Agriculture and NGO's reports on Somali region.

Methods of Data Collection

In this component both primary and secondary data were collected. The required primary data was collected by using household survey with Semi-structured questionnaire, field observation and focus group discussions with camel owner pastoralists. Whereas, secondary data were collected based on published and unpublished data such as district and regional bureau of agriculture and NGOs reports, and related website such as FAO, World Bank IPMS-Ethiopia.

Household Survey

The semi- structured questionnaire was designed to collect both qualitative and quantitative data for this study. The survey was focused to collect information on indigenous knowledge and practice of pastoralist use for camel mineral supplementation. The experience of camel herding, season of camel drinking water wells, number of water wells availability for that location, importance of water wells drinking camels, number of times supplementing the water wells, availability of soil salt in that location, seasons of supplementation on camel, importance of soil salt, behavioral condition observed when the camel need mineral salt supplementation, number of plant species which are salt plant located in that locality, list of their names, season available and importance that plant species for camel supplementation.

Field Observation

Apart from collecting data through questionnaires, field observations were done to have an insight into the water wells, soil salt and other plant species which are salt plants located in the area.

Methods of Data Analysis

For survey parts SPSS software (version 26.0) were used in the analysis. The quantitative data was analyzed by the use of descriptive statistics such as percentage, frequency and interpreted by tabular and graphs while qualitative data were narrated, and explained logically based on the

existing condition and literatures. The statistical differences between means was estimated by the LSD test.

RESULTS AND DISCUSSION

Socio-economic Characteristics

One hundred eight households (180) were subjected to the interview. The age and family size of the respondents is summarized below (Table 1). The age of the respondents ranged from as young as 20 to >55 years old; overall, the proportion of the respondents with the age range between 20 and 35 years were young adults, and those within the age range of 36 to 55 years were adults above 36, while those in the above (>55) years were small in number in all study woreda (9.4). This indicates a lower proportion of the nonproductive population and a fair population growth rate in the study areas. For this study, the majority of the respondents were in the age range of 35–44, which counts (59.4) across the study areas, followed by 45–54 (21.1). The average family size per household across the surveyed areas was comparable the average values at the national (5.2) levels (CACC, 2003). However, the average family size was less than that reported by Lishan (2007) in Shinile and Dembel districts, and also report of Fikru, and Gebeyew (2015) (11± 0.6) for Jarar zone Somali regional state. The high family size around lowland area may be due to the cultural practice of polygamy for most of the pastoralists in the study area. Or could be related to the relatively labor sharing for diversified herding management and the weak family planning services.

Table 1: Profile of family size and age of the respondents in the district

Parameters	Location									Over all (N=180)
	Xamaro (N=20)	Sagag (N=20)	Garbo (N=20)	Gode (N=20)	Qoxle (N=20)	Danbal (N=20)	Bombas (N=20)	Kabridahar(N=20)	Degahbour (N=20)	
Sex										
Male	85	90	95	85	95	75	95	90	90	88.9
Female	15	10	5	5	5	25	5	10	10	11.1
Age(years)										
<25	0	0	0	5	0	0	0	0	5	1.1
25-34	5		20	25	0	15	5	10	0	8.9
35-44	70	100	30	55	35	75	80	35	55	59.4
45-54	25	0	30	15	45	5	15	15	40	21.1
>55	0	0	20	0	20	5	0	40	0	9.4
Marital status										
Married	95	85	100	80	100	65	100	100	80	89
Single	5	15	0	20	0	25	0	0	20	9.9
Divorced	0	0	0	0	0	10	0	0	0	1.1
Education status										
Illiterate	20	35	20	45	45	50	45	30	45	37.2
Read and write	0	0	0	0	0	20	20	0	0	4.4
Religious Education(Quran)	80	65	80	55	55	30	35	70	55	58.3
Diploma and above	0	0	0	0	0	0	0	0	0	0
Mean±(SEM) Family size	4.8±0.26	5.6±0.36	4.4±0.3	5.3±0.2	5.1±0.17	5.4±0.2	6±0.7	6.1±0.37	5.5±4.8	5.45±0.12

N = number of respondents, SD= standard deviation.

Eighty-eight percent of the respondents were males, with only 11.1% being females (Table 1). Since camels are usually herded by males, this is a common finding (Mohamed et al., 2013; Simenew *et al*., 2013). The majority of the respondents were married (89), and the average family size was 5.45 in the study areas. The divergence in family size between 11.0.6 reported by

Fikru and Gebeyew (2015) in the Jarar zone and 4.95 described by Mehari et al. (2013) in the Fafan zone of SRS might relate to spatial and temporal factors of the research. The majority of respondents had religious education (58.3) and could read and write the Quran and other religious books, followed by illiteracy (37.2), and the remaining 4.4 could read and write Somali language.

Except religious education majority of the respondents were showed the high level of illiteracy in the study area, the educational level attended by the household heads were very low, and this is in line with the case reported by Simenew *et al*., (2013) reported that education is very poor and most of pastoral areas in (Somali Regional State) were illiterate (94%). This low level of educational achievement in the study area is attributed to less number of basic primary school coverage in the study area and pupils are required to travel long distances even to the nearest primary schools, which leads to limited access to modern education opportunities, this result also in line with the findings of Abayneh, (2013) in the YabelloWoreda, Borena zone.

Sources of Mineral Supplements for Camels

All the respondents supplement minerals to their camels, but the sources of minerals are different based on the accessibility of those minerals (Table 2). Due to the fact that camels can receive enough food from rangeland during the wet season and that their body weight increases, pastoralists believe that camels need mineral supplements during this period. According to pastoralists, the majority of camels' bodies are malnourished and their capacity decreases during the dry season due to a shortage of grazing on the range land. In this case, the camel's body doesn’t need mineral supplementation, and pastoralists will not allow their camel to consume any kind of minerals. As the pastoralists believe that camels will die immediately since their abilities are lessened.

Moreover, the pastoralist believes that during dry season the mineral contents of the mineral water wells raised and camel cant able to drink it. From the study areas pastoralist perception on the ability of different mineral sources to satisfy mineral needs of camels varied from site to site depending on the particular source that was accessible to the herders. According to this finding, the majority of the respondents supplement mineral water wells for their camels (71.7), followed by salty soil and halophytic plants (15 and 8.9, respectively). This shows how mineral water wells are best and preferred by the pastoralist for supplementation than other sources of mineral water.

The final option for supplementation is table salt, which is only offered when the sources mentioned above are unavailable. According to pastoralists, giving camel's table salt cannot be a good form of mineral supplementation because it could endanger their life. Among study sites Danbal and Bombas pastoralist uses salty soil and commercial salts since respondents from these two sites perceived their areas as not having rich natural mineral sources. In contrast, respondents from other study sites did not use commercial salts at all since they viewed the natural mineral sources in their area as adequate.

Table 2: Source of mineral supplementation and season of supplementation

	Location									
Parameters	**Xamaro**	**Sagag**	**Garbo**	**Gode**	**Qoxle**	**Danbal**	**Bombas**	**Kabridahar**	**Degahbour**	**Overall**
TMS										
Mineral water wells	100	75	55	80	90	40	15	100	90	71.7
Soil Salts	0	5	0	0	10	50	60	0	10	15
Halophytic plants	0	15	45	20	0	0	0	0	0	8.9
Table Salts	0	5	0	0	0	10	25	0	0	4.4
SSP										
Wet season	100	100	100	100	100	100	100	100	100	100
Dry season	0	0	0	0	0	0	0	0	0	0

TMS; types of supplementation SSP; season of supplementation.

Frequency of Mineral Water Supplementation and Distance to Travel

According to the participants, it may have taken the pastoralists more than a week to travel along distance on their camels to get to the mineral water wells (Table 3)**.** The majority of pastoralists travel more than thirty kilometers (56.7) to reach mineral water wells for their camels. While some of them travel between ten and thirty kilometers (25.6). This shows that the majority of the pastoralists are far from the mineral water well locations. The majority of the respondents believe that once the camel showing deficiency signs needed to drink the water for 2 to 3 consecutive

weeks for the signs to disappear (75.6). While some respondents (12.8) think more than four times is sufficient. However, this is reliant on the mineral content of the water wells.

Table 4: frequency of mineral water supplementation and Distance for camels in the study areas

Parameters	Location									
	Xamaro (N=20)	**Sagag (N=20)**	**Garbo (N=20)**	**Gode (N=20)**	**Qoxle (N=20)**	**Danbal (N=20)**	**Bombas (N=20)**	**Kabridahar(N=20)**	**Degahbour(N=20)**	**Over all (N=180)**
	%	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
FMWS										
Once per month	5	0	0	0	0	0	0	0	0	0.6
Twice per month	15	15	10	20	0	10	10	10	10	11.1
Two-three weeks	80	85	90	70	80	45	70	85	75	75.6
More than three weeks	0	0	0	10	20	45	20	5	15	12.8
DTSM										
<1km	0	0	0	0	5	0	10	0	0	1.7
1-10km	5	0	0	0	15	10	65	20	30	16.1
10-30km	35	25	15	35	25	50	25	0	20	25.6
>30 km	60	75	85	65	55	40	0	80	50	56.7

DTMS; Distance travelled to mineral supplementation, FMWS; frequency of mineral water supplementation

Perceived mineral deficiency signs

All the respondents interviewed during were aware that camels required mineral supplementation lack of which would result in deficiency signs. The respondents identified several signs indicative of mineral deficiency in camels (Table 2). These were grouped into four categories i.e. those relating to camel behavior, production, physiological and physical changes. According to respondents at all study locations, and in accordance with Kaufmann (1998), the three most significant indicators of a mineral shortage were decreased milk production (63.3), restlessness (52.8), and insufficient rumen fill (51.7). The pastoralist also cited other symptoms of mineral deficiency, such as lack of frothiness in milk, refusal of calves, chewing woody materials, licking urine and soil, drinking litter water, high worm loads, and chewing bones. This result agrees with Kuria S. G.'s findings from his 2003 study, Mineral Supplementation in the Manyatta-based Milking Camels. According to the respondents, camels may experience abortion and difficulty releasing the placenta if they are deficient in minerals, which could endanger their lives. All the respondents were amazed at why camels chew bones during mineral deficiency. This is because bones contained calcium, phosphorus, and magnesium; they would have linked this camel behavior to a mineral deficiency. The pastoralist agreed that a camel's performance may suffer once it suffers from a mineral shortage. The milk production will drop by 50% or more, which would not be sufficient for the calves and herders. Even milked milk lacks frothiness, which pastoralists view as a sign of poor milk quality. The camel also exhibits a high level of restlessness, which can lead to yelling, aggression, refusing of calves, chewing on wood and bones, loss of appetite, and drinking little water. This conclusion is consistent with Kabaija and Little's (1988) findings, which revealed that animal performance can suffer from mineral deficiency. The pastoralists are familiar with mineral deficiency symptoms and once the pastoralist observed such symptoms, they supplement minerals that are available in their location. The pastoralist said by their local language "*Naag aan dhalayn ninka qaba iyo hal jeelan ninka dhaqda aya ugu aqli xun aduunka"* which means the two most idiotic persons in the world are a woman who doesn't give birth to a married guy and a person who is raising a camel with a mineral deficiency.

Table 4: *Deficiency signs observed by respondents expressed as a percentage of total*

		Location									
Category of symptoms	**Observed signs**	**Xamaro (N=20)**	**Sagag (N=20)**	**Garbo(N=20)**	**Gode (N=20)**	**Qoxle (N=20)**	**Danbal (N=20)**	**Bombas (N=20)**	**Kabridahar(N=20)**	**Degahbour(N=20)**	**Over all (N=180)**
		%	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Production	Reduced milk yield	50	65	60	40	75	60	55%	90	75	63.3
	Lack of frothiness in milk	20	20	15	35	10	25	20	10	5	17.8
	Refusing of calves	25	5	15	25	10	10	20	0	15	13.9
	Poor meat taste	5	10	10	0	5	5	5	0	5	5
Behavior	Restlessness	65	75	60	45	50	35	50	55	40	52.8
	Dullness	5	5	10	10	10	10	5	5	5	7.2
	Chewing woody material	10	10	5	15	15	20	20	15	25	15
	Chewing bones	10	10	20	20	15	25	20	5	10	15
	Licking urine & soil	10	10	5	10	10	10	5	20	20	10
Physiology and physical appearance	Drink litter water	15	15	10	30	35	55	10	0	30	22.2
	Inadequate rumen fill	60	60	40	15	30	40	80	75	65	51.7
	Skin disease	0	5	15	15	0	0	5	10	5	6.1
	High worm load	25	20	35	40	7	5	5	15	0	20

N=numberrespondents,

Importance of mineral supplements in camels

All of the study sites' pastoralists were aware of the value of mineral supplementation and its advantages for camels. The participants agreed that the evaluation of observable and measurable signals made it simple to identify the effects of supplementing. These elements can be broadly characterized as changes in camel behavior, changes in production qualities, health and physical and physiological changes to the camel body. Table 4 lists the observed consequences as perceived by pastoralists. The respondents perceived that increase milk yield (78.3) and physical changes (79.4) were the most significant signs of sufficient mineral supplementation. This was explained by the fact that such changes were obvious and directly benefited herders. Changes in feeding preferences (95) were similarly simple to see and directly affected the amount of milk produced each day. Other changes like a higher incidence of conception, better mothering, bigger camels with better bodily conditions, cleaner and shiny hair coats, and a higher resilience to disease were also less acknowledged by participants, maybe because they were of less immediate consequence. The respondent claims that after giving the camel mineral supplements, the milk yield would rise by 50% and the milk's flavor was improved. This find is in line with the finding of (Kuria 2003). Among the source of mineral supplementation mineral water wells is more preferable by the pastoralist since the camel quickly response it and provide high milk yield. On the other hand, when the camel provided salty soil and table salty it will take several weeks for response.

Table 5: Respondents perception of effects of mineral supplementation on camel perform*ance*

		Location									
Category of changes	**Perceived effects**	**Xamaro (N=20) %**	**Sagag (N=20) %**	**Garbo(N=20) %**	**Gode (N=20) %**	**Qoxle (N=20) %**	**Danbal (N=20) %**	**Bombas (N=20) %**	**Kabridahar(N=20) %**	**Degahbour(N=20) %**	**Overall (N=180) %**
Production	Higher milk yield	75	80	80	65	78	90	70	80	85	78.3
	Stronger calves	5	5	10	5	5	5	5	10	5	
	Better milk and meat taste	20	15	10	30	20	5	20	10	5	5.6
	Higher conception rate	0	0	0	0	2	0	0	0	5	15
	Tasty body fat	0	0	0	0	0	0	5	0	0	0.6
Behavior	Better mothering	45	50	70	40	55	65	80	50	75	58.9
	Very stable	55	50	30	80	40	35	20	50	25	41.1
Physiology	Better feeding appetite	100	100	95	100	90	90	95	95	90	95
	Better dehydration resistance	0	0	5	0	10	10	5	5	10	5
physical appearance	Bigger camels of better body condition	85	45	70	90	70	90	95	80	90	79.4
	Cleaner and shiny hair coat	15	55	30	10	30	10	5	20	10	20.6
Health	Higher disease resistance	80	65		80	70	55	60	70	75	66.1
	Fewer ecto-parasites and occurrence of skin diseases	10	15	20	10	20	20	20	10	15	16.7
	Lower worm	10	0	0	10	10	25	20	20	10	17.2

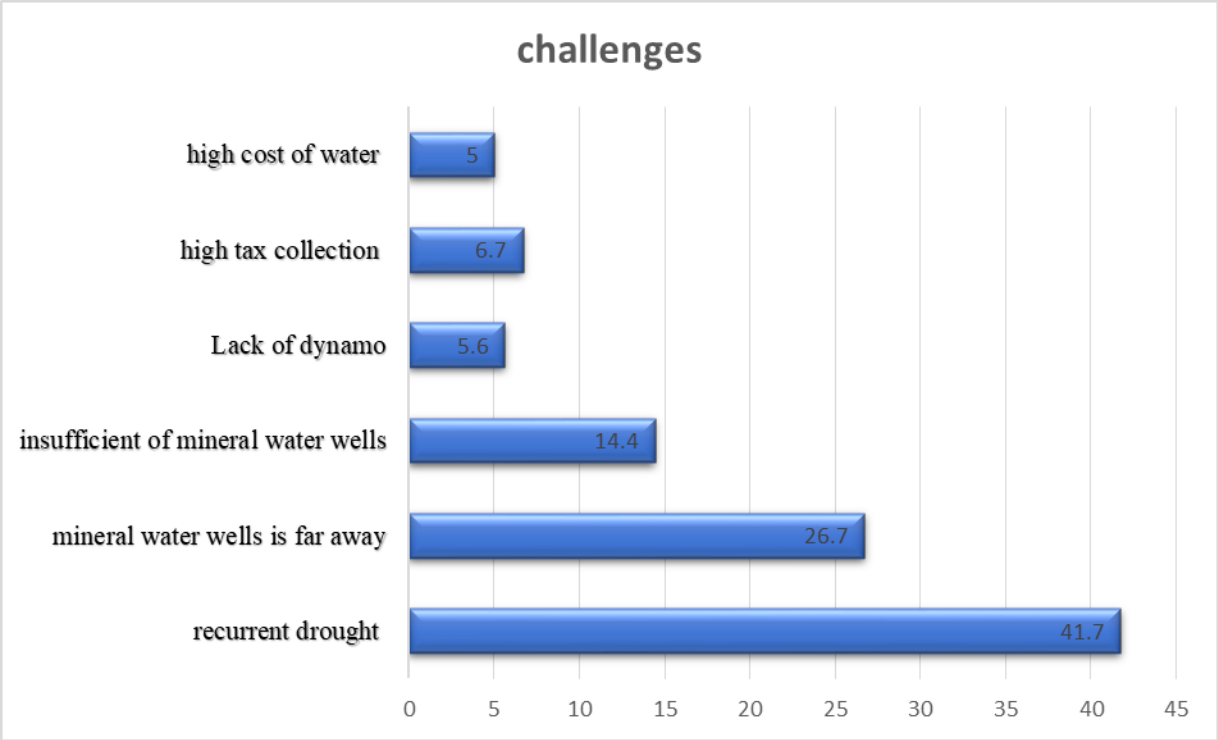
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N=number of respondents,

Challenges faced by the pastoralist in the study areas.

According to the respondents the major constraints compromising camel mineral supplementation in the study areas were recurrent drought (41.7), followed by long distance water well location (26.7) and a smaller number of mineral water wells (14.4). Lack of dynamo and drought, are among others. All other constraints of camel in the study area are similar.

Figure 1: *Major Constraints to camel mineral supplementation ranked according to importance*



CONCLUSION AND RECOMMENDATIONS

Majority of the camel herds were males since camels are usually herded by males and majority of the respondents were in the age range of 35–44, which counts (59.4) across the study areas, followed by 45–54 (21.1). From the study areas pastoralist perception on the ability of different mineral sources to satisfy mineral needs of camels varied from site to site depending on the particular source that was accessible to the herders. According to this finding, the majority of the respondents supplement mineral water wells for their camels (71.7), followed by salty soil and halophytic plants 15 and 8.9, respectively. This shows how mineral water wells are best and preferred by the pastoralist for supplementation than other sources of mineral. The majority of the respondents believe that once the camel showing deficiency signs needed to drink the water

for 2 to 3 consecutive weeks for the signs to disappear (75.6). While some respondents (12.8) think more than four times is sufficient. However, this is reliant on the mineral content of the water wells. According to respondents at all study locations, and in accordance with Kaufmann (1998), the three most significant indicators of a mineral shortage were decreased milk production (63.3), restlessness (52.8), and insufficient rumen fill (51.7). The pastoralist also cited other symptoms of mineral deficiency, such as lack of frothiness in milk, refusal of calves, chewing woody materials, licking urine and soil, drinking litter water, high worm loads, and chewing bones. According to the respondents, camels may experience abortion and difficulty releasing the placenta if they are deficient in minerals, which could endanger their lives. The respondents perceived that increase milk yield (78.3) and physical changes (79.4) were the most significant signs of sufficient mineral supplementation. This was explained by the fact that such changes were obvious and directly benefited herders. Changes in feeding preferences (95) were similarly simple to see and directly affected the amount of milk produced each day. Other changes like a higher incidence of conception, better mothering, bigger camels with better bodily conditions, cleaner and shiny hair coats, and a higher resilience to disease were also less acknowledged by participants, maybe because they were of less immediate consequence. The respondent claims that after giving the camel mineral supplements, the milk yield would rise by 50% and the milk's flavor was improved. According to the respondents the major constraints compromising camel mineral supplementation in the study areas were recurrent drought (41.7), followed by long distance water well location (26.7) and a smaller number of mineral water wells (14.4). Based on the afore-mentioned findings the following recommendation is forwarded;

- It is recommended that different samples should be collected from mineral water wells, salty soil and halophytic plants for laboratory analysis for different season.
- In order for pastoralists to water their camels without suffering, the livestock office should try to make dynamos and generators at the locations of the mineral water wells.
- According to this finding the number of mineral water wells are insufficient for the pastoralist so the concerned offices should work to maintain the existing mineral water wells.

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Camel Milk Production Practices and Marketing System under the Emerging Peri-Urban and Pastoral Production Systems in Selected Potential Zones of Somali Region, Ethiopia

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Abstract

A cross-sectional study was carried out to assess camel milk production practices and marketing systems under the emerging peri-urban and pastoral production system in selected potential zones of Somali Regional State. A multi-stage sampling procedure was used in this study. The survey studies were based on a total of 260 households/farms from (emerging per-urban (n=120) and traditional pastoral system (n=140)) was randomly selected for the survey interviews. Data from the selected producers were collected by using questionnaire survey and field observation. The results showed that the majority of the sampled household heads in pastoral (94.2%) and Peri-urban (60%) production systems were illiterate. The study results also indicated that none of the respondents washed the udder of milking camel before milking. Moreover, only 5.7 % of pastoralists and 12.5% of peri-urban wash their hands before milking. Equipment made of wooden materials are mainly used for milking, whereas, plastic jerry-cans were most commonly used for milk transportation. About 26.4% of the pastoralists and 87.5% of the peri-urban were cleaning milk vessels regularly; however, majority of the respondents both production systems were using water from non-tap sources for hygienic practices. Bosciaminimifolia, Acacia ethaica and Blanitesgalabra were the most commonly used plant species for smoking in the study area. Majority of respondents in Pastoral (75.1%) and pre-urban (86.7%) production were sale their camel milk through nearest market center. In pastoralist production system majority of respondents indicates that, the range of milk price was (60.45±1.28 birr) and (85.27±2.14 birr) in wet and dry seasons respectively. In addition to, peri- urban production system the camel milk price was (100.23±2.69 birr) and (120.2±2.85 birr) in wet and dry season respectively. Therefore, Camel milk production practices and marketing systems should be followed to improve the quality and suitability of camel milk for its intended use in the study area.

Key words: *Camel milk, Marketing, Peri-Urban and Pastoral Production, Somali Region.*

INTRODUCTION

Camel husbandry practices in different parts of the world are a traditional nomadic management system and a transhumant, sedentary, semi-intensive, and intensive management system (Faraz *et al.,* 2021b). In Ethiopia, semi-intensive and intensive management practices are not practiced for camel production as compared to other animals. There is no improvement in housing, feeding, and watering to advance the production system. Camel management practice in Ethiopia is basically traditional and the pastoralist under this management only practiced an extensive range

of camel production systems and there is no improved forage production for meat, milk, and draft purpose (Yosef *et al.*, 2014b). Dromedary camels produce more milk for a longer period of time than any other milk animal held under the same harsh conditions. Camel milk is a valuable food source for humans in the arid and semi-arid environment of eastern Africa (Farah *et al.*, 2007); particularly, it is a primary source of food, nutritional and income security all year round for some pastoralists in the region (Elhadi *et al.,* 2015; Kebede *et al.,* 2015; Wako, 2015). Furthermore, camel milk enhances livelihoods and contributes to national and global economic growth and development (Faye *et al.*, 2011). Camel milk is also used as a traditional medicine to treat several diseases, and as a result, it builds the immune system of human beings when consumed occasionally (Kumar *et al.*, 2004; Sharma and Singh, 2014; Yadav *et al.*, 2015; Jilo, 2016). Therefore, camel milk is at the core of some pastoralists' culture, life and health and is considered as white gold of the desert (Gul *et al.,* 2015). The pastoral area of Ethiopia is the main camel belt in the horn of Africa. It is known by a camel culture, a monoculture which is expressed as an adaptation to arid ecology through dependence on the camel based on uniform husbandry methods and mobility (Tefera, 2012). In Ethiopia, camels are mainly reared in Somali and Afar regions and Borena and Kereyu areas of Oromia region (Tekle and Tesfay, 2013). Ethiopia holds a third of the world camel population that is about 8.1 million heads (CSA, 2021). Most of the Ethiopian pastoralists use milk as a staple food, which indicates the prestigious value of camel in the region. As a result, camels' contribution to immediate and direct household income was low in comparison with other livestock products (Tadesse *et al.,* 2013). Despite the significance of camel milk to livelihoods of the pastoralists in the region, camel milk production potential, hygienic practices and its marketing has not been fully explored by government and private sectors as compared to cows' milk. In addition, previous studies on camel production systems in the region concentrated only on pastoral system which is mainly practiced in the region (Mohamed *et al.,* 2002; Seifu, 2007; Hassen *et al.,* 2022) and there is little or no available information on the peri-urban camel production system in the region. Therefore, the objective of this study was to characterize camel milk production and marketing systems under the emerging pre-urban and traditional pastoral production system in selected potential zones of Somali region.

MATERIALS AND METHODS

Description of study areas

Degehbur district is one of the eleven districts of Jarar zone, Somali region. The district is located at 8° 12' 60.00" N latitude and 43° 33' 59.99" E longitude at an altitude of *1,044*meters above sea level and about 160 km east of Jigjiga, the capital city of Somali region. It has minimum and maximum temperatures of 21 and 33˚C, respectively. The mean annual rainfall and humidity of the area ranges from 300 to 475.8 mm and 31 to 36%, respectively. The rainfall pattern is erratic and has uneven distribution. The farming system in the district is primarily pastoralists, who mainly keep livestock, particularly camel, cattle, sheep and goats and to some extents are Agro-pastoralist that cultivate crops like sorghum and maize (IPS, 2002). The district has bi-modal rainfall pattern, usually occurring during the months of April to June (spring season) and October to December (autumn season) (IPS, 2002). Sagag district is one of the seven districts of Nogob zone, Somali region. The district shares borders with Jarar zone in the northeast and Gerbo district in the southeast. The district is located at 209 km south of Jigjiga at 6° 39' 40.42"N latitude and43° 47' 27.04"E longitude and with an altitude of 729 meters above sea level. The district has a mean annual rainfall and humidity ranges of 289 to 450mm and 45 to 47%, respectively (NMA, 2007). It has a minimum and maximum temperatures of 21.9and 31.43˚C, respectively. The farming system in the district is primarily pastoralists, who mainly keep livestock, particularly camel, cattle, sheep and goat and to some extents are Agro-pastoralist that cultivate crops like sorghum and maize (IPS, 2002). The district has bi-modal rainfall pattern, usually occurring during the months of April to Jun (spring season) and October to December (autumn season) (IPS, 2002). Kebridahar district is one of the ten districts of Korahey zone, Somali region. The district is located at 6°44'29.95"N latitude and 44°15'43.61"Elongitude and at an altitude of *1,609* meters above sea level and about 410km east of Jigjiga. The climate of Kebridahar district is characterized as tropical semi-arid. A vast area of the district experiences high temperature and low precipitation with mean annual temperature ranging 20.75 to 31.25˚C. The annual rainfall of the districts varies between 295 and 596 mm (NMA, 2007). The farming system in the district is primarily pastoralists, who mainly keep livestock, particularly camel, cattle, sheep and goats and to some extent Agro-pastoralist that cultivate crops like sorghum and maize (IPS, 2002). The district has bi-modal rainfall pattern, usually occurring during the months of April to June (spring season) and October to December (autumn season) (IPS, 2002). Shabeley

district is one of the eleventh districts of Fafan zone, Somali region. The district is located at 4°42'53.0"N latitude 45°12'54.0"Elongitude and at an altitude of 1850meters above sea level and about 25km southwest of Jigjiga. The mean annual rainfall is 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^{o}C with an overall average of 18.7^{o}C (NMA, 2007).

Study Design

This research work was a cross-sectional study conducted to collect relevant information on hygienic camel milk production and marketing system of in the study area.

Sampling Method and Sample Size Determination

A multi-stage sampling procedure was used in this study. In the first stage, from the eleven zones of Somali region, four zones (Jarar, Korahey, Nogob and Fafan) were selected purposively based on their camel population. In the second stage, four districts (Degehbur, Kebridahar, Sageg and Shabeley) were selected from the zones in purposive sampling technique again based on their camel population. The third stage, two kebeles (pastoral and peri-urban) from each district which have high camel milk production potential was selected purposively. In the fourth stage, sample households were selected by using simple random sampling technique. The sampling frame of Kebeles will be obtained from respective district livestock and agriculture development offices. The household size was determined according to the formula given by Arsham, (2007) for survey studies: $N = 0.25/(SE)^2$ Where, N = sample size; SE = Standard error. Accordingly, by assuming standard error of 3.1% as follows, $N=0.25 / (0.031)^2 = 260$; a total of 260 households/farms from (emerging per-urban (n=120) and traditional pastoral system (n=140)) was randomly selected for the survey interviews.

Methods of Data Collection

Primary and secondary data were the sources of information used for the study. Primary data sources were collected by using structured questionnaire with open-ended and close-ended questions, focus group discussion, key informant interview and field observation in the respective selected districts and the secondary data was collected from different regional, zonal and district level of the pastoral offices. The questionnaire was designed to obtain information on general household characteristics (age, marital status, education level, family size, purpose of keeping camel), camel management practices such as (housing type, housing materials, hygiene of houses and equipment, type of available feed resources and feeding system, water resource

and watering frequency, type of mineral supplementation and frequency of supplementation, milking frequency, milk marketing constraints and channels.

Data Analysis

The data collected using questionnaire survey and field observations were analyzed using SPSS (version, 20) software package. Descriptive statistics were used to quantitatively express the responses of the study participants with respect to their demographic characteristics as well as the hygienic practices and marketing system in the study area. Chi-square test was employed to examine the differences among categorical variables and Fisher's exact test was employed to examine if the cells less than five digits. The differences were considered to be significant at the level $P<0.05$.Using the model:

$Yij = \mu + \alpha i + eij$

Where, Yij = individual observation for each test

μ = the overall mean

αi= the production system (i=2; pastoral & pre-urban)

eij= the error term

RESULTS AND DISCUSSION

Demographic Characteristics of the Households

Majority of the respondents in pastoral (89.2%) and peri-urban (81.6%) production systems were male headed households while the rests were females. Most of the respondents in pastoral (62.1%) and peri-urban (64.2%) production systems belonged to the age group of 31-45 years; this indicates that the strongest and active age groups were carrying out camel herding activities in the study area. According to the study findings, the majority of the respondents in pastoral (94.2%) and Peri-Urban (60 %) production systems were illiterate (Table 1). Furthermore, none of the respondents in both production systems didn't get any training on hygienic milk production practices**.** The finding is in agreement with the findings reported in many pastoral areas of Ethiopia (Beruk and Tafesse, 2000). Similarly, Ma'alin *et al.* (2022) reported higher illiteracy in Godey, Adadle, Dhanan and Ber'ano districts of Shabele zone, Somali regional state. Lack of education and training on hygienic milk production practices exacerbates the risk of milk contamination with spoilage and pathogenic

microorganisms at farm level.

Table 1: Sex, age, educational level and family size of the households in the study area

	Pastoral		Peri- Urban		Overall		P-value
Descriptors	**N**	**%**	**N**	**%**	**N**	**%**	
Sex							
Male	125	89.2	98	81.6	223	85.7	0.52
Female	15	10.7	22	18.3	37	14.2	
Age (years)							
<30	19	13.5	23	19.2	42	16.2	
31-45	87	62.1	77	64.2	164	63	<0.0001
46-60	29	20.7	17	14.1	46	17.7	
>60	5	3.5	3	2.5	8	3.1	
Educational Status							
Illiterate	132	94.2	72	60	204	78.5	
Primary school	0	0	23	19.2	23	8.8	0.03
Junior grades	0	0	15	12.5	15	5.7	
Religious school	8	5.7	10	8.3	18	6.9	
Family Size (Mean + SE)	6.40±0.28^{b}		7.38±0.32^{a}		6.89±0.30		

SE = Standard Error.

Purpose of Camel Keeping

The result of the study indicated that farmers in the study area were kept camels mostly for milk, meat, social and cultural and for income generation as 1st, 2nd, 3rd and 4th in ranking. Moreover, farmers in the study area graded the selling of live camels and their products and/or both followed by ritual ceremony (e.g. marriage event) purpose as 5th level in ranking (Table 2). This finding is in line with Hassen *et al. (*2022), who stated that majority of respondents in Degehbur keep camel mostly for milk production followed by meat production and social and cultural. Pastoralists keep camel due to its higher volume of milk which is six times higher than that of indigenous cattle kept in the dry areas (Field, 2005). On the other hand, the Somali region has been considered to have one of the largest camel herds, and people living there strongly rely on camel milk and meat (Asres and Yusuf, 2014).

Table 2: Purposes of keeping Camel in the study area

	Pastoral						Peri-urban					
Purpose	**R1**	**R2**	**R3**	**R4**	**R5**	**Index**	**R1**	**R2**	**R3**	**R4**	**R5**	**Index**
Milk	28	16	10	3	0	0.27	26	17	9	4	0	0.26
Meat	12	19	9	5	4	0.23	0	0	4	6	10	0.11
Social& cultural	7	11	20	5	3	0.22	2	12	15	11	5	0.21
Income	0	5	8	14	9	0.17	2	3	9	10	15	0.18

Index= [(5 for rank 1) + (4 for rank 2) + (3 for rank 3) + (2 for rank 4) + (1 for rank 5)] divided by the sum of all weighed purposes of camel keeping mentioned by the respondents, R=Ran.

Management Practices of Camel

Feed Resources and Availability

Table 3: Major feed resources for camels

Parameters	**Pastoral**		**Peri-urban**		**Overall**	
Wet season	**N**	**%**	**N**	**%**	**N**	**%**
Communal pasture	128	91.4	85	70.8	213	82
Crop residues	0	0.0	10	8.3	10	3.8
Private pasture	12	8.6	25	20.8	37	14.2
Dry season						
Communal pasture	121	86.4	38	31.6	159	61.2
Private pasture	19	13.5	73	60.8	92	35.4
Pasture and crop residue	0	0.0	9	7.5	9	3.4

Major feed resources for camels in the study area are indicated (Table 3). The majority of respondents in pastoral (91.4%) were communal natural pastures in the wet season, respectively. While the majority of respondents were peri-urban, 86.4% had private natural pastures from the dry season. All of the interviewed households reported that the most common feed utilized by camels during the wet season was natural pasture from communal grazing lands in the area. There was a significance difference ($P<0.05$) of feed sources during dry season between pastoral and peri-urban production system. Pastoralist's mainly utilize communal natural pasture while peri-urban utilize communal natural pasture, crop-residue with natural pasture and private natural pasture.

Table 3: Major feed sources of wet and dry seasons in the study area.

N=Number of respondents.

Watering frequency and source of water

Frequency watering in wet, dry seasons and source of water in the study area are given in (Table 4). During the wet season, the majority of the respondents in pastoral (70 %) and pre-urban (67.5%) production systems were using water from wells and ponds, respectively. During the dry season, from pastoral (89.3%) and peri-urban (71.7%) were using wells followed by pumped well waters. This has been reported long ago in Somali region (Abebe, 1991). Distances to watering points vary for the wet and dry season. While most pastoralists and pre-urban communities travel 1-2km during wet seasons, this is elevated to longer than 5-10km in dry season. With regards to frequency of watering, the majority of the respondents in pastoral (90%) and pre-urban (94.2%) of camel herders' water their camels once in a month followed by more than one month during wet season. As indicated in Table 4, during the dry season, from pastoral (81.4%) and pre-urban (79.2%) camels drink water mainly once in two weeks. This finding is line with Simenew *et al*. (2013) reported once in two weeks, dry season watering frequency for Afar camels.

Table 4: Frequency of watering during wet, dry season, and source of water

Water Sources		**Pastoral**	**Peri-urban**		**Overall**	
Wet season	**N**	**%**	**N**	**%**	**N**	**%**
Well (bore hole)	98	70	35	20.8	133	51.2
Ponds	31	22.1	72	67.5	103	39.6
Pumped	11	7.9	13	11.6	24	9.2
Dry season						
Well (bore hole)	125	89.3	86	71.7	211	81.2
Pumped well water	15	10.7	34	28.3	49	18.8
Watering frequency wet season						
Once in two weeks	5	3.5	3	2.5	8	3.1
Once in a month	126	90	113	94.2	239	92
>one month	9	6.4	4	3.3	13	5
Watering frequency dry season						
Once a week	11	7.8	5	4.2	16	6.2
Once in two weeks	114	81.4	95	79.2	209	80.4
Once in a month	15	10.7	20	16.6	35	13.4

N= Number of respondents

Camel housing system

All respondents (100%) in the study area indicated that calves and mature camels were housed separately. Mature camels were housed in the open field around their home. Camel calves were housed in well-protected enclosures inside their home which was constructed from wood (like *Acacia Abyssinica*) and fencing by available piece of thorn wood (like *Prosopis julifora*) and different bush plants. This type of house is locally called as *'EDEG'*. The purposes of housing camel in the study area were to protect them from predators, extreme climate at night and theft. However, the house does not protect camel from rain and mud because the structure lacks roof and constructed on earthen floor. This undoubtedly results in soiling of teats, udders and other body part of milking camel while they are lying in muddy *'kraals'*, and cause the contamination of milk with harmful microorganism during milking especially when udder and teats were poorly cleaned before milking.

Mineral Supplementation

All respondents (100%) practice mineral supplementation. The majority of the respondents in pastoral (78.6%) and peri-urban (62.5%) use mineral water and salt soil respectively. In addition to, the majority of the respondents in pastoral (96.4%) and peri-urban (94.2%) provide

mineral supplementation to their camel during wet season. All the respondents believed that the animals that lick salt get stronger during the dry season and lactating camels produce more milk. The synergistic effect of salt on camel milk production has also been reported by Abule *et al*. (2004) in Afar region. The pastoralist in the study area move their camels a long distance to provide most popular well water having mineral salt in Jarar and Nogobzones particularly Bulale and Sulul well water in dry season, respectively (Table 5).

Table 5: Type and time of mineral supplementation in camels

Parameter	**Pastoral**		**Pre-urban**		**Overall**	
Type of mineral	**N**	**%**	**N**	**%**	**N**	**%**
Mineral water	110	78.6	75	62.5	185	71.2
Salt	5	3.6	26	21.6	31	11.9
Salt soil	25	15	19	15.8	44	17
Seasons						
Wet season	135	96.4	113	94.2	248	95.4
Dry season	5	3.6	7	5.8	12	4.6

N = number of respondents

Hygienic Camel Milk Production Practices

Water Sources used for Hygienic Practices

The majority of the respondents in pastoral (60.1%) and Peri-urban (50%) production systems were using water from wells and ponds, respectively for hygienic practices. This finding agrees with Bereda*et al.* (2013) who reported majority (64.4%) of respondent in Ezha district, Ethiopia were using water from non-tap sources for hygienic practices. Using water obtained from non-tap sources for hygienic practices during milk production and postharvest handling may leads to milk contamination with spoilage and pathogenic microorganisms (Jayarao *et al*., 2004). If it is difficult to get potable (safe to drink) water for cleaning practices, water obtained from river, stream, spring and hand dug well should be treated prior to use (Bereda *et al*., 2012; Zelalem, 2012). However, none of the respondent in the study area was treating water from non-tap sources prior to use for hygienic practices. Thus, it is important to heat or chemically treat water from non-tap sources so as to enhance or boost for hygienic practice.

Table 6: Source of water in the study area

	Pastoral		Peri-urban		Overall (260)	
Parameter	**N**	**%**	**N**	**%**	**N**	**%**
Water sources						
Wells (bore hole)	85	60.1	55	45.8	140	53.8
Ponds	52	37.1	60	50	112	43.1
Pumped water wells	3	2.1	5	4.2	8	3.1

N= Number of respondents

Housing and Cleaning Practices

The result of the study revealed that the majority of respondents in pastoral (51.4%) and Peri-urban (73.3%) production system clean the barn once per week (Table 7). Moreover, none of the observed ***'kraals'*** was provided with bedding material. This is in lined with Hassen *et al.*, (2022), who reported that, the pastoral and agro-pastoral production systems in Degehbur district do not use bedding material for their camels and clean the barn once a week. Therefore, maintaining the sanitary condition of barn is important for the production of good hygienic quality of milk. In addition to this, kept for clean, dry and comfortable bedding condition minimizes the growth of pathogenic microorganisms. Moreover, proper and clean housing environment is a prerequisite to produce milk and milk products of acceptable quality (Tassew, 2007).

Table 7: Cleaning practices of camel house in the study area

	Pastoral		Peri-urban		Overall		P-value
Frequency of barn cleaning	**N**	**%**	**N**	**%**	**N**	**%**	
Once per week	72	51.4	88	73.3	160	61.5	
Once per two weeks	64	45.7	30	25	94	36.2	0.03
>two weeks	4	2.9	2	1.7	6	2.3	

N = Number of respondents

Milking and Hygienic Handling Practices

Milking and hygienic practices during milking

All respondents in the study area camels are milked in the *kraals* where there is no roof and wall (Table 8). This is in line with Tamirat *et al*. (1999), who reported that milking in different parts of Ethiopia was done in the open air in grazing field and in front of homestead, which

were unclean for clean milk production. The result of the current study indicated that all respondents in both production systems were not washing udder before milking (Table 8). The finding also agrees with Hassen *et al.,* (2022) who reported that udder of milking camel was not washed prior to milking. Failure to wash udder before milking undoubtedly expose milk for microbial contamination (Mohammed *et al.,* 2016). The hygienic conditions are different according to the production system, adapted practices, level of awareness, and availability of resources (Zelalem, 2003). Milk can be contaminated by microorganisms at any point from production to consumption. FSA (2006) indicated that cleaning of the udder before milking is important to remove both visible dirt and bacteria from the outer surface of the udder. Getachew (2003) also indicated that milk producers should follow hygienic practices (clean utensils, washing milkier's hands, washing the udder, use of individual towels) during milking and handling, before delivery to consumers or processors. The result of this study showed that the majority in pastoralists (94.3%) and Pre-urban (87.5%) respondents did not wash their hands before milking (Table 9). The finding is comparable with Bashir and Ahmed (2018) who reported that half (50%) of the respondents in Afar zone didn't wash their hand before milking.

Table 8: Milking frequency and hygienic practices during milking in the study area

	Pastoral		**Peri-urban**		**Overall**	
Parameters	**N**	**%**	**N**	**%**	**N**	**%**
Milking frequency						
Twice a day	140	100	107	89.2	247	95
Three times a day	-	-	13	10.8	13	5
Method of milking						
Hand milking	140	100	120	100	260	100
Udder washing						
No washing at all	140	100	120	100	260	100
Hand washing before milking						
Yes	8	5.7	15	12.5	23	8.8
No	132	94.3	105	87.5	237	91.2

Means within a row are significantly different at ($P < 0.05$), N = Number of respondents

Milk handling equipment, smoking and cleaning practices

More than half of pastoralist respondents were using plastic containers for raw camel milk

transportation while 84.2% of Peri-urban camel production system were using stainless steel can for camel milk transportation. Similar findings were reported by Hassen *et al*. (2022) as the use of plastic containers dominated the milk market in Degehbur district of Jarar Zone, Somali region of Ethiopia especially for milk transport and storage purpose. Moreover, the finding also agrees with Mattias (2013) who reported that the majority of milk producers used plastic jerry cans for milk handling in Kiambu County in Kenya. The use of plastic for milk handling is not advisable as such practice highly contributes raw milk for microbial contamination (Omore *et al.,* 2005). Stainless steel equipment is mostly preferred (Bereda *et al.,* 2012; Zelalem,2012). The result of the study indicated that all respondents in both production system were used smoking plants like Maygaag (*Bosciaminimifolia*), Sogsog (*Acacia ethaica*) and Kadi (*Blanitesgalabra*) (Table 10).The finding agreed with Eyassu (2007) who reported that woods of tree species of Kadi (*Blanitesgalabra*), Sogsog (*Acacia ethaica*) and Wigir (*Olea Africana*), use for smoking milk containers by nomadic pastoralists in Shinile and Jigjiga zones of Somali region. Majority of the respondents in pastoral (61.4%) and peri-urban (77.5%) used smoking to improve taste and flavor as well as to increase shelf life of milk (Table10). This agrees with the finding of Abebe *et al.* (2013) who reported that the purpose of smoking was to improve the taste and flavor of milk products, as well as to increase the shelf life of the product in Ezha district of Gurage zone. Moreover, the finding also in line with the finding of Fikireneh *et al.* (2012) who reported that about 93.3% of respondents smoked their milk handling equipment to improve flavor and aroma of milk and milk products in mid rift valley of Ethiopia. Other studies have also reported on the use of smoke fumigation in the pastoral system (Wayua*et al.,* 2009; Kipsang, 2011). Most losses of dairy products occur because of a combination of poor production and /or handling practices and lack of technical knowledge. Among others, lack of knowledge on clean milk production, use of unclean milking equipment coupled with lack of potable water for cleaning purpose probably contributed to the poor hygienic quality of dairy products produced in Ethiopia (Zelalem and Faye, 2006).

Table 9: Milk handling equipment's, smoking and cleaning practices in the study area

	Pastoral		Peri-urban		Overall	
Parameter	**N**	**%**	**N**	**%**	**N**	**%**
Cleaning milk vessels regularly						
Yes	37	26.4	105	87.5	142	54.6
No	103	73.6	15	12.5	48	45.4
Smoking milk containers						
Yes	124	88.6	118	98.3	242	93.1
No	16	11.4	2	1.7	18	6.9
Purpose of smoking containers						
Give flavor & aroma	31	22.1	19	15.8	50	19.2
Increase shelf life	23	16.4	8	6.7	31	12
Both	86	61.4	93	77.5	176	68.8
Containers used for delivery/transportation						
Plastic	129	92.1	19	15.8	148	57
Stainless steel cane	11	7.9	101	84.2	112	43.1
Plants used for smoking						
Maygaag (*Bosciaminimifolia*)	96	68.7	85	71	181	69.6
Sogsog (*Acacia ethaica*)	28	20	13	10.8	41	15.8
Kadi (*Blanitesgalabra*)	16	11.4	22	18.3	38	14.6

N = Number of respondents

Major Constraints of Hygienic Camel Milk Production

The majority of the respondents in pastoral (with an index value of 0.24) and Pre-urban (with an index value of 0.22) production system ranked barn hygienic as the 1stmost important problem contributing for contamination of the milk in the study areas (Table 6). This is in line with Ruegg (2006), who reported that practices that expose teat end to wet and muddy pens increase the risk of occurrence of mastitis, and hence milk contamination with microorganisms. Poor hygienic was also ranked one of the major constraints of camel production in the study area (Table 6). The finding is comparable with that of Worku *et al.* (2014), who reported poor handling practices for instance unclean milking equipment as one of the major constraints of camel milk commercialization in Ethiopia. Poor hygienic production of milk (unclean udder due to lack of washing the udder before milking, unclean hands, poor

personal hygiene and health status, unclean milking containers due to lack of clean water, unclean milking sites) is more likely to cause milk-borne diseases and the natural antimicrobial factors can only provide a limited protection against specific pathogens for a short period. This is in line with Mohammed *et al.* (2016) who reported milk –borne disease is higher when the milk is consumed in its raw state as commonly practiced by the local producers.

Table 10: Ranking of major camel milk hygienic constraints in the study area

	Pastoral						Peri-urban					
Constraints	**R1**	**R2**	**R3**	**R4**	**R5**	**Index**	**R1**	**R2**	**R3**	**R4**	**R5**	**Index**
Barn hygienic	33	10	7	9	0	**0.22**	25	18	13	2	0	**0.24**
Poor hygienic Production	17	20	9	8	4	**0.21**	8	20	17	3	0	**0.20**
Sources of washing Water	10	4	18	9	3	0.16	8	5	13	11	2	0.16
Disease and parasites	5	4	11	9	11	0.15	0	6	9	7	11	0.13
Lack of veterinary Service	0	5	8	15	8	0.13	0	7	6	8	10	0.12
Lack of market	0	6	2	9	14	0.11	0	3	8	7	9	0.11

Index= [(5 for rank 1) + (4 for rank 2) + (3 for rank 3) + (2 for rank 4) + (1 for rank 5)] divided by the sum of all constraints of camel production mentioned by the farmers, R=Rank.

Milk Marketing

Milk selling in the study area

As shown in (Table 10) majority of respondents in Pastoral (75.1%) and pre-urban (86.7%) production were sale their camel milk through nearest market center. In the current study, respondents practice informal marketing system where they sale their milk. Camel milk was one of the income sources for pastoralists in the study area. Most respondents preferred camel milk than milk of other animals because they believe that camel milk has a medicinal value, best quality, nutritious, easily digestible, whitens a tea more than other milk types (according to the respondents, it has twice as much whitening concentration compared with other milk types). As indicated by the study some of the respondents did not sale all milk go to the

market. After that either they take back to the home and used for family consumption or sale at low price. The majority of respondents sold their milk to household consumers. Similar to the current result, Mebrahtu *et al. (*2017) indicates that majority of respondents sold their milk to household consumers in Afar regional state.

Table 11: Sale of milk in the study area

Variables	Pastoral (%)	Peri-urban (%)	Overall
Do you sale camel milk?			
Yes	75.1	86.7	78.8
No	27.9	13.3	21.2
Did you sell all milk go to the market always			
Yes	70.7	92.5	80.7
No	29.3	7.5	19.2
Consumers			
Household consumer	80.7	58.3	70.3
Café	19.3	41.7	29.6

N = number of respondents

Seasonal price of camel milk, market place and transportation means

The survey result in pastoralist production system majority of respondents indicates that, the range of milk price in wet season was (60.45±1.28 birr), while (85.27±2.14 birr) in dry season. In peri- urban production system the camel milk price was (100.23±2.69 birr) in wet season, while (120.2±2.85 birr) in dry season (Table 3).The survey result is higher than the Omer (2019) report who shows that the mean average price of milk per liter in wet season was 12.05±2.14 and in dry season 22.55±2.51 ETB in Degehbur Woreda, Jarar Zone due to inflation. According to the result of the current study the lowest price occurs in wet season, because of more supply of milk to markets due to high availability of feed and high number of milking camels in wet season. Whereas maximum price occurs during dry season when there is low supply of milk in the market as a result of fed shortage and low number of milking camel. In the dry seasons since the supply of camel milk is low and the demand for it is high. As shown in Table 3 the respondents were used drought animal, household labor and vehicle as means of transportation during milk marketing. Similar to the current study the result of Omer (2019) shows that majority of the respondents were using animal, household labor and vehicle as means of transportation, which accounts 58.7%, 38.7% and 2.6% respectively. Based on the current survey result there were limitation of transport, although camel and human back were major means of transportations.

The closer the market, less time it takes to travel, less milk spoilage would be incurred. This may reduce losses of energy, time and producers would get fair price for their milk. Majority of the respondents in the study area sale their camel milk at nearby market. Majority of respondents both in pastoral and pre-urban production system select the market place based on price of milk per litter. The result of the current study agrees with Mohamed (2014) the criterion mostly used in selecting milk marketing out let was price of milk per liter. The survey result of Ayanel (2019) shows that the most criteria of camel milk marketing selection were distance of market (40.6%) and market reliability (46.5%) and this result disagree with the current result. Choice of market outlet is the farmers decision on where to or not to sell their farm produces. Before choosing a market outlet, farmers consider the costs associated with transportation, profits, level of trust among the available channels and familiarity of the markets (Ahmed *et al*., 2016).

Table 12: Seasonal price of milk, transportation means and market place

Variables	Pastoral	Peri-urban	Overall
Price of milk (Mean ± SD			
Price per liter in wet season	60.45±1.28	100.23±2.69	80.34±1.98
Price per liter in dry season	85.27±2.14	120.2±2.85	102.74±2.51
Means of transportation for milk marketing (%)			
On foot	80	18.3	51.5
On animal	5.7	2.5	4.2
On car	14.3	79.2	32.7
Selling place of camel milk (%)			
Farm gate	7.9	4.2	6.2
Nearby market	90.1	95.8	93.8
Criteria in selecting market place (%)			
Price of milk	63.5	84.2	73.1
Distance of market	24.3	4.2	15
Market reliability	12.1	11.7	11.9

N = number of respondents

Camel Milk Marketing Channels

Marketing channel is a prearranged network of different agencies and institutions which in combination perform all the activities required to link producers with consumers for accomplishing marketing tasks (Jaleta, 2011). Camel milk marketing channels from the time

milk flow from the producers to final consumer through different channels in the study areas was indicated below (Figure 2). In any marketing process there is a chain/sequence of steps through which a given product passes starting from production area until it reaches the final consumer. Likewise, in the study area camel milk as a product passed through hands of different market intermediaries to reach their final end users. The camel milk flow begins with the producers, whole sellers, retailers and consumers, in order to generate cash to cover various family expenses. According to the result around four camel milk marketing outlets were identified, as the respondents reported the least beneficiaries are the producers due to lack of transportation and infrastructure. The hierarchy of the camel marketing system from producers at the top to the final consumer at the bottom involved a number of different types of milk marketing channels.

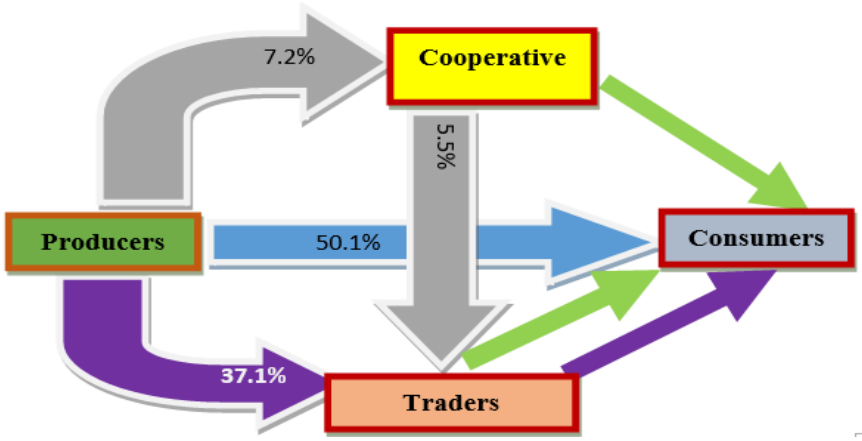


Figure 2: Camel milk market channels

Table 13: Camel milk marketing channels

No. of channels	Channels	Percent
Chanel I	Producer- Consumer	50.1
Chanel II	Producer- cooperative- Consumer	7.2
Channel III	Producer-Traders- Consumer	37.1
Channel IV	Producer- Cooperative- Traders- Consumer	5.5

Milk Marketing Constraints

Long distance to market, high cost of transport, insufficient amount of milk produced, spoilage and cultural limitation were the reasons of the producers for not selling fresh whole milk both in both pastoral and pre-urban production system. This study is line with Lumadede *et al*.,

(2010) who reported that seasonality of milk production, milk spoilage, lack of milk collecting facilities and processing, poor hygienic standards are major challenges in raw milk marketing. Seasonal variation in camel milk production in pastoral production systems is great and it is believed that some surplus milk is wasted during the rainy seasons when production is high (Agrawal *et al*., 2013). The result of Omer (2019) indicates that lack of transportation, poor infrastructure, price, and poor milk handling (traditional) technologies were main challenges remarked in difficulties of fresh milk marketing in Degehbur Woreda, Jarar Zone and this result agree with the current study. In the current study the respondents stated that, during the wet season a large amount of milk surplus wasted due to lack of transportation. This result agrees with previous literature, Ahmed (2002) lack of road infrastructure to transport milk from pastoralist areas (remote areas) was the major constraints in Afder zone (Table 14).

Table 14: Major camel milk marketing constraints in the study area

Parameter	Descriptions	Rank based on their severity
Major constraints		
	Distance to Market	1st
	Lack of transportation facility	2nd
	Lack of market or collection center	3rd

CONCLUSION AND RECOMMENDATIONS

From this study it can be concluded that camel play an important role in the livelihoods of the pastoralists and pre-urban in the study area. Majority of the respondents in both production systems in the study areas were illiterate. The major feed resources were natural pasture and crop residues which are relatively low in quality. Wells and ponds are the main water sources during the wet season from pastoral and peri-urban communities respectively. While wells are the main source of water in the dry season for both seasons. Traditional hand milking was a common practice of milking and all of the respondents do not wash the udder of the animal at all. This indicates poor hygienic practices in the study area. The milking equipment were mainly plastic materials, which are difficult to clean and disinfect, and thus it might contribute to poor quality of the milk. *Acacia ethaica, B. minimifolia, Blanitesgalabra*and *Solanum Carense*were the most commonly smoking plant species in the study area. The marketing system identified in the study area was mostly informal marketing system, in which the producers sell their milk and milk

products to household customers or the local market. The milk produced was sold mostly to individuals and some to cafes and restaurants. Price of milk per liter was used mainly as the milk marketing out let selection criterion while distance of market place also determined the criterion used to some extent. It was also revealed that the main means of transport used in transporting milk for sale was on animal and on foot delivery. The most important problems experienced in camel milk marketing were long distance to market, high cost of transport, insufficient amount of milk produced and spoilage. Therefore, solving feed and water problems, improving animal health and breeding. Based on the above-mentioned findings of this study the following recommendations are forwarded:

- Proper intervention on infrastructure, transportation and providing producers with the necessary equipment and materials for milk handling, processing and storage could be made available.
- Provision of training to the pastoralists is crucial so as to improve their knowledge and skills on the animals management, hygienic milking procedures, and on production of quality milk.
- Further researches should be conducted on preservation and processing of camel milk in the study area.

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On-farm Performance Evaluation of Small Ruminants in Fafan Zone, Somali Regional State: To promote Community Based Breeding Program

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ABSTRACT

A study was conducted to evaluate on-farm growth performances of short ear Somali goat and Black head Somali sheep at Harshin, Kebribeya and Shabelley districts of Fafan Zone, Somali region, to promote community-based breeding program. Study districts were selected based on goat and sheep production potential while does and ewes were selected based on the breeding history. Productive performances were collected from 245 does and 260 ewes kept under traditional management system. Data on productive performances were analyzed using General Linear Model of statistical analysis system. Group discussion revealed that small ruminant's rearing for income generation and household milk and meat consumption were common and contribute to livelihood in all the study areas. Fixed effect of location of flock, sex of lambs/kids and parity of does and ewes have significant impact on productive performance of short ear Somali kids and Black head Somali lambs. Small ruminants in Harshin scored higher growth parameters compared to small ruminants in Kebribeyah and Shabelley districts this variation may be due to within population variation of small ruminant and feed availability difference in the study areas. The overall birth weight of short ear Somali goats and Black head Somali sheep were 2.26 ± 0.27 kg and 2.39 ± 0.07 kg respectively. Male kids and lambs have heavier live body weight at birth, three, six and average daily body weight gain compared to female kids and lambs. Higher pre-weaning growth performance of kids were observed compared to lambs pre-weaning growth which is mainly due to the mothers' milk feeding and availability was higher in does compare to ewes especially during feed shortage periods whereas post-weaning growth were higher for lambs compared to kids since, post weaning growth performance mainly depend on the non-mothers' milk feed staff. Kids and lambs born from does/ewes at second and third parties revealed greater performance for growth traits. Three is a positive correlation between kids' and lambs' birth weight and pre-weaning growth performances whereas less impact on post weaning growth because post weaning growth highly affected by the environmental (non-genetic) factors. Three-month weight and six-month weight have the highest correlation coefficient with average daily body weight gain of kids and lambs. The overall productivity of the goat and sheep can be improved by giving emphasis to the improvement in management, nutrition and breeding practices.

***Keywords**: Goat and sheep on-farm productive, reproductive performance*

INTRODUCTION

Livestock, particularly goat and sheep, have an important contribution in marginal areas and pastoral production systems, which are less suitable for crop production, but have the potential to maintain large flock size of farm animals. The demand for sheep and goat products in Ethiopia has increased due to a growing human population, urbanization and demand from Gulf States. To fill the demand and productivity gaps in Ethiopia, alternative production improvement is urgent task of governmental and non-governmental organizations.

Centralized breeding schemes, undertaken by non-profit oriented governmental farms, involving complex breeding processes such as recording, genetic evaluation, selection, distribution of genetically improved animals, and feedback to farmers/pastoralists and cross breeding with exotic breeds were not bring a successful result under low input production system (small holder farmer and pastoral production system) in developing countries like Ethiopia (Haile *et al.*, 2018). In developing economies, livestock improvement is achieved through an aggressive involvement of livestock owners. A new approach gaining global interest is a community-based breeding program (CBBP). Programs that adopt this strategy take into account farmers'/pastoralists' needs, views, decisions and active participation, from inception through implementation, and their success is based upon proper consideration of farmers' breeding objectives, infrastructure, participation and ownership (Sölkner *et al.,* 1998; Wurzinger *et al.,* 2011 and Mueller *et al.,* 2015; Haile *et al*., 2018).

Designing a community-based breeding program is much more comprehensive than simply applying genetic theories to achieve increased productivity. Instead, its success combines infrastructure, community development and the opportunity for improved farmers/pastoralist livelihoods by creating integrated processes for productive breeding of adapted animals and the markets for their products.

Performance recording is an important tool to suggest a breeding policy for a given area. Reproductive and productive performances are important indicators of genetic potential adaptability and management adequacy (Abegaz *et al.,* 2002; Getahun, 2008). The process could be facilitated, coordinated and assisted by outsiders like development and research experts of

governmental and non-governmental organizations. However, setting up and implementation of any breeding program in pastoral areas of Ethiopia remain challenging due to mobility, high temperatures, recurrent droughts and poor infrastructure. Therefore, the current monitoring study was designed to evaluate the productive and reproductive performances of sheep and goats under the traditional management practices to promote community-based breeding programs in pastoral and agropastoral communities.

MATERIALS AND METHODS

Description of the Study Areas

The study was conducted in Fafan Zone of Somali Regional State located at 628 km east, of Addis Abeba. Fafan zone is situated in the northern part of Ethiopian Somali regional state with total land coverage of the zone is 40, 861 km^2 of which the rangeland extends over 36, 629 km^2 (IPS, 2002). Harshin, Kebribeyah and Shabelley districts were among the eleven districts of Fafan zone was selected for the community-based breeding program project based on the small ruminant flock potentialities, practicing cultivation of different crops and road accessibility. Study districts have an altitude range from 500 to 1650 m.a.s.l. and lies between approximately 8°44′N to 11°00′N latitude and 40°22′E to 44°00′E longitude (IPS, 2002). The mean minimum and maximum temperature ranges from 16 to 20 °C and 28–38 °C, respectively (NMSA, 2005). The rainfall distribution in the study zone is very erratic with a mean annual rainfall of 600 to 700 mm (NMSA, 2005). Study districts comprises pastoralism, agro-pastoralism and sedentary production systems.

Identification of Target Communities and Small Ruminant Selection

Before starting the program, we were assessed the small ruminant breeding potential and experiences of the communities in Fafan zone. Brief discussions and field visits were carried out in three districts of Fafan zone, namely Harshin, Kebribeyah and Shabelley. Two rural kebeles (Table 1.) per each district were purposively selected and discussion on community-based breeding program was made with community representatives and local administration. After reach of communal agreement between the researchers, livestock owners and woreda experts, five-day training was provided to the communities on overall objectives and technical aspects of the project. Target communities were selected based on their willingness, stock potential (> 25

small ruminants), experiences in small ruminant and forage production and road accessibility. Sheep and goats were identified and registered and marked with non-removable permanent marker.

Table 1. Cooperatives and their members on Small ruminant Community Based breeding Program

Cooperatives name	District	Number of cooperative members	Flock Size/species	Remarks
Amadle,	Shabelley	15	150	
Dheghabiyale	Shabelley	15	150	
Gillo	Kebriybeyah	15	150	
Guyo	Kebriybeyah	5	150	
Kuda ramole	Harshin	30	150	
Farah Liban	Harshin	10	150	Migrated

The simulated breeding program was structured into two-tiers involving the small ruminant community-based breeding Program (CBBP) as a nucleus and the surrounding flock as the base population. This means the spread of the genetic gain to the surrounding flock/base population was assumed via the buck/ram selection in the CBBP.

Animal Management and Monitoring

The age and parity of does and ewes in the flock were determined by dentition and information obtained from owners at the beginning of the field research work. Animals were reared under traditional management and uncontrolled mating practiced. Records on birth date, birth weight, pre-weaning growth, weights at three and six months, sex of lamb/kid, parity and average daily body weight gains were taken during the monitoring. Animals were weighed using suspended weaning balance at birth, one month, two-month three month and six-months age. Animals were vaccinated/dewormed and sprayed against internal and external parasites respectively.

Long term objective of community-based breeding program is to designed independent breeding communities/breeders through comprehensive breeding strategies (selection, crossing, stock replacement, production of improved forage production and optimization of forage nutrients and

self-health care of their animals). Therefore, the researcher provides training and demonstration on production of improved forage production.

Data Collection Procedures

Initially a total of 1000 does and ewes (500 per species) with multiparity and good health records were selected and identified through non removal marker. However only 245 does and 260 ewes were used for on-farm performance evaluation. The remaining animals were lost from the flock through migration, mortality and sell at some point during the monitoring period and data collected from these animals were discarded. Therefore, productive performance was taken from a total of 505 animals. In this study growth performance of kids and lambs were collected from January to June 2023. Growth records such as birth weight, pre-weaning weight, three-month weight, six-month weight and average daily body weight gain were recorded regularly and managed in MS-Excel computer program.

Data Analysis

Data on productive performances were analyzed using the general linear model procedures of Statistical Analysis System (SAS, 2009). The fixed effects were considered district, parity of ewe/doe and sex of the lam/kid. Duncan's multiple range tests was used to examine mean significant differences at ($p < 0.05$) among districts, parity and sex of the lamb/kid. The statistical models for growth /reproductive performances (birth weight, live body weight for three and six months and average daily body weight gain) of representative small ruminants in Fafan zone were summarized as:

Model (Reproductive Performances)

$Y_{ijk}=\mu + D_i + P_j + S_k + \varepsilon_{ijk}$

Where;

Y_{ijk} = the response variables (birth weight, average weaning weight, body weight at one, two three and six months and average daily body weight gain in kg);

μ = the overall mean;

D_i = fixed effect of the i^{th} district (Harshin, Kabribeyah and Shabelley);

P_j= fixed effect of the j^{th} parity (1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th});

S_k= fixed effect of the k^{th} sex (male and female);

ε_{ijk}= random error term.

RESULTS AND DISCUSSION

Sheep and Goat Production Objectives

Performance evaluation programs are utilized to obtain fair comparisons among all animals being considered for replacements within a flock. Fair comparisons are possible only when environmental differences are taken into account. Before on-farm performance evaluation, breeding objectives and reproductive performances of sheep and goats were assessed and analyzed in the first phase of the project and the result is indicated in Table 2 and 3) respectively.

Table 2 showed that the purpose of keeping small ruminants and their respective rank in all the study areas. Better understanding of the purposes of keeping small ruminant is a prerequisite for defining breeding goals (Jaitner *et al*., 2001). Primary reason for keeping sheep and goat in all study areas was income generation with 0.441 index value followed by as sources of food (milk and meat). Other reasons mentioned by small ruminants' owners and their respective indices were), social security (0.059) and social prestige (0.026). Similar findings have been reported in the intergovernmental authority on development (IGAD) countries (Djibouti, Eritrea, Ethiopia, Somalia, Uganda and Kenya) where pastoralists keep livestock to provide food (Sanford and Ashley, 2008; Anne *et al*. (2016). Agro-pastoral communities sell their animal and animal products for the purpose of predominant to pay for school fees, health care, to buy family foods and social securities were notably considered of great importance. In addition to that majority of respondents in Harshin, Kabribeyah and Shabelley indicated that's Slaughtering of sheep and goats for family/home consumption is done mostly during religious festivals and wedding ceremony.

Group discussion revealed that small ruminant's rearing for income generation and household milk and meat consumption were common and contribute to livelihood in the study areas, especially as alternative income sources to the poor. Knowledge of reasons for keeping animals is a prerequisite for deriving operational breeding goals (Jaitner *et al.*, 2001).

Table 2. Sheep and goat production objectives in the study areas

Districts	Sheep Production objectives	Ranks			Index
		1st	2nd	3rd	
Harshin	Income	29	7	8	0.454
	Meat	5	12	15	0.225
	Milk	2	16	12	0.208
	Social Security	3	3	4	0.079
	Social Prestige	1	2	1	0.033
	Over all	40	40	40	0.999
	Goat Production Objectives				
	Income	15	19	19	0.425
	Milk	20	11	8	0.375
	Meat	3	7	12	0.146
	Social Security	2	2	0	0.042
	Social Prestige	0	1	1	0.013
	Over all	40	40	40	1.001
Shabelley	**Sheep Production objectives**				
	Income	24	17	13	0.496
	Meat	8	10	15	0.246
	Milk	6	8	10	0.183
	Social Security	2	4	2	0.067
	Social Prestige	0	1	0	0.008
	Over all	40	40	40	1.00
	Goat Production Objectives				
	Income	16	24	12	0.45
	Milk	16	7	9	0.296
	Meat	8	4	6	0.158
	Social Security	0	1	11	0.054
	Social Prestige	0	4	2	0.042
	Over all	40	40	40	1.00
Kabribeyah	**Sheep Production objectives**				
	Income	20	20	12	0.467
	Meat	12	12	12	0.3
	Milk	3	6	5	0.108
	Social Security	4	2	8	0.10
	Social Prestige	1	0	3	0.025
	Over all	40	40	40	1.00
	Goat Production Objectives				
	Income	12	12	20	0.333
	Milk	14	17	11	0.363
	Meat	8	4	8	0.167
	Social Security	4	6	1	0.104
	Social Prestige	2	1	0	0.033
	Over all	40	40	40	1.00

Reproductive Performances of Sheep and Goats

Age at first mating (Sexual Maturity)

Puberty in the lamb/kid is the time at which animals ready for mating to replace their offspring. The age at puberty depends primarily on the growth of the lamb/kid, which depends on the supply of sufficient and quality nutrition during the growth period. On-farm average male sexual maturity of Black head Somali sheep was 8.76 ± 0.14 months while female sexually mature at 9.84 ± 0.18 months age. Similarly male goats sexually mature at 9.15 ± 0.19 age months and female goat matured at 9.83 ± 0.16 months age. As indicated in Table 3 there is statistically significant difference ($p < 0.05$) of age at first mating (sexually maturity) for both species and sexes across the study sites. Small ruminant reared under Harshin agro-pastoralists have relatively better age of puberty (8.83 ± 0.17 for goat and 8.43 ± 0.12 Sheep) compared to Kabribeyah (10.68 ± 0.16 for goat and 11.05 ± 0.19 for sheep) and Shabelley (9.99 ± 0.14 for goat and 10.05 ± 0.18 for sheep) this could be due to the within population variation and better feed availability in the study districts. Poor reproductive performances were observed at Keberibayah compared to Harshin and Shabelley districts mainly due to less access to feed espically during the dry seasons, which is highly affected to productive and reproductive performances of small ruminates under traditional management system. Similar finding was reported by Helen *et al*. (2015) age of sexual maturity for Black head Ogaden sheep range from 7.07 ± 0.19 to 10.22 ± 0.17 months in Pastorals and agro-pastoral production systems. Furthermore, Kiflay *et al.* (2019) also reported that 8.3 ± 0.09 months for comm Tigray highland sheep under comparative study of different management practices in northern Ethiopia.

Lambing and Kiding interval

Lambing/kidding interval is the period between two consecutive parturitions that determines reproductive efficiency in sheep and goat production. The mean ± SE, lambing interval and kidding interval were 7.36 ± 0.16/8.15 ± 0.7, 9.91 ± 0.17/8.55 ± 0.16 and 8.53 ± 0.15/8.45 ± 0.19 Months

for Harshin, Kebriy-bayah and Shabelley districts for goat and sheep respectively which is lower than 13.8 ± 0.27 months lambing interval of Black head Ogaden sheep at Jigjiga agro-pastoralists production system (Helen *et al*., 2015). This variation might be due to limited area covered by the previous researchers compared to the current study and season of the study. Furthermore, areas with better flock size (maximize within population vibration) and feed availability have high probability for better reproductive performance including lambing interval, weaning age and lifespan of ewes and does under agro-pastoral communities. Males are sold at early age during the holy days and festivals. Furthermore, farmers across the study sites sell their animals when they are faced with financial problems. Sheep and goats are primarily sold in the nearby market where local traders are principal actors in the marketing process. Overall, across of the study areas, average market ages of ram and buck were 10.75 and 11.61 months respectively. This finding is similar with report of Kiflay *et al*. (2022) for common Tigray highland sheep in northern Ethiopia.

Table 3. Small ruminant reproductive performances at agro-pastoral communities

Parameters	Districts (Mean ±SE)						P-value
	Harshin		Kabribeyah		Shabelley		
	Goat	Sheep	Goat	Sheep	Goat	Sheep	
Female average weaning age	3.12 ± 0.06^{b}	3.20 ± 0.08$^{\mathbf{C}}$	3.52 ± 0.17$^{\mathbf{a}}$	4.25 ± 0.16^{a}	3.32 ± 0.06$^{\mathbf{a}}$	3.88 ± 0.12$^{\mathbf{b}}$	P < 0.0133
Male average weaning age	3.04± 0.05$^{\mathbf{b}}$	3.05 ± 0.06$^{\mathbf{c}}$	3.30± 0.06^{a}	3.33 ± 0.02$^{\mathbf{b}}$	3.91± 0.07^{a}	3.85 ± 0.03^{a}	P < 0.0133
Average Kiding/Lambing interval	8.56 ± 0.16^{b}	8.55 ± 0.07$^{\mathbf{a}}$	10.42 ± 0.09^{a}	8.60 ± 0.07$^{\mathbf{a}}$	9.74 ± 0.10$^{\mathbf{a}}$	9.63 ± 0.39^{a}	P < 0.0133
Doe/Ewe Lifespan (Longevity)	7.36 ± 0.16$^{\mathbf{b}}$	8.15 ± 0.7$^{\mathbf{a}}$	9.91 ± 0.17^{a}	8.55 ± 0.16$^{\mathbf{a}}$	8.53 ± 0.15^{b}	8.45 ± 0.19^{a}	P < 0.014
Female average age at sexual maturity	8.83 ± 0.17^{c}	8.43 ± 0.17$^{\mathbf{c}}$	10.68 ± 0.16^{a}	11.05 ± 0.19$^{\mathbf{a}}$	9.99 ± 0.14$^{\mathbf{a}}$	10.05 ± 0.18$^{\mathbf{b}}$	P < 0.001
Male average age at sexual maturity;	8.18 ± 0.18$^{\mathbf{c}}$	7.98 ± 0.14$^{\mathbf{c}}$	10.06 ± 0.20$^{\mathbf{a}}$	9.60 ± 0.15$^{\mathbf{a}}$	9.20 ± 0.19$^{\mathbf{b}}$	8.7 ± 0.13$^{\mathbf{b}}$	P < 0.001
Male market age	12.34 ± 0.21$^{\mathbf{a}}$	10.88 ± 0.20$^{\mathbf{a}}$	11.40 ± 0.15$^{\mathbf{ab}}$	10.73 ± 0.21$^{\mathbf{a}}$	11.10 ± 0.18$^{\mathbf{b}}$	10.65 ± 0.22$^{\mathbf{a}}$	P < 0.041

Body Weight (Growth) Performance

Birth Weight

The mean (Mean ± SE) for birth weight of lamb and kids is presented in Table 4. The average birth weight (kg) were 2.26 ± 0.27 kg and 2.39 ± 0.07 kg for Somali short ear goat and Black head Somali Sheep respectively. Birth weight is the starting point to determine pre-weaning growth rate. It can be affected by season of the year, breed type, sex and litter size (Browning, 2007). Madibela *et al*. (2002) reported about Tswana goats' birth weight as was positively correlated with the growth rate of the animals. Small ruminants found in Harshin were scored significantly higher birth weight compared to Kebribeyah and Shabelley districts. This variation could be due to within population difference, feed availability and other external factors. Similar to current finding was reported by Kiflay (2019) was investigated 2.35 ± 0.03 kg for common Tigray highland sheep on-farm performance evaluation at Atsebi-Wonberta and Mekelle areas of Tigray region. How ever, the current finding is lower than Mahilet *et al*. (2022) reported that 2.99 ± 0.14 kg birth weight for Somali short ear goat at Haramaya University dairy goat farm while higher than Kefyalew *et al*. (2020) reported that 1.69 ± 0.08 kg birth weight for indigenous goats in Gayint district, Ahmara region. These variations could be due to management system, breed, season, location and year of data records.

Pre-weaning (growth) Weight

Pre-weaning growth is the body change of the animal from birth to before weaning the animal or the animal growth during the milk feeding time. The average mean kid growth at one month and two-month age was 3.84 ± 0.12 kg and 5.82 ± 0.16 kg respectively (Table 4). Similarly, lambs show good pre-weaning (one month and two months') growth performance as indicated in Table 4. The average lamb one month and two months growth (body weight change) were 3.38 ± 0.10 kg and 4.93 ± 0.14 kg respectively. Kids show better pre-weaning growth performance compared to lambs this is due to does provide more milk than ewes. Pre-weaning growth is highly affected by the milk yield of the dam because the kids and lambs mainly depend on milk feeding. Similar finding was reported by Htoo (2015) pre-weaning growth of kids and lambs were highly influenced by the milk yield of the mother and the small ruminant production management system. The weight gains of kid and lambs were significantly different among the three districts

($p < 0.05$) and higher growth were observed in Harshin compared to Kebribeya and Shabelley districts.

Table 4. lam and kid growth performance under three study districts

Species	Districts	Growth performance (kg)						CV (%)	p-value
		BW	1 MW	2 MW	3 MW	6 MW	ADG		
Goat		Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE		
	Harishn,	2.46 ± 0.09[a]	4.74 ± 0.18[a]	6.90 ± 0.20[a]	9.38 ± 0.25[a]	11.84 ± 0.28[a]	0.056 ± 0.002[a]	28.29	0.016
	Kabribeyah	2.18 ± 0.06[b]	3.53 ± 0.11[b]	5.47 ± 0.15[b]	7.56 ± 0.17[b]	9.85 ± 0.21[b]	0.043 ± 0.001[b]	22.54	< 0.001
	Shabelley	2.13 ± 0.65[b]	3.25 ± 0.08[b]	5.09 ± 0.12[b]	7.36 ± 0.15[b]	9.48 ± 0.19[b]	0.041 ± 0.001[b]	20.92	< 0.001
	Overall	2.26 ± 0.27	3.84 ± 0.12	5.82 ± 0.16	8.1 ± 0.19	10.39 ± 0.23	0.047 ± 0.001	23.92	0.006
Sheep	Harishn,	2.67 ±0.09[a]	3.67 ± 0.10[a]	5.5 ± 0.16[a]	7.76 ± 0.22[a]	12.78 ± 0.42[a]	0.056 ± 0.002[a]	27.60	< 0.001
	Kabribeyah	2.26 ± 0.06[b]	3.32 ±0.09[b]	4.73 ± 0.13[b]	6.80 ± 0.18[b]	10.37 ± 030[b]	0.045 ± 0.001[b]	26.75	< 0.001
	Shabelley	2.25 ± 0.06[b]	3.16 ±0.10[c]	4.56 ± 0.14[b]	6.57 ± 0.17[b]	9.70 ± 0.28[c]	0.041 ± 0.001[b]	29.20	< 0.001
	Overall	2.39 ± 0.07	3.38 ± 0.10	4.93 ± 0.14	7.04 ± 0.19	10.95 ± 0.33	0.047 ± 0.001	27.85	< 0.001

[a-c] Means with in a row with different superscripts differ (P < 0.05); ADG = Average Daily body weight Gain; BW = Birth Weight, MW = Month Weight (1, 2, 3, 6 Months), SE = Standard Errors

Weaning Weight (90 days)

The average weaning weight of kids and lambs in Harshin, Kebribeyah and Shabelley districts were 9.38 ± 0.25 and 7.76 ± 0.22, 7.56 ± 0.17 and 6.80 ± 0.18, 7.36 ± 0.15 and 6.57 ± 0.17 kg respectively. These findings were lower than the Mhailet *et al*. (2022) reports 15.83 ± 2.03 kg for weaning weight of Somali goat at Haramaya University dairy goat farm under intensive management system. These finding revealed that, the performance of kid is higher than lambs in all study districts under the traditional management practice. These variations among two species are indicated that milk yield of the animal is highly influenced on growth of kids and lambs before they were well established rough feeding practice. Furthermore, weaning weight significantly ($p < 0.05$) higher in Harshin district compared to Kebribeyah and Shabelley districts this might be due to the more feed available and high within population variation prcesns in Harshin compared to Shabelley district and there is positive correlation with birth weight and pre-weaning weight.

Six Month Weight

The findings pertaining to the six-month weight performances of the ewes and does are presented in Table 4. The findings also show that six-month weight of the kids and lambs varied ($P < 0.05$) among the three study districts. This variation may be due to the availability of feed resource difference and individual animal variation among the study areas. The current result of six-month weight (10.39 ± 0.23 and 10.95 ± 0.33 kg for kids and lambs respectively) was similar to Tesfay *et al*. (2020) findings for local goat (11.35 ± 0.15 kg) at Fantale district, Oromia region. How ever, six-months weight of the kids and lambs in the current study is lower than Hulunim *et al*. (2019) (12.58 ± 0.87 kg) and Abdimalik *et al*. (2022) (14.25 ± 1.50 kg) reports respectively. This variation might be due to management system and year of data performance data collection. Lambs showed higher six-month weight compare to kids since the post weaning growth is mainly depend on the forage feeds conversion efficiency but not milk feed. Small ruminant owners' sale their male kids and lambs at six-month age for their children school fee, household food fee and medical needs. Hence, six-months weight is crucial and has great economic importance in meat goat and sheep production.

Average Daily Body Weight Gain (ADG)

The overall means of daily body weight gain between study locations from birth to 180 days were significantly ($p < 0.05$) different. The variation in growth performance among districts is associated to the differences in management practices followed, within population difference and the availability of feed. The variation recorded in growth performance among the study districts could be an asset and gives a direction to improve the genetic potentials of local sheep with a long-term selection effort. Similar investigation was reported 0.05 ± 0.01 kg/day for average daily body weight gain of common Tigray highland sheep (Kiflay, 2019). However, the average daily body weight gain in the present study was lower than values (0.083 ± 0.89 kg/day) reported by Kiflay *et al*. (2014) for Black head Somali sheep under on station management system. All the sheep and goat breeds across the world influence of environmental determinants in growth trajectory of the sheep (Safari *et al.,* 2005; Mekuriaw and Haile, 2014). Therefore, Growth and reproductive performance of indigenous sheep and goats could be improved through improvement of environmental factors which post weaning daily body weight gain is highly influenced by non-genetic factors.

Sex Effect

Male kids and lambs were significantly ($p < 0.05$) heavier than females for birth weight, pre-weaning weight, three-month weight, six-month weight and average daily body weight gains (Table 5). In agreement with the current study, Kiflay (2019) and Daskiran *et al.* (2010) reported that male lambs grew faster and attained larger mature weight relative to female. The larger weight of males in comparison to female kids/lambs could be due to presence of sexual dimorphism as caused by the hormonal differences in their endocrinological and physiological functions. The presence of a Y-chromosome and the products of srygene have sex-specific effects on fetal growth thus the males grow faster than females in uterus (Loos *et al.*, 2001).

Table 5. lam and kid growth performance difference between male and female

Species	Sex	Growth performance (kg)						CV (%)	p-value
		BW	1 MW	2 MW	3 MW	6 MW	ADG		
Goat		Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE		
	Male	2.36 ± 0.06[a]	3.75 ± 0.09[a]	5.76 ± 0.12[a]	8.10 ± 0.14[a]	10.61 ± 0.18[a]	0.046 ± 0.001[ns]	26.86	0.027
	Female	2.05 ± 0.05[b]	3.51 ± 0.11[b]	5.36 ± 0.15[b]	7.47 ± 0.18[b]	9.82 ± 0.24[b]	0.043 ± 0.001[ns]		
	Overall	2.21 ± 0.06	3.63 ± 0.10	5.56 ± 0.14	7.79 ± 0.16	10.22 ± 0.21	0.045 ± 0.001		
Sheep	Male	2.78 ± 0.06[a]	4.04 ± 0.09[a]	6.02 ± 0.12[a]	8.32 ± 0.16[a]	13.09 ± 0.30[a]	0.057 ± 0.001[a]	23.22	< 0.001
	Female	2.07 ± 0.04[b]	2.88 ± 0.06[b]	4.09 ± 0.08[b]	6.03 ± 0.10[b]	9.01 ± 0.17[b]	0.039 ± 0.001[b]		
	Overall	2.43 ± 0.05	3.46 ± 0.08	5.06 ± 0.10	7.18 ± 0.13	11.05 ± 0.24	0.048 ± 0.001		

[a-b] Means with in a row with different superscripts differ ($P < 0.05$); ADG = Average Daily body weight Gain; BW = Birth Weight, MW = Month Weight (1, 2, 3, 6 Months), ns = non-significant, SE = Standard Errors

Parity Effect

Kids and Lambs born from ewes in their earlier parity (2-3) were consistently heavier than kids and lambs born at earlier (1^{st}) and later (5^{th}) parities which revealed that the best performance for growth traits (Table 6). Kiflay (2019) and Brehanu and Aynalem (2009) have reported similar finding for local sheep. Ewes in their middle parity attained their physiological maturity and have lamb of better birth weight than ewes in their early and older ages, which are not able to produce to their production capacity. Therefore, it may be suggested that it will be unwise to cull an ewe based on the performance of her first parity, rather the ewe should be serviced and used up to the fifth parity while giving adequate flushing and steaming-up diets before making a decision.

Table 6. lam and kid growth performance under different parities

Species	Parity	Growth performance (kg)					
		BW	1 MW	2 MW	3 MW	6 MW	ADG
Goat		Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
	1	2.05 ± 0.13[b]	3.30 ± 0.20[ns]	4.75 ± 0.24[b]	6.56 ± 0.29[b]	8.31 ± 0.37[b]	0.035 ± 0.002[b]
	2	2.37 ± 0.08[a]	3.81 ± 0.12[ns]	5.63 ± 0.16[a]	7.73 ± 0.16[a]	10.31 ± 0.23[a]	0.044 ± 0.001[a]
	3	2.31 ± 0.09[ab]	3.69 ± 0.15[ns]	5.65 ± 0.20[a]	7.91 ± 0.24[a]	10.38 ± 0.31[a]	0.045 ± 0.002[a]
	4	2.11 ± 0.09[ab]	3.57 ± 0.19[ns]	5.53 ± 0.23[a]	7.92 ± 0.27[a]	10.57 ± 0.35[a]	0.047 ± 0.001[a]
	5	2.06 ± 0.08[b]	3.59 ± 0.16[ns]	5.90 ± 0.22[a]	8.34 ± 0.26[a]	10.65 ± 0.31[a]	0.048 ± 0.002[a]
	p-value	0.040	0.442	0.047	0.003	0.006	0.002
	CV%	27.76	28.95	26.60	22.21	21.92	25.59
Sheep	1	1.95 ± 0.13[c]	2.46 ± 0.16[c]	3.40 ± 0.17[d]	4.83 ± 0.22d	6.90 ± 0.24[d]	0.028 ± 0.001[e]
	2	2.05 ± 0.07[c]	2.78 ± 0.10[c]	4.01 ± 0.13[c]	5.96 ± 0.19c	8.95 ± 0.30[c]	0.038 ± 0.001[d]
	3	2.48 ± 0.06[b]	3.48 ± 0.08[b]	5.06 ± 0.12[b]	7.15 ± 0.14b	10.96 ± 0.31[b]	0.047 ± 0.002[c]
	4	2.42 ± 0.08[b]	3.59 ± 0.13[b]	5.33 ± 0.19[b]	7.54 ± 0.21b	11.92 ± 0.38[b]	0.053 ± 0.002[b]
	5	2.76 ± 0.09[a]	4.15 ± 0.12[a]	5.90 ± 0.20[a]	8.44 ± 0.30[a]	13.25 ± 0.48[a]	0.058 ± 0.002[a]
	p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	CV%	25.36	25.05	24.81	21.6824.73	24.73	27.30

[a-e] Means with in a row with different superscripts differ (P < 0.05); ADG = Average Daily body weight Gain; BW = Birth Weight, MW = Month Weight (1, 2, 3, 6 Months), ns = non-significant; SE = Standard Errors

Correlation of Growth Traits

Correlation among growth traits (birth weight to six-month weight and average daily body weight gain) is presented in Table 7. Correlation between body weights of kids and lambs from birth to weaning may give a clearer picture of physical development of kids and lambs. Table 7, clearly showed that birth weight has great influenced on the pre-weaning growth of kids and lambs while less impact on post weaning growth because post weaning growth highly affected by the environmental (non-genetic) factors. Three-month weight and six-month weight have the highest correlation coefficient with average daily body weight gain of kids and lambs because their growth is depended on the roughage feed conversion efficiency and transition period (from milk feed to roughage feeds). Similar literatures were reported by Hanford *et al*. (2003) reported that correlation between birth weight and weaning weight was moderate for the Columbia breed; Matika *et al*. (2001) found that genetic correlations between birth weight and other weights up to 18 months were high (0.75-0.85).

Table 7. Statistical correlation among the small ruminant growth performances in the study areas (Above the diagonal for goat and below the diagonal for sheep; goat= 245 & sheep = 260).

Traits	BW	1 MW	2 MW	3 MW	6 MW	ADG
BW	1.00	0.67	0.59	0.46	0.42	0.38
1 MW	0.87	1.00	0.82	0.70	0.68	0.54
2 MW	0.77	0.89	1.00	0.90	0.85	0.74
3 MW	0.73	0.84	0.93	1.00	0.92	0.86
6 MW	0.73	0.82	0.89	0.92	1.00	0.96
ADG	0.61	0.74	0.84	0.89	0.98	1.00

ADG = Average Daily body weight Gain; BW = Birth Weight, MW = Month Weight (1, 2, 3, 6 Months

Conclusions and Recommendations

Sheep and goat in the study areas were principally bred as source of income, meat and milk for home consumption, social security and social prestige. The average birth weight (kg) were 2.26 ± 0.27 kg and 2.39 ± 0.07 kg for Somali short ear goat and Black head Somali Sheep respectively. Better growth performance kids and lambs were scored in Harshin district compare to Kebribeyah and Shabelley districts. Small ruminants show great variation on growth performance within the population but the growth performance in the current study is lower than others findings which might be due to occurrence of frequent drought and non-selection mating practice. Growth rate of lambs or kids, particularly during the early ages of growth, is strongly influenced by milk production potential of the female animals, the environment under which the animals are maintained, including the availability of adequate feed sources both in quantity and quality. Therefore, the presences of different productive and reproductive performance of sheep and goat in Fafan zone indicated that there is a room for genetic improvement of small ruminants through collaboration of all stakeholders. To achieve small ruminant sustainable genetic improvement in the study areas the following recommendations are suggested:

- Provide continuous training and capacity building of livestock owners on modern livestock husbandry and breeding practices.
- Livestock owners should support and incentivized different agricultural inputs (veterinary service, medicine, concentrate feed, reproductive technology tools, Pastoral and agro-pastoral training centers, improved house equipment's, improved forage packages and nursery sites)
- Create market linkage between pastoralist/agro-pastoralist and customers and legal traders

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Assessment of Local Dairy Cattle Production Potential and Marketing System in Fafan Zone, Somali Regional State

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ABSTRACT

This study was conducted to assess dairy cattle production potential and milk marketing practices in Fafan zone of Somali region, Ethiopia from February to April 2023. A total of 120 household heads (20 per-rural kebeles), two milk (Lefasie and Bombas) market places were selected purposively and interviewed with structural questionnaires to obtain information on the management practices of Agro-pastoralist, productive and reproductive performances indigenous dairy cows, Agro-pastoral dairy cattle breeding objectives, cattle breeding and section criteria and milk marketing practices. The data were analyzed using both statistical package for social sciences (SPSS, 2019) and statistical analysis system (SAS, 2009). Statistical significance among the study districts were tested using Tukey test at $p < 0.05$ level of confidences. Cattle flock size in Awbare (11.38 ± 0.82) and Gursum (12. ± 0.09) was significantly ($p < 0.001$) higher than compared to the Harow (7.25 ± 0.57) district while higher sheep and goats (13.53 ±0.87) flock size were observed at Harow district. The major feed resources were natural pasture, crop residues, and crop-residues and concentrate feeds. Majority of the respondents (95%) in Agro-pastoral production system of the study areas were used separate open kraals surrounded by thorny acacia trees and stones and husband share the highest contribution on cattle management. Primary reason for keeping cattle in all three study areas was milk production followed dual purpose and Agro-pastoralist practiced uncontrol natural mating. The overall means ± SE of milk yield per day/cow, lactation length and milk prices per liter was 3.52 ± 0.17 liters, 5.59 ± 0.22 months and 86.33 ± 0.66 Birr/ liter respectively. Better daily milk yield was observed at Awbare (4.1 ± 0.22 liter/day) compared to Harow (3.61 ± 0.17 liter/day) and Gursum (2.86 ± 0.13 liter/day). Better reproductive performances (age of first calving, average weaning age and calving interval) were observed in Gursum district compared to Awbare and Harow. Frequent drought occurrence, shortage of feed and prevalence of diseases with limited veterinary extension service and long distance to get market service are the main constraints of dairy cattle production in Fafan zone of Somali region. Therefore, it is concluded that there is clear variation on productive and reproductive performance of dairy cattle between the study areas this implies good opportunity for dairy cattle genetic improvement. Further study for within population genetic diversity is important for future improvement interventions.

Key words: *Local dairy cattle production potential marketing system*

INTRODUCTION

The total annual national milk production in Ethiopia from about 12.58 million milking cows is estimated about 3.895 billion liters, which is 1.48 liters/cow on average (CSA, 2020). According Brasesco *et al*. (2019) the average annual per capita consumption of milk is 56.2 liters which is below recommended of 200 liters. The main problem of milk production in the country is that of the poor genetic potential of the indigenous cattle, which gives rise to low milk output. Low productivity of cattle because of their Genetic makeup increased the running and investment cost per unit. Milk production is as low as 0.5 to 2 liters per day over a lactation period of 160 to 200 days (Ulfina and Lemma, 2019). Improving the feeding, water availability and health care of the indigenous cattle did not increase the quantity of milk per day to allow the animals to be used for commercial market-oriented milk production. In order to improve the low productivity of local cattle, selection of the most promising breeds and crossbreeding of these indigenous breeds with high producing exotic cattle has been considered as a practical solution (Tadesse, 2002). The success of dairy production in general and crossbreeding programs in particular needs to be monitored regularly by assessing the productive performance under the existing management system and it is essential for the development of appropriate breed improvement strategies (Alemshet *et al*., 2017). Daily milk yield of local cattle in Somali region was 1.48 liters per animal/day with the average 6 months lactation period. Total cattle milk production in 2019 was 177,582,308 liters (CSA, 2020). Thus, figures clearly show that dairy cattle milk production is very far from the demand (currently above 100 Birr per liter milk prices) of the society in the region. However, there is no commercialized and governmental improved dairy development institutions in Somali region even the society are very connected with milk food. Therefore, there is a need to have long-term plans for breeding programs of dairy cattle, which adequately respond to both the present and anticipated future market needs in the Somali regional. Hence this research was done with the aim of assessing and identifying dairy cattle production potential and breeding objectives including marketing system, production constraints and opportunities of the Agro-pastoral communities in Fafan zone.

MATERIALS AND METHODS

Description of the Study Areas

Fafan zone is one of the nine administrative zones of the Somali regional state (SRS) and it located at 620 km east of Addis Ababa, capital of Ethiopia. Fafan is situated in the northern part of SRS and borders in the east with republic of Somalia, in the west with Oromia regional state and Fik zone, and in the south with Degehbur zone. The total land cover is 40,861 km2 of which the rangeland extends over 36, 629 km^2 (IPS, 2002). About 52.6%, 31% and 7% of the landscape of the zone can be categorized as flat to gentle slopes, hills and steep slope, respectively. Midland (1500–2300 m.a.s.l.) Agro-ecology constitutes about 95% of the Jigjiga zone (IPS, 2002). Temperature is generally high all the year round with mean minimum and maximum values around 20 ^{0}C and 35^{0}C, respectively. The mean annual rainfall is 660 mm and bimodal. The camel population of the region is estimated at 1,417,080, from which 81,221 are found in Jigjiga zone (CSA, 2008). The current study was conducted at Awbare and Gurdum districts of Fafan zone. Awbare district is located in the Northeastern corner of the Jigjiga city capital of Somali regional state with 74 km far from Jigjiga city and bordering Northern Somaliland and lies from 9^0, 18' and 10^0, 12' N Latitude and 42^0, 37' and 43^0, 26' E longitude (BOFED, 2011). The altitude of Awbare district ranges from 1074 (*Ilala-dhere* kebele) to 2107(*Hero-geel*, kebele) m.a.s.l. (BOFED, 2011). According to traditional description of the landscape in Ethiopia Awbare district 61% coverage is *Woyne-Dega* (midland) and rest is *kola* (lowland). The climate of the district is semi-arid and is marked by seasonal variations, receiving an annual rainfall that varies from 400 to 900 mm and mean annual daily temperature is 19^{0}c (BOFED, 2011). The rainfall pattern of Awbare district is bimodal type of rainfall classified as a short rainy season (from July to September) and a main rainy season from March to May (BOFED, 2011). Gursum district is the second study area set at 517 kilometers from Addis Ababa, and fifty kilometers from Jigjiga, borders within the north Ajersagora, east and south jigjig and Kebribeyah woreda respectively, and Babile in west. Geographically, Gursum district is found with associate in altitude starting from 1200–2950 m.a.s.l (NMSA, 2005). Per the distribution of precipitation in study space from Gregorian calendar month to October, with the very best rain falling in August, September and October. The precipitation distribution of the study space was bimodal occurring from Feb to Apr (short rain season) and June to September (long rain season). Whereas, mean annual precipitation

is 740.6mm/year (Milkesa and Kurtu, 1997). This shows solely a small distinction in temperature throughout the year, with the most popular months throughout April to June (maximum 29.4°C and minimum 12.8°C) during October (NMSA, 2005). All study areas have potential for farm animal production that is principally commenced by pastoral and Agro-pastoral. Agriculture is that the main bread and butter supply of the agricultural population within the districts. Major cultivated crops in all study areas are sorghum and maize. Livestock production (cattle, sheep, goat and camel) is an integral a part of the pastoral livelihood in the all-study districts.

Sample Size and Sampling Techniques

Prior to site selection, discussion was made with key informants such as Agro-pastoralists' representatives/elders, livestock experts and different development agents at kebele level. Three study districts and six rural kebeles were purposively selected based on the dairy cattle potential, and milk marketing trends and willingness of the respondents for interview and focus group discussion. A total of 120 household heads (20 per-rural kebeles), two milk (Lefasie and Dhegahle) market places were selected purposively and interviewed with structural questionnaires. Physical observation on overall dairy farm activities and milk marketing practices. One focus group discussion (8 -12 participants each group) for each rural kebele was conducted to get further information on common agricultural activities, dairy cattle breeding objectives, dairy cattle production and market trends, major production constraints.

Data Sources and Method of Data Collection

The study was used both primary and secondary data sources. The primary data were collected from respondents through semi-structured questionnaires, focus group discussion, key informant interviews and field observation while secondary data were obtained from published documents, research findings, farm record data's, agricultural office reports and other non-governmental offices sources. Filed survey and market observation were carried between March and first May 2023.

Data Management and Analysis

Both statistical package for social sciences (SPSS, 2019) and statistical analysis system (SAS, 2009) was used to analysis categorical and quantitative data sets respectively. Analyzed statistically data were presented using means, frequency distribution, percentages, standard error of mean and different charts. Chi-square-test was used to examine differences between levels of significance of sex, age categories, marital status, agricultural farming activities and respondents'

income sources whereas significance variation for flock composition, productive and reproductive performances were tested using Tukey test at $p < 0.05$ level of confidences among the study districts. Furthermore, indices were calculated for all ranking data (Breeding bull and cow selection criteria and major production constraints) using the formula: Index = Σ[3 for rank 1 + 2 for rank 2 + 1 for rank 3] given for an individual reason divided by Σ[3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all reasons where indices represent weighted averages of all rankings for a particular trait or reason (Kosgey and Okeyo, 2004).

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Respondents

Briefly description of socioeconomic characteristics of respondents in any survey study is very important concept to see jointly the impact of their agricultural activities and their livelihood on the economical and national developments.

Household Characteristics

Table 1. Presents some key characteristics of the respondents (sex, family size and marital status) across the study districts. The overall average age of the household head was 46.77 ± 11.32 years, which indicate that the dairying farm was generally run by adults' people with a good experience Around 87% of the respondents were male while the remaining 15% are female, which indicated that males have dominant in the agricultural activities and household headed in Fafan Zone. All of the respondents (100%) were follower of Muslims. The overall mean family size was 8.03, which is comparable with the estimation of 8.80 persons per household reported in other area Hashin district, Fafan zone reported by Kiflay *et al* (2023), Asaminew and Eyasu (2009) reports that 8.2 family size s in Bahir Dar Zuria. The interviewees stated that large family size was very important source of labor for dairy activities. All respondents did not use any family plan to control their family size, which they considered against the rule of "God". Furthermore, majority (85%) of the respondents were married and household decision made by male.

Table 1. Household characteristics of respondents

Respondent characteristics	Districts						Overall N = 120		X^2 values
	Awbare (N = 40)		Gursum (N = 40)		Harow (N = 40)				
	N	%	N	%	N	%	N	%	
Sex									
Female	6	15.00	0	0.00	10	25.00	16	13.33	10.96
Male	34	85.00	40	100.00	30	75.00	104	86.67	
Family size (N = 120)									
Age categories (years)									
< 10	1.38	19.41	2.33	26.94	0.75	8.98	1.49	18.55	36.99
10 – 15	1.20	16.90	1.95	22.54	1.45	17.36	1.53	19.05	10.89
16 – 20	1.33	18.73	1.20	13.86	1.73	20.71	1.42	17.68	27.74
21 – 30	0.95	13.38	0.85	9.83	1.78	21.31	1.19	14.82	26.68
31 – 40	1.15	16.20	1.18	13.64	1.1	13.17	1.14	14.19	8.03
41 – 50	0.58	8.17	0.83	9.60	1.18	14.13	0.83	10.34	17.99
> 50	0.53	7.46	0.33	3.81	0.38	4.54	0.41	4.73	17.05
Total	7.1	100.0	8.65	100	8.35	100.0	8.03	100.0	
Marital Status									
Single	-	-	-	-	-	-	-	-	
Married	35	87.5	40	100.00	27	67.5	102	85.0	16.86
Divorced	5	12.5	0	0.00	13	32.5	18	15.0	
Age (Mean ± SD)									
Age	46.28 ± 12.56		46.35 ± 11.92		47.68 ± 9.50		46.77 ± 11.32		99.02

N = Number of Respondents, SD = Standard Deviation, X^2 = Chi-square



Figure 1. Discussion with kebele leaders before selection respondents, FGD and Individual interview

Educational Status Respondents

The educational status in the current study in the presented in (Figure 1). Only 33% of respondents can read and write while 49% were illiterate. This finding is similar to Kiflay *et al*. (2023) reported around 56% of respondents in three districts (Harshin, Kebribeyah and Shebelle) of Fafan zone were illtreat but greater than 32% illiteracy rate reported in Tigray (Kiflay, 2019). This variation could be due to the education facilities availabilities and livelihood mode

difference of the society. But there were better educational backgrounds in Fafan zone compare to different zones in Somali region. The presence of better educational background in Fafan zone would be a good opportunity for enhancing animal genetic improvement programs, since literate communities are more likely better to adopt and practice new technologies and also to keep performances records of farm animals.

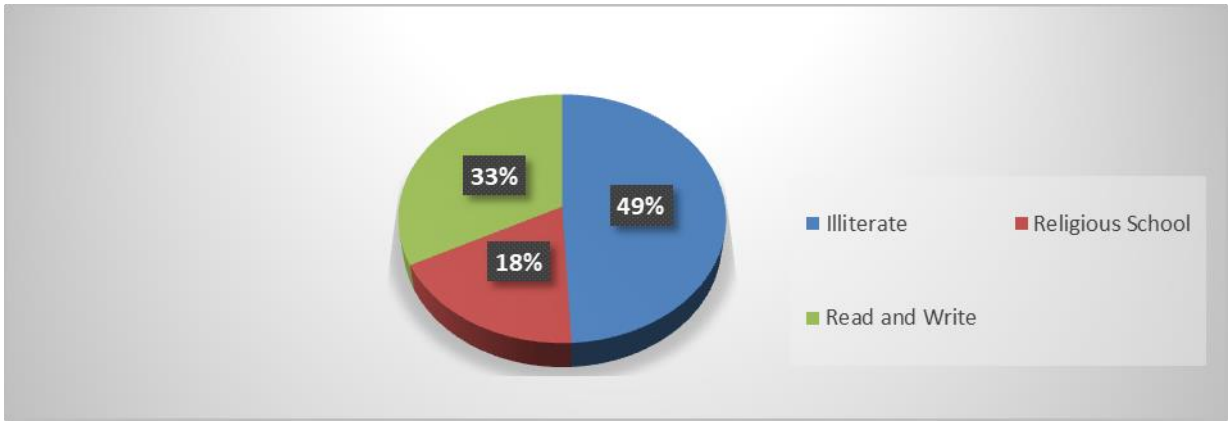


Figure 2. Summary for educational status of respondents

Agricultural Farming Activities and Income Sources of Respondents

Around 70% of the respondents (Table 2) were Agro-pastoralist which practiced cultivation of different crops (Sorghum and Maize) parallel to livestock rearing. Majority of the respondents (65%) they get income though sailing of crop, livestock and livestock product to fulfil their daily, needs and school fee. Crop residues they can used as animal feed during the drought period when the quality and amount of Natural pasture decline. Similarly finding was reported that Agro-pastoralist used crop residue as main animal feed during drought season at Narok and Kajiado, Keyna (Khainga *et al*., 2015).

Table 2. Respondents' agricultural activities and income resources

Response variables	Districts						Overall N = 120		X^2 values
	Awbare (N = 40)		Gursum (N = 40)		Harow (N = 40)				
	N	%	N	%	N	%	N	%	
	Farming activities								
Agro-pastoral	28	70.0	26	65.0	29	72.5	83	69.17	8.90
Pastoral	8	20.0	7	17.5	11	27.5	26	21.67	
Irrigation	4	10.0	7	17.5	0	0.0	11	9.16	
Total	40	100.0	40	100.0	40	100.0	120	100.0	
	Sources of income								
Livestock sale	3	7.5	2	5.0	5	12.5	10	8.33	13.61
Livestock product sale	2	5.0	8	20.0	2	5.0	12	10	
Crop sale	2	5.0	4	10.0	2	5.0	8	6.67	
Crop and livestock product sale	1	2.5	5	12.5	5	12.5	11	9.17	
Crop, livestock and livestock product sale	32	80.0	21	52.5	26	65.0	79	65.83	
Total	40	100.0	40	100.0	40	100.0	120	100.0	

N = Number of respondents, X^2 = Chi-square value

Cattle Herd Structure and Livestock Composition

Livestock composition per household in all study areas are presented in Table 1. The overall mean of cattle owners was around 11 cattle per-households. Cattle, sheep and goats were sharing the highest contribution of flock compositions in the study areas but donkey and camels share the lowest number of the livestock population on all study areas which indicates Agro-pastoralist which were found in Awbare, Gursum and Harrow districts preferred ruminants for milk and meat production. Similarly, African development group (2010) reported that around 35 sheep per household, 6.5 camel and 4.6 cattle per households in Somalia. Traditionally, livestock production has been an important source of income for the rural poor in all the study areas. It is anticipated that expansion of livestock production will offer one of the best opportunities for improved livelihoods and economic integration between pastoralists and farmers in the region under the improved management systems. The current findings indicate that the cattle flock size in Awbare and Gursum was significantly ($p < 0.001$) higher than compared to the Harow district while higher sheep and goats flock size were observed at Harow compared to Gursum but non

significance difference in camel population among the three districts. This clearly indicate that Awbare and Gursum districts have a potential for dairy cattle production improvement through different reproductive biotechnologies. Similarly, Idirs (2022) assessed that the presences of high dairy cattle in Awbare district. Therefor further genetic improvement interventions are vital for these potential areas.

Table 3. Cattle herd structures and flock compositions in the study areas

Livestock Species	Districts (Mean ± SE)			Overall Mean ± SE	P value
	Awbare	Gursum	Harow		
Cattle herd composition					
Female calves	1.78 ± 0.22^{b}	2.95 ± 0.31^{a}	1.20 ± 0.14^{b}	1.98 ± 0.22	< 0.001
Male calves	1.25 ± 0.12^{a}	1.53± 0.16^{a}	0.85 ± 0.13^{b}	1.21 ± 0.14	< 0.004
Pregnant cows	1.68 ± 0.17^{a}	1.38 ± 0.17^{ab}	1.23 ± 0.15^{b}	1.43 ± 0.16	< 0.007
Non-pregnant cows	3.05 ± 0.42^{a}	3.01 ± 0.24^{a}	1.65 ± 0.17^{b}	2.57 ± 0.28	< 0.009
Milking cows	1.95 ± 0.14^{ab}	2.33 ± 0.38a	1.3 ± 0.16^{b}	1.86 ± 0.23	< 0.016
Bulls	1.08 ± 0.15^{ns}	1.03 ± 0.11^{ns}	0.93 ± 0.09^{ns}	1.01 ± 0.12	0.672
Oxen	0.8 ± 0.09^{a}	0.6 ± 0.17^{a}	0.2 ± 0.06^{b}	0.53 ± 0.11	0.025
Total cattle	11.38 ± 0.82^{a}	12.85 ± 0.90^{a}	7.25 ± 0.57^{b}	10.49 ± 0.76	< 0.001
Camel	1.48 ± 0.12^{ns}	1.35 ± 0.16^{ns}	1.1 ± 0.14^{ns}	1.31±0.14	0.157
Goats	5.98 ± 0.48^{b}	5.75 ± 0.45^{b}	13.53 ± 0.87^{a}	8.42 ± 0.60	< 0.001
Sheep	12.28 ± 0.98^{a}	7.83 ± 0.65^{b}	11.65 ± 0.88^{a}	10.59 ±0.84	< 0.006
Donkey	0.83 ± 0.09^{b}	1.58 ± 0.15^{a}	1.30 ± 0.07^{a}	1.24 ± 0.10	< 0.001
Chickens	2.85 ± 0.38^{b}	3.65 ± 0.34^{b}	4.73 ± 0.33^{a}	3.74 ± 0.35	< 0.001
Overall livestock population	34.78 ± 0.67^{b}	33.00 ± 0.47^{b}	39.83 ± 0.90^{a}	35.87 ± 0.68	< 0.014

a-b Means with in a row with different superscripts differ (P < 0.05); CV = Coefficient of variance, ns = non-Signiant, SE = Stander Error.

Cattle Husbandry Practices

Feed resources in Fafan zone

The main feed resources are presented in Figure 2. The availability of feed resources varied depend on season. The main resource of feed in the study areas were natural pasture crop residues and supplemented with few concentrate feeds (wheat bran and formulated dairy feeds). Natural pasture was contributed largest proportion followed by crop residues supplementation of contrate feeds play great role during dry seasons. This study agrees with the report of Teshome *et al*. (2010) in Rayitu district, natural pasture and tree branch were the main feed resource during wet season. Focus group discussion with key informants indicated that availability of feed

resources and crop residues varied among the seasons. Crop residues from maize and sorghum were the dominant in all study areas. The most coping mechanism of feed shortage during dry season was sending to other areas of the feed availability were the main coping mechanisms used against critical feed shortage. Which is in agreement with reports in central and southern highlands of Ethiopia as indicated that there is increasing importance of crop residues as a livestock feed (Seid, 2014).

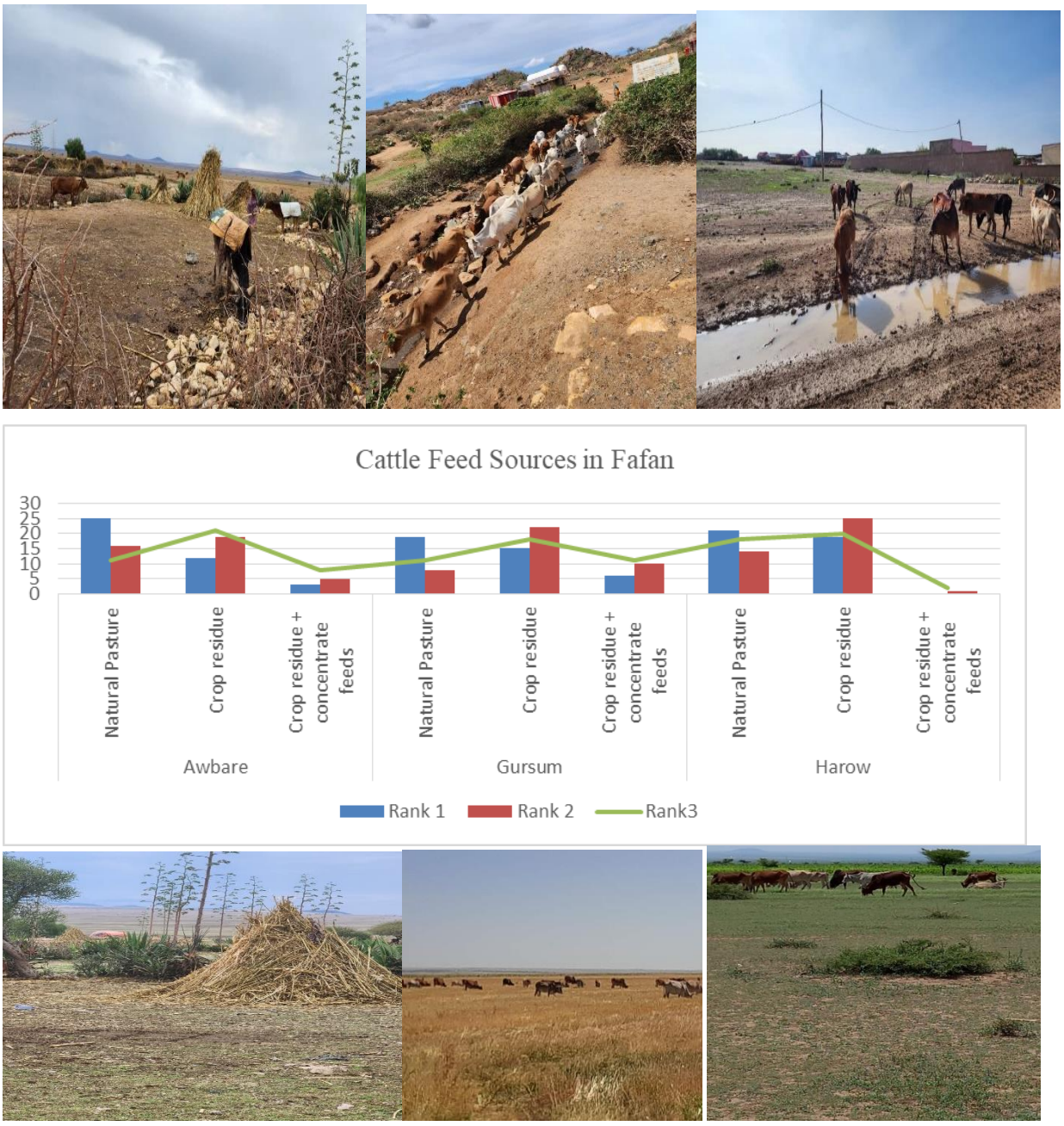


Figure 3. Cattle feed resources in the study area

Cattle Housing System and Management Engagements of Households

Figure 3. Presented that husband contributed the highest share in cattle management followed by children in all study areas while wives little contributed in feeding and house cleaning. Similar study. This is in line with previous studies of Fikru and Omar (2015) who reported that husband and children were the main source of labor for livestock management in Awbare and Shinile districts of Somali region.

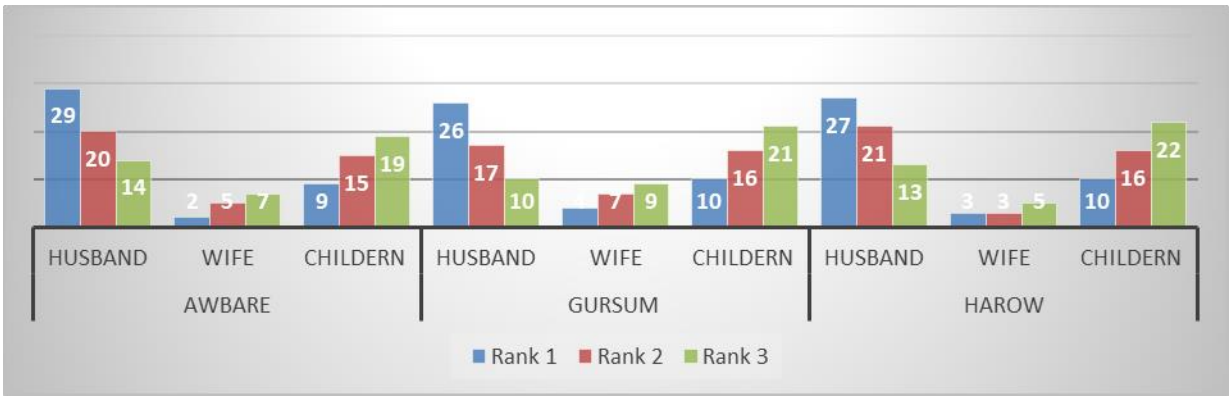


Figure 4. Cattle management engagements of households

Majority of the respondents (95%) in Agro-pastoral production system of the study areas were used separate open kraals surrounded by thorny acacia trees and stones (Figure 4). Housing of livestock is one of the primordial features pertaining to good husbandry practices. Similar practice was also reported by Aman (2018) who reported that the cattle in the lowlands are housed in the kraal's which however provides limited protection against the natural calamities and the predators.

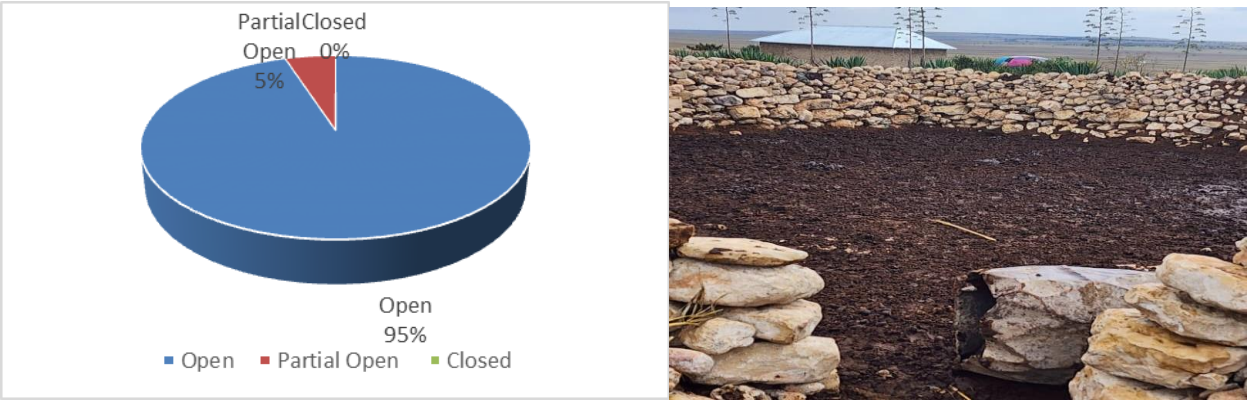


Figure 5. Open cattle housing system

Breeding Objectives Cattle at Fafan Zone

Better understanding of the purposes of keeping dairy cattle is a prerequisite for defining breeding goals (Jaitner *et al*., 2001). Primary reason for keeping cattle in three study areas was milk production with 0.444 index value for income generation and home consumption followed dual purpose for meat and milk (0.335 index value) and few (0.22) cattle producers used as meat sources for sale to generate income for school and medical fee. Other reasons mentioned by cattle' owners were, for social prestige and gifts for different social ceromancies. Similar findings were reported that primary reason of female cattle rearing in Somali region was for milk

production while male kept as a ransom for conflict resolution (Yesihak, 2019). Some findings from Arsi and central highland smallholder dairy owners kept cattle for multi-purposes (milk, meat, power and manure), (Aman, 2021). This interest variation among smallholder dairy cattle producers might be due to the difference in agricultural activities, mostly highlanders depend on crop production and livestock reared for traction purpose while lowland (pastoral and Agro-pastorals) their life is depending on livestock and livestock by products.

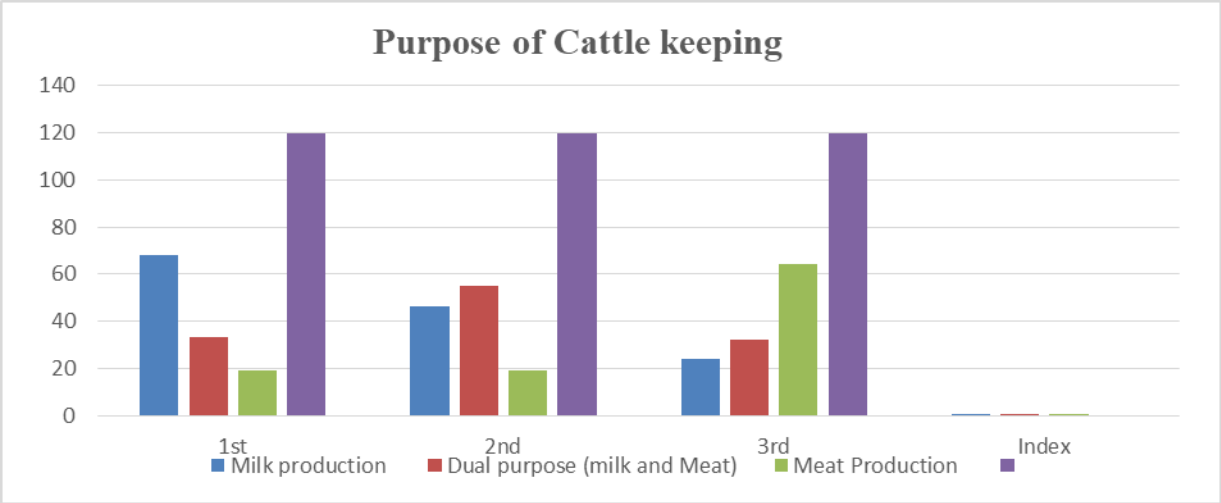


Figure 6. Cattle breeding objectives at Fafan Zone

Milk Production and Marketing Practices

Milk production in Ethiopia is largely from by the smallholder farmers in the high lands the pastoralists/Agro-pastoralist in low land areas of the countries. However, the production is not market oriented and a minor portion of the locally produced milk enters the commercial sector owing to the marketing constraints and lack of processing techniques suitable for smallholder dairying. Milk production in the study areas were highly seasonally dependent. Better milk yield and lactation lengthen were scored around Awbare and Harrow compared to Gursum this variation could be due to breed variation and management differences on the study areas. In the study areas, milk was channeled to consumers through informal/traditional marketing systems. The informal market involves direct delivery of fresh milk by producers to consumer in the immediate neighborhood and sale to collectors or traders nearby towns. The informal system is characterized by no licensing requirement to operate, low cost of operations, high producer price compared to formal market and no regulation of operations. Better prices (95 Birr/liter) were

observed in and around Gursum compare to Harrow (79 Birr/liter). The price variation is due to the distance of milk marketing, Gursum relatively near to Fafan and Jigjiga compare to Harrow.

Table 4. Cow milk yield and milk marketing system in Fafan Zone

	Districts (Mean ± SE)					
Variables	**Awbare**	**Gursum**	**Harrow**	**Overall**	**CV (%)**	**P-value**
Lactation length (months)	6.18 ± 0.15a	4.9 ± 0.20^{b}	6.68 ± 0.30^{a}	5.59 ± 0.22	25.77	<.0001
Daily milk yield (liter)	4.1 ± 0.22^{a}	2.86 ± 0.13^{b}	3.61 ± 0.17^{a}	3.52 ± 0.17	32.48	<.0001
Milk yield per lactation (liter)	722.63 ± 0.40^{a}	441.38 ± 0.19^{b}	663.0 ± 0.74^{a}	609.10 ± 0.44	42.93	<.0001
Daily home consumption (liter)	1.49 ±0.09^{ns}	1.31 ± 0.08^{ns}	1.51 ± 0.15^{ns}	1.44 ± 0.35	47.62	0.3661
Daily soled (liter)	2.61 ± 0.25^{a}	1.55 ± 0.18^{b}	2.1 ± 0.18a^{b}	2.09 ± 0.20	62.75	0.0020
Milk price per liter (Birr)	85.25 ± 0.80^{b}	95.25 ± 0.80^{a}	78.50 ± 0.37^{c}	86.33 ± 0.66	5.03	<.0001
Market distance to sale milk (Km)	7.34 ±0.52^{b}	8.76 ± 0.98^{b}	24.83 ± 0.68^{a}	13.64 ± 0.73	42.01	<.0001

a-c Means with in a row with different superscripts differ (P < 0.05); CV = Coefficient of variance, ns = non-Signiant, SE = Stander Error.

Reproductive Performances of Indigenous Cattle at Fafan Zone

The results on reproductive performance, viz average age of sexual maturity, average weaning age, calving interval, male market age and cow reproductive life span across all districts are presented in Table 5. Good reproductive performance is a prerequisite for any successful dairy production program. Presences of differences in reproductive performance between indigenous cattle breeds and their variation allow for the selection of suitable breeds for a given environment.

Age at first calving

The current study revealed that there is significance ($p < 0.001$) variation of age at first Calvin (AFC) among the study districts. Cattle breeds found in Gursum give birth at earlier age (3.33 ± 0.10 years) compared to cattle breeds found in Awbare (4.25 ± 0.16) district. This variation could be due to both genetical (breed) and environmental (management and nutrition) effects. Finding of the current finding is similar to Kumar (2014) reports (3.28 ± 0.14 years) of indigenous cows in semi-arid areas of Tigray whereas longer than Gebriel (1983) report (2.82 ± 0.68 years) for Arsi cattle breeds found in the central highland of Ethiopia. Furthermore, Masama *et al*. (2003) reported that management and nutrition status of the cows influences their pre-pubertal growth rates and later their productive

and reproductive status. Delay in the attainment of sexual maturity leads to economic loss, due to an additional, non-lactating, unproductive period of the heifer/cow over several months (Mukasa, 1989).

Calving interval (CI)

The calving is a period between two consecutive parturitions. The average calving interval of the current study was found to be 18.62 ± 0.72 months for local cattle (Table 5). There is no significant difference in calving interval among the study areas. The current finding was longer than the calving interval of local cattle (15.61 ± 2.38) found in central Tigray (Aberha *et al*., 2020) but similar to Kerryu cattle (18 months) reported by Shiferaw (2014). Factors contributing for long calving interval are age of cows, breed of cows, calving season and forage availability. Cattle breeds with a short calving interval is tend for more farm profits. If the calving interval is long, the total number of calving in cow lifespan and total milk yields will be decreased.

Male sexual maturity and marketing age

Early male sexual maturity in Gursum was observe compare to Awbare and Harawa districts and the overall male sexual maturity was 3.59 ± 0.15 which is comparable to Begait cattle (3.18 ± 0.01) during on-farm reproductive performance evaluation (Mulgeta, 2015). Fast male puberty in Gursum might be due to better management and cattle breed differences found in three districts. Male sexual maturity mainly determined by genetic and non-genetic factors. The average male market age of local cattle found in Awbare, Gursum and Harow was 3.77 ± 0.18 years, which is highly varied between seasons and feed availabilities.

Table 5. Reproductive performances of indigenous cattle in Fafan Zone of Somali region

Reproductive Traits	District (Mean ± SE)			Overall	CV	p-value
	Awbare	Gursum	Harow	(Mean±SE)	(%)	
Age of first calving (years)	4.25 ± 0.16^{a}	3.33 ± 0.10^{b}	3.43 ± 0.13^{b}	3.67 ± 0.13	20.62	< 0.001
Average weaning age (months)	4.98 ± 0.19^{a}	4.25 ± 0.25^{a}	4.73 ± 0.14^{ab}	4.65 ± 0.19	27.00	0.035
Calving interval (months)	18.2 ± 0.58^{a}	18.95 ± 0.96^{a}	18.70 ± 0.62^{a}	18.62 ± 0.72	26.83	0.79
Cow life span (years)	9.83 ± 0.33^{b}	11.33 ± 0.52^{a}	10.30 ± 0.26^{ab}	10.49 ± 0.37	23.28	0.022
Male average age of sexual maturity (years)	3.95 ± 0.16^{a}	3.28 ± 0.09^{b}	3.55 ± 0.19^{ab}	3.59 ± 0.15	26.91	0.009
Market age of Male (year)	3.85 ± 0.18^{a}	4.31 ± 0.22^{a}	3.14 ± 0.15^{b}	3.77 ± 0.18	31.14	< 0.001

a-b Means with in a row with different superscripts differ (P < 0.05); CV = Coefficient of variance, ns = non-Signiant, SE = Stander Error

Cattle Breeding and Selection Criteria's

Cattle breeding practices

The study revealed that natural service (100%) was the widely used breeding method and artificial insemination service was uncommon. Even though pilot project of dairy cattle crossing using artificial insemination was tested at farm level but due to different reasons the project was completely failed. All respondent used natural uncontrol mating during animals released on communal grazing. The sharing of breeding bull could attribute to the possible incidence of getting reproductive diseases, since farmers had no any control measures against sexually transmitting diseases before using available bulls for mating. In addition, the use of own bred bull within the herd for a long time could increase the chance of inbreeding. Those respondents who practiced heat detection observe their cows when they are in heat by the swelling, mucus discharge and redness of vulva and restlessness, frequent bellowing, loss of appetite and reduced milk yield.

Breeding male selection criteria

The ranking of traits for selecting breeding males as perceived by Agro-pastoralists was summarized in Table 6. Pedigree, body conformation and growth rate were the top three breeding male/bull selection criteria within index value 0.210, 0.199 and 0.176 respectively in the study area. Similar findings were reported on breeding bull selection by Zewdu *et al*. (2018).

Table 6. Breeding male selection criteria's in the study area

Male selection criteria	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Index
Appearance/conformation	44	28	16	12	12	10	10	0.1994
Pedigree	28	38	31	13	14	13	7	0.2101
Growth	21	23	25	25	17	9	12	0.1759
Adaptability	5	8	14	18	19	13	15	0.0961
Color	11	12	23	25	21	19	23	0.1452
Horn condition	3	5	6	12	17	24	12	0.0714
Temperament	8	6	5	15	20	32	41	0.1018

Breeding female selection criteria

The index value showed that milk yield was ranked first in the selection of breeding females with an index value of 0.256, 0.196, and 0.173, for milk yield, pedigree and body confirmation respectively. In accordance with the present result, previous studies by Takele (2005), Godadaw *et al*. (2014), Ftiwi and Tamir (2015), Girma *et al*. (2016), Belay and Zeleke (2021) have

demonstrated that milk yield is the primary interest of the livestock keeper in a different part of the country while Ftiwi and Tamir (2015) stated that physical appearance (body shape, udder size and teat position) is one of the preferred traits in the selection of breeding cows. Adaptability was given relatively little emphasis in selecting breeding cows.

Table 7. Breeding female selection criteria's in the study area

Female selection criteria	Rank-1	Rank-2	Rank-3	Rank-4	Rank-5	Rank-6	Rank-7	Index
Adaptability	2	1	5	5	15	12	14	0.0440
Age of sexual maturity	7	6	9	14	18	22	24	0.0917
Appearance/conformation	28	26	15	19	13	15	10	0.1732
Calving interval	12	16	17	20	24	22	20	0.1432
Milk Yield	38	30	34	29	23	20	19	0.2560
Mothering ability	9	8	12	13	14	19	20	0.0961
Pedigree	24	33	28	20	13	10	13	0.1958

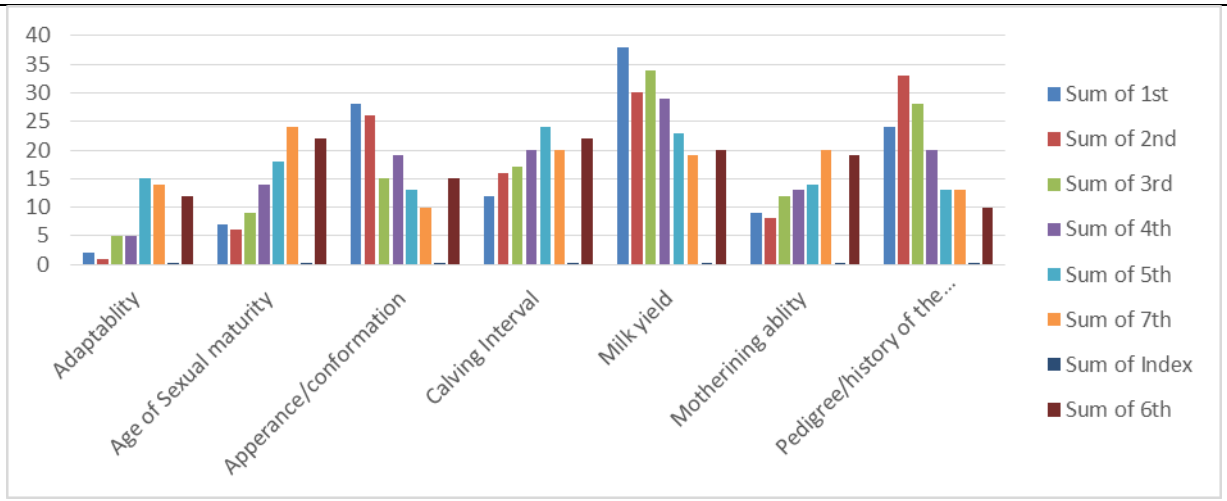


Figure 7. Agro-pastorals' selection criteria for dairy cow animals

Cattle Production Constraints

The result of the focus group discussion (Table 8.) highlighted that occurrence of frequent drought (41%) adversely affected livestock production and productivity in general and milk production in particular throughout Somali region. Unfortunately, arid and semiarid areas of the horn Africa affected by climate changes every year but the severity of drought impact on livestock productivity of the last three years (2020, 2021 and 2022) was very high. Similar un published reports indicated that Somali region was extremely affected (losing more than 250,000 cattle by the year 2020/2021) by drought (LLRP, 2022). During the drought season the quality and quantity of animals feed highly decreased, which highly affected dairy animals need high nutritious feeds. In addition to drought and feed shortage prevalence of different disease and inadequate veterinary service, poor breeding practices and long market distance for milk and

milk products are the main dairy cattle production challenges in the study areas. Similarly, Yisak (2019) reported that Ogaden cattle at Shabele zone, Somali region highly affected by feed/water shortage (drought), diseases Prevalence and poor artificial insemination services.

Table 8. Major constraints of cattle at Fafan

Major cattle production constraints	Rank 1	Rank 2	Rank 3	Index
Drought	65	33	31	0.4056
Feed shortage	35	37	52	0.3208
Diseases and lack of skilled Veterinarians	20	50	37	0.2736



Figure 8. Major cattle production constraints

CONCLUSION AND RECOMMENDATIONS

It is concluded that there is clear variation on productive and reproductive performance of dairy cattle of the three studied areas. The average daily milk yield varies from 2.86 litter per day in Gursum) to 4.1 liter per day in Awbare districts of Fafan zone, this clearly implies that the presence of genetic variation among the studied population in Fafan zone which is important to improving of milk yield through selection and crossing. Furthermore, there is also conceive environment for boosting of milk yield in the areas due the high milk demand (86.33 Birr/litter) in and around Jigjiga because of the culture of frequent use of milk in Somali region. However, there is frequent drought occurrence and prevalence of diseases with limited veterinary extension service in the areas. Therefore, to solve the existing problems of the Agro-pastoral dairy cattle production in the study area, the following recommendation are forwarded:

- Develop systematic and strategic feed conservation techniques
- Create awareness and provided different sustainable disease management strategies

- Governmental and non-governmental organizations should create suitable environments for Agro-pastoral dairy cow cooperatives through different techniques.
- Need within and between population genetic characterization.

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Evaluation of Production Potential and reproduction Performance of selected Improved Chicken Breeds in Fafan Research center, Somali Region, Ethiopia

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ABSTRACT

This research aimed to evaluate the production potential and growth performance of four improved chicken breeds (Tetra, Bovan Brown, Lohman, and Sasso). A total of 400 pullets were randomly assigned in a Completely Randomized Design experiment with genotypes as treatments. The birds were kept in a partitioned open-sided deep-litter house with 100 pullets in each compartment and were fed commercial layer mash. The parameters evaluated during the experiment included age of sexual maturity, body weight, egg production rate, egg weight, egg quality parameters, feed intake, feed conversion, and mortality rate. The study found that Bovan Brown had the best reproductive performance, while Lohman had the highest egg production, and Sasso had the highest body weight gain per week. In addition, Bovan Brown had the largest egg weight, yolk color, albumin weight, and shell weight. The study also found that Bovan Brown had the lowest mortality rate compared to the other breeds. Based on the result, Bovan Brown breed was the most suitable for local conditions. Further research into genetic traits to enhance breeding programs and improve production performance is recommended. Implementing these recommendations would contribute to improving the profitability and sustainability of chicken farming in Ethiopia.

Keywords: *Bovan Brown, Sasso, Tetra, productive performance, egg quality, Lohman*

INTRODUCTION

Ethiopia is naturally endowed with different agroecological zones, suitable environmental conditions, and is home to many livestock species. It is also suitable for livestock production. An estimate indicates that the country is home to about 57.01 million poultry (CSA,2021). By these numbers, poultry is ranked second next to cattle. The Ethiopian poultry population is almost entirely composed of indigenous chickens. Poultry includes cocks, cockerels, pullets, laying hens, non-laying hens, and chicks. Recent estimates showed that 78.85%,12.02%, and 9.11% are indigenous, hybrids, and exotic poultry, respectively (CSA, 2021). Poultry production is one of the key livestock subsectors in Ethiopia. It plays important roles in terms of generating employment opportunities, improving family nutrition, and empowering women. It is a suitable business for poor households due to the small quantity of land needed and the low investment costs required to start up and run the operation (FAO, 2019).

Ethiopian poultry is an estimated total population of 57 million. Poultry includes cocks, cockerels, pullets, laying hens, non-laying hens and chicks. Most of the poultry are lying hens

(34.26 percent), followed by poultry are chicks (32.86 percent). Pullets are estimated to be about 6.47 million in the country. Cocks and cockerels are also estimated separately, and are 6.38 million and about 3.27 million, respectively. The others are non-laying hens that make up about 4.59 percent (2.61 million) of the total poultry population in the country. With regard to breed, 78.85 percent, 12.02 percent, 9.11 and percent of the total poultry were reported to be indigenous, hybrid and exotic, respectively (CSA, 2021).

In Ethiopia, poultry industry plays a significant role in the supply of human food (eggs and meat) in rural and urban area and as a source of income, especially to small holder farmers. About 95.86% of the total national poultry products (eggs and meat) are contributed by indigenous chickens kept under village management system while the remaining 1.35% is obtained from intensively kept exotic breed of chickens and 2.79% are obtained from hybrids. Poultry meat and eggs are relatively cheap and affordable sources of protein for most consumers, compared to other animal products such as beef. At the household level poultry is important to the nutritional well-being of household members especially children and as income source for women. However, the per capita poultry and poultry product consumption in Ethiopia is one of the lowest in the world: 57 eggs and 2.85 kg of chicken meat per annum. The marketing system of poultry and poultry products is generally informal and poorly developed (Gebre M,2018).

In Ethiopia, poultry (chicken) production plays a significant role in the supply of human food (eggs and meat) in rural and urban area and as a source of income, especially to small holder farmers. The role of poultry in Ethiopia became very important over time (Alemu *et al.*, 2009). Huge livestock population in general and poultry in particular, could be expected to increase its contribution to the total agricultural output as well as to improve the living standards of small holder farmers (Thomas et al., 2009). This is mainly due to their small size, fast reproduction, low labor, low energy and low initial capital requirement and less detrimental impact on the environment compared to other livestock (David, 2010). Human population growth, urbanization and income improvements are causes of increased demands for foods of animal origin in the developing countries (Abdullah et al., 2011). Shortage of animal protein availability is a major problem in Africa and common cause for infant mortality (Mengasha, 2011).

Generally, in order for decision-makers to address the poultry related challenges in production and marketing and to improve the livelihoods and food security of rural households by enhancing the benefits from poultry through appropriate production and marketing extension, it is essential

to demonstrate the modern technologies of poultry production through participatory approach that could generate appropriate technology, which is for socially acceptable, environmentally sound and economically feasible. However, attempts have been made to introduce different exotic breeds of chickens to be used by their own or for crossbreeding with the indigenous chickens.

Poultry production in the country in general is characterized by extensive production system and the productivity is low. Despite the importance of chickens to the small-scale farmers by providing high protein products (eggs and meat), most communities lack the required husbandry skills, knowledge, training and opportunity to effectively improve their household chicken production (Podchalwar, 2011). Little attempts have been made by introducing exotic breeds. However, there are a number of challenges and obstacles (constraints) limiting the success and profitability of those exotic chickens kept under both backyard and semi-intensive production system in the country. Thus, further researches are required to undertake in order to evaluate and determine production performance of chickens and recommend suitable husbandry practices. Thus, this project was implemented to compare and evaluate production potential, adaptability and growth performance of four improved chicken breeds with great emphasis on their reproduction performance, egg quality characteristics and disease resistance traits of the four different improved chicken breeds in the study site.

MATERIALS AND METHODS

The research work was undertaken on the evaluation of production potential and growth performance of four improved chicken breeds suitable for Agro-pastoral farming. The study was undertaken at Fafan Agricultural Research Center under the Somali Pastoral and Agro-pastoral Research Institute (SoRPARI), Somali Regional State of Ethiopia.

Location

Fafan Agricultural Research Center is located about 46 km in the western side of Jigjiga town and located adjacent to the main road from Jigjiga to Harar. It is situated at an altitude of 1600-1700 m above sea level. The rainfall pattern of the area is bi-modal amounting to an average of 750 ml and extending from March to April and the long rain season from June to September. The mean annual temperature is 21^{o}C, with a mean minimum and maximum temperature of 14^{o}C and 28 °C respectively.

Study Design and Experimental Units

The objective of this work was to evaluate the production potential and reproductive performance of four different improved at Fafan Research Center chick. A total of four hundred (400) of 11 weeks old pullets composed of Tetra, Bovan brown, Lohhman and Saso breeds will be purchased from Ethio-Chickens Plc. Four hundred of 11 weeks old pullets were randomly assigned in a Completely Randomized Design experiment for a period of up to 60 weeks with genotypes as treatments. There were four replicates with hundred (100) pullets in each replicate group.

Management of the On-Station improved Pullets

The birds were kept in a partitioned open-sided deep-litter house constructed with concrete blocks with 100 pullets in each compartment. The birds were maintained in floor pens each pen measuring 300cm by 200cm on deep litter system for about the end of the experiment project. The stock density was 0.15m²/bird. The feed and water were supplied in 2.5kg capacity hanging feeders and 3L capacity plastic fountain drinkers respectively. The birds were fed with commercial layer mash purchased from Ethio chicken PLC. The plastic drinkers were cleaned daily throughout the experimental period. Twelve hours of natural light which is supplemented with artificial lighting throughout the experimental period was provided to the birds. All the required vaccination, vitamins and treatments were provided to the birds properly during the study.

Data Collection and estimated Parameter

During the experiment, the parameters that was evaluated were the age of sexual maturity (age at first laying), Body weight measurement, Egg production rate, Egg weight, Egg quality parameters, Feed intake and feed conversion and Mortality rate.

Data Analysis

The data obtained on age of maturity and egg laying performances and body weight measurement were subjected to one-way analysis of variance with effect using SPSS version 23. When significant differences among means were found, means were separated using least significant difference (LSD) test.

RESULTS AND DISCUSTION

Sexual maturity (age at first laying) of the four improved chicken breeds

The figure below indicates that age at first laying per week of Bovan Brown, Lohman, Tetra and Sasso Breeds was week 21, 23, 22 and respectively. This indicates that Bovan Brown has best reproductive performance compared to the three breeds. This could be due

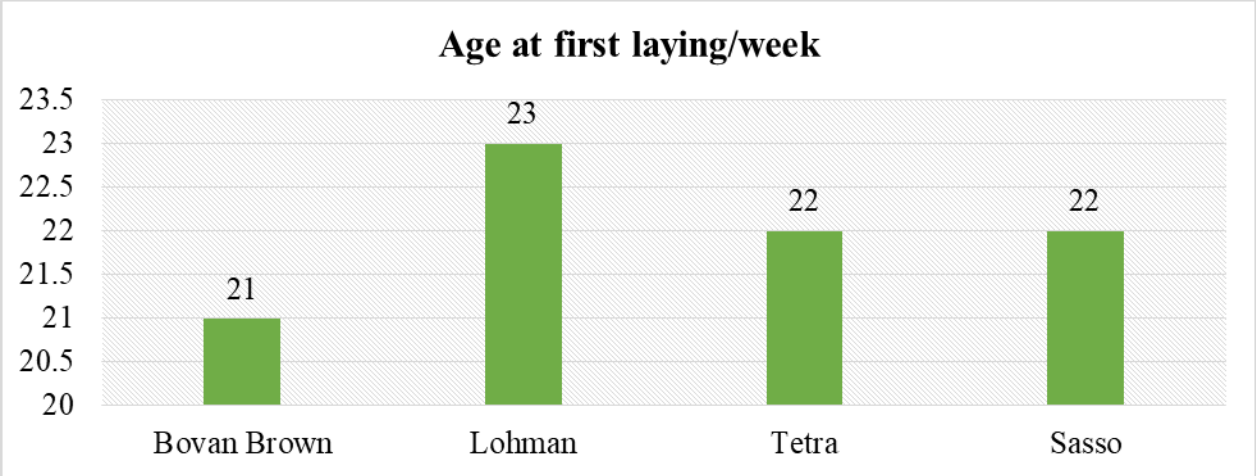


Figure 1. ***Age at first Laying of the four experimental chicken breeds***

Feed intake per week of the four improved chicken breeds

The feed intake of the four breeds in the experimental study is presented in Table 1. The result of this study is indicated that there is significant difference of the average feed intake per week of the four breeds in the experiment with F-test of 15.38 having p-value of <0.001. The Lohman breed has the highest feed intake (74.14 ± 1.729 kg per week) whereas the Tetra has the lowest feed intake (58.74 ± 1.88). As indicated in LSD of Post hoc test, there is no average feed intake difference between Sasso, Lohman and Bovan Brown chicken breeds.

Table 1: Least square means of Feed Intake per week of Four Improved Chicken Breeds during experimental period

Parameter	Breed	Minimum	Maximum	Mean ± SEM	F	P-value
Feed intake	Bovan Brown	36.0	90.0	65.69 ± 1.61	15.38	< 0.001
per week	Lohman	42.0	112.0	74.14 ± 1.72		
	Tetra	35.0	70.0	58.74 ± 1.88		
	Sasso	65.0	112.0	70.26 ± 1.52		

Average Egg Production of The Studied Four Improved Chickens

The result of this study is indicated that there is significant difference of the average egg yield per week of the four breeds in the experiment with F-test of 107.65 having p-value of <0.001. The Lohman breed has the highest egg production (371 ± 14.89 per week) whereas the Sasso has the lowest egg production (124.97 ± 4.03). As indicated in LSD of Post hoc test, there is significant egg production difference between the experimented four chicken breeds (Table 2). Differences between strains with mean egg production at different production phases were related with genetic potential of each strain and ability of survival.

Table 2: Mean and Standard error of Egg yield per week of Four Improved Chicken Breeds during experimental period

Breed	**Minimum**	**Maximum**	**Mean ± SEM**	**F**	**P-value**
Bovan Brown	58.0	478.0	330.46 ± 13.63	107.65	< 0.001
Lohman	109.0	528.0	371.00 ± 14.89		
Tetra	30.0	260.0	191.18 ± 8.79		
Sasso	63.0	159.0	124.97 ± 4.03		

Body weight and Average daily gain

The result of this study is indicated that there is significant difference of the average body weight gain per week of the four breeds in the experiment with F-test of 24.19 having p-value of <0.001. The Sasso breed has the highest body weight gain per week (2.52 ± 0.06 Kg per week) whereas the Lohman has the lowest body weight gain per week (1.52 ± 0.02). According to LSD of Post hoc test, there is significant egg production difference between Sasso and other three chicken breeds. But there is no significant difference among Bovan Brown, Lohman and Tetra (Table 3). The high body weight of Sasso breed might due to that breed is dual purpose (both meat and egg type).

Table 3: Mean and Standard error of Body Weight gain in Kg per week of Four Improved Chicken Breeds during experimental period

Parameter	Breed	IBW* (Kg)	FBW* (Kg)	Mean ± SEM	F	P-value
Body weight gain in Kg per week	Bovan Brown	1.24	1.81	1.58 ± 0.02	24.19	< 0.001
	Lohman	1.23	1.93	1.52 ± 0.02		
	Tetra	1.00	10.20	1.61 ± 0.18		
	Sasso	1.48	3.10	2.52 ± 0.06		

IBW = Initial body weight; FBW* = Final body weight*

Survival rate of the experimented four improved chicken breeds

The mortality percentages in the study area are presented in Figure 2. The current study result indicated that the Bovan Brown breed were attained the least mortality rate (4%) than other breeds distributed, which could be related with the breed adaptation character to the environment. The highest mortality rate was attained by the Sasso (35%) during the study period.

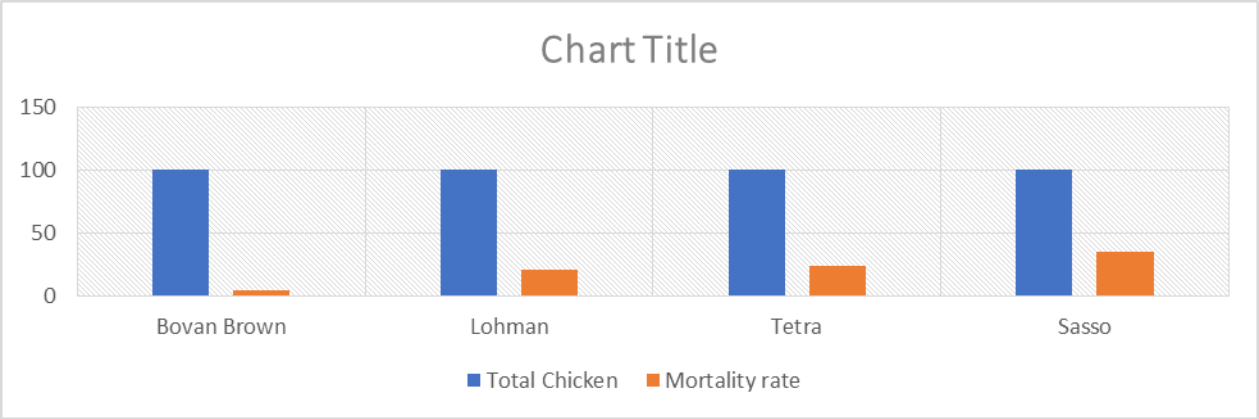


Figure 2. Survival and Mortality rate of four chicken breeds under experiment

Egg Quality Analysis

This study indicated that Bovan Brown has the largest egg weight, yolk color, Albumin weight and shell weight compared to the three breeds. While Sasso has the best Yolk height and weight and Lohman has the largest albumin height (Table 4). The F-test values indicate statistical significance for the differences in yolk color, albumin height, yolk height, and shell weight among the breeds. However, the p-values indicate that the observed differences in egg weight, albumin weight, and yolk weight between the breeds are not statistically significant.

Table 4: Least square mean (LSM ± SE) of external and internal Egg quality traits of four improved chicken breeds**.**

Breed	**Egg Quality Parameters**						
	Egg Weight	**Yolk Weight**	**Albumin Height**	**Albumin Weight**	**Yolk Height**	**Yolk Weight**	**Shell Weight**
	Mean ± SEM	**Mean ± SEM**	**Mean ± SEM**	**Mean ± SEM**	**Mean ± SEM**	**Mean ± SEM**	**Mean ± SEM**
Bovan Brown	62.76 ± 1.57	12.60 ± 0.24	8.72 ± 0.16	39.02 ± 1.02	14.81± 0.16	15.46± 0.43	6.21±0.29
Lohman	59.74 ± 1.56	9.80 ± 0.37*	9.14 ± 0.25	38.72 ± 1.06	14.94± 0.38	14.94±0.38	6.16±0.23
Tetra	57.22 ± 2.06	8.80 ± 0.37	7.82 ± 0.12	34.90 ± 2.04	14.08± 0.09	13.57±0.35	5.77±0.08
Sasso	60.44 ± 1.67	11 ± 0.54	7.66 ± 0.29	36.20 ± 1.60	15.08±0.24	16.46±0.19	5.51±0.11
F-test	**1.73**	**16.73**	**10.59**	**1.78**	**3.33**	**11.86**	**2.73**
P- value	**0.2**	**<0.001**	**<0.001**	**0.19**	**0.04**	**<0.001**	**0.07**

***Mean ± SEM**

CONCLUSION AND RECOMMENDATIONS

This research aimed to evaluate the production potential and growth performance of four improved chicken breeds (Tetra, Bovan Brown, Lohman, and Sasso). A total of 400 pullets were randomly assigned in a Completely Randomized Design experiment with genotypes as treatments. The experimented chickens were kept in a partitioned open-sided deep-litter house with 100 pullets in each compartment and were fed commercial layer mash. The parameters evaluated during the experiment included age of sexual maturity, body weight, egg production rate, egg weight, egg quality parameters, feed intake, feed conversion, and mortality rate. The study found that Bovan Brown had the best reproductive performance, while Lohman had the highest egg production, and Sasso had the highest body weight gain per week. In addition, Bovan Brown had the largest egg weight, yolk color, albumin weight, and shell weight. The study also found that Bovan Brown had the lowest mortality rate compared to the other breeds. Based on the result, Bovan

Brown breed was the most suitable for local conditions. This study also shows that each of the four improved chicken breeds has unique characteristics and advantages. Based on the aforementioned conclusion, the following recommendations are forwarded

- ❖ The Bovan Brown breed is recommended for farmers who are more interested in reproductive performance while the Sasso breed is highly recommended for those farmers/entrepreneurs who focused on high body weight gain, and Lohman is recommended for high egg production.
- ❖ Also, the current study suggests that farmers should consider the unique characteristics of each breed according to their production goals.
- ❖ Additional research investigations should be conducted to understand the genetic potential of chicken breeds and to develop breeding programs for the local markets.
- ❖ Additionally, breeds that can adapt to different environmental conditions and diseases should be furtherly studied through research
- ❖ Finally, farmers are advised to prioritize the health and welfare of their chicken flock to improve production performance.

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Identification of Honey Bee Flora, Production Practices and Effect of Season on Physico-Chemical Properties of Honey in Selected Zones of Somali Region

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ABSTARACT

The study was conducted two potential zones of Somali region to assess and characterize honey bee flora, beekeeping production and handling practices and to evaluate Physico-Chemical Properties based on different harvesting seasons of Honey in selected Zones of Somali region. For this study six districts were selected using purposive sampling methods. A total of 120 beekeepers with equal proportion from the six districts were selected randomly. The study comprises three parts including assessment about bee keeping production practices, field work with honey bee flora identification and physico-chemical determination of honey. The physical and chemical properties were determined following the standard procedure set by International Honey Commission. Twenty-four honey samples were collected from six districts and analyzed for nine honey physico-chemical properties. The primary reason of beekeeping production in the study areas was income generation and consumption. the traditional hives were the most commonly used hives as majity of the respondents implied and main source of their foundation colonies was by catching the swarms. The overall honey yield was 6.125±0.59 and 11.56± 0.43 per hives per harvesting season in traditional and modern hives respectively. the honey harvesting is carried out at night time. pest and predators, absconding and scarcity of water were major constrains of beekeeping production in the study areas. The major pest and predators limiting the beekeeping production in the study areas were ants and Honey Badgers. A total of 2,366 honey bee forage plants which are belong to different genera and families mainly fifteen species were identified and recorded. The combined mean of the free acidy and PH of the honey samples in the study areas were 35.83+0.34 meq. Acid/kg and 4.159 respectively. The mean value of combined effect of hydroxymethylfurfural ***(HMF)*** *and Water-Insoluble matters were 7.36+0.525 and 0.4125+0.014 respectively. As the result of the laboratory test shows the combined mean of sugars (glucose and fructose) content was* ***24.191±.3270*** *and* ***35.90±0.351*** *respectively and there was a significance difference among the study districts with effect of the season and the higher value of glucose and fructose was reported sample from the Lagahida and Salaha. The studied districts have high production potential for honey bee floras which is suitable beekeeping production therefore further research is required in the areas of participatory research action through community participatory approach, bee foraging and optimization of physico-chemical properties is highly recommended.*

Key words: *Honey bee flora, physico-chemical properties, production practices*

INTRODUCTION

Beekeeping is an important component of agriculture and rural development program of many countries. It helps to provide security in nutrition, economy and ecology (Jeil et al., 2020; Güler, 2021). Besides, it does not compete with other resources in the farming system, it is income generation activity and supplement annual income for the beekeepers through sell of bee products (honey, beeswax, and bee colonies). It also serves as a healthy food for consumers (FAO, 2015).Ethiopia is the home of diverse fauna due to its varied ecological and climatic conditions (Beyene et al., 2016). This is the prime reason for the availability of large colony numbers in the country. In Ethiopia, three types of beehives (traditional, intermediate, and improved) are known, with more than 10 million colonies, from which more than 90% are traditional hives (CSA, 2021).

The total annual honey production in the country is estimated about 129 million kilograms of which the greater portion is harvested from traditional beehives (CSA, 2021). Identification and mapping of honey source plants are very important for the selection of suitable apiary sites and also to determine the honey bee colony carrying capacity of an area (Beyene and Hiwot, 2015). According to Rucker et al. (2002) Production of honey and other products depend on availability of floral resources (bee forage) and is a very important field for most beekeepers in the world. Beekeeping is more dependent on the suitability of an area than any other livestock production (Nuru, 2018).

Takele Geta Gina, (2014) conducted research titled 'Potential of Honey Production and its Utilization for Food Security in FiltuWoreda, Liben Zone, Somali Regional State, Ethiopia' and tried to assess the honey production potential and it is utilization for food security without identification of spatially honey flora species abundance areas in the region. However spatially mapping bee flora species is useful for bee keepers to exploit the resources. Physicochemical parameters of natural honeys, such as moisture content, ash, , pH and free acidity, hydroxy methyl furfural sugar contents(glucose and fructose), sucrose content have been strictly defined and constitute the quality indicators characterizing individual honey varieties (Juszczak.2009) .These mentioned factors vary by regional and climatic conditions (Lazaridou A 2004) .To date, numerous studies have been done to determine the chemical properties of honey (Juszczak.2009).

It is well known that the different honey types of the world show great variation in their physico-chemical properties and biological composition (Muli, 2007). So, it is very important to study the physicochemical composition of honey, which is greatly influenced by the geographical region, floral source and climate (Thrasyvoulou, 2011).Thus, while the country is a principal producer of honey, it has the potential to improve yields and harvest more if existing beekeepers are able to overcome significant issues regarding inputs, technical skills, and climate change adaptation (Dong *et al*., 2016; Gratzer *et al*., 2021). In order to exploit the country's production potential, the government has given consideration to developing the beekeeping subsector as a strategy for the reduction of poverty and the diversification of export commodities (Shapiro *et al.,* 2015).

Somali Region, large proportion of inaccessible lands for agriculture are covered with various types of trees, shrubs, bushes, and field flowers that make this part of the regions still to be potential for beekeeping. However, it requires making efforts to address some of the major problems of beekeeping and to keep it productive in the sustainable way. In region, the majority of the households keep bees and honey serves as a source of cash incomes for many households. Thus, in order to produce and improve the quality of honey that meets the demands of national and international markets and quality criteria, information about the quality of honey produced in the area is important. Therefore, the present study aims to assess the beekeeping production and handling practices ,to identify and map the availability of major honey flora species in selected districts of Somali region in order to propose potential and suitable areas for beekeepers in the region and also to elaborate the physico –chemical chacharcteticts of in different harvesting seasons is a prerequisite for attaining a successful beekeeping in Somali region. Therefore, this study was aimed to identify and characterize honey bee flora, production systems including handling practices, challenges and the opportunities of honey bee and also to evaluate effect of season on Physico-Chemical Properties of Honey and also in selected Zones of Somali region

MATERIALS AND METHODS

Description of the study areas

The study was conducted in two zones namely, Erer and liban of Somali region which have high production potential for beekeeping and honey bee floras. Erer**,** formerly known as Nogob, is one of the eleven zones of the Somali Regional State of Ethiopia. Erer zone is bordered on the south

by Godey zone, on the southwest by Afder zone, on the west and northwest by the Oromia Region, on the north by Fafan zone, on the east by Jarar zone, and on the southeast by Korahey zone. Erer river flows through this zone. Erer zone has eight woredas namely; Fiq, Hamaro, Lagahida, Salahad, Mayumuluka, Qubi, Yahoob and Waangay. Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this zone had a total population of 227,137, of whom 33,930 or 9.74% are urban inhabitants and a further 193,207 or 55.45% were pastoralists. Liben is a zone in Somali Region of Ethiopia. Liben is bordered on the south by Kenya, on the northwest by the Oromia Region, on the northeast by Afder, and on the southeast by Somalia's federal state of Jubaland. Towns in Liben zone include Filtu, Bokolmayo, DekaSuftu, and Dolo.

Study Design

The study was cross sectional study and contains three components: survey filed work and laboratory work. The survey part was conducted to collect relevant information on honey bee floras identification and, honey production systems, constraints and opportunities and the field work was carried out for identification and mapping of major honey bee floras while the laboratory work was conducted to evaluate and determine the physical and chemical properties of honey produced in the study areas for two different seasons.

Sampling Techniques and Sample Size

A multi-stage sampling technique was applied. At the first stage, two zones from the eleven zone of the Somali regional State were selected purposively based on beekeeping and honey production potential with consultation of the regional offices. At the second stage, a total of six district which have high honey flora and honey production potential were selected purposively. At the third stage, twelve (12) kebeles from the six districts were selected purposively; and last stage households that are beekeepers and produce honey from the selected *kebeles* were identified and selected randomly. In this regard 120 household were selected from the 12 kebeles.

Methods of Data Collection

Primary and secondary data were used for this study. Primary data was collected by using semi-structured questionnaire that was prepared and used for interviewing selected beekeepers, focus group discussions, key informants' interview and personal observations. Two focus group discussion were held within each district with a minimum of eight members from each location.

Secondary data was also collected from regional, zonal livestock and districts and pastoral development office focusing on honey flora, beekeeping production system and production practices of honey in the study area. The major parameters studied in this study were included:- purpose of beekeeping production, beekeeping production practices, honey production yield, handling practices of honey bee, constraints and opportunities of beekeeping in the study areas Pests and predators of honeybee, Honeybee Absconding, physico chemical properties of honey and major species of honey bee floras and their mapping.

Procedures and Determination of plant Abundance

Data collection methods

To identify honey flora species abundance areas, purposive sampling method was used. Six districts were selected as study area based on prior available information about honey production in the area. The abundance of honeybee plant was determined using Tesfu *et a*l., (2021) plant abundance determination methods. For each study site one larger field plot of 50m-by- 50m (25000m^2) areas was selected systematically and their respective coordinates was recorded using GPS device. Within each larger plot four quadrats of 30mx30m (900m^2) were established. All bee forage plant species in each quadrat were recorded with their local names.

Honey forage plant species mapping methods

All mapping methods depend on available material, as well as hardware, software, knowledge, and experience (Takácsand Molnár 2009).field survey mapping methods was selected for the honey bee forage species abundance classification. This method is based on in situ observations aided with GPS location, and delineation during Field Survey (Rodwell 2006). Accordingly, the abundance of bee forage plants (number of plants observed per unit area (plot) was used to determine the abundance level of honey bee forage plant species in each study site. The abundance map was prepared based on the number of honey bee forage plant species recorded from each study sites and shapefile of their respective study districts using GIS software. Data was prepared in excel in a format that can be readable to the GIS software and then classified.

Honey Sampling and Physicochemical Analysis

Honey sampling

The honey samples were collected six potential districts from the two most beekeeping potential zones of the region. The sample preparation procedure were according to the Codex Alimentarius Committee on Sugars (2001). A total of 24 honey samples (4 from each district)

was randomly collected from beekeepers (producers) in the selected districts in two different seasons. The honey samples (1000 ml each) were collected in a fresh, clean polyethylene bottle containers, labeled with numbers, place, and date of collection. The samples were then stored at room temperature until analysis then after the samples transported in to Ethiopian conformity assessment enterprise laboratory at Addis Ababa. Each honey sample was analyzed separately for the selected physico-chemical quality parameters.

Physicochemical Properties Analysis

The honey samples were analyzed at Quality and Standard Authority of Ethiopia (QSAE) following standard procedures in Ethiopian conformity assessment enterprise laboratory at Addis Ababa. The honey samples were analyzed for moisture (%), f, pH, acidity (meq/kg), ash (%), water-insoluble matter (g/100g), hydroxy-methylfurfural (mg/kg) fructose (%), glucose and sucrose (%).

Data Analysis

The data which is collected through the survey were analyzed using simple descriptive statistics (*i.e.* means, frequency, and percentage) and the categorical variables were compared by using che-x^2 test using Statistical Package for Social Science ver. 16 (SPSS, version 26). Furthermore, parameters like constraints of beekeeping production and major pests and predators of honey bee were analyzed using simple ranking methods. Parameters like Honey quality data, were analyzed by one-way ANOVA using Gen state software version 15. For the interaction effect two-way ANOVA were applied. The mean values of honey samples from the different harvesting seasons and locations (districts) were compared by using least significant difference (LSD), whenever ANOVA shows statistically significant difference among means. The following statistical Model were used to compare both effect season and location independently across the locations.

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

Where, Y_{ij} = honey quality parameters (response variable),

μ = overall mean,

A_i = effect of i^{th} location

B_j= effect of the season

e_{ijk}= random erro.

RESULTS AND DISCUSSION

demo-graphic characteristics of household

The demo-graphic characteristics of the respondents in the study areas are indicated in Table 1.The result of the study indicated that 79.2 % of total sampled households were male headed households while the remaining (20.8%) were female headed which implies the female involvement of beekeeping practices is low. This probable might be due to difficulty to perform the activities of the beekeeping like harvesting as mostly the hives hung in long trees , the cultural barrier and lack of empowerment this result is line with the study of (Getachew,2018) in Keffa Zone , South –West Ethiopia who indicated that most of the beekeeping activities are involved by males. The age characteristics indicated that most of the respondents are within the range of 26-40 years (46.67%) followed by those who are 45-60 years (40.83%) and the remaining (12.5%) were above 61 years. This could explain that beekeeping is an activity which can be carried out at different age groups and in most cases, the productive age groups are actively engaged in beekeeping. It is believed that educational level of the household head has an influence on adopting modern beekeeping system. The majority (70%) of the interviewed households in the study areas were Illiterate (unable to write and read). Whereas, the remaining (30%) of the respondents were literate having different educational background. With regard to marital status, the majority (70%) of total interviewed households were married while the remaining 30% were widowed and divorced. As the result implies, the married households are significantly engaged in beekeeping than others. This could explain that beekeeping requires stability and married couples are using different options for asset building. According to the result of the study the overall average family size of the study districts was 6.4± 0.375 and there was no significance difference among the studied districts as indicated in Table1.the report of the average family size in this study is in line with that of Ma'alin *al.* (2022) who reported that of 6.41±1.3 reported by Ma'alin *et al.*, (2022) for Shabele zone of Somali region.

Table 1**:** Characteristics of the sampled households (%)

	Erer zone				Liban zone		N=120
Variables	**Lagahida**	**Salahad**	**Qubbi**	**Mayumuluko**	**Gurabakaksa**	**Guradhamle**	**Overall**
Sex	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Male	80	85	75	80	75	80	79.2
Female	20	15	25	20	25	20	20.8
Age (years)	**%**	**%**	**%**	**%**	**%**	**%**	**%**
26-40	55	35	40	55	60	35	46.67
45-60	40	50	50	30	25	50	40.83
> 61	5	15	10	15	15	15	12.5
Marital status	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Married	70	65	75	65	70	75	70
Divorced	30	35	25	35	30	25	30
educational status							
Illiterate	55	60	65	75	85	80	70
literate	45	40	35	25	15	20	30
family size	**6.15±0.42**	6.4±0.38	6.5±**0.25**	6.25±**0.41**	6.55±**0.34**	6.7±**0.45**	6.4±**0.375**

Purpose of beekeeping production

As the result of the finding indicates the primary reason of beekeeping production in the study areas was combination of income generation and consumption as the majority (75%) of the respondents reported followed those who used as home consumption only and income generation only which accounts 15% and 10% respectively. The result of this finding is in contrast with the report of Anza *et al.*, (2021) at Arbaminch who reported the main purpose of keeping in that areas is for income generation only.

Table 2: purpose of beekeeping in the study areas**.**

Purpose of	Erer zone (n=80; 20 in each district)				Liban zone (n=40; 20 in each)		N=120
	Lagahida %	Salahad %	Qubbi %	Mayumuluko %	Gurabakaksa %	Guradhamle %	Overall %
for income	5	15	5	5	10	15	10
Income & home consumption	75	65	85	80	70	75	75
home consumption	15	20	10	15	20	10	15
p-value	**0.00**						

Beekeeping production Practices

Type and number of hives per household in the study areas

The type and number of hives per households are indicated in Table 3. The majority (65%) of the respondents among the different districts reported that the types of available hives are traditional followed by those (19.17%) who have both traditional and modern beehives whereas the

remaining 17.5% of the respondents have modern hives only. As the result of study indicates there is a significant difference at $p<0.05$ among the studied districts with respect to the type of available hives as the result of the study implies the availability of modern of hives are very minimum in Gurabaksa and Guradamole district of liban zone. The overall average numbers of traditional and modern hives per household in the study areas are 4.78±0.58 and 1.25±0.34 respectively.

Table 3**:** Type of beehive (%) and number of hives/HH in the study area

Type of beehive	**Erer zone**			**Liban zone**			
	Lagahida	**Salahad**	**Qubbi**	**Mayumuluko**	**Gurabakaksa**	**Guradhamle**	**Overall**
Traditional beehive	45 [a]	35[a]	65[a]	45[a]	100[a]	100[a]	65
Modern beehive	35[b]	25[ab]	20	25	0	0	15.83
both	20[ab]	40[b]	25	30	0	0	19.17
p-value	0..00						
no hives/hh	**Mean+ SEM**	**Mean+ SEM**	**Mean+ SEM**	**Mean+ SEM**	**Mean+ SEM**	**Mean+ SEM**	**Mean+ SEM**
Traditional hive	3.025**+0.57**	3.6**+0.59**	5.3**+0.92**	4.55**+0.75**	5.5+0.44	6.7**+0.26**	4.78**+0.58**
Modern hive	2.95+0.98	1.9**±0.32**	0.85**±0.31**	1.8**+0.41**	0	0	1.25**+0.34**
p value=0.000							

Placement of the Beehive and sources of honey bee colony

placement of beehive and sources of honey bee colonies of interviewed respondents in the study area are presented in Table 4. As the study revealed, most beekeepers (60.83%) in the study areas hung their beehives on trees in dense forest whereas 28.33%of the respondents kept their beehive in the backyard and only 9.17% of the beekeeper's practices both hanging on the trees and backyards. As the finding of the study implies Beekeepers in the study areas prefer to hung their beehives in dense forest far away from residential area where there is ample bee forage .As 65 % of the respondents reported the main source of their foundation colonies was by catching the swarms followed by those who obtained from their parents and purchasing of the foundation colonies from the other beekeepers was not common practice in the study areas. This clearly shows that swarming of bees is still a source of foundation stock in traditional beekeeping practices this study is in line with other study conducted in South Wollo Zone, Amhara, Ethiopia which implies that the catching the swarms is the common sources of bee colony (by (Bihonegn and Begna,2021)

Table 4: Placement of beehive and sources of honey bee colony (%) by sample households

Placement of beehive	**Erer zone**				**Liban zone**		**N=120**
	Lagahida	**Salahad**	**Qubbi**	**Mayumuluko**	**Gurabakaksa**	**Guradhamle**	**Overall**
	%	**%**	**%**	**%**	**%**	**%**	**%**
Hanging on trees	50	60	60	70	55	70	60.83
Backyard	35	20	35	20	40	20	28.33
Both	15	10	5	10	5	10	19.17
p-value	0.367						
Source of honeybee colony	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Catching swarms	55[a]	60[a]	65[a]	70a	75[a]	65[a]	65
Gift from parent	40[a]	20[b]	35b	30[b]	25[b]	30[b]	30
Buying	5[b]	20[b]	0	0	0	5	5
p-value =0.000							

Honey Production Yield

Regarding the honey production, the overall honey yield was 6.125±0.59 and 11.56±0.43per hive per harvesting season in traditional and modern hives, respectively. highly Signiant difference ($p < 0.05$) in honey yield in between traditional and modern beehives among the studied districts (Table 5). But there is no significance difference the yield obtained from traditional and modern hives across the studied districts. However further study is highly recommended for comparative study of traditional and modern hives across the studied districts through participatory approach to ensure the potentiality of the for-beekeeping production in the areas.

Table 5: Honey yield (kg) in the study area (Mean ± SD) by sampled households**.**

Type of beehive	Erer zone			Liban zone			
	Lagahida Mean± SEM	**Salahad** Mean± SEM	**Qubbi** Mean± SEM	**Maymluko** Mean± SEM	**Gurabakaksa** Mean± SEM	**Guradhamle** Mean± SEM	**Overall** Mean± SEM
Traditional hive	6.625±0.59	6.05±0.8	6.25±0.71	5.95±0.58	6±0.6	6.25±0.28	6.125±0.59
Modern hive	11.55±0.44	11.5±0.46	11.05±0.45	11.7±0.43	-	-	11.56±0.43

Handling Practices of Honey

Honey harvesting practices

Honey harvesting practice activities are summarized in Table 6. As the result of the study implies the majority (86.67%) of respondent reported that the use of smoke and fire during honey harvesting is very common practice and the honey harvesting is carried out at night time. This affects honey quality because smoke and ashes from the fire ends up mixing with the harvested honey. The present result is in line with the findings of Lomiso (2019), Kebede (2011) and Shenkute *et al.* (2012) who reported the smoke and fire employed while harvesting honey may dust the honey with ash and the honey may absorb the smoke which cause contamination to the honey. Regarding the frequency of honey harvesting 75% of the respondents reported that the honey is harvested in two times a year and some of considerable respondents (19.17%) also reported that the honey might be harvested three times in a year. The result of this study is in line with that of Fikru*et al.* (2015) who reported that, in Ethiopia, there are generally two honey harvesting seasons, the major one lasting from October to November and the second one being from April to June.

Table 5: Methods, frequency and time of harvesting (%).

variables	Erer zone			Liban zone			N=120
	Lagahida	Salahad	Qubbi	Mayumuluk	Gurabakaksa	Guradhamale	Overall
Methods of harvesting							
Smoking	5	10	20	25	10	10	13.33
Smoking & fire	95	90	80	75	90	90	86.67
frequency of harvesting							
once a year	5	5	10	5	0	10	5.83
twice a year	75	80	75	80	70	70	75
three times a year p-value= 0.000	20	15	15	15	30	20	19.17
Harvesting time	**%**	**%**	**%**	**%**	**%**	**%**	**%**
day time	15	25	15	20	30	15	20
Night time	75	70	75	70	60	80	71.66
other	10	5	10	10	10	5	8.33

Honey Storage and Collection Materials

The majority (65%) of the respondents in the study areas indicated that the honey can be stored 1-6 months whereas 16.67% of the respondents reported that they do not store honey because of high demand of honey in the study area and secondly because of lack of storage facilities. But sometimes the beekeepers store their honey for prolonged period as the some of the respondents indicated about 7-12 months and 1-2 years with percentage of 9.17% and 7.5% respectively and

this might happen when at the time of, they could not get buyer or to get better price in off time. Beekeepers use different storage containers for collection and storage. Majority (58.33%) of the respondents use commonly used plastic jericans where as 23.33% and 18.33% beekeepers use clay pot and jog respectively. This indicated that there was no proper storage materials used in the study area. According to the Ethiopian honey quality standard (Edessa:2005) storage containers made of improper material shall be coated completely with bees wax or food grade plastic lines to avoid any direct contact between honey and the container.

Table 6: Honey storage period, collecting and storage materials (%)

honey storage	**Erer zone**			**Liban zone**			
period	**Lagahida**	**Salahad**	**Qubbi**	**Mayumuluko**	**Gurabakaksa**	**Guradhamale**	**Overall**
not store	15	20	20	15	20	10	16.66
1-6 month	65	65	65	70	60	70	65.83
7-12 months	10	5	10	5	10	15	9.17
1-2 years	10	5	5	10	10	5	7.5
Material used for honey	**%**	**%**	**%**	**%**	**%**	**%**	**%**
plastic material	85	65	45	40	60	65	58.33
clay pot	15	35	10	10	35	15	23.33
Jog	0	0	45	50	5	10	18.33
p-value =0.000							

Honey straining practices

The majority (64.2%) of the respondents in the study areas were not practiced honey straining before consumption and selling. As the majority of the respondents reported the main reason for not straining of honey were lack of knowledge and materials. In other hand a considerable respondent about 35.83% of the respondents were practiced straining and Some of the reasons for straining being both preventing dead bees and to obtain pure honey. According to the group discussion and key informant interview the only means of straining honey were hand and cloth and most of the beekeepers simply crush and squeeze the honey comb and remove the floating impurities by hands.

Table 7**:** Honey straining practices (%).

variable	Erer zone				Liban zone		
	Lagahida	**Salahad**	**Qubbi**	**Mayumuluko**	**Gurabakaksa**	**Guradhamle**	**Overall**
honey straining	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Yes	40	45	20	35	35	40	35.83
No	60	55	80	65	65	60	64.2
if yes advantage of straining	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Preventing dead bees	15	15	5	10	5	10	10
Gaining Pure Honey	10	25	10	20	30	30	20.83
both	15	5	5	5	0	0	5
If no reasons not straining	**%**	**%**	**%**	**%**	**%**	**%**	**%**
lack of material	15	15	20	15	15	10	15
lack of knowledge	25	20	25	15	25	30	23.33
both	20	20	35	35	25	20	25.83

Constraints and Opportunities of Beekeeping in the Study Areas

The major constraints limiting the beekeeping production practices in the studied districts were presented in (Table 9). the major constraints of beekeeping in the study areas were pest and predators, absconding and scarcity of water with index values of 0.245,0.225 and 0.227 respectively. The present study is in lined with that of Yirga *et al.*, (2012), who reported that bee pests, predators and absconding are major constraints affecting beekeeping sub-sector in northern Ethiopia. The other constraints reported by respondents were included lack of beekeeping equipment including the modern hives and shortage of bee forage and this is also consistent with Fikru et al. (2015), who reported that during the field survey, the interviewed beekeepers in Jigjiga zone responded that some bee equipment, such as modern bee hives, wax printers, and honey extractors, are very expensive, and thus farmers cannot afford to buy and use these equipment. Despite all the constraints and challenges currently facing the beekeeping subsector,

there are still enormous opportunities and potentials to boost honey production in the studied Districts. Based on the information captured from key informants and focus group discussions as well as field observations, the major opportunities for beekeeping development are: increasing hive products' demand, availability of honeybee floral resources, and availability of honeybee resources.

Table 8**:** Major constraints of beekeeping

pests and predators	N	Erer zone						Liban zone						overall
		R1	R2	R3	R4	R5	Index	N	R1	R2	R3	R4	R5	Idex	Idex
Absconding of bees	80	28	20	21	8	2	0.25	**38**	10	10	13	5	0	0.20	0.225
Pests & predator	77	23	20	22	12	0	0.27	**40**	13	9	7	7	4	0.22	0.245
Water scarcity	73	19	12	20	22	0	0.26	**36**	8	11	9	8	0	0.194	0.227
Beekeeping equipment	62	7	19	12	10	14	0.11	**37**	5	4	6	11	10	0.198	0.154
Shortage of bee forage	40	3	8	3	15	17	0.05	**35**	4	7	5	9	11	0.188	0.119
total	**332**	**80**	**79**	**78**	**61**	**33**	**1.01**	**186**	**40**	**40**	**40**	**40**	**25**	**1**	**0.97**

*Constraints were ranked based on the number (frequency) of respondents prioritize the problems

Pests and predators of honeybee

The major pest and predators limiting the beekeeping production in the study areas are presented in Table 10. As the result of the study indicates ants and honey badgers are major pest and predators limiting the beekeeping production with index value of 0.216 and 0.207, respectively followed by Spiders, Lizards and wax moth with index values of 0.1975, 0.1925 and 0.187, respectively.

Table 9**:** Major pests and predators of honeybee

pests and predators	N	Erer zone						Liban zone							
		R1	R2	R3	R4	R5	index	N	R1	R2	R3	R4	R5	Idex	overall index
Honey badgers	80	30	20	21	8	1	0.214	**38**	10	10	13	5	0	0.20	0.207
Ants	79	21	20	22	16	0	0.212	**40**	13	9	7	7	4	0.22	0.216
Spiders	75	19	12	20	22	2	0.201	**36**	8	11	9	8	0	0.194	0.1975
Lizards	70	7	19	12	15	17	0.187	**37**	5	4	6	11	10	0.198	0.1925
Wax moth	69	3	9	5	19	33	0.186	**35**	4	6	5	9	12	0.188	0.187
total	**373**	**80**	**80**	**80**	**80**	**53**	**1**	**186**	**40**	**41**	**40**	**40**	**25**	**1**	**1**

Honeybee Absconding

Absconding refers to the sudden departure of the whole colony from a hive while migration is the seasonal movement of bees from one Agro-ecology to another as a coping strategy. Shortage

of bee forage causes the honeybee colony to migrate to areas where resources are available for their survival. Shortage of bee forage directly associated with off flowering period of major honeybee plants. The existence of honey bee pests and predators and off-flowering of honey bee plants ultimately resulted in frequent absconding of colonies and high migratory tendencies. During honey harvesting from traditional hives the beekeepers may dismantle the hive, damage the brood, and abandon. The study indicated that 94.17% of the respondents experienced the absconding of honey bee colony whereas only 5.83% of respondents where not reported this phenomenon. Various causes of absconding were identified in the present study (Table 12). Accordingly, pest and predators destroying the nest during honey harvesting, forage shortage and scarcity of water are the reasons for absconding as indicated by the participants of the focus group discussion. Improvement of the overall management like regular inspection, regular feeding etc., are the only means of controlling mechanism; however, the majority of the 74.17% were not taken any kind of controlling mechanisms for absconding.

Table 10**:** Occurrence of honeybee absconding (%)

variable	Erer zone				Liban zone		N=120
	Lagahida (n=20)	Salahad (n=20)	Qubbi (n=20)	Mayumuluko (n=20)	Gurabakaksa (n=20)	Guradhamle (n=20)	Overall
Occurrence of absconding	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Yes	90	85	100	95%	100	95	94.17
No	10	15	0	5	0	5	5.83
Control mechanism of absconding	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
Overall management	30	35	0	10	35	10	20
Do nothing	60	50	100	85	65	85	74.17

Major Species of honey flora in the study areas

Honey bee plant species dominance

The honey bee forage plants data from each plot were summarized and registered under their respective study districts as indicated in Table 12. A total of 2,366 honey bee forage plants which are belong to different genera and families were identified and recorded. These plant species was identified by the local community as a major bee forage plants in the study area. This indicates the availability of diverse bee forage plant species in the area and can be created abundance sources of nectar for the honey bees in different seasons of the year. Ahmed A. et al (2017). Also stated Ethiopia has an estimate of 7000 floral species. However, only few of which

are identified as major bee plants in their contribution for honeybees. In our study these bee forage plants were identified during field observation with experienced beekeepers familiar with the plants that produce nectar pollen, generally the availability abundance bee forage plants are very important for honey production in the study area. As the result of the study indicates the major honey bee flora species and their percentage in the study sites (districts).From the above table ‘cadad’ and ‘bilcin’ are most abundant honey bee flora species in the study area, whereas ‘gacmadheer’ and ‘Timir gel jire’ are least available honey bee flora species. In the district wise Salahad is the 1st rank interms dominance of honey bee floras followed by Lagahida.

Table 11: Dominance of honey bee floras

honey bee flora species		DISTRICTS							Rank	
Botanical name	**Local Name**	**Gora Bakaksa**	**Guradamole**	**Mayimulok**	**Qubi**	**Salahad**	**Lagahida**	**Total**	**%**	**Ranks**
Acacia senigal	Cadaad	72	106	77	60	68	107	490	20.71	1
AciaReficiens	Qansax	0	0	0	0	145	0	145	6.13	7
Acacia Milifora	Bilcin	65	82	56	50	15	94	362	15.3	2
Acacia Horidida	Sarman	26	0	40	38	86	84	274	11.58	4
BosiaMinimifolia	Maygaag	0	0	27	0	66	0	93	3.93	8
Terminalia poly carpa	Hareri	71	38	32	48	50	0	239	10.10	5
Capparidaceae family	Gabre	0	0	0	0	34	22	56	2.37	10
Acacia Tortelis	Qudhac	77	30	56	53	34	66	316	13.35	3
GrewiaTembensis	Midhayo	0	0	0	0	0	55	55	2.32	11
GrewiaPensilata	Hohob	0	0	0	0	0	21	21	0.89	13
EphorbiaRobock	Qamami	0	0	39	31	0	20	90	3.8	9
Kirkiaburger	Dofar-Qod	16	0	0	0	0	29	45	1.9	12
Acacia Bussia	Galol	28	48	36	32	2	0	146	6.17	6
Canthiumsetiflorum	GacmaDheere	10	0	0	8	0	0	18	0.76	14
	Timir Gel Jir	0	0	0	16	0	0	16	0.67	15
Total Species /Districts		**365**	**304**	**363**	**336**	**500**	**498**	**2366**	**99.98**	
Ranks		3	6	4	5	1	2			

A total of 2,366 honey bee forage plants which are belong to different genera and families were identified and recorded. All spatial analyses were performed using (Arc map 10.8 version) and then the honey bee forage plant species was classified in to the three categories using 'Natural breaks algorithms 'classification method in arc map, namely 'Abundance, more abundance and much more abundance. As shown (Figure 1).

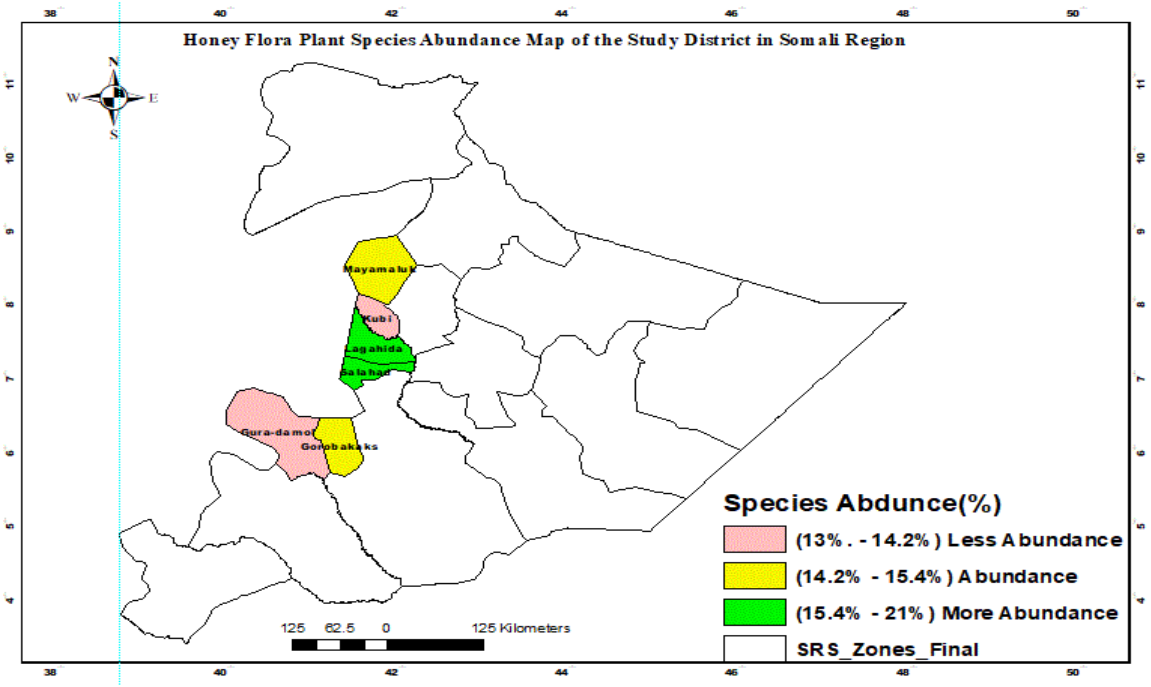


Figure 1: Honey bee forage plants abundance map

As shown in the above map. we used these terminologies because Abundance refers to the number of any species present in a given area. As Barbara J. et al (2012) stated Species-abundance distributions are a convenient and common method for describing ecological communities and no agreement has been reached as to which models are best, this lack of agreement is in part owing to the inherent differences in the abundance measure used. Accordingly, the abundance labels that can reflect our study objectives were used. Then study sites that has number of honeys be plants between (304-336) are categorized abundance and study sites that has number of honeys be plants between (336-365) more abundance, whereas those has number of honeys be plants between (365-500) much more abundance. This result shows areas around Lagahida and salahad districts have move honey bee forage plants then other districts (table 2)

Table 12**:** Honey bee forage plants abundance labels

No	Abundance label	No of plants	districts	Rank
1	Abundance	304 -336	Gura-damole and Qubi	3
2	More abundance	336-365	Gura-baqaqsa and maymuluqo	2
3	Much more abundance	365-500	Lagahida and salahad	1

Physico-chemical properties of honey

Physico-chemical properties of honey at Summer and Winter seasons

The physico-chemical properties of honey samples collected from six districts at summer and Winter seasons are presented in Table 14. The overall means of pH obtained from the studied districts were 4.13± 0.04and 4.17±0.06in summer and winter season respectively. Based result of the of the study the overall mean of pH of both seasons across the districts fulfills the requirement of quality criteria of International honey quality standards which ranges from 3.25-4.5and there was slightly significance difference among the samples collected from the study districts. The low amount of pH found in honey is greatly important during storage of honey as they influence the texture, keep the stability and prolong the shelf life of honey (Bogdanov, 2002). The overall mean value of free acidity of honey samples were 37.99±0. 35meq. Acid/kg and 33.68 ± 0.332meq. Acid/kg in summer season and winter respectively. There was significance difference at $p<0.05$ among the studied districts and the highest free acidity was observed the samples from Gurabakaksa and Gudamole in both seasons. The sample from the studied districts were within the limit set in Ethiopian accepted national standard (less than 40 meq. acid/kg of honey) except the samples from Gurabakaksa and Gudamole which is within the international honey quality level (≤ 50 m eq/kg. Acidity of the honey is one of its merits for its antimicrobial property. When the acidity becomes high, the honey becomes sour (Alemayehu, 2011).

The overall averages of hydroxymethylfurfural (HMF) content of the honey samples analyzed in this study were 6.39+0.44mg/kg and 8.33+0.59mg/kg in summer and Winter respectively. There was a significance difference at($p<0.05$) across the study districts. The highest HMF content was obtained the samples from Mayimulko and Qubi summer and Winter season respectively, whereas the lowest HMF content were obtained the samples from Guradhemole and Gorabaksa in both seasons. The amount of HMF in honey is one of the important indicators of honey quality. In fresh honey, HMF is present only in trace amounts and its concentration increases

with storage and prolonged heating of honey (Bogdanov, 2011, Diez, 2002) reported that the hydroxymethylfurfural content of honey is an indicator of its freshness.

The overall means of moisture content of honey in the study areas were 21.62±0.24 and 20.89±0.197 in Summer and Winter seasons respectively, there was a significance difference at ($p<0.05$) among the studied districts. The higher moisture contents were reported the samples from Guradamole and Gorabakaksa, whereas the lowest moisture contents recorded in Lagahida and Salahad in both seasons. However all of the honey samples across the studied districts had moisture content within the accepted range in the international standard level. Moisture content is one of the most attribute to be considered in the quality of honey since it affects its shelf life and consumer preferences. The overall mean of water-insoluble maters of the analyzed samples collected in summer and winter season from the different districts in the study areas were 0.53±0.021g/k and 0.29±0.01g/kg respectively.

There was a significance difference the honey samples among the studied districts. The highest water-insoluble maters were reported the samples from Gorabakaksa and Guradamole in both seasons and lowest water-insoluble maters was observed the samples from the Mayimuluko and Qubi in summer and Winter respectively. Honey's water-insoluble matter (solids) includes wax, pollen, honey comb and debris particles. Honey's water-insoluble matter is used as criterion for cleanness of honey. As the result of the laboratory indicates the water-insoluble maters of the analyzed samples from the studied districts were considerable higher and might due to poor hygienic and harvesting conditions. Mineral (ash) content: The average mineral (ash) content of the honey samples in summer and winter season were 0.48±0.0084and 0.42±0.0095respectivelywhich falls within the limit set of national and international standard, however there was a significance difference among the studied districts. The highest ash contents were obtained the samples from Gurabakaksa and Guradamole in both seasons.

The higher contents of ash in the above mentioned samples might be due to the higher altitude of the areas and the type of the honey bee floras available. The overall mean of Glucose in the study areas were 23.53±0.286and 24.85±0.363 in summer and winter respectively. There was a significance difference at ($p<0.05$) among the study areas as the result implies the higher Glucose contents were reported from the Lagahida and Salahad in both seasons. The average contents of fructose in the study districts were 37.18±and 34.62+0.34 in summer and winter

respectively. There was significant difference ($p < 0.05$) in honey sugar content of the samples collected among the studied districts. The result confirmed the averages of sugar contents (Glucose and Fructose) of the samples met national (ECAE, 2005) and European (HC, 2002) honey standard requirement of which ≥ 60%. The overall mean of sucrose contents in the honey samples in the study areas were 0.27±0.015and0.28±0.0071 in summer and winters season respectively. Although a small amount of sucrose is found in honey, it is a major honey quality criterion to indicate adulterated honey. Honey samples which were adulterated with processed sugars had above the Maximum limit of sucrose and HMF level that make losing of the freshness and destroy the quality of honey (Tesfaye *et al*., 2016).Based on the international regulations, any commercially available "pure"-labeled honey products that are found to have in excess of 5% by weight of sucrose or maltose are considered to be adulterated (Codex Alimentarius Commission. 2001).

Table 13**:** Physico-chemical properties(mean+SE) of honey at summer and winter seasons

	Erer zone				Liban zone		
Parameters	**Lagahida**	**Salahad**	**Qubbi**	**Mayumuluk**	**Gurabakaks**	**Guradhamle**	**Overall**
				Season1(Summer)			
pH	4.05±0.05[b]	4.05±0.05[b]	4.32±0.005[a]	4.15+0.05[ab]	4.15+0.03[ab]	4.145±0.035[ab]	4.13± 0.04
Acidity (meq. /kg)	32.81±0.42[c]	33.07±0.16c	36.02±0.03b	36.97±0.075[b]	44.02±0.52[a]	45.02±0.52[a]	37.99±0.35
HMF (mg/kg)	6.25±0.45[b]	5.90±0.10[b]	12.10+0.85[a]	12.475+0.48[a]	0.850±0.05[c]	0.79±0.01[c]	6.39±0.44
Moisture (%)	21.30+0.20[b]	21.25+0.25[b]	21.02±0.325	20.46±0.235	22.75+0.25[a]	22.93±0.07[a]	21.62±0.24
Insoluble matter (g/kg)	0.46+0.015[b]	0.48+0.005[b]	0.53+0.02[b]	0.035+0.005[c]	0.83+0.015[a]	0.83±0.015[a]	0.53+0.02
Ash (%)	0.36+0.02[b]	0.37+0.01[b]	0.40+0.00[b]	0.31±0.01[c]	0.75+0.01[a]	0.72±0.01[a]	0.48±0.008
Glucose (%)	27.90+0.4[a]	27.95+0.35[a]	18.58+0.08[c]	18.43±0.23[c]	24.12+0.32[b]	24.20+±0.225[b]	23.53+0.28
Fructose (%)	48.05+0.25[a]	47.75+0.55[a]	23.20+0.1[c]	23.15±0.15[c]	40.51+0.39[b]	40.40+0.5b	37.18+0.516
Sucrose (%)	0.32±0.03	0.24±0.01	0.25±0.01	0.25±0.01	0.31±0.015	0.275±0.005	0.27±0.015
				Season2(Winter)			
pH	4.275±0.07a	4.325±0.03[a]	40.05±0.05[a]	4.1±0.1a	4.140±0.04a	4.150±0.03[a]	4.17±0.06
Acidity (meq. /kg)	23.62±0.12e	27.23±0.52[d]	35.03±0.04[c]	33.92±0.12c	40.08±0.47b	42.17±0.37[a]	33.68 ± 0.33
HMF (mg/kg)	12.07±0.57a	11.95±0.72[a]	12.37±0.57a	11.97±0.97a	0.85±0.05	0.795±0.005	8.33±0.59
Moisture (%)	19.20±0.2c	19.20±0.2c	20.85±0.15b	20.45±0.25b	22.75±0.25a	22.93±0.075[a]	20.89±0.19
Insoluble matter (g/kg)	0.01±0.005[b]	0.03±0.2[b]	0.02±**0.20**[b]	0.03±0.009[b]	0.85±0.01[a]	0.83±0.01[a]	0.29±0.01
Ash (%)	0.31±0.005[b]	0.315±0.005[b]	0.31±0.005[b]	0.335+0.01	0.615±0.015[a]	0.635±0.15a	0.42±0.009
Glucose (%)	31.98±0.48[a]	31.98±0.48[a]	18.55±0.105[c]	18.45+0.22[c]	23.96±0.46[b]	24.19±0.24b	24.85±0.36
Fructose (%)	40.2±0.3[a]	40.15±0.35[a]	23.25±0.05[b]	23.25+0.05[b]	40.50±0.4[a]	40.35±0.55[a]	34.62±0.34
Sucrose (%)	0.32±0.005[a]	0.29±0.005[ab]	0.23±0.005[c]	0.29±0.01[ab]	0.27±0.005[b]	0.30±0.01[ab]	0.28±0.007

The Interaction Effect of the Season on Physico-Chemical Properties of Honey

The physico-chemical properties of honey based on the effect of the season and districts are presented in Table 15. The combined mean of PH value and free acidy of the honey were 4.16±0.051 and 35.83+0.34meq respectively. The combined mean values of hydroxymethylfurfural (HMF) was 7.36±0.525 and there was a significance difference among the studied districts with respect the seasons. The combined mean of moisture contents was 21.24+0.2169 even though the higher moisture contents are observed the samples from Guradamole and Gorabaksa. All samples are withing the national standard range which is 23. As the result indicated the combined mean of Ash contents in the study areas was 0.45+0.013 and there was a significance difference among the study districts.

The highest ash contents were reported the samples from the Guradamole and Gorabaksa. The combined mean value of Water-Insoluble matters was 0.41±0.014 which is higher than that of the national and international standard and these might associate with hygienic condition during straining and harvesting. As the result of the laboratory test shows the combined mean of sugars (glucose and fructose) content was 24.191±0.3270 and 35.90+0.351respectively and there was a significance difference among the study districts with effect of the season and the higher value of glucose and fructose was reported sample from the Lagahida and Salahad. As the result of the laboratory test shows the combined mean of sucrose was 0.27±0.037.

Table 14: Combined physico-chemical properties the honey samples (season*districts)

Parameters	**Erer zone**			**Liban zone**			
	Lagahida	**Salahad**	**Qubbi**	**Mayumuluko**	**Gurabakaksa**	**Guradhamle**	**Overall**
Season*distiricts	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE
pH	4.162±0.105	4.188±0.116	4.188±0.115	4.125±0.0677	4.145±0.029	4.147±0.026	4.159n±0.051
Acidity (meq./kg)	28.22±3.76^{e}	30.15±2.41^{d}	35.45±0.40^{c}	35.45±1.25^{c}	42.05±1.66^{b}	43.60±1.22^{a}.	35.83±0.34
HMF (mg/kg)	9.162±2.415^{b}	8.912±2.49^{b}	12.238±0.60^{a}	12.225±0.658^{a}	0.85±0.041^{c}	0.792±0.0067^{c}	7.36±0.53
Moisture (%)	20.25±0.872^{b}	20.23±0.857^{b}	20.94±0.218^{b}	20.46±0.198b	22.75±0.2041^{a}	22.93±0.061^{a}	21.24±0.22
Insoluble matter (g/kg)	0.2400±0.184^{b}	0.2575±0.186^{b}	0.2750±0.204^{b}	0.035±0.009^{c}	0.884±0.017^{a}	0.8275±0.011^{a}	0.41±0.014
Ash (%)	0.3350±0.022^{bc}	0.3450±0.025^{bc}	0.36±0.037^{b}	0.32±0.013^{c}	0.667±0.044^{a}	0.695±0.05^{a}	0.45±0.013
Glucose (%)	29.94±1.70^{a}	29.96±1.68^{a}	18.57±0.076c	18.44±0.182^{c}	24.04±0.33^{b}	24.20±0.19^{b}	24.191+0.34
Fructose (%)	44.12±3.213^{a}	43.95±3.125^{a}	23.23±0.067^{c}	23.20±0.1^{c}	40.50±0.322^{b}	40.38±0.429b	35.90 +0.35
Sucrose (%)	0.3175±0.017^{a}	0.2675±0.03^{bc}	0.2375±0.012^{c}	0.27±0.018^{bc}	0.29±0.015^{ab}	0.2875±0.012^{ab}	0.28+0.037

CONCLUSION AND RECOMMENDATIONS

The studied districts have adequate natural resources and a long tradition and culture of beekeeping even though the involvement of the females for beekeeping practices is low among the studied districts compared to the males. This probable might be due to the cultural barrier and lack of empowerment. The finding of the study indicated the most available hives being traditional one which implies traditional beekeeping practices are common production system among the studied districts. Most beekeepers in the study areas hung their beehives on trees in dense forest far away from residential area where there is ample bee forage, and the main source of their foundation colonies being by catching the swarms from the forest. The information obtained from the beekeepers implies overall honey yield was around 6kg and 11.5 per hives per harvesting season in traditional and modern hives, respectively which implies the potentiality of the areas. As the result of the study implies the use of smoke and fire during honey harvesting is very common practice and the honey harvesting is carried out at night and mostly the honey is harvested two times in a year. Furthermore the finding of the study implies the majority of the respondents in the study areas indicated that the honey can be stored 1-6 months using plastic material which implies that there was no proper storage materials used in the study area. As the result of the study elaborated lack straining practices of the honey after harvesting is common because of lack of knowledge as well as lack of straining materials. The finding of the study indicated, the major constraints of beekeeping were the pest and predators, absconding, scarcity of water and lack of beekeeping equipment's including modern hives in their respective order. Despite all the constraints and challenges currently facing the beekeeping subsector, there are still enormous opportunities and potentials to boost honey production in the studied Districts. Based on the information captured from key informants and focus group discussions as well as field observations, the major opportunities for beekeeping development are: increasing hive products' demand, availability of honeybee floral resources, and availability of honeybee resources. The result of the present study indicated that most physico-chemical properties of honey of the honey samples collected from the six districts for both seasons in the study areas fulfilled international honey quality standards but insoluble matter which is associated with hygienic and harvesting practices ad solid and moisture contents in the case of Guradamole and Gorabakaksa. Furthermore the interaction effect of the season and the districts shows that there is a significance difference at $p<0.05$ for the analyzed parameters of the physico-chemical

properties of the honey samples. Based on the aforementioned conclusion the following recommendations are forwarded.

- Encouragement and empowerment of the pastoral and Agro pastoral communities particularly females for beekeeping activities through awareness creation and training is high is appreciated.
- improvement of beekeeping productivity are highly needed through introduction and demonstration of beekeeping technologies and improved management system.
- Handling practices of honey in the study areas needs to be improved through introduction of improved technology of honey handling practices.
- To overcome the constraints of beekeeping production in the study areas introduction of modern management practices is highly recommended.
- scientific control measures and management of pests and predators are highly recommended
- Appropriate handling practices should be used to keep the quality off honey among the study areas.
- The studied districts have high production potential for honey bee floras which is suitable beekeeping production therefore participatory research action through community participatory approach and bee foraging is highly recommended.
- Further studies shall be under taken for confirming species structure, composition of honey bee flora , flowering calendar and poisonous plant to bees for the optimization of honey quality.

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Forage crops

Evaluation on Adaptation, Biomass Production and Nutritive Value of Desho Grass at Different Agro-Ecologies in Somali Regional state, Ethiopia.

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Abstract

The study was conducted at Fafan and Godey in 2022 production season with the objective to evaluate Adaptation, Biomass Production and Nutritive Value of Desho Grass varieties and two Agro-Ecologies in Somali Regional state, Ethiopia. Three desho grass varieties; Kindo Kosha DZF No# 591, Areka DZF No# 590 and Kulumsa DZF No # 592 were evaluated. The study was conducted using 3 x 3 factorial arrangements in randomized complete block design with 2 factors (plant varieties and location) with three replications (RCBD). Data on growth yield and yield related parameters were collected and analyzed using Gestate software. The result from analysis of variance varieties, location and their interaction exhibited highly significant different (P<0.001) on plant height, number of tilers per plants and dry matter yield for all varieties. The combined mean showed that the tallest plant height (66.68cm) was recorded for Areka-DZF#590 varieties, while the lowest plant height was observed by KK1-DZF#591(60.73). The largest number of tillers (147.8) was recorded from KK1-DZF#591 while the lowest number of tillering was recorded from Kulumisa-DZF#592(101). The largest dry matter yield was recorded from Areka-DZF#590(33.55), While the lowest DMY was recorded from Kulumisa-DZF#592(22.1). The highest DM content was recorded from Kulumisa-DZF#592 (91.1%) and (93.4%) at Fafan and Godey locations respectively. At Fafan and godey location the highest CP was recorded from Areka-DZF#590(14.37) and KK1-DZF#591(13.7) respectively. Areka DZF No# 590 varieties performed much better in the current study and produced high dry matter yield and high-quality nutrition at Fafan location, while KK1-DZF#591 shows better performance in dry matter yield and nutrition at Godey location. Therefore, Areka DZF No# 590 is highly suggested for Fafan location for their dry matter yield and nutritional values, whereas KK1-DZF#591 is recommended for Godey location based on their better performance than other desho grass varieties. Agronomic and animal evaluation of desho grass under on-farm condition is worthwhile.

Keyword: *agronomic performance; Crude protein; Dry matter yield; Desho grass variety;*

INTRODUCTION

To combat the livestock feed shortage, the use of indigenous forage plants as a feed source is recommended. Among such types of forage species, which has multifaceted potential, is *Desho* grass. *Desho* grass is a very palatable species to cattle and sheep (Ecocrop 2010) and considered as king of grass (Leta et al. 2013).Currently, it is utilized for soil conservation practices and

livestock fodder in the highlands of Ethiopia (Leta et al. 2013). Despite its presence in different parts of the country, there is scarcity of information on the agronomic practices of *Desho* grass.

Desho grass *(Pennisetum pedicellatum)* is among the indigenous grass in Ethiopia belonging to the Poaceae family of monocot angiosperm plants. Desho grass is perennial grass collected from Chencha district in Southern Ethiopia (Welle et al., 2006). It grows in naturally spreading across the escarpment of the Ethiopian highlands and used for multiple purposes (Smith, 2010). Desho grass is used as a year-round livestock fodder. It is a very palatable species to cattle and sheep (Ecocrop, 2010) mainly grown on small home plots used for livestock fodder, soil conservation practices, and sold for income generation as small business opportunity mostly for high land Ethiopian farmers (IPMS 2005; Shiferaw *et al.,* 2011; Leta *et al.,* 2013). To maintain the sustainability of the intervention, the plot is permanently made inaccessible to free grazing livestock; instead, a cut-and-carry system is encouraged (Danano, 2007). Due to its rapid growth rate, Desho grass provides regular harvests, even reaching monthly cuts during the rainy reason. Once a year, just before the dry season, sufficient grass is harvested and stored as hay and can prepared as silage to feed the livestock until the rains return (Danano, 2007).

Ethiopian Minister of Agriculture and Rural Development was documented planting of Desho grass technology as an example of a locally tried and tested land management technique as a success to mitigate land degradation (Bimrew *et al.,* 2017). On the other hand, very little work has been done in collection and conservation of indigenous forage species, which have invaluable importance in the livelihood of the farmers.

Ethiopia Desho grass is a perennial plant which was first identified in the Southern region of the country at Chencha in 1991 and was utilized for soil conservation and animal feed (Welle *et al.*, 2006). It is one of the potential forages grasses available in Ethiopia which has a potential role in providing a significant amount of quality forage, both for the smallholder farmer as well as intensive livestock production systems with appropriate management practices (Leta *et* al., 2013; Asmare *et al.,* 2016). Study undertaken by Asmare *et al.* (2015) indicated that it is chemically composed of 92.22, 86.80, 8.07, 73.73, 48.45, 5.96, and 56.92% by for dry matter, organic matter, crude protein, neutral detergent fiber, acid detergent fiber, acid detergent lignin and invitro organic matter digestibility in order. The grass is drought resistant plant, used as feed for ruminants (FAO. 2010; EPPO, 2014). It has the potential of meeting the challenges of feed scarcity since it provides more forage per unit area and ensures regular forage supply due to its

multi-cut nature (Ecocrop, 2010). However, so far detail study that conducted on farm about its adaptation, yield and nutritive value under lowland area particularly in Somali region is highly scarce.

Efforts have been made in introduction, evaluation and selection of cultivated forage and pasture crops by the national and regional agricultural research systems and Universities during the last three to four decades. However, adequate numbers of forage varieties and production package targeting various agro-ecologies and production systems are not yet adequately developed. In the interest of offering baskets of technological options and also from perspectives of climate change, there is dare interest to bring on board research focusing on indigenous grasses (Berekit *et al.,* 2016). There are certain information generated on *desho* grass in the form of newsletter and working papers in Ethiopia (Smith, 2010; Leta*et al.,* 2013) and this implies that it is calling for detail investigation of adaptability, productivity and nutritive value of grasses at different altitude and different location within altitude. Thus, the current study was conducted with the objective to evaluate Biomass yield, Adaptation, and Nutritive Value of Desho Grass at Different Agro-Ecologies in Somali Regional state, Ethiopia.

MATERIALS AND METHODS

Experimental Layout, Design and Treatments

The study were conducted using 3 x 3 factorial arrangements in randomized complete block design with 2 factors (plant varieties and locations) with three replications (RCBD). The grass were planted using vegetative root splits in 8 rows on a well-prepared soil. There were three Desho grass Varieties (Kindo Kesho DZF#591, Kulumsa-DZF#592 and Areka-DZF-590) and there 3 repli cations, each containing 9 treatments resulting to 27 plots in total. Distance between plot and replications (blocks) were 1 and 1.5 meter, respectively**.** The spacing between rows and plants were 100cm and 50 cm, respectively.

Data Collection Procedure

Agronomic data and dry matter determination

Data on agronomic performance of the plant were recorded throughout the growing season during the study. Data that were recorded throughout the experimental period on plant height (PH) and number of tillers per plant (NT). To determine plant height at each harvesting time, the

height of plant from ground to the tip of the main stem were measured from randomly selected 10 plants using a meter tape (cm) that was randomly selected from each experimental plot. The number of tiller per plant were recorded at each harvesting times by counting the number of tillers developed from 10 randomly selected plants from each plot. To determine the Biomass production, Total forage yield per plot of the middle rows excluding border rows were harvested from each plot at 5cm above the ground and then weighed in kg. About 500 gm. of fresh sub sample weight was randomly taken from each plot at a time of harvesting when the stage of harvesting reached (Tessema, 2002b). The fresh weight were taken in the field using a top-loading sensitive laboratory balance. Fresh sub samples was taken from each plot and each plant species separately, weighed and chopped into short lengths (2-5cm) for dry matter determination. To estimate dry matter yield (DMY) in the field, the fresh sample were weighted and the weighed fresh (FW ss) sub sample was oven dried at 60^0C for 72 hours and reweighed (DW ss). Then the dry matter yield per hector was calculated using the formula of (James 2008). as shown below.

DM yield (t/ha) = (10 x TFW x SSDW) / (HA x SSFW) Where:
10 = constant for conversion of yields in kg/m2 to tone/ha;
TFW = total fresh weight (kg);
SSDW = sub-sample dry weight (g); HA = harvest area (m2), and
SSFW = sub-sample fresh weight (g)

Chemical Composition

All samples of plot were analyzed for DM, Ash and CP, according to the procedures of AOAC (1990). The crude protein (CP) content was calculated by multiplying N content with a factor of 6.25, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) was analyzed as per the procedure of Van Soest and Robertson (1985). The N content of the samples were determined by the micro-Kjedal method and CP was calculated as N x 6.25. It was determined by harvesting the grasses from an area of $3m^2$ from 3 central rows.

Statistical Analysis

Data on agronomic traits, biomass yield and chemical composition was subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of the statistical analysis system (Genstat, versions17). Differences among treatment mean were separated using two way Anova Duncan's Multiple Range Test (DMRT), when treatment effects were significant ($P< 0.05$). Means was separated using least significance difference (LSD).

RESULTS AND DISCUSSIONS

Analysis of variance (ANOVA)

The combined analysis of variance for all varieties at different environmental conditions for dry matter yield and yield-related traits is presented in Table 1. The result from the analysis of variance varieties, location, and their interaction exhibited highly significant differences (P<0.001) on plant height, number of tilers per plant, and dry matter yield for all desho varieties. On the other hand, the chemical composition parameters such as ADL, ASH, ADF, and DM content showed a highly significant difference (P<0.001) in location and variety. While the genotype-environment interaction was insignificant (P > 0.05) among tested desho varieties. CP was not affected by varieties and locations, but the genotype-environment interaction exhibited highly significant (P≤0.01) differences among all varieties. NDF, which is another important parameter for quality evaluation, showed that there was a highly significant (P≤0.001) difference among the studied varieties. The presence of significant differences among varieties indicates the presence of genetic variability for each of the characters among the tested desho varieties.

Table 1: Combined Mean Square values from ANOVA for Desho grass varieties at Godey and Fafan research centers.

Source of variation	d.f.	Mean square								
		PH	NTP	DMY T/h	CP	DM%	ASH	ADL	ADF	NDF
Block	2	0.020	0.7222	24						
location	1	861.125**	3606.7222**	112.5**	0.650ns	29**	2.34*	4.88**	154.12**	370.8**
variety	2	53.385**	15196.0556**	204.85**	0.676ns	1.21ns	5.93**	3.75**	41.027**	74.7*
Location. Variety	2	123.485**	2085.0556**	368.57**	16.75**	0.37ns	0.185ns	0.523ns	1.105ns	30.74*
Error	12	1.3	0.3	0.01	1.146	0.659	0.31	0.152	2.693	6.87
Total	17									

*(Keys: *, **: significant at 5% and 1% respectively, D.f=Degree of freedom, PH=Plant height, = NTP=number of tillers per plant, DM= Dry matter yield tone per hectare, DM%= dry matter percent, CP = Crude protein; Ash= Ash percentage; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; LSD: Least Significance difference; CV= coefficient variation ;)*

Combined Mean Performance of the Desho grass Varieties

Plant Height (PH).

The analysis of variance revealed that varieties, location and their interaction had highly significant (P<0.001) influence on plant heights (Table 2). Plant height is an important parameter contributing to yield in forage crops (Tessema et al., 2002). according to the combined mean, the tallest plant height (66.68cm) was recorded for Areka-DZF#590 varieties, Followed by Kulumisa-DZF#592(63.3), while the lowest plant height was observed by KK1-DZF#591(60.73).

Differences of plant height among the vrieties might also come from the genetics of the grass species, in the area where the experiments were conducted. This study is also inline with Gadisa Birmaduma *et al.,* 2019, Tekalegn Yirgu *et al.,*2017 and Asmare et al., 2017 who reported a significany variation of plant height among the evaluated varieties

Number of tiller per plants

The analysis of variance revealed that varieties, location and their interaction had highly significant (P<0.001) influence on number of tiller per plants (Table 2). The largest number of tillers (147.8) was recorded from KK1-DZF#591, followed by Areka-DZF#590 (137). Furthermore, the lowest number of tillering were recorded from Kulumisa-DZF#592(101). The results on number of tillers per plant for all tested Desho grass from this study is in line with previously study by Demeke *et al.,* 2017).

Table 2. Combined mean of agronomic performance of desho grass varieties at Godey and Fafan Location

Varieties	PH	NTP
Areka-DZF#590	66.68^{c}	137^{b}
KK1-DZF#591	60.73^{a}	147.8^{c}
Kulumisa-DZF#592	63.33^{b}	101^{a}
Mean	**63.58**	**128.61**
CV%	**1.8**	**0.4**
LSD	**2.1**	**1.03**

(PH=Plant height, = NTP=number of tillers per plant, DM= Dry matter yield tone per hectare CV; coefficient variation, SD=least significance difference)

Dry Matter Yield

The result from analysis of variance varieties, location and their interaction exhibited highly significant different (P<0.001) on Dry matter yield (Table 3). At Fafan and Godey research

stations, the highest dry matter yield, (45.1 and 28 t/ha), respectively, were recorded for Areka-DZF#590 and KK1-DZF#591; while the minimum recorded dry matter yield (20 and 22 t/ha) were for Kulumisa-DZF#592 and Areka-DZF#590 respectively. Regarding to combined mean the highest Dry matter was observed from Areka-DZF#590(33.55), followed by KK1-DZF#591(26). While the lowest DMY was recorded from Kulumisa-DZF#592(22.1). The result obtained on dry matter yield from this study is in line with that of Tekalegn *etal.,* 2017, Denbela Hidosa *etal.,* 2020 and (Gadisa, *etal.,* 2019) who reported a significant variation of dry matter yield of the studied varieties.

Table 3. Dry matter Yield of desho grass varieties as affected by location at Fafan and Godey.

	Locations		
Varieties	**Fafan**	**Godey**	**Combined Mean**
Areka-DZF#590	45.1[a]	22[c]	33.55[a]
KK1-DZF#591	24[b]	28[a]	26[b]
Kulumisa-DZF#592	20[c]	24.17[b]	22.1[c]
Mean	**29.72**	**24.7**	**27.2**
CV%	**0.6**	**0.7**	**0.4**
LSD	**0.38**	**0.381**	**0.19**

(CV=coffecient variation; LSD=least significance difference)

Chemical composition of Desho grass varieties

Dry Matter Content.

The result from analysis of variance showed that only location had a highly significant(P >0.001) effect on DM (table 4). The highest DM content was recorded from Kulumisa-DZF#592 (91.1) (93.4) at Fafan and Godey locations respectively.

Ash Content.

According to the analysis of variance The varieties and location had significant (P<0.05) effect on the ash content of different grass species, while their interaction had non significant effect (table 4). At Fafan location the highest ash contents were recorded from Kulumisa-DZF#592(16.2) while lowest ash content was observed from Areka-DZF#590(14.3). Similarly, in Godey the highest ash contents were observed from Kulumisa-DZF#592(15.7). the difference

might have been caused partly by the dilution effect of higher yields in the presence of a constant amount of available minerals in the soil. This finding is in agreement with previous study Denbela *et al*., 2020.

Acid Detergent Fiber (ADF)

The result from analysis of variance varieties, and location showed highly significance (P<0.001) difference but their interaction exhibited non-significant different on ADF (Table 4). The highest ADF content was observed from KK1-DZF#591 (52.2) and Kulumisa-DZF#592 (46.4) at Fafan and Gode locations respectively. This variation my be due to the genetics difference of the varieties and location. Moreover, the ADF value obtained from this study was comparable to the previous finding by (Denbela *et al*., 2020) which ranged from 50.23- 43.62%. Asmare *et al.*, 2017 and Denbela *et al*., 2020 also reported a significance variation of ADF among the tested varieties.

Table 4: Across location mean performance of chemical compositions of Desho grass variety.

	Locations							
	Ash		**ADF**		**DM%**		**ADL**	
Varieties	**Fafan**	**Godey**	**Fafan**	**Godey**	**Fafan**	**Godey**	**Fafan**	**Godey**
Areka-DZF#590	13.99^{c}	13.69^{b}	47.04^{b}	42.3	90.03	93.15	11.367^{c}	10.73^{b}
KK1-DZF#591	14.64^{b}	14.08^{b}	52.17^{a}	45.33	90.27	92.5	13.487^{a}	11.77^{a}
Kulumisa-DZF#592	15.94^{a}	15.72^{a}	51.87^{a}	46.37	91.11	93.38	12.2^{b}	11.4a^{b}
Mean	15.22	14.50	50.36	44.67	90.47	93.1	12.35	11.3
LSD	0.89	1.3	1.35	4.6	1.55	1.7	0.733	0.82
CV%	2.9	4.5	1.3	5.2	0.9	0.9	3	3.6

(DM%= dry matter percent; Ash= Ash percentage; ADF= Acid detergent fiber; LSD: Least Significance difference; CV= coefficient variation)

Crude Protein Content (CP %).

The result from analysis of variance varieties, and location showed none-significance (P<0.001) difference but their interaction exhibited highly significant different on CP (Table 5).At Fafan location the highest CP was recorded from Areka-DZF#590(14.37) while lowest CP was recorded from Kulumisa-DZF#592 (10.67). On the other hand, at Godey location the highest content of CP was observed from KK1-DZF#591 (13.7) followed by Kulumisa-DZF#592 (10.6). Regarding the combined mean the highest CP was recorded from Areka-DZF#590 (12.57) and the lowest dry CP was recorded from KK1-DZF#591 (11.9). The result obtained from this study

on CP values for all tested varieties with different agro-ecologies is in line with previously studies by (Denbela *et al,* 2020; Asmare *et al*., 2018; Asmare *et al*., 2018; Genet Tilahun *etal*. 2017). It has been stated that CP content ranging between 7 and 7.5% is required to satisfy the maintenance requirement of ruminant animals (Van Soest, 1982). Hence, the observed CP content of desho grass hay can satisfy the maintenance requirements of animals.

Neutral Detergent Fiber Content (NDF)

According to the analysis of variance, NDF was highly significantly ($p<0.001$) influenced by the tested varieties (Table 5) for both locations. According to the combined mean the highest NDF was observed from KK1-DZF#591(86.02), while the lowest NDF was recorded from Areka-DZF#590 (79.12). Regarding the locations, in Fafan the highest NDF content was observed from KK1-DZF#591(8.3.27) while in Godey the highest NDF content was found Kulumisa-DZF#592(90.9). Moreover, the NDF obtained from this study for all studied varieties are in line with the finding by (Denbela Hidosa *et al.,* 2020).

Table 5: Nutritional Values of Crude protein (CP) and Nutrient detergent fiber (NDF) based on locations

	Locations					
	CP			NDF		
Varieties	**Fafan**	**Godey**	**Combined Mean**	**Fafan**	**Godey**	**Combined Mean**
Areka-DZF#590	14.37^{a}	10.77^{b}	12.57^{a}	75.33^{b}	82.9^{c}	79.12^{b}
KK1-DZF#591	12.2^{ab}	13.6^{b}	11.9^{b}	83.27^{a}	88.77^{b}	86.02^{a}
Kulumisa-DZF#592	10.67^{b}	11.73^{a}	12.2^{ab}	76.77^{ab}	90.93^{a}	83.85^{a}
Mean	**12.4**	**12.03**	12.22	**78.5**	**87.53**	**82.99**
CV%	**11.3**	**4.8**	**8.8**	**4.6**	**0.8**	**3.2**
LSD	**2.8**	**1.2**	**1.9**		**1.5**	**4.66**

(DM%= dry matter percent; Ash= Ash percentage; ADF= Acid detergent fiber; LSD: Least Significance difference; CV= coefficient variation, NDF= Neutral detergent fiber, CP = Crude protein)

Conclusion and Recommendations

The present result demonstrated that the tested desho grass varieties showed significant difference in most of the studied traits in the study area due to the vareties, location and their interaction. Adaptability and productivity of the tested desho grass varieties, top two desho varieties were recommended to be very potential under the study area and similar agro-ecology.

In conclusion, Amongst the evaluated desho grass varieties, Areka DZF No# 590 and KK1-DZF#591 varieties performed much better in the current study and performed best in all studied parameters. Areka DZF No# 590 and 7KK1-DZF#591 were the top two desho grass varieties recommended to be demonstrated on farm conditions and could play an important role in providing high dry matter yield, seed yield and with significant good nutritional quality. Therefore, livestock producers (both under smallholder farmers and semi-intensive livestock producers) could utilize as feed in cut and carry feeding system in highlands of fafen and godey areas and similar agro-ecologies of south Eastern Ethiopia.

Based on this finding the recommendation of Areka DZF No# 590 is highly suggested for Fafan location based on its dry matter yield and high crude protein and lower NDF and ADF. Whereas KK1-DZF#591 is recommended for Godey location based on their better performance on dry matter yield and nutritional values than other desho grass varieties in Gode location. Desho grass has a low crude protein content (CP), so it should be supplemented with local protein sources such improved and native leguminous fodders, agro-industrial waste, and brewery byproducts. The final remark is that further work should be done on chemical composition of the tested genotypes and live-animal performance fed with these grass genotypes.

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Evaluation on Adaptation, Biomass Production and Nutritive Value of Napier Grass at Agro-Ecologies in Somali Regional state, Ethiopia

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Abstract

The study was conducted at Fafan, Dolo ado and Godey in 2022 production season with the objective to evaluate Adaptation, Biomass Production and Nutritive Value of Napier Grass at Different Agro-Ecologies in Somali Regional state, Ethiopia. Three Napier grass varieties; Napier -16819, Napier-16784 and Napier-16791 were evaluated. The study was conducted using 3 x 3 factorial arrangements in randomized complete block design with 2 factors (plant varieties and locations) with three replications (RCBD). Data on growth yield and yield related parameters were collected and analyzed using Gen-Stat software. The result from analysis of variance varieties, location and their interaction exhibited highly significant different (P<0.001) on plant height, number of tilers per plants and dry matter yield for all locations. Combined means squares showed that the tallest and shortest plant height was recorded from N-16791(215.9 cm) and N-16819(163.1 cm) respectively. Moreover, the highest and lowest number of tillers were recorded from N-16984 (16.46) and N16819 (14.54) respectively. Regarding the combined mean the highest dry matter yield was recorded from N-16791(125.9 t/ha) and the lowest dry matter yield was from N-16819 (88.6 t/ha). The highest and lowest mean DM content was recorded from N-16791(93.06%) and N-16819(91.8) respectively. The highest and lowest Ash content was recorded from N-16819(19.5) and N-16791(14.3) respectively. Furthermore, the highest mean of NDF were recorded from N-16784(86.6) while the lowest NDF were recorded from N-16791(82.49). The highest ADF were recorded from N-16819 (56.9) while the lowest ADF was observed from N-16791 (47.6). Regarding the combined mean the highest CP was recorded from N-16791(10.1) while the lowest CP was recorded from N-16784(7.3). N16891 and N16819 varieties performed much better in the current study and produced high dry matter yield and high crude proteins.Napier-16791is highly suggested for Fafan location and similar environment due to their high dry matter yield and high protein contents. Whereas for Godey and Dolo-ado Napier-16819 varieties is highly suggested for their high dry matter yield and high crude protein contents.

Keywords*: *agronomic performance; Crude protein; Dry matter yield; Napier grass variety;

INTRODUCTION

Livestock production is an integral part of the subsistence crop-livestock systems in the Ethiopian highlands, as livestock provide draft power for land preparation and threshing, plus a source of cash income and assets and nutrition for the rural communities. In addition, livestock are considered as a mobile bank that can be hired, shared, inherited and contracted by rural households (Amede et al. 2005). However, the contribution of this subsector to date has been suboptimal (CSA 2016). One of the important constraints causing low productivity of livestock is low quality and insufficient supply of forage (FAO 2010).

To combat the livestock feed shortage, the use of indigenous forage plants as a feed source is recommended. Among such types of forage species, which has multifaceted potential, is *Napier grass*. *Napier grass* is a very palatable species to cattle and sheep (Ecocrop 2010) and considered as king of grass (Leta et al. 2013).Currently, it is utilized for soil conservation practices and livestock fodder in the highlands of Ethiopia (Leta et al. 2013). Despite its presence in different parts of the country, there is scarcity of information on the agronomic practices of *Napier grass*.

Napier grass *(Pennisetum purpureum)* is among the indigenous grass in Ethiopia belonging to the Poaceae family of monocot angiosperm plants. Napier grass is perennial grass collected from Chencha district in Southern Ethiopia (Welle et al., 2006). It grows in naturally spreading across the escarpment of the Ethiopian highlands and used for multiple purposes (Smith, 2010). Napier grass is used as a year-round livestock fodder. It is a very palatable species to cattle and sheep (Ecocrop, 2010) mainly grown on small home plots used for livestock fodder, soil conservation practices, and sold for income generation as small business opportunity mostly for high land Ethiopian farmers (IPMS 2005; Shiferaw et al., 2011; Leta et al., 2013). To maintain the sustainability of the intervention, the plot is permanently made inaccessible to free grazing livestock; instead, a cut-and-carry system is encouraged (Danano, 2007). Due to its rapid growth rate, Napier grass provides regular harvests, even reaching monthly cuts during the rainy reason. Once a year, just before the dry season, sufficient grass is harvested and stored as hay and can prepared as silage to feed the livestock until the rains return (Danano, 2007).

Ethiopian Minister of Agriculture and Rural Development was documented planting of Napier grass technology as an example of a locally tried and tested land management technique as a success to mitigate land degradation (Bimrew et al., 2017). On the other hand, very little work

has been done in collection and conservation of indigenous forage species, which have invaluable importance in the livelihood of the farmers.

Due to the production system is based on natural pasture and linked with crop production related milk availed form market is seasonal and the price of the milk is highly fluctuated in Somali region pastoral and agro pastoral areas. Therefore, adequate quantity and quality of feed resource is crucial for animal production in mostly dairy and beef cattle. Hence, introduction of high yielding and nutritious indigenous forage species like Napier grass is the notable issue to minimize feed shortage in both quality and quantity especially during dry season. Thus, the research will have with the objective of Evaluation of Napier grass (*Pennisetum pedicellatum* Trin) lines for their adaptability, agronomic Performance, Herbage Yield and Nutritive Value at different agro-ecologies and production system of Somali region under irrigation in study areas.

MATERIALS AND METHODS

Experimental Layout, Design and Treatments

The study was conducted using 3 x 3 factorial arrangements in randomized complete block design with three replications (RCBD). There were three Napier grass Varieties (Napier-16819, Napier-16784 and Napier-16791) which made up nine treatments. There were 3 replications, each containing 9 treatments resulting to 27 plots in total. Distance between plot and replications (blocks) was 1.5 and 2 m respectively**.** The spacing between rows and plants were 100cm and 50 cm, respectively

Land preparation and Management

The experimental land was ploughed and harrowed two times by making the soil fine-tilth and were leveled before planting. The total area experimental area was 12 m x 26 m (312 m2) with 27 plots with each plots size will be 12m2.. Napier grass was planted using vegetative root splits in 8 rows on a well-prepared soil. All other agronomic managements were applied as per the recommendation.

Data Collection Procedure

Agronomic data and dry matter determination

Data on agronomic performance of the plant were recorded throughout the growing season during the study. During the experimental period plant height (PH), Dry matter yield and number of tillers per plant were recorded. To determine plant height at each harvesting time, the height of plant from ground to the tip of the main stem was measured from randomly selected 10 plants using a meter tape (cm) that was randomly selected from each experimental plot. The number of tiller per plant were recorded at each harvesting times by counting the number of tillers developed from 10 randomly selected plants from each plot. To determine the Biomass production, Total forage yield per plot of the middle rows excluding border rows were harvested from each plot at 5cm above the ground and then weighed in kg. About 500g of fresh sub sample weight was randomly taken from each plot at a time of harvesting when the stage of harvesting reached (Tessema, 2002b). The fresh weight were taken in the field using a top- loading sensitive laboratory balance. Fresh sub samples were taken from each plot and each plant species separately, weighed and chopped into short lengths (2-5cm) for dry matter determination. To estimate dry matter yield (DMY) in the field, the fresh sample were weighted and the weighed fresh (FW ss) sub sample was oven dried at 60^0C for 72 hours and reweighed (DW ss).

Then the dry matter yield per hector was calculated using the formula of (James 2008). as shown below.

DM yield (t/ha) = (10 x TFW x SSDW) / (HA x SSFW)

Where:

10 = constant for conversion of yields in kg/m2 to tone/ha;

TFW = total fresh weight (kg);

SSDW = sub-sample dry weight (g); HA = harvest area (m2), and

SSFW = sub-sample fresh weight (g)

Chemical Composition Analysis Procedures

Dry matter (DM) content was determined by oven drying of all the samples at 105^0C for 24 hours. Total nitrogen (N) was determined by the Kjeldhal method (AOAC, 1990). Crude protein (CP) was calculated by this formula N x 6.25. Ash was determined by complete burning of the feed samples in a muffle furnace at 500^0C overnight according to the procedure of AOAC (1990). The structural plant constituents such as Neutral Detergent Fiber (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) was analyzed by using the detergent extraction

method (Van Soest *et al*., 1991). Hemicellulose was calculated by subtracting the ADF from the NDF content while cellulose was determined by subtracting the ADL from the ADF content.

Statistical Analysis

Data on agronomic traits, biomass yield and chemical composition was subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of the statistical analysis system (Genstat, versions17). Differences among treatment mean were separated using two way Anova Duncan's Multiple Range Test (DMRT), when treatment effects were significant ($P< 0.05$). Means was separated using least significance difference (LSD).

RESULTS AND DISCUSSIONS

Analysis of variance (ANOVA)

Performance of Napier grass varieties at different locations and their interaction are presented in Table 1. The result from analysis of variance varieties, location and their interaction exhibited highly significant different (P<0.001) on plant height, number of tilers per plants and dry matter yield for all varieties. This means the interaction of varieties and location affected nearly all of morphological parameters which imply that all factors have importance in determining the performance of grasses tested in the current study.

Moreover, all Nutritional quality parameters showed a highly significant difference (P<0.001) in location, variety and their interaction among tested Napier varieties. The study also proved differences in morphological performance, nutrition, and productivity among the studied grasses in different agro ecological conditions of the region.

Table 1: Combined Mean Square values from ANOVA for Napier grass varieties at Godey, Dolo and Fafan research centers.

Source of variation	d.f.	Mean square								
		PH	NTP	DMY T/h	CP	DM%	ASH	ADF	ADL	NDF
Block	2	3315.	7.5	327.2						
Location	2	1022ns	985.8**	11542.3**	112.860**	4.244*	111.7416**	45.443**	29.1126**	174.2792**
Variety	2	6266*	9.73**	3147.7*	20.492**	3.749*	51.5898**	196.177**	11.5804**	50.0226**
Location. Variety	4	936ns	4.72**	380.6*	0.743*	3.850*	18.7129**	57.163**	20.5231**	12.1900**
Error		1050	0.93	600.2	1.250	1.021	0.6494	1.22	0.39	0.8141
Total	26									

*Keys: *, **: significant at 5% and 1% respectively, D.f=Degree of freedom, PH=Plant height, = NTP=number of tillers per plant, DM= Dry matter yield tone per hectare*

Combined Mean squares of agronomic Performance of the Napier grass Varieties

Plant Height (PH).

According to the results of the combined analysis of variance over the three environments, plant height was highly significantly (P<0.001) affected by interaction, varieties and environments, The highest plant height was recorded from N-16791(215.9) followed by N-16984(87.3), while shortest plant height was recorded from N-168. similarly (Habtie Arega et al., 2020) reported a significant variation of plant height among the tested varieties.

Number of tiller per plants

Analysis of variance showed that there was a highly significant (P ≤ 0.01) effect on plant height due to main factors of variety and there were a significant effect on varieties, location and the interaction effect of variety and location (Table 1). The highest number of tiller per plant was recorded from N-16984 (16.46) followed by N16791 (16.2), while the lowest number of tillers were recorded N16819 (14.54). This variation between varieties might be due to the well-established root development and nutrient uptake ability of the grasses which in turn could be manifested by the increase in plant height. This finding is in line with the report of (Habtie Arega et al., 2020).

Table 2: Combined mean of agronomic performance Napier grass varieties at Godey, Dolo ado and Fafan Location.

Varieties	PH	NTP	DMY(t/ha)
N-16791	215.9^{c}	16.21^{b}	125.9^{b}
N-16984	187.3^{bc}	16.46^{b}	109.9^{ab}
N-16819	163.1^{a}	14.54^{a}	88.6^{a}
Mean	188.8	15.74	**108.1**
CV%	**17.2**	**6.1**	**22.7**
LSD	**56**	**1.67**	**42.4**

(DMY= dry matter yield; CV= coefficient variation; PH= plant height, NT= number of tillers, LSD=least significance difference)

Dry Matter Yield

Analysis of variance showed that there was a highly significant (P ≤ 0.01) effect on dry matter yield due to main factors of variety and there were a significant effect on varieties, location and the interaction effect of variety and location (Table 1). At Godey and Fafan research stations, the highest Dry matter yield, (146.2 and 136.5 t/ha), respectively, were recorded for variety N-

16791; while the recorded minimum dry matter yield (104 and 82.3 t/ha) were from N-16819. However, at Dollo-ado research station the highest Dry matter yield were recorded from N-16791(85.22).

Regarding the combined mean the highest dry matter yield was recorded from N-16791(125.9 t/ha) and the lowest dry matter yield was from N-16819 (88.6 t/ha). The highest dry matter yield of the varieties N-16791and N-16984 could be due to their Differences in growth habit and their inherent genetic potential among the varieties which may have resulted to the reported variation in dry matter yield performance.

The highest total DM yield observed in all locations by all studied grasses varieties is in line with (Inyang *et, al*., 2010; Feyissa, *et, al*., 2014) findings. The increase in yield could be attributed to the development of more tillers, which increased leaf formation, leaf elongation, and stem development. This finding is in line with (Zewdu, 2005; Tessema et al., 2002; Ishii *et al.*, (2005), the tallest varieties showed higher dry matter yields than the shorter varieties.

Table 3. Dry matter Yield of desho grass varieties as affected by location at Fafan, Dolo and Godey.

	Locations			
Varieties	**Fafan**	**Godey**	**Dolo- Ado**	**Combined Mean**
N-16791	136.5^{a}	146.2^{a}	85.22^{a}	125.9^{b}
N-16984	95.3^{b}	125.1^{b}	79.44^{a}	109.9^{ab}
N-16819	82.3^{c}	104^{c}	57.78^{a}	88.6^{a}
Mean	**104.7**	**125.1**	**74**	**108.1**
CV%	**0.1**	**9.7**	**46.4**	**22.7**
LSD	**0.05**	**22.04**	**78**	**42.4**

Combined Mean squares ANOVA for Chemical composition of Napier grass Varieties

Dry Matter Content (DM %)

Analysis of variance showed that there was a highly significant ($P \leq 0.01$) effect on DM content due to main factors of variety and there were a significant effect on varieties, location and the

interaction effect of variety and location (Table 1). The highest combined mean of DM content was recorded from N-16791(93.06%), followed by N-16784(92.18). While the lowest dry matter content was obtained from N-16819(91.8). This finding was in conformity with previous results reported by (Habtie Arega et al., 2020).

Ash Content.

Analysis of variance showed that there was a highly significant ($P \leq 0.01$) effect on Ash content due to main factors of variety and there were a significant effect on varieties, location and the interaction effect of variety and location (Table 1). The highest Ash content was recorded from N-16819 (19.5) while the lowest ash was recorded from N-16791(14.3). This finding is in line with previous results reported by (Habtie Arega et al., 2020).

Neutral Detergent Fiber Content (NDF)

Analysis of variance showed that there was a highly significant ($P \leq 0.01$) effect on NDF due to main factors of variety and there were a significant effect on varieties, location and the interaction effect of variety and location (Table 1).

The highest mean of NDF were recorded from N-16784(86.6) while the lowest NDF were recorded from N-16791(82.49). This finding is in agreement with with previous results reported by Habtie Arega et al., (2020).

Acid Detergent Fiber (ADF)

Analysis of variance showed that there was a highly significant ($P \leq 0.01$) effect on ADF due to main factors of variety and there were a significant effect on varieties, location and the interaction effect of variety and location (Table 1). The highest ADF were recorded from N-16819 (56.9) while the lowest ADF was observed from N-16791 (47.6). This difference might due to the genetic make up and location.

Table 4: Combined mean for chemical compositions of Napier grass variety grown under Fafan, Gode and Dolo Research centers.

Varieties	DM%	ASH	ADL	ADF	NDF
N-16791	93.06[a]	14.73[c]	11.6[b]	47.62[c]	82.49[b]
N-16819	91.8[b]	19.5[a]	13.73[a]	56.91[a]	82.55[b]
N-16784	92.18[ab]	16.88[b]	11.98[b]	51.44[b]	86.6[a]
Mean	**92.35**	**17.04**	**12.44**	**51.99**	**83.88**
CV%	**1.1**	**4.7**	**5.1**	**2.1**	**1.1**
LSD	**1.73**	**1.38**	**1.01**	**1.89**	**1.55**

(DM%= dry matter percent, CP = Crude protein; Ash= Ash percentage; NDF= Neutral detergent fiber; ADF= Acid detergent fiber; LSD: Least Significance difference; CV= coefficient variation=Napier grass)

Crude Protein Content (CP %).

The result from analysis of variance varieties, location and their interaction showed highly significance (P<0.001) difference on crude protein (Table 1). At Fafan location the highest CP was recorded from N-16791 (14.34) while lowest CP was recorded from N-16784(10.9). On the other hand, at Godey location the highest content of CP was observed from N-16819 (8.2) followed by (7.66). For dolo-ado the highest CP was found from N-16819(7.77), while the lowest CP content was observed N-16784(5.5) .Regarding the combined mean the highest CP was recorded from N-16791(10.1) while the lowest CP was recorded from N-16784 (7.3). This finding is in agreement with the finding of (Habtie Arega et al., 2020).

Table 5: Crude protein content (CP) of Napier grass based on locations

	Locations			
Varieties	**Fafan**	**Godey**	**Dolo-Ado**	**Combined Mean**
N-16791	14.34[a]	7.66	7.52[a]	9.81[a]
N-16819	14.27[a]	8.2	7.77[a]	10.102[a]
N-16784	10.93[b]	5.2	5.93[b]	7.36[b]
Mean	**13.18**	**7.02**	**7.07**	**9.09**
CV%	**2.9**	**26.8**	**3.3**	**12**
LSD	**0.76**	**3.8**	**0.5**	**1.92**

(CV=coefficient variation; LSD=least significance difference; N=Napier grass

Conclusions and Recommendations

The analysis of variance indicated that there was significant difference among genotypes for on plant height, number of tilers per plants and dry matter yield and the nutritional qualities for all Napier grass across the testing environments. Based on the results of data analysis the highest combined mean yield was observed for 16791 and 16819.

The outcome suggests that the all Napier varieties were well adapted and being productive in terms of plant height, biomass yield, and dry matter yield for all locations, which is hopeful to fill the gap of low quality and quantity for the community's supply of livestock feed. Napier grass varieties of 16791 and 16819 performed much better in the current study and produced high dry matter yield at all locations. Additionally, the nutritional qualities (chemical composition) seemed encouraging, especially for the dry matter and crude protein in N16791 and 16819 as well as the lower ADF, NDF and ADL content compared to other varieties. It is possible to come to the conclusion that these grass varieties can be used as energy supplement for all locations, which was suffering from poor quality roughage and low energy feed and digestible crop residues, which were the main livestock feed sources particularly in this region.

Based on this finding the recommendation of Napier-16791is highly suggested for Fafan location and similar environment due to their high dry matter yield and high protein contents. Whereas for Godey and Dolo-ado Napier-16819 varieties is highly suggested for their high dry matter yield and high crude protein contents. The final remark is that further work should be done on chemical composition of the tested genotypes and live-animal performance fed with these grass genotypes.

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RANGELAND AND AGRO-FORESTRY RESEARCH DIRECTORATE

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Wild Edible Fruits Diversity and their Traditional Uses for Local Livelihood in Dollo, Qorahy and Nogob Zones, Somali Region, Ethiopia

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Abstract

The study on Wild Edible Fruits Diversity and their Traditional Uses for Local Livelihood was conducted in Dollo, Qorahy and Nogob Zones, Somali Region, Ethiopia. The objectives of the study were to identify abundance, dominance and diversity of wild edible fruits and to analyze factors affecting wild edible fruits. The study was carried out at three different zones, namely 'Dollo , Nogob and Qorahy located in Somali Regional State (SRS). The study was carried out thorough discussion held with local communities', district agricultural experts and local elders who have knowledge on the study species. Vegetation survey was conducted by making Transect Walk and field observation to select representative area for vegetation abundance. Based on the analysis of data gathered, total of twenty wild edible plant species (herb, Liana's shrubs and tree) where identified from Warder and Qorahay Total of eight families where identified, in terms of species richness. The dominant family was apocynecea with six species fallowed by malveceae five species. The top three families contribute about 30 percent on the seven-plant family recorded in the study area. The wild edible plant species are underutilized and threatened by growing harvesting pressures in natural ecosystems. It is important to raise rural households' level of awareness about wild edible fruits management, marketing, and utilization at home.

Key words: *livelihood, wild edible fruit, Diversity, Traditional uses*

INTRODUCTION

Human beings are known to use wild plants in different ways since the start of human civilization, thus there is close relationship between people and plants (Rajbhandary *et al*., 2020). Nature is bestowed with diverse life forms on which human beings survived and life is maintained. Before the start of domestication of crop plants, primitive man used to eat different types of fruits, leaves, root of plants collected from the wild for their survival. Wild edible plants are the species those are neither cultivated nor domesticated but growing wild and are however

edible (Beluhan and Ranogajec, 2010). The primitive man through trial and error has selected many wild edible plants which are edible and subsequently domesticated them then after (Niveditha, 2017). The wild fruit plants are an important source of food and many wild edible plants are nutritionally rich and can supplement nutritional requirements of human and livestock, especially the vitamins and micronutrient (Mohapatra and Panda, 2009) for poor communities in many rural parts of the world (Chakravarty *et al*., 2016). Rural people are still not only depending either for nutritional needs or for daily food securities but also for their primary health care treatments on wild edible fruits. This wild edible fruits significantly influences their livelihood and food security in rural people (Rafiqul Islam *et al*., 2019).

Edible wild fruit plants (EWFPs) refer to species that are neither cultivated nor domesticated but are available from their wild natural habitat and used as food sources (Beluhan and Ranogajec, 2010). Despite the primary reliance of most agricultural societies on staple crop plants, the tradition of eating EWFP products continues today. In addition to their role in closing food gaps during periods of drought or scarcity, they play an essential role in maintaining livelihood security for many people in developing countries (Afolayan and Jimoh, 2009). Besides, Ethiopian EWFPs are faced with threats related to habitat loss and degradation; hence a complementary in situ and ex situ conservation measure is vital to conserve the WEP wealth of the country (Ermias and Lulekal *et al.*, 2011). EWFPs have been a focus of research for many ethnobotanists in recent decades. Currently, global interest is increasing in documenting ethnobotanical information on neglected wild edible food sources (Bharucha and Pretty, 2010). Since traditional knowledge on EWFPs is being eroded through acculturation and the loss of plant biodiversity and indigenous people and their cultural background, promoting research on wild food plants is crucial to safeguard this information for future societies (Asfaw, 2009). In Somali region there are diverse wild edible fruits. Wardher, Qabridar and Garbo are among potential area were availability of wild fruits very high. This most valuable wild edible fruits remain undocumented in the region particularly in shrub land where there is a relatively large supply of edible products. furthermore, indigenous knowledge about the use of WEFs has not been sufficiently documented, leading to a cultural erosion of their uses. this situation, thus, greatly undermines their conservation and sustainable utilization. therefore, this study designed to fill this knowledge gap on this resource and the over all object of this research is wild edible

fruits diversity and their traditional uses for local livelihood in Dollo, Qorahay and Nogob zones, Somali region, Ethiopia.

OBJECTIVES

- To identify abundance and diversity of wild edible fruits in the study area.
- To collect and identify traditional uses wild edible fruits in the study area

MATERIALS AND METHODS

The Study area and site selection

The present study was carried out in three districts from Dollo, Nogob and Korahy (one district per each zone) were selected purposely based on their potential which were obtained by a thorough discussion with local leader/ elders who have knowledge on the study species. As the aim of this particular research was to study wild edible fruits bearing species, further discussions were made focused on the availability, abundance and distribution of the study species.

Accordingly, Kabri dahar district from Korahey, Garbo district From Nogob and Warder district from Dollo were selected. The selected study sites were found to be have the best habitats that harbour most of wild edible fruits species with good abundance.

Methods of data collection

Vegetation data collection

Transect Walk and field observation was made to select representative area for vegetation data collection and then three transact line laid after site selection in Ado kebele. In each transect 10 plots with a size of 20m x 20m were established. A total of 30 plots in three transect in Ado Kebele (warder Woreda) established and similarly 30 plots in 3 transect were also made in Karinmile kebele (Kabri dahar Woreda) and Karin agaag kebele (Garbo Woreda). A totally 90 plots in each site established and wild edible fruit bearing species survey was conducted. In each plots all necessary data was collected and recorded on a diversity of the wild edible fruits bearing species, data on frequency, abundance of tree, tree/shrub and shrub species rooted in all sample plots.

Sampling Procedure and Determination of Sample Size

Selection of household respondents

A multi-stage sampling procedure was used to select sample households. In the first stage three districts with higher abundance and distribution of the study species were selected purposively and in the second stage six kebeles were selected from the two districts. Then the number of households who are native to district and know the socio- economic uses of the gum and resin in the area were selected based on probability proportional to the size (number of households of the three districts) following the formula developed by Green (1991).

$N \geq 50 + 8m$---------- (1)

N= Sample size required

m= Variables/predictors (in our case, the variables were 10).

For this study, the number of households (N) selected for face-to-face interview were 130: $N \geq 50 + (8*10) = 130$. The numbers of households from each district were determined proportional to the total number of households in each district. A total of six Kebeles, from three districts were systematically identified and 50, 45 and 45 households were randomly selected from Warder, Qabridahar and Garbo districts respectively.

Data collection

Close and open-ended questionnaires were developed and face to face semi-structured interviews were under taken to assess the factors affecting wild edible fruit bearing species. The questions were prepared in to 'Somali language'. Enumerators who were researchers, knowledgeable about the area were involved in data collection. In addition, 10 key informant interviews and 12 Focus group discussions were conducted to get general information on the vegetation status, production and the traditional uses and challenges faces; and factors affecting of the species production and conservation. The information generated here was used to validate the information collected from household respondents.

Data Analysis

In this portion of data analysis data was analysed by using descriptive statistics such as frequencies and percentages to analyse the demographic characteristics of the house hold. Moreover, Shannon diversity index was used to compute species diversity among the different sites.

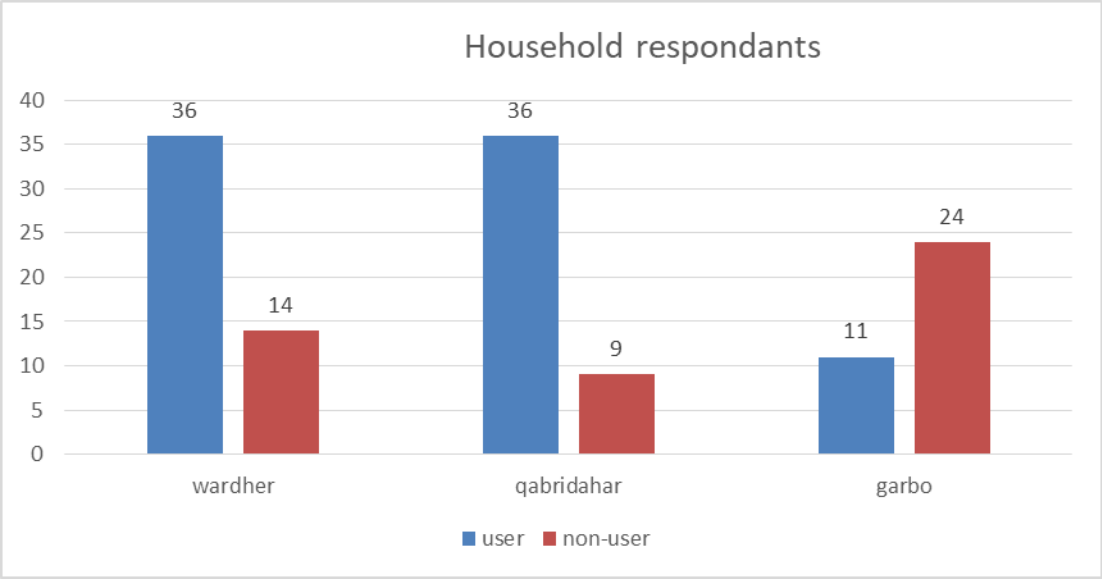
RESULT AND DISCUSSION

Demographic and Socioeconomic Characteristics

A total of one hundred thirty sample households had completed the interview. Among the total households 30% were female respondents and 70 % were male. Besides, 100% of the respondents were Muslim in religion and majority of 82.3% of the respondents were illiterate. The most respondents' family size was about 6-10 which is about 44.6 (Table 1).

Table 1. Demography of household respondents

Variable	**Alternatives**	**Total (n = 130**	**Percentage (%)**
Sex	Female	39	30.0
	Male	91	70.0
Age	20-40	43	33.1
	41-60	43	33.1
	61-70	31	23.8
	>71	13	10.0
Education	Illiterate	107	82.3
	grade8-10	22	16.9
	>grade 12	1	.8
Household size	1-5	28	21.5
	6-10	58	44.6
	>10	44	33.8
Land size	0-3h	77	59.2
	4-5h	40	30.8
	>6h	13	10.0



Majority of the wild edible fruit users in Warder and Kabri dahar were about 36% in each district while in Garbo 11% and non-user respondents in warder, Kabridahar and Garbo were 14, 9 and 24% respectively.

Total of twenty WEFP species (herb, Liana's shrubs and tree) where identified from Warder and Korahay. Total of eight families where identified, in terms of species richness. The dominant family was apocynecea with six (25%) species fallowed by malveceae five (30%) species. The top three families contribute about 30 percent on the seven-plant family recorded in the study area.

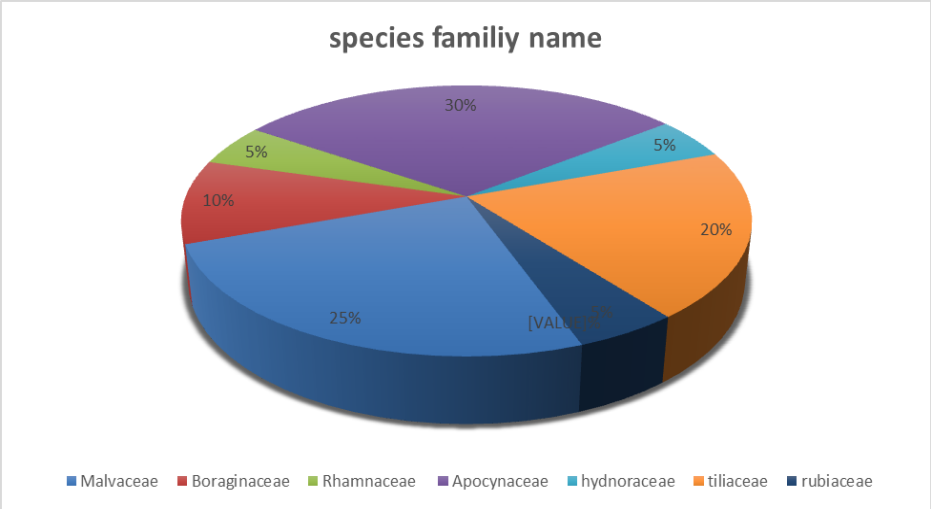


Figure1. Percent proportion of plant family per species

Table 2. Scientific, local, family name and growth habit of wild edible fruit species

Scientific name	**Family name**	**Local name of species in (Somali)**	**Growth habitat**	**Parts used**
Grawiapenicilata	*Malvaceae*	Hohob	S	Fruit
Grewiatenax	*Malvaceae*	Dhafaruur	S	Fruit
Grewiavillosa	*Malvaceae*	Gomesh	S	Fruit
	Hydnoraceae	Ciid	S	Fruit
gardenia florii	*Apocynaceae*	Himir	S	Fruit
Cordia sinensis	*Boraginaceae*	Madheedh	S	Fruit
Givotiagosl	*Apocynaceae*	Gosey	S	Fruit
Zizphusmauritiana	*Rhamnaceae*	Gob	T	Fruit
Commeliniaspp	*Tiliaceae*	Kordhis	S	
Cucumelakelleri	*Apocynaceae*	Uneexo	H	Bud/root
Cynanchum	*Apocynaceae*	Dombir	H	Bud/root

Pterodisousobtusiflorus	*Apocynaceae*	Cialal	H	
	Rubiaceae	Jacjacle	Sh	
Cyperusobtusiflorus	*Tiliaceae*	Goon	H	
Ehicostemal	*Apocynaceae*	Askax	H	
Hydro abyssinica	*Tiliaceae*	Liko	H	
Dobera glabra	*Apocynaceae*	Garas	T	Fruit/seed
	Tiliaceae	Madaxbuq	L	
	Malvaceae	Kidi	T	Fruit
		Midhacas	S	Fruit
		Dhiin	S	Fruit
		Ilcas	S	Fruit
		Dhambac	S	Fruit
		Maygaag	S	
		Mindoy	S	

Table 3. Species richness, diversity an of tree/shrub species in three districts of Somali Region

No.	**Diversity and Richness**	**Warder**	**Qabridahar**	**Garbo**
1	Species rich ness (WEF bearing spp.)	18	20	16
2	Species evenness	2.843	0.957	0.874
3	Shannon-Wiener diversity of wild edible fruit spp.	0.952	2.867	2.423

As predicted in the table 3, Kabri dahar has the highest species richness about 20 different wild edible fruits were recorded followed by Warder which was about 18 species and the least was Garbo which was about 16 fruit species respectively. The species were more even in Warder 2.843 followed by Kabri dahar about 0.957 and Garbo 0.874 but in species diversity wiener

diversity index has Identified that wild edible fruit species was the most divers Kabri dahar followed by Garbo and then Warder district.

Table 4. Frequency, relative frequency, abundancy and relative abundance of tree/shrub species at warder district

Local name of species in (Somali)	F	r-f	Abundance	r-abundance
Hohob	29	17.791	1122	79.40
Dhafaruur	22	13.496	67	4.74
Gomesh	20	12.269	40	2.830
Ciid	20	12.269	59	4.175
Himir	14	8.588	30	2.123
Madheedh	12	7.361	31	2.193
Gosey	6	3.680	11	0.778
Gob	5	3.067	6	0.424
Kordhis	3	1.840	4	0.283
Uneexo	2	1.226	2	0.141
Dombir	4	2.453	6	0.424
Cialal	5	3.0674	9	0.636
Jacjacle	3	1.840	4	0.283
Goon	5	3.067	5	0.353
Askax	1	0.613	1	0.070
Liko	4	2.453	7	0.495
Garas	5	3.067	5	0.353
Madaxbuq	3	1.840	4	0.283
Total	163	100	1413	100

In the table 4, in Warder district a total of 18 wild edible fruit species were recorded the most top three dominate species were *hohob,* (which is the commercialized and known as the most attractive wild fruit in the area), *dafaruur and ciid,*. But the rarest specie was *askax*.

Table 5. Frequency, relative frequency, abundancy and relative abundance of tree/shrub species at Qabridahar district

Local name of species in (Somali)	**Frequency**	**R-frequency**	**Abundance**	**R- Abundance**
Hohob	28	9.621	276	10.538
Dhafaruur	27	9.278	305	11.645
Gomesh	21	7.216	192	7.331
Ciid	24	8.247	207	7.903
Himir	21	7.216	182	6.949
Madheedh	22	7.560	156	5.956
Gosey	13	4.467	124	4.734
Gob	12	4.123	121	4.620
Kordhis	12	4.123	68	2.596
Uneexo	9	3.092	93	3.550
Dombir	11	3.780	147	5.612
Cialal	12	4.123	131	5.001
Jacjacle	23	7.903	118	4.505
Goon	7	2.405	79	3.016
Askax	9	3.092	74	2.825
Liko	5	1.718	80	3.054
Garas	6	2.061	74	2.825
Madaxbuq	17	5.841	62	2.367
Dheen	7	2.405	83	3.169
Kidi	5	1.718	47	1.794
Total	291		2619	

As mentioned in the table 5, in Garbo district a total of 16 different wild edible fruit species were recorded and the most top three dominate species were *defaruur*, *hohob* and *ciid*. But the rarest species *kidi.*

Table 6. Frequency, relative frequency, abundancy and relative abundance of tree/shrub species at Garbo district

Local name of species in (Somali)	**F**	**r-f**	**Abundance**	**r-abundance**
Hohob	30	6.818	415	9.290
Ciid	30	6.818	1434	32.102
Gombesh	30	6.818	329	7.3651
Jacjacle	30	6.818	279	6.2458
Askax	28	6.363	144	3.2236
Uneexo	27	6.136	165	3.6937
Dhambac	26	5.909	183	4.0967
Dhafaruur	27	6.136	214	4.7906
Mindoy	26	5.909	182	4.0743
Midhacas	27	6.136	158	3.5370
Dhiin	25	5.681	149	3.3355
Dombir	24	5.454	131	2.9326
Madheed	25	5.681	142	3.1788
Ilcas	28	6.363	166	3.7161
Maygaag	29	6.590	183	4.0967
Himir	28	6.363	193	4.3205
Total	440	100	4467	100

As mentioned in the table 6, in Garbo district a total of 16 different wild edible fruit species were recorded and the most top three dominate species were *ciid, hohob* and *gombesh*. But the rarest species *dombir, madheedand* and *dhiin.*

Traditional/Indigenous uses of wild edible tree fruit species

Traditional use of wild edible tree fruits, ten tree fruit species was identified as most valuable by the respondents based on their food, medicinal and other values. The various uses of these species are summarized in table 7. The traditional methods of fruit collection are picking, shaking stems and throwing objects to dislodge the fruits or even destructive harvesting as branches were lopped to harvest fruit in a short time. Most of the wild edible tree fruits in districts were eaten fresh and raw. Wild edible tree fruits play a vital role in subsistence economy and livelihood of people in this small kebeles in the sites. A variety of these fruits with enormous economic potential can be seen grown in the districts. These fruits are used for food traditionally by native people as nutritional diet. Some fruit species are commercially important and also have medicinal value such as *grawiapenicilata* and *grewiatenax*. *Hydro abyssinica* and many others

were used for spices and pickle purpose along with medicinal and other uses. These species are free and accessible to the local communities. Some of these food plants are supplementary nutrition.

7. Indigenous uses of wild edible tree fruit species

Botanical Name	**Indigenous uses**
Zizphusmauritiana	Fruits edible, fodder, fuel wood, leaves are good ingredients for composts. It is highly valued for constriction, agricultural implements etc
Grawiapenicilata	Fruits are edible. Pulps of the fruits are sweet and juicy and can be stored for a longer time due to its high keeping quality. the fruits are used in treating constipation. Also used as house constriction and fodder
Grewiatenax	Fruit extracts used for curing constipation and steams used for poles.
Grewiavillosa	Fruits edible, leaves are good fodder. Seed is extracted from the fruit and used locally. It is believed to have medicinal properties and prevents constipation.
Hydro abyssinica	Root or bud edible, traditionally it is used for the tooth pain and treatment of ellagic, the paste of it provides delicious fruit
Dobera glabra	Fruits edible, leaves are good fodder. Seed is extracted from the fruits and used as food after cooked.
Cordia sinensis	Fruits edible, fairly good nutritious fodder and fuel wood, the fruits and the leaves give a dark green dye
gardenia florii `	Fruits are edible, and highly valued as a source of traditional fruit.

Role of Wild edible fruits Enhancing rural livelihood

According FG discussants, fruit trees make a variety of contributions to households' livelihood. Direct consumption of the fruit has nutritional benefits while fruit sale is an important source of income particularly for women, children and old men. The wild fruit trees provide a range of environmental benefits and contribute to development of permanent wild fruits.

In this study, Respondents have exposed that wild edible fruit products enhance resilience to drought through different mechanism. Respondent also indicated that wild edible fruit could play a great role in enhancing drought impact by enhancing income, serving as a source of food,

micro-climate amelioration as well as environmental protection both from wind or rain by conserving soil and water.

Marketing of Fruit Products

Marketing of wild fruit products is studied by considering the situation in the district. As per the findings of the field visit, marketing of various fruit products such as *Zizphusmauritiana, grawiapenicilata, grewiatenaxand grewiavillosa* was carried out. According to FG discussants signposted to their confab that traditional marketing system is used via users of wild fruit to sell fruit product. In districts as the FGDs asserted, the local collectors usually interact with farmers on one-to-one basis, either buying from them at the field or at roadsides near villages markets where many fruit user are located. Local collectors, Provincial wholesale markets and street market provide the most convenient way that users sell their produce. user respondents in the district generally use to distribute their main fruit crops to collectors 60%, and local markets 40%, These buyers usually supply fruit to larger smuggling market systems, and trade to Somalia and Somali land towns. This study is consistent with previous study of Bhawat (2017) that fruit farmers in Chanthaburi used traditional markets to sell the fruit products.

As the FGDs revealed, even though the price is changed in the fruit products through season but the price sold to fruit for the last year is shown in the below.

Table 8. Last year price of the fruits in the districts

No	**Fruits**	**units/kg**	**Price/birr**
1	*Hohob*	1kg	200
2	*Gob*	1kg	100
3	*Gombesh*	1kg	60
4	*Ciid*	1kg	70

Focus groups discussants as well as the key informants stated that the price of the fruit products for the last five years have skyrocketed. Because of the grave famine and starvation which has

occurred in the region. The user respondents asserted in to their words that the price rise for the last year helped them to come over the drought and climate shocks. Since the asset or the income generated enabled the households to withstand drought consequences. According the KIs, wild fruits also play a great role on providing products and services. Those in the area provide food, fodder and shade for both animals and households.

Major challenges affecting wild edible fruit species

- ✓ Culturally poor market access,
- ✓ Poor skill and collection of fruit products: - local collectors lack a good skill and knowledge to utilize the resource
- ✓ Lower price for fruit products: - less quality of the product leads less income
- ✓ Inaccessibility of production area: - challenges are faced while collecting the product harshness of the area.
- ✓ Poor knowledge on production process, storage and quality of fruit product
- ✓ Limited financial service
- ✓ Absence of support from gos and NGOs

CONCLUSION AND RECOMMENDATION

Wild edible fruit species have an appreciable role in supplementary food provision, income generation and diversification, nutritional security in different parts of Ethiopia. Moreover, the species are multipurpose, thereby important for fodder, fuel-wood, and timber production among others. However, the species are underutilized and threatened by growing harvesting pressures in natural ecosystems. Many edible fruit-bearing wild species are in the early stage of domestication by farmers with low production. Most indigenous fruit species have not been brought up to their full potential in terms of quality, the scale of production, and the market.is indicates a pressing need for domestication and improvement of some wild edible fruits for increased production, diversifying income for small-scale farmers, sustainable utilization, and conservation of the species. number of promising wild edible fruit species for domestication and wider cultivation is considerable in the region. A review identified widely utilized and priority wild edible fruit species based on their wider utilization, preference by the farmers/ user

community, product marketability, and conservation needs for the species. widely utilized and marketed priority wild edible fruit species for domestication and improvement include Zizphusmauritiana, grawiapenicilata, grewiatenaxand grewiavillosa.

Based on the study conducted and major findings, the following recommendations has been forwarded.

- ✓ And nutritional analysis of the fruit products is very mandatory
- ✓ Participatory forest management needs to be established at community level
- ✓ Product diversification is very important which are key to ensuring supply chain resilience and efficiency
- ✓ Local harvesters can strengthen though capacity building in terms of harvesting skills and market price determination
- ✓ It is necessary to strengthen promotion work through agricultural experts and DA's of the district, to raise rural households' level of awareness about collection and us of wild edible fruits.
- ✓ Resource mapping and regeneration status of wild edible fruit species needs to be studded.
- ✓ Further works/research is important on management, sustainable harvest and their domestication and propagation methods.

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Introduction of Grow boxx (Groasis Waterboxx) Technology in Conservation of Yicib Plant Species (*Cordeauxia edulis*)

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ABSTRACT

Cordeauxia edulis, commonly known as Yeheb or Yicib, is an endemic tree species in Ethiopia and Somalia. It is a valuable source of food for both humans and animals and possesses drought tolerance and desertification-resistant traits. However, the population of Cordeauxia edulis is rapidly declining due to factors such as overgrazing, habitat fragmentation, overexploitation, and low regeneration rates. To address this issue, the study aimed to conserve and propagate Cordeauxia edulis by introducing a growboxx system. The specific objectives of the study were to determine the optimal growth conditions for Cordeauxia edulis in the growboxx system and assess the survival rate of seedlings propagated using the growboxx compared to other method of direct transplanting. The research was conducted in Bokh, a district in the Somali Regional State of Ethiopia, where Cordeauxia edulis is currently found. The experiment followed a randomized complete block design with three replications. A total of 180 Cordeauxia edulis tree plants were used with a spacing of 2 meters between blocks and 1 meter between plots. The growboxx system, a newly invented technology for dryland areas with erratic rainfall, was utilized to raise the seedlings of Cordeauxia edulis. Data were collected on growth parameters such as plant height, number of leaves and branches, and survival rates within the growboxx system at regular intervals. The collected data were analyzed using analysis of variance (ANOVA) and descriptive statistics, the results indicated that using a growboxx had a significant positive effect on the growth of Cordeauxia edulis. The treatment group with the growboxx showed higher values for all measured parameters, except for average leaf width. This suggests that the use of a growboxx promotes plant growth in terms of height, number of leaves, number of branches, and leaf length. The adoption of the growboxx system in the conservation and propagation of Cordeauxia edulis is recommended based on the positive outcomes observed in this study. The growboxx system provides precise control over the growing environment, protects plants from predators, and allows for cultivation in arid regions with limited water availability. By adopting this system, better growth and survival rates of Cordeauxia edulis seedlings can be achieved, contributing to the conservation efforts of this valuable tree species.

Keywords: *Cordeauxia edulis,* Yicib, Growboxx, endemic species, optimal growth conditions, survival rate.

Introduction

Cordeauxia edulis, commonly called *Yeheb* or *Yicib* (in Somali), is a small tree or shrub species endemic to Ethiopia and Somalia. It is hardy to drought and a source of food to both animals and humans. *Cordeauxia edulis* Hemsl is a multi-branched evergreen shrub that belongs to the family

*Fabaceae or Leguminoseae (*Ali, 1988*).* It is highly branched bush with thick and vertical branches, with an average height of 2-3 meters but it can grow up to 4m high in sheltered spots. It has a taproot system up to 3 m deep with small secondary rhizomes near the surface and nodules on younger roots. *C. edulis* is a drought resistant and desertification tolerant plant. For optimal plant development, average temperature and rainfall requirements are 25°C – 28°C and 85-400 mm/year, respectively. It grows on red, alkaline, low nitrogen content, fine to coarse sand or grit to loamy textured, sandy soil (Convention on Biological Diversity (CBD), 2009). *C. edulis* prefers elevated stands, where no water accumulates.

It is a multi-purpose plant where most parts of the plant are used. It is an evergreen shrub and produces seeds called Yeheb nut (Katz, 2008). The seeds are edible and eaten fresh, roasted, boiled or dried (Teketay and Eshete, 2004). The nut is the staple food for the local people which is the same as food of rice and dates (Kazmi, 1979). Additionally, since it is nutritious, the local people in the border line between Somalia and Ethiopia often prefer it as a stable food like maize and sorghum. The harvested nut is sold on the market and even exported to the coastal cities of Somalia as source of income to the local people (Miège and Miège, 1978; Bally, 1966; Mussa, 2010; Brink, 2006).

The yeheb plant species are about to be eradicated almost to where it used to dominate in Dollo region and currently on going to be terminated through overgrazing, clearing yeheb trees for construction and firewood, erosion and drought were the reasons for the dying of *C. edulis*. On the contrary, the size of the wild population of *C. edulis* in its natural habitat is reported to decline rapidly, owing to habitat fragmentation, overexploitation, and a low rate of regeneration. Moreover, it's emphasized that its distribution area is speedily narrowing because of the increase of the population and their herds the plant is very much exploited, men harvest almost all the seeds for their own consumption and for sale.

Unfortunately, *Cordeauxia edulis* faces numerous challenges that threaten its existence. Overgrazing, clearing of Yeheb trees for construction and firewood, erosion, and drought have contributed to the decline of this species. The wild population of *Cordeauxia edulis* in its natural habitat is dwindling rapidly due to habitat fragmentation, overexploitation, and a low rate of regeneration. It is classified as rare and at risk of extinction according to the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Plants.

To mitigate the imminent loss of *Cordeauxia edulis*, urgent conservation efforts are required. This study aims to contribute to the conservation and propagation of the Yeheb plant species by introducing the use of a growboxx system. The growboxx provides an innovative approach to seedling production and offers the potential to enhance the survival rate and growth performance of *Cordeauxia edulis* seedlings. The study aims to compare the survival rate and growth performance of Yeheb seedlings planted with the growboxx and the traditional direct transplanting method. The study also aims to determine the optimal growth conditions for Yeheb seedlings. The results of this study will provide useful information for the conservation and sustainable management of *Cordeauxia edulis*.

MATERIALS AND METHODS

Description of study area

The study area was Bokh district, located in Dollo zone of the Somali Regional State in Ethiopia (figure 1). This district is the only remaining habitat of yeheb, a drought-resistant shrub that is native to Ethiopia. The majority of the people in Bokh are pastoralists who rely on livestock for their livelihood. The climate of the area is arid, with an annual rainfall of 150–250 mm that occurs in two unreliable rainy seasons. The area also experiences two long dry seasons that last for at least 5 months each.

The south-west monsoon brings the main rains in March/April to May/June; while the north-east monsoon brings rain in October–November. The area is frost free with a mean annual temperature of 28 °C. The altitude ranges from 300–1,000m above sea level. The mean monthly wind speed is 2–3 km h^{-1} except during the south-west monsoon, when it is 4–5 km h^{-1}. Mean annual potential evapotranspiration is 1,700–2,600 mm (Drechsel & Zech, 1988; Yusuf, 2010).

Its geographical feature is arid plateau with thick browsing vegetation and localized grazing areas. It is known for its dominance of the yeheb plant that favors the type of soil which is mostly red and sandy rich in ferrous oxide and absorbs water quickly.

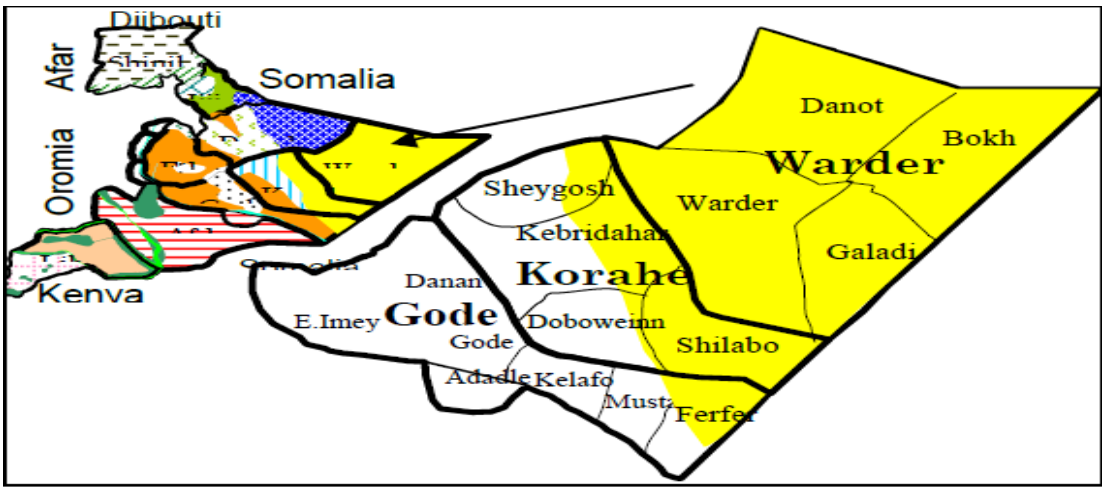


Figure1: Map of the study area

Experimental Design and Treatments

The study compared two methods of planting *Cordeauxia edulis* seedlings: growboxx and direct transplanting. Growboxx is a square box made of recycled paper pulp, with a hole in the center for planting a tree seedling, while direct transplanting is the traditional way of digging a hole and planting the seedling in the soil. The study used a randomized complete block design with three replications and two treatments. Each block had two plots, one for each treatment, with a distance of 2m between them. Each plot contained 30 seedlings, with a spacing of 1m within the plot. The total number of seedlings was 180. The seedlings were obtained from a nursery and planted in the field on October 12, 2022 and monitored for 9 months.

Data Collection

The following measurements were taken in the field to assess the growth performance of the yeheb trees:

- **Survival rate**: This was calculated as the percentage of the seedlings that survived in each plot at 3rd, 6th, and 9th months after planting, based on the initial number of seedlings planted in each plot.
- **Plant height**: This was measured as the vertical distance from the base of the stem to the tip of the highest leaf, using a ruler or a measuring tape in centimeters (cm).
- **Number of branches per plant**: This was counted as the number of lateral shoots that emerged from the main stem of the plant.

- **Leaf number per plant**: This was counted as the number of leaves that were present on the plant, including those on the main stem and the branches.
- **Leaf length**: This was measured as the length of the longest dimension of the leaf blade, excluding the petiole, using a ruler in centimeters (cm).
- **Leaf width**: This was measured as the width of the widest dimension of the leaf blade, perpendicular to the leaf length, using a ruler in centimeters (cm)

2.4. Data Analysis

The data analysis was performed using SPSS statistical software version 20. The General Linear Model (GLM) procedure was applied to conduct analysis of variance (ANOVA) on the collected data. Descriptive statistics, such as mean, percentage, and standard deviation, were calculated and reported for each variable. One-way ANOVA was used to study the significant difference among the samples with respect to the study parameters. Least significant difference (LSD) at $P < 0.05$ was used to determine whether means are significantly different.

RESULTS AND DISCUSSION

Yeheb Growth Performance Analysis

Survival Rate

The table below (Table 1) shows the survival rate of yeheb trees planted with growboxx and direct transplanting at 3, 6, and 9 months after planting. The survival rate is the percentage of the seedlings that survived in each plot, based on the initial number of seedlings planted in each plot. The table indicates that the survival rate of yeheb trees planted with growboxx was higher than that of yeheb trees planted with direct transplanting at all time intervals. This suggests that growboxx may have a positive effect on the survival of yeheb trees in arid and semi-arid regions.

The survival rate of yeheb trees planted with growboxx decreased slightly from 94% at 3 months to 88% at 9 months, while the survival rate of yeheb trees planted with direct transplanting decreased more sharply from 82% at 3 months to 76% at 9 months. This indicates that growboxx may help to maintain the survival of yeheb trees over time, while direct transplanting may expose the seedlings to more environmental stress and mortality.

The difference in survival rate between the two methods of planting increased from 12% at 3 months to 16% at 9 months. This implies that growboxx may have a more pronounced effect on the survival of yeheb trees as time goes by, compared to direct transplanting

Table1 Survival rate of yeheb trees planted with growboxx and direct transplanting

Time Interval	Method of Transplanting	N	Survival rate		
			Survived	Not survived	Percentage
3 Months	Control(without growboxx)	90	74	16	82%
	Treatment(with growboxx)	90	85	5	94%
6 Months	Control(without growboxx)	90	70	20	78%
	Treatment(with growboxx)	90	81	9	90%
9 Months	Control(without growboxx)	90	68	22	76%
	Treatment(with growboxx)	90	79	11	88%

However, it is important to note that the overall survival rate for both groups during the year-long trial period was 86%, indicating that some plants did not survive regardless of whether they received the growboxx treatment.

It is important to consider other factors that may have influenced the survival rate, such as environmental conditions, soil quality, and pest and disease pressure, among others, to obtain a more comprehensive understanding of the impact of the growboxx treatment on the survival of the plant species. Additionally, further research may be necessary to determine the long-term effects of the growboxx treatment on the survival and growth of the plant species

Controlled environments, such as growboxes or greenhouses have been widely recognized for their positive impact on plant growth. They allow for precise regulation of environmental factors, such as temperature, humidity, light, and carbon dioxide levels, which can optimize plant growth and development (Li et al., 2020; Körner, 2019).

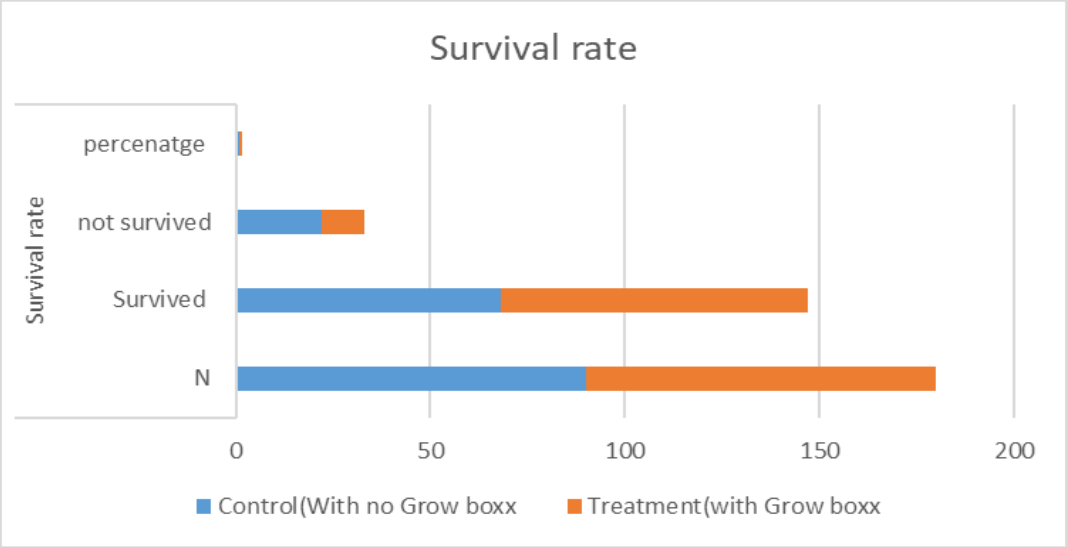


Fig 2. Survival rate of yeheb with and without growboxx

Plant Height

Height is an important metric to evaluate the growth performance of plant species. It is an indicator of the plant's ability to photosynthesize and produce biomass. The height of a plant is a critical parameter that reflects its overall health and productivity. It is often used as a proxy for biomass production and can be an indicator of the plant's ability to withstand environmental stresses.

The table below (Table 2) presents the height data of a plant species under two different conditions, with and without the growboxx treatment.

In the context of the analysis presented in the table (table 2), the height data of the plant species under two different conditions were compared - with and without the Growboxx treatment.

The control group, which did not receive the Growboxx treatment, had a mean height of 8.264 cm, which was lower than the mean height of the treatment group (10.563 cm) that received the Growboxx treatment. This difference in mean height was statistically significant, as evidenced by the standard deviations of the two groups, which were 2.366 cm and 2.665 cm, respectively.

The minimum and maximum heights of the treatment group were also higher than those of the control group, indicating that the Growboxx treatment had a positive effect on the growth performance of the plant species. The wider range of heights in the treatment group suggests that the treatment may have induced more variability in the growth response of the plant species.

Growboxx structures provide protection against external stressors, including harsh weather conditions, pests, diseases, and herbivores. This protection can enhance plant survival rates and overall growth performance (Gómez et al., 2019; Massa et al., 2019).

Table 2 Height (cm) of yeheb trees planted with and without growboxx

	Plant Height (cm)			
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Control(without growboxx)	3	13	8.264	2.366
Treatment(with growboxx)	5	17	10.563	2.665

Number of Leaves per Plant

Leaves number is another important metric that can be used to assess the growth performance of a plant species. It is an imperative parameter that can provide valuable insights into the growth performance of a plant species. Leaves are the primary sites of photosynthesis in plants, and thus, the number of leaves can be a good indicator of a plant's ability to produce biomass and fix carbon dioxide.

The treatment group, which received the Growboxx treatment, had a higher mean number of leaves (31.6) than the control group which did not receive growboxx treatment (25.71).

The minimum and a maximum number of leaves in the treatment group were 12 and 60, respectively, while in the control group they were 8 and 43, respectively. The standard deviation of the number of leaves was 10.364 in the treatment group and 7.409 in the control group.

These results suggest that the growboxx treatment had a positive effect on the growth performance of the plant species, as evidenced by the higher mean number of leaves in the treatment group compared to the control group. However, there was also more variability in the average number of leaves in the treatment group, as indicated by the higher standard deviation.

Table 3: Number of leaves per plant of yeheb trees planted with and without growboxx

	Number of Leaves per plant			
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Control(without growboxx	8	43	25.71	7.409
Treatment(with growboxx)	12	60	31.6	10.364

Number of Branches per Plant

The number of branches is an important parameter that reflects the growth pattern of a plant species. Branches are the primary sites of lateral growth in plants, and the number of branches can be an indicator of the plant's ability to produce biomass and allocate resources efficiently, therefore, the analysis of the number of branches is presented in the table below

The table below (Table 4) indicates that the Growboxx treatment had a positive effect on the growth performance of the plant species. The treatment group had a higher mean number of branches (7.65) compared to the control group (4.6), indicating that the treatment enhanced the branching ability of the plants. The minimum and maximum number of branches in the treatment group (3 and 12, respectively) were also higher than those in the control group (2 and 8, respectively), further supporting the positive effect of the treatment on lateral growth.

However, the higher standard deviation in the treatment group (1.906) compared to the control group (1.488) suggests that the Growboxx treatment induced greater variability in the number of branches among the plant species.

Table 4 Number of branches per plant for yeheb trees planted with and without growboxx

	Number of Branches per plant			
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Control(without growboxx)	2	8	4.6	1.488
Treatment(with growboxx)	3	12	7.65	1.906

Leaf Length

The analysis of the leaf length data is presented in the table below (Table 5). Leaf length is an important parameter that can provide valuable insights into the growth performance of a plant species. Leaf length is one of the key morphological traits of leaves, and it can be used as an

indicator of the plant's ability to produce biomass and allocate resources efficiently. The results suggest that the Growboxx treatment had a positive effect on the growth performance of the plant species. The treatment group had a higher mean leaf length (1.421cm) compared to the control group (1.2 cm), indicating that the treatment led to an increase in leaf size. The minimum and maximum leaf lengths in the treatment group (0.6 cm and 2.5 cm, respectively) were also higher than those in the control group (0.1 cm and 2 cm, respectively), further supporting the positive effect of the treatment on leaf size.

However, the difference in mean leaf length between the two groups was relatively small, and the standard deviation of the leaf length data was similar in both groups, indicating that there was not a significant difference in the variability of leaf length between the two groups.

Overall, the analysis of leaf length in the plant species under the two conditions suggests that the Growboxx treatment had a positive effect on leaf size.

Table 5: Leaf Length for yeheb trees planted with and without growboxx

	Leaf Length (cm)			
	Minimum	Maximum	Mean	Std. Deviation
Control(without growboxx)	0.1	2	1.2	0.4171
Treatment(with growboxx)	0.6	2.5	1.421	0.432

Leaf width

The table below (Table 6) shows the leaf width data for the plant species under the two conditions. The control group, which did not receive the Growboxx treatment, had a mean leaf width of 0.834 cm, with a minimum and a maximum leaf width of 0.5 and 2 cm, respectively. The standard deviation of the leaf width data was 0.3141 cm. The treatment group, which received the Growboxx treatment, had a higher mean leaf width of 0.919 cm, with a minimum leaf width of 0.5 cm and a maximum leaf width of 2 cm. The standard deviation of the leaf width data was 0.357 cm. The analysis of the leaf width data suggests that the Growboxx treatment had a positive effect on the growth performance of the plant species, as evidenced by the higher mean leaf width in the treatment group compared to the control group. However, the difference in mean leaf width between the two groups was relatively small, and the standard deviation of

the leaf width data was similar in both groups, indicating that there was not a significant difference in the variability of leaf width between the two groups.

Table 6 Leaf width of yeheb trees planted with and without growboxx

	leaf width (cm)			
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Control(without growboxx)	0.5	2	0.834	0.3141
Treatment(with growboxx)	0.5	2	0.919	0.357

Based on the table below (Table 7), it appears that using a growboxx had a significant effect on the growth of the plants. The treatment group, which received a growboxx, had significantly higher values for all the measured parameters except for average leaf width. This suggests that the growboxx helped to promote plant growth in terms of height, number of leaves, number of branches, and leaf length.

Table 7 Means Comparisons between treatment and control at 0.05 significant levels (Mean ± SE).

Experiment	**PH (cm)**	**NLPP**	**NBPP**	**LL(cm)**	**LW (cm)**
Control(without Growboxx	8.264 ± 0.408^{a}	25.71 ± 1.020^{b}	4.6 ± 0.204^{b}	1.2 ± 0.087^{b}	0.834 ± 0.065^{a}
Treatment(With Growboxx	10.563 ± 0.300^{b}	31.6 ± 1.168^{a}	7.65 ± 0.214^{a}	1.421 ± 0.049^{a}	$0.919 \quad 0.040^{a}$

Means with the same letter in a column are not significantly different at $P \leq 0.05$. PH= plant height; NLPP = number of leaves per plant; NBPP = number of branches per plant; LL = leaf length; LW (cm) = leaf width.

CONCLUSION AND RECOMMENDATIONS

Based on the results of the experiment, it can be concluded that using a growboxx had a significant effect on the growth of yeheb plant species. The treatment group, which received a growboxx, showed significantly higher values for all the measured parameters except for average

leaf width. This suggests that the use of a growboxx can promote plant growth in terms of height, number of leaves, number of branches, and length of the leaves.

The use of a growboxx can have several benefits in the plantation of yeheb plant species and other plants. Firstly, it allows for precise control over the growing environment, which can help to promote plant growth and improve growth performances. By controlling factors such as temperature, humidity, and protect from the wind, a growboxx can create the optimal conditions for plant growth, regardless of the external environment. Secondly, growboxx can help to protect plants from predators such as squirrel, as they provide a physical barrier between the plants and the outside environment. Finally, growboxx can be used to grow plants in areas with limited water availability and dry environments.

Based on the significant positive effects observed in the treatment group, it is recommended to:

- Adopt the use of growboxx in the plantation and conservation of yeheb plants because Growboxx provide a controlled environment that promotes plant growth and protects against external stressors, ultimately enhancing the survival and development of yeheb plants.
- Extension services should disseminate Growboxx technology to smallholder farmers to improve plantation of the valuable plant trees
- Further research should be done across diverse soil types and agro climatic zones to evaluate optimal conditions where Growboxx performs the best.
- Engage local communities, conservation organizations, and relevant stakeholders in the implementation and promotion of growboxx usage for yeheb plant conservation. Foster partnerships to ensure knowledge sharing, community involvement, and long-term sustainability of yeheb plant conservation efforts

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Preliminary Survey and Documentation of Wildlife (Mammals) Resource-Base and Constraints in Somali Region, Ethiopia

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ABSTRACT:

*The study was carried out with objective to assess the diversity and abundance of mammal species, identifying threats and constraints faced, documenting distribution and habitat preferences. The methodology involves selecting purposefully three Agro-ecological zones (namely; Tepid to cool moist plain, Hot arid lowland, and Warm moist lowland land) which comprise 83.95% (31,474,039.9 ha.) of area coverage of Somali region. In each Agro-ecological Zone three Woredas were selected purposively, and in each Woredas, three patches of habitats based on the vegetation structures and topography of the landscapes (i.e., 3 AEZs * 3 Woredas * 3 Habitats) were selected. The study adopts descriptive research design for its helpful to obtain relevant information from concerned respondents. The research also discusses the results, as expressed in the cumulative result of the three AEZs, KIIs and FGDs which shows that there is a decreasing trend of wild animals. Some antelopes like Lesser kudu, Oryx and carnivores like lions have gone under decreasing trend owing to settlements and related natural resource degradations along with recurrent droughts and illegal hunting. Based on the research findings we recommend protected area expansion and management, habitat restoration, wildlife monitoring, and human-wildlife conflict mitigation through the establish of community-based conservation areas and promote sustainable land-use practices. Since, one of the main emphases is on the involvement of local communities in conservation efforts and the integration of their traditional knowledge and practices. The research also underlines the need for further research and monitoring of mammal populations, capacity building, education, and the development of policy and legal frameworks to support wildlife conservation.*

Key words: *Species diversity, habitat, Conservation, Poaching, Illegal, Wildlife.*

Introduction:

According to Ethiopian Wildlife Conservation Authority, it is recorded 240 species of mammals and 845 species of birds, of which 22 species mammals and 24 species of birds are endemic, six reptiles and 33 amphibians are also known to be restricted in Ethiopia (MoAWLCA, 1997). In the Somali region the wildlife habitat is due to unnecessary killing, deforestation, expansion of settlement and agricultural practices. The term wildlife applies correctly to both plants and animals in East Africa however it has come to imply particularly the wild fauna (Rashid, 1996). In the Somali Region there are a number of mammals, birds, reptiles, amphibians, fishes and

invertebrates uniquely adapted to the arid and semi-arid conditions. The most ferocious wild animals are Lion, Hyena, Leopard, Fox, Hunting dog, crocodile, various types of Snacks and Cobra while usually hunted wild animals are ORIX gazellabeisa (Biciid), Tragelaphus Scriptus (Balanqo), Tragelaphus imberis (Goodir), Tragelaphus stresiceros (Qombor), Gazella species (Cowl-daba-cad), Ammordracas clarkei (Dabataag) and litocranius walleri (Garanuug), Other predominant wild animals are Zebra, Hare, Giraffe, Baboon, Hippopotamus, Ostrich, Monkey and Elephant (Ahmed, 1999). There are also a number of birds known only in the Somali Region which are restricted to the Somali–Masai biome, particularly along the four rivers of the region which are Wabi Shabelle, Ganaale, Weeyb and Daawo rivers, the last three rivers join at Doolow and make Jubbba river. Only two sites between Boqolmaanyo–Doolow and Lower Wabi-Shabelle to Wardheer are found to host 47 species relatively uncommon elsewhere in Ethiopia. The following bird species are restricted to survive in the Somali–Masai biome and are little known to the rest of Ethiopia. These includes little Brown Bustard, White-winged Dove, Short-billed Crombec, Somali Bee-eater, Short-tailed Lark, Chestnut–headed Sparrow Lark, Hauglin's Bustard, Somali weatears, Hunter's Sunbird, Smaller Back Billied Sunbird Golden palm weaver, Somali Sparrow, parrot-billed Sparrow, Magpie Starling, Masked Lark, Collared Lark, Golden pipit, Monogolian plover, Violet-tipped Courser, Scaly Babbler, Jubbaland weaver and water thick–knee (Ahmed, 1999).

The Somali Region in Ethiopia is a unique and diverse ecosystem that is home to a wide range of wildlife species, particularly mammals. However, there is limited scientific research and documentation on the wildlife resource-base as well as constraints faced by these species in this region. This research project therefore aimed to conduct a preliminary survey and documentation of the wildlife resource-base and constraints in order to inform future conservation efforts and management strategies.

Thus, this piece of writings proposes a comprehensive research plan to document and survey mammal species in the Somali Region for it aims to address the lack of extensive scientific studies on the wildlife resources and constraints faced by these species. The research's objectives include assessing the diversity and abundance of mammal species, identifying threats and constraints faced, documenting distribution and habitat preferences, and providing recommendations for conservation strategies.

METHODS AND MATERIALS

Description of Study Area

Somali region locates (between 7°26′19″N and 44°17′49″E) is found in the South-east of Ethiopia. Two areas (Garaale and Babile) were designated by as a protected area. A climatic data for the study areas of ten consecutive years was obtained (ENMA, 2022). The study areas rainfall distribution, a long rainy season from June to September and a dry season from November to February in the semi-arid areas and short rainy (Deyr) season from October to December and long rainy season (Gu') from April to June in Dry arid Ogaden areas. The average mean monthly maximum temperature is above 27°C, and the average mean monthly minimum temperature is 15°C. The average mean monthly rainfall of the areas varies between <500mm (December) and 1,200mm (July).

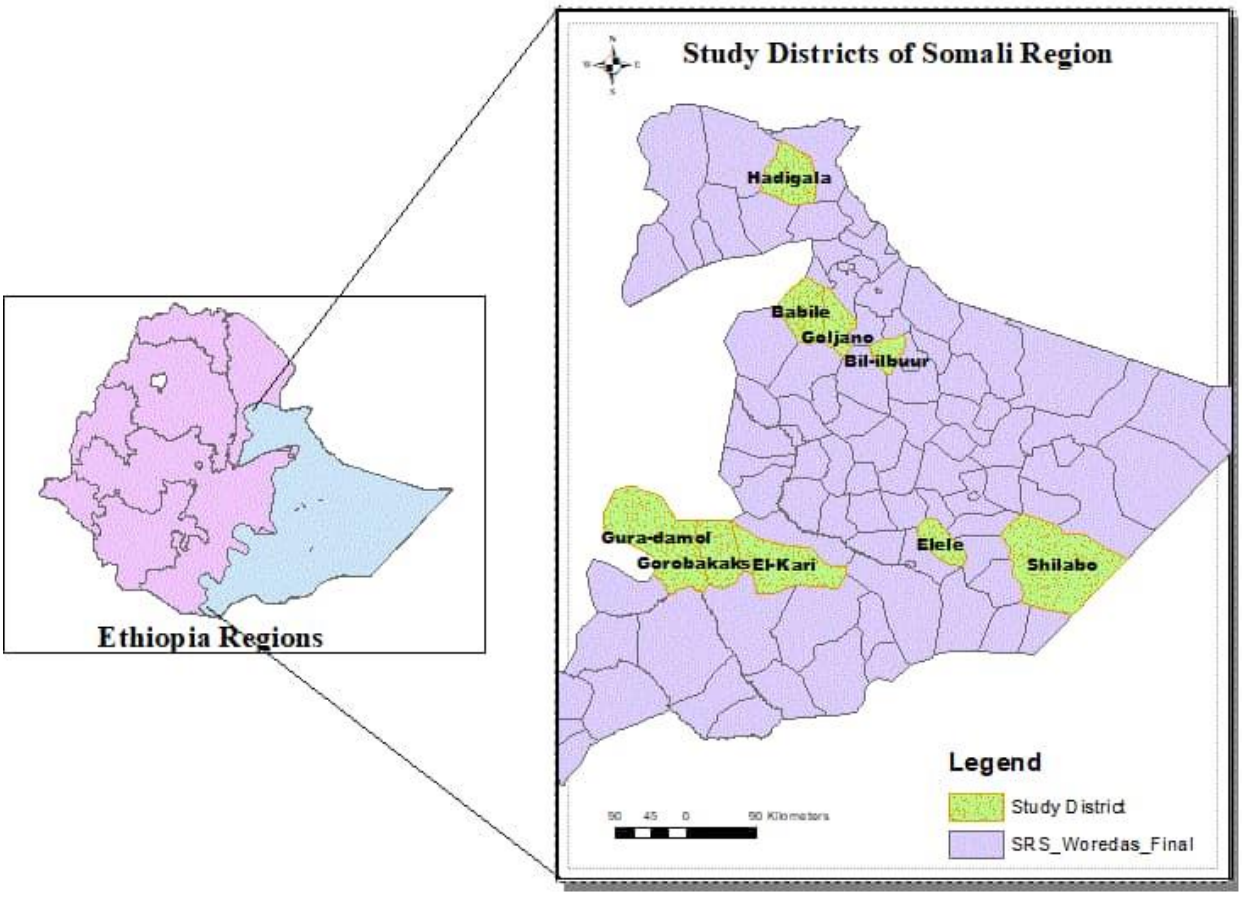


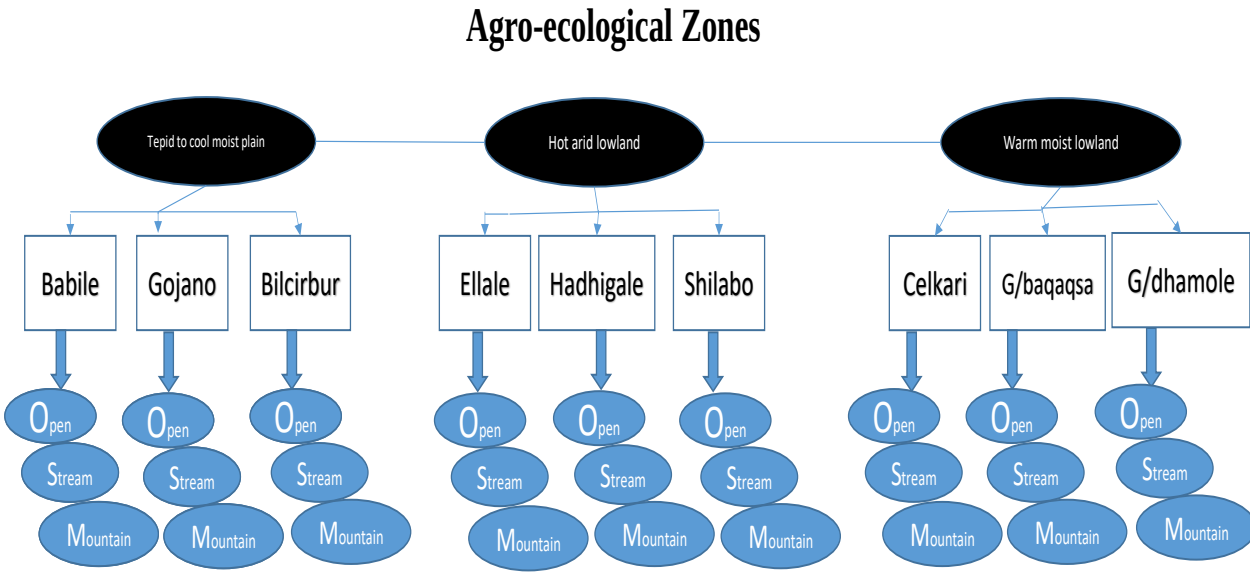
Figure 3. Map of intervention districts (Sampling locations in SRS)

Study Design

This study adopts descriptive research design. This was selected with the assumption that were helpful to obtain relevant information from concerned respondents on the, assessing the resource base information and attitudes of local communities towards wildlife importance, conservation and managements of pastoralist in selected Woredas of *Somali* regional state and to gain detailed data from large number of respondents to draw the necessary conclusion.

Sampling procedure and sample size

In this study *three* Agro-ecological zones (namely; *Tepid to cool moist plain*, *Hot arid lowland*, and *Warm moist lowlandland*) were selected purposively, which comprise 83.95% (31,474,039.9 ha.) of area coverage of Somali region. Each Agro-ecological Zones *three* Woredas were selected purposively, and each Woredas, three patches of habitats based on the vegetation structures and topography of the landscapes were purposively selected (i.e., 3 AEZs * 3 Woredas * 3 Habitats).



This study was based on the smallest administrative units, sub-villages, as sampling units in the hierarchy of the general administrative structure of the FDRE. Based on geographical positions (nearness) two different sites were selected as a target study area.

Altogether, 90 respondents were selected for key informant interviews from each target sub-village. Both qualitative and quantitative methods were employed to dig out historic and current

information on wildlife, and human-wildlife interactions and communities' attitudes towards wildlife. Close ended and open ended questions were used to find out current subjective population status of specific species, general wildlife population trends, and population trends based on carnivore and herbivore broad categories.

A total of eighteen focus group discussions were held in the study areas (both sites in each district), one FGD in each sub-villages consisting of 8-16 members each. FGDs consisted of youths and elders mostly males, with the exception of some with few numbers of female participants to get agreed upon truths about current and past social, ecological and economic facts were conducted.

Data Collection Method

Apart the above a survey was conducted in 27 habitats from nine sampled woredas for eighteen consecutive days excluding travel and other business days covering a total distance of 600kms in field survey i.e. 22.2km for each selected habitat, when the activities of mammals are more active: early morning from 6:00 to 10:00 and from 16:00 to 19:00 (Legese et al., 2019). During data collection, the observers was walking on foot along the road counts established and directly count all the individuals sighted with their respective species using unaided eyes and binocular. The presence of mammalian species was also detected based on sign marks, including footprints, faecal droppings, vocalizations and scent marks. Each sampling block was surveyed for six days during each of the three sampling phases mentioned in below table.

Table 1: Area coverage of the study

AEZs and Districts: 9	*Tepid to cool moist plains*			*Hot arid lowland*			*Warm moist lowland*		
	Babile	Goljano	Bilcirbur	Ellale	Hadhagale	Shilabo	Celkari	Gorbaqaqsa	Guradamole
KM: 600	66.6	66.6	66.6	66.6	66.6	66.6	66.6	66.6	66.6
Days:18	2	2	2	2	2	2	2	2	2

Primary and secondary sources were used to collect both qualitative and quantitative data. To obtain information on wildlife condition in selected districts, primary data were collected through observation, key informant interviews and focus-group discussions. On the other hand,

the respondents were observed about their habits, culture and how they share the information very keenly using non participatory method and proportionate respondents were also used for focus group-discussions, mainly at evening time. Secondary data were collected from different sources like the regional BoFED, Statistical Authority, BoA, EWCA, MoEP, Academic Institutions, NGOs, districts, zones and regional concerned offices and others which are considered relevant sources for this research project.

Data Analysis

The study was analyzed (a) communities' perceptions on poaching and (b) community involvement in anti-poaching activities as well as illegal trade trafficking on wildlife in general and the endangered species like cheetah in particular.

The analysis used a concept-driven coding approach to identify patterns and similarities between the various data obtained (Nowell et al., 2017). To improve consistency between researchers, a priori coding framework was created by the research team using the data collection instrument (Blair, 2015). Emergent codes obtained from the households were included in the framework as and when they emerge. Data collected from field observations such as species compositions, number, abundance, distributions and wildlife status were analyzed using descriptive statistics and species diversity index. Mammalian species diversity of the study area was computed using Shannon–Weaver Index of diversity: $H' = -\sum PilnPi$, where H′ is the Shannon index of diversity, Pi is the proportion of individuals of a species in a sample and ln = Natural logarithm (Shannon & Weaver, 1949). Simpson index of diversity is followed (1−D) using the formula: J = a/a+b+c, where 'a' is the observed common species in 'a and b' and 'b' = species present in 'a', but absent 'b': 'c' = species present in 'b', but absent in 'a'; S = the number of species in each habitat; ln = Natural logarithm was computed to determine the evenness and dominance among the mammalian species. Finally, relative abundance was used to compute for each species occurrence in the study areas.

Result and Discussions

Results

Agro ecology Based Wildlife Species Trend

Table 2a. Trend of Wildlife on the Basis of Types of Species

Districts	Trend of Wildlife Based on Focus Group Discussion				
	Target Sub-villages	Increasing	Decreasing	Locally Extincting	Extinct
Tepid to cool moist plains					
Babile	Kore	Caracal, Hyena, Jackal Qalami, Bakayle, Porcupine (Kashito)	Elephant, Lesser kudu, Mokey, Leopard, cheetah, Lion	Oryx, Giraffe	Rhinoceros, Wild dog, Ostrich
	Jida	Caracal, Hyena, Jackal Qalami, Bakayle, Porcupine (Kashito)	Elephant, Lesser kudu, Mokey, Leopard, cheetah, Lion	Oryx, Giraffe	Rhinoceros, Wild dog, Ostrich
Goljano	Sanmadhedhle	Lesser kudu, Geranuk, dik-dik, Hyena, Common chacal, Grivet monkey, Hamardias baboon, Wild cat, Rabit, Common Warthog	Lion, leopard,	Oryx, Giraffe	Rhinoceros, Wild dog, Ostrich
	Qodaxle	Lesser kudu, Geranuk, dik-dik, Hyena, Common chacal, Grivet monkey, Hamardias baboon, Wild cat, Rabit, Common Warthog	Lion, leopard	Elephant, Giraffe, Gazella	Rhinoceros, Wild dog, Ostrich
Bilcirbur	Mandoyaley	Dik-Dik, Hyena, Common chacal, Grivet monkey, Wild cat, Rabit, Common Warthog	Oryx, lion, leopard, Gazella	Elephant, Gazella,	Zebra, Rhinoceros, Wild dog, Ostrich
	Bohalaley	dik-dik, Hyena, Common chacal, Grivet monkey, Wild cat, Rabit, Common Warthog	lion, leopard, Oryx	Gazella,	Rhinoceros, Wild dog, Ostrich

Table 2b. Trend of Wildlife on the Basis of Types of Species

Districts	Trend of Wildlife Based on Focus Group Discussion				
	Target Sub-villages	Increasing	Decreasing	Locally Extincting	Extinct
Hot arid lowland					
Ellale	Dhure	Gazella, Common Warthog and Dig-Dig	Lion, Leopard	Oryx, lion, Lesserkudu,	Rhinoceros, Wild dog, Ostrich
	Bargun	Gazella, Common Warthog and Dig-Dig	Lion, Leopard	Oryx, lion, Lesserkudu,	Rhinoceros, Wild dog, Ostrich
Hadhagale	Biyo Garaca	Common Warthog, Common chacal	Gazella, Tortoise	Oryx, Somali wild ass (Equus africanus somaliensis	
	Gedweyn	Common Warthog, and common chacal	Gazella, Tortoiose	Oryx, Somali wild ass (Equus africanus somaliensis and buffalo	
Shilabo	Baliwarir		Ostrich, Oryx	Dero	Rhinoceros wild dog
	Qarsoni		Ostrich, Oryx	Dero	Rhinoceros, Wild dog

Table 2c. Trend of Wildlife on the Basis of Types of Species

Districts	Trend of Wildlife Based on Focus Group Discussion				
	Target Sub-villages	Increasing	Decreasing	Locally Extincting	Extinct
Warm moist Lowland					
Celkari		Hyena	All others decreased	-	Elephant, Rhinoceros, Wild dog, Ostrich
		Giraffe, Hyena, Leopard, Caracal, Lesser kudu, Gerenuk, Lion, Jackal	Oryx	Lion	Elephant, Rhinoceros, Wild dog,
Gorabaqaqsa	Xagermoqor	Leopard, Giraffe, Hyena	Oryx	Lion	Lion, Zebra
	Gedir	Caracal, Hyena, Jackal, Tortoise, Leopard, Gerenuk	Lesserkudu, Cheetah	Lion	Elephant, Rhinoceros, Wild dog, Ostrich
Guradhamole	Qundhi	Leopard ,Hyena, cheetah	Oryx, Lesser kudu	Lion	Elephant, Rhinoceros, Zebra
	Elgari	Leopard ,Hyena, Giraffe	Oryx, Girrafe	-	Elephant, Rhinoceros, Zebra

The FGD in the target sub-villages mentioned that some wild animals have gone on decreasing and some others increasing. There are also some which are on the process of local extinction. Among those decreased drastically Oryx and Lesser kudus are prominent ones from the antelopes. The FGDs also confirmed that wild animals like elephants with exception of Babili, Rhinoceros and zebras had already extincted from all study areas long years ago. Wild dogs are also locally extincted from most of the study areas (Table 2abc). It was revealed by the FGD participants that the reason for the extinction of those wild animals like elephants and rhinoceros was mainly due to killings for their ivory tusks and horns respectively. Besides the above reasons, however, environmental degradation exacerbated by human settlement induced conflict factors contributed the highest share for the degradation of the natural resource in general and the wildlife in particular during the last 10 years.

Wildlife Species, Number, Distribution and Status

Wildlife Species Composition

Wildlife species composition in different agro-ecological zones as depicted in the following tables.

The *Tepid to cool moist plateaus* areas of the study districts comprised 10 wildlife species. *Grivet monkey, Common warthog, Salt dik-dik, Hamardias baboon, Lesser kudu, Common jackal, Geranuk, Black backed jackal, Isabeline gazelle* and *Rabbit were* identified as common wildlife species among the three districts; and their relative abundance increased with the selected districts, from *Babile*, to *Bilcirbur* and then *Goljano*.

Table: 3. List of wildlife species with their relative abundance (road count) under Tepid to cool moist plains agro-ecological zone

No	Species	*Tepid to cool moist plains*								
		Babile			Goljano			Bilcirbur		
		O	S	M	O	S	M	O	S	M
1.	Ammodorcas clarkei	0	0	0	0	0	0	0	0	0
2.	Beyra	0	0	0	0	0	0	0	0	0
3.	Black backed jackal	0	2.7	2.7	0	0	0	0	0	0
4.	Common jackal	2.7	2.7	0	2.6	0	0	0	3.9	0
5.	Common warthog	0	0	0	0	3.9	2.6	19.7	7.8	0
6.	Geranuk	2.7	0	0	1.3	0	0	3.9	0	0
7.	Grivet monkey	67.6	0	0	42.1	19.7	0	39.2	0	0
8.	Guenther's dik-dik	0	0	0	0	0	0	0	0	0
9.	Hamardias baboon	0	0	0	0	0	13.2	0	0	0
10.	Isabeline gazelle	0	0	0	2.6	0	0	0	0	0
11.	Lesser kudu	8.1	0	2.7	0	3.9	1.3	0	0	2.0
12.	Olive baboon	0	0	0	0	0	0	0	0	0
13.	Rabbit	0	0	0	0	0	0	2.0	0	0
14.	Rock hyrax	0	0	0	0	0	0	0	0	0
15.	Salt dik-dik	0	0	10.8	0	0	6.6	0	17.6	3.9
16.	Somarring gazelle	0	0	0	0	0	0	0	0	0

O = open-plain land; S = streams/riverine; M = mountainous/hilly areas

Table: 4. List of wildlife species with their relative abundance (road count) under Hot arid lowland agro-ecological zone

No	Species	*Hot arid lowland*								
		Ellale			Hadhagale			Shilabo		
		O	S	M	O	S	M	O	S	M
1.	Ammodorcas clarkei	0	0	0	0	0	0	28.6	0	0
2.	Beyra	0	0	0	0	0	1.2	0	0	0
3.	Black backed jackal	0	0	0	0	1.2	0	0	0	7.1
4.	Common jackal	1.3	2.5	0	0	0	0	0	7.1	0
5.	Common warthog	15.2	2.5	3.8	1.2	8.4	0	28.6	14.3	0
6.	Geranuk	6.3	0	3.8	0	0	0	0	0	0
7.	Grivet monkey	0	0	0	0	0	0	0	0	0
8.	Guenther's dik-dik	0	0	0	0	0	0	0	0	7.1
9.	Hamardias baboon	0	0	0	0	0	0	0	0	0
10.	Isabeline gazelle	0	0	0	4.8	0	0	0	0	0
11.	Lesser kudu	0	0	0	0	0	1.2	0	0	0
12.	Olive baboon	0	0	0	0	0	0	0	0	0
13.	Rabbit	0	0	0	0	1.2	1.2	0	0	0
14.	Rock hyrax	0	0	0	0	0	0	0	0	0
15.	Salt dik-dik	11.4	0	6.3	0	0	2.4	0	0	0
16.	Somarring gazelle	30.4	16.5	0	14.5	63.9	0	0	0	0

O = open-plain land; S = streams/riverine; M = mountainous/hilly areas

The Hot to warm arid lowland areas of the study districts comprised 12 wildlife species Somarring gazelle, A. clarkei, Common warthog, Salt dik-dik, Black backed jackal, Common jackal, Guenther's dik-dik, Geranuk, Isabeline gazelle, Beyra, Lesser kudu and Rabbit were identified as common wildlife species among the three districts; and their relative abundance increased with the selected districts, from Hadhagale to Shilabo and then Ellale.

Table: 5. List of wildlife species with their relative abundance (road count) under warm moist lowland agro-ecological zone

No	Species	*Warm moist lowland*								
		Celkari			Gorbaqaqsa			Guradamole		
		O	S	M	O	S	M	O	S	M
1.	Ammodorcas clarkei	0	0	0	0	0	0	0	0	0
2.	Beyra	0	0	0	0	0	0	0	0	0
3.	Black backed jackal	0	0	0	0	0	0	0	5.0	0
4.	Common jackal	9.8	0	0	0	0	3.0	0	0	5
5.	Common warthog	23.8	9.5	0	0	12.1	0	0	30.0	0
6.	Geranuk	0	4.8	0	6.1	9.1	24.2	10.0	0	0
7.	Grivet monkey	0	0	0	0	0	0	0	0	0
8.	Guenther's dik-dik	19.0	0	0	0	0	0	0	0	0
9.	Hamardias baboon	0	0	0	0	0	0	0	0	0
10.	Isabeline gazelle	0	0	0	0	0	0	0	0	0
11.	Lesser kudu	0	0	4.8	0	0	3.0	0	0	0
12.	Olive baboon	0	0	0	0	0	0	0	0	0
13.	Rabbit	0	0	0	0	0	0	0	0	0
14.	Rock hyrax	0	0	0	6.1	12.1	0	0	0	0
15.	Salt dik-dik	0	9.5	9.5	6.1	18.2	0	40.0	0	10.0
16.	Somarring gazelle	0	9.5	0	0	0	0	0	0	0

O = open-plain land; S = streams/riverine; M = mountainous/hilly areas

The *Hot to warm moist midland* areas of the study districts comprised 9 wildlife species *Salt dik-dik, Common warthog, Geranuk, Guenther's dik-dik, Rock hyrax, Somarring gazelle, Common jackal, Black backed jackal* and *Lesser kudu* were identified as common wildlife species among the three districts; and their relative abundance increased with the selected districts, from *Guradhamole* to *Celkari* and then *Gorabaqaqsa*

Wildlife Species Diversity and Abundance in different agro-ecological zones and districts.

Different agro-ecological zones.

Table: 6 Effect of Agro-ecological zones on wildlife species diversity, species evenness, species richness, total wildlife abundance at different types of habitat patches

Factor Levels and interaction effect	Shannon diversity	Species Evenness	Abundance	Species richness
Tepid to cool moist plain areas				
Babile	0.083[a]	0.79[a]	86.43 [a]	3.1 [a]
Goljano	0.071[b]	0.72[b]	9.2 [b]	3.0 [b]
Bilcirbur	0.032	0.79[a]	78.75 [a]	4.2 [a]
Hot arid lowland areas				
Ellale	0.207[b]	0.79[a]	85 [b]	4.3 [a]
Hadhagale	0.219[a]	0.60[b]	94.20 [a]	3.8 [a]
Shilab	0.062	0.74[a]	99.20 [a]	3.5 [b]
Warm moist lowland				
Celkari	0.103[a]	0.77[a]	79 [b]	4.1 [a]
Gorabaqaqsa	0.071[b]	0.59[b]	103.19 [a]	3.1 [b]
Guradhamole	0.038	0.73[a]	91.25 [a]	3.3 [a]
Production System (PS)				
F (df = 2, 22)	0.01	4.31	0.1	0.05
P	0.339	0.04	0.77	0.822
Lsd	NS	0.06	NS	NS
Grazing Type (GT)				
F (df = 2, 22)	11.03	8.49	3.02	2.45
P	0.001	0.001	0.065	0.095
Lsd	0.13	0.08	NS	NS

Df = degree of freedom, F-ratio = F test value, P = probability value; NS = non-significant. Means with the same letter in columns within each production system (PS) are not significantly different at $P \leq 0.05$.

Wildlife species evenness was significantly higher in the *Tepid to cool moist plains* than *Hot arid lowland* and *Warm Moist Lowland areas*. This result indicates that in the *Hot arid lowlands* and

Warm moist lowlands wildlife was equally distributed (Table 6). Wildlife species evenness were significantly increased from lowest of Goljano, then Bilcirbur and Babile District areas of the Tepid to cool moist plain agro-ecological zones were equally distributed (Table 6). They were also significantly increased from Hadhigale, then Shilabo, and Ellale District areas of the Hot arid lowland agro-ecological zones and significantly increased from Gorabaqaqsa, then Guradhamole, and Celkari District areas of the Warm moist lowland agro-ecological zones (Table 6).

Wildlife species diversity was significantly increased from Bilcirbur, Goljano, and then Babile District areas of the Tepid to cool moist plain agro-ecological zones. It also increased from Shilabo, Ellale, and then Hadhigale District areas of the Hot arid lowland agro-ecological zones (Table 6). Wildlife species diversity were also significantly increased from Guradhamole, Gorabaqaqsa, and then Celkari District areas of the Warm moist lowland agro-ecological zones (Table 6).

Wildlife Species Similarity

The highest three Jaccard coefficient similarity index (0.69, 0.63 and 0.25) for wildlife species composition was recorded between the Babile-Goljano distric areas of the *Tepid-cool moist mid highland*; and Celkari-Gorabaqaqsa district areas and Ellale-Shilabo district areas of the *Warm moist plain* and *Warm moist lowlands*, respectively. The lowest three Jaccard coefficient of similarity index (0.18, 0.20 and 50) was obtained between the Ellale-Hadhagale and Hadhagale-Shilabo district areas of the *Hot arid lowland*; and Bilcirbur-Shilabo district areas of the *Tepid-cool moist plain* and *Hot arid lowland*: and Cekari-Guradhamoledistrict areas of the *Warm moist lowland*, respectively (Table 7). This result indicated that wildlife species similarity was high between Babile-Goljano and Celkari-Gora-Baqaqsa district areas in both *Tepid-cool moist plain* and *warm moist lowland* areas. Less species similarity was recorded between *Warm arid lowland* and *Tepid-cool moist plain* of the Ellale-Hadhagale and Hadhagale-shilabo district areas. This result could be related to the variation of species communities between the *Tepid-cool moist plain* and *Hot arid lowland* district patch habitat type.

Table 7. Jaccard coefficient of similarity for wildlife species under three agro-ecological zones with three patch habitats in nine (9) districts of Somali Regional State, Ethiopia

		Agro-ecological Zones								
		Tepid-cool moist plains			*Hot arid lowland*			*Warm moist lowland*		
		Babile	Goljano	Bilcirbur	Ellale	Hadhagale	Shilabo	Celkari	Gorabaqsa	Guradhamole
Tepid-cool moist plains										
	Babile	-								
	Goljano	0.69	-							
	Bilcirbur	0.63	0.67	-						
Hot arid lowlands										
	Ellale	0.38	0.44	0.50	-					
	Hadhagale	0.25	0.31	0.36	0.18	-				
	Shilabo	0.22	0.18	0.20	0.25	0.18	-			
Warm moist lowland										
	Celkari	0.44	0.50	0.56	0.71	0.36	0.33	-		
	Gorabaqsa	0.50	0.56	0.63	0.57	0.27	0.22	0.63	-	
	Guradhamole	0.57	0.44	0.50	0.67	0.30	0.43	0.50	0.57	-

Discussion

Wildlife trend and community attitude

The cumulative result of the three AEZs, KIIs and FGDs show that there is a decreasing trend of wild animals. Some antelopes like Lesser kudu, Oryx and carnivores like lions have gone under decreasing trend owing to settlements and related natural resource degradations along with recurrent droughts and illegal hunting. This agrees with Tefera (2011) that also illustrates reduction of diversity and density along with distribution of wildlife throughout Ethiopia in the past century owing to various anthropogenic pressures. The decrease in antelopes (especially Lesser kudu) is attributed to its use as food and medicinal purpose. The three major reasons for the reduction of wild animals are human settlement induced factors (increase in livestock population; and deforestation for settlements and agriculture), recurrent droughts and illegal hunting in their order. These findings are in line with Demeke *et al* (2015) which states that there are major land use changes which are associated with expansion of cropland cultivation and human settlements into areas that previously serves as wildlife habitats.

The decrease in lions is mainly due to human lion conflict as a result of human and livestock attacks. The same situation was also reported by Kahsay *et al* (2007) that asserted the human lion conflict in Soro District of Hadiya Zone, Zone 3 of the Afar Region and Liben Zone of the Somali Region are the best examples where depredation cases of hundreds of livestock of various types and significant number of people by lions were reported. The negative attitudes of communities towards the carnivores also originate from carnivore attacks against humans and livestock in accord to the majority of the FGD and KII members in the discussion sessions.

Based on the study it is evident that there is gradual shift from pure pastoralism to agro pastoralism which is also another threat to wildlife habitats and cause for wildlife population reduction in the area as farming needs two things at the same time; one sedentary settlement and another, clearing of the vegetation. Jabessa *et al* (2015) stated that people who are relinquishing the pastoralist system (which writers connote them as TOPs, drop-outs or transitioning pastoralists) have been increasing from time to time even though no survey has been made yet to substantiate quantitatively.

Most KIIs and FGDs mentioned frequent sightings of giraffe in some of the study areas according to two members of Hagarmogar kebele during the FGD "*We always come across each*

other specially in the water points during the nights it comes around our settlements." During the ground study the team observed three giraffes in Warm moist lowland areas (Gorabaqaqsa District). The team also observed five giraffe foot prints at a time in the same place. It was also common to observe these foot prints in many places in both target district sites (celkari and Gorabaqaqsa). This might show better giraffe population in the target areas and vicinities than other areas. This agrees with Fedlu *et a*l (2021) which stated it is well known that frequency of sightings have strong connection with wildlife abundances. It was also evident that the human settlements are not densely populated in the area based on the data collected from FGDs and actual ground observations.

In Wildlife Resource-Base and Mammal Species Diversity the preliminary survey identified a wide range of mammal species in Somali Region, including but not limited to elephants, lions, cheetahs, leopards, hyenas, gazelles, giraffes, and various antelope species. The region's diverse ecosystems provide suitable habitats for these mammals. **In terms of Endemic and Threatened Species** the study revealed the presence of endemic and threatened mammal species in Somali Region (table 2.) These include the Somali wild ass (Equus africanus somaliensis), Speke's gazelle (Gazella spekei), and the Ethiopian wolf (Canis simensis). The conservation of these species is of utmost importance to maintain the region's biodiversity.

When it comes to Constraints to Wildlife Conservation (Habitat Loss and Fragmentation)**,** the expansion of agriculture, urbanization, and infrastructure development has led to habitat loss and fragmentation, posing a significant threat to wildlife populations in the Somali Region. Encroachment into natural habitats has resulted in reduced available space for wildlife and increased human-wildlife conflicts.

Poaching and illegal wildlife trade is prevalent issues in Somali Region. The demand for wildlife products, such as ivory, skins, and bush meat, has led to the decline of several mammal species. Strengthening law enforcement and raising awareness among local communities are crucial to protect the wild life.

Finally, as shown in the result Wildlife species evenness being significantly higher in the Tepid to cool moist plains than Hot arid lowland and Warm Moist Lowland areas indicates that in the Hot arid lowlands and Warm moist lowlands wildlife were equally distributed and Therefore, this could be related to the presence of settlements and recurrent droughts in the Ellale, Shilabo, Celkari and Guradhamole district areas.

The significantly increasing Wild life species diversity and Evenness from lowest of one agro ecological zone and/or location to the other could also be related to the presence of illegal hunting, recurrent droughts and human settlements as well as high grazing pressure and mobility of humans and livestock.

Conclusion and Recommendations

The following conclusions can be drawn from the results of the research: As shown in the analysis above it was important in providing insights on how the perceptions, attitudes, and current practices may influence wildlife sustainability and its supporting institutions. In the study areas anthropogenic factors had been highly increasing through past years causing high degradation on the natural resources in general and wildlife resources in particular. Had it not been for human and livestock disturbances it would have been possible to observe better wild animal population including giraffe than actually seen on the ground. There is illegal hunting of antelopes like lesser kudu and others for medicinal and other purposes, which cannot be special for giraffe too though not mentioned by respondents. Based on the road count study, FGDs and KIIs and observations from the ground the findings depict that there can be better population of giraffes in warm moist lowland than other areas. From FGDs, KIIs and other informal communications it is evident that the number of carnivores, with the exception of hyena, in general and lions in particular had diminished a lot in the past years. The main cause for this reduction is human-carnivore conflicts that resulted killings using guns, poisoning, and traps.

Based on the preliminary survey and documentation of mammal species in Somali Region, the following potential conservation strategies can be recommended for the sustainable management of mammal populations:

1. *Protected Area Expansion and Management:* Identify key habitats and areas of high species richness for designation as protected areas or national parks. Strengthen the management of existing protected areas, collaborate with local communities and stakeholders to establish community-based conservation areas and promote sustainable land-use practices.

2. *Habitat Restoration and Enhancement:* Implement habitat restoration programs, particularly in degraded areas, to increase the availability of suitable habitats for mammal species. Promote reforestation initiatives and the restoration of riparian zones by the concerned stake holders.

3. *Wildlife Monitoring and Research*: Establish long-term monitoring programs to track population trends, distribution patterns, and ecological interactions of mammal species.

4. *Human-Wildlife Conflict Mitigation*: Develop and implement strategies to reduce human-wildlife conflicts, particularly in areas where local communities rely on the same resources as mammal species.

5. *Capacity Building and Education:* Provide training and capacity building programs for local communities, park rangers, and wildlife authorities to enhance their knowledge and skills in wildlife conservation and management.

6. *Policy and Legal Framework:* Advocate for the development and implementation of policies and regulations that support wildlife conservation and sustainable management practices.

- ✓ Strengthen law enforcement efforts against wildlife trafficking and illegal hunting activities through
- ✓ Collaborate with relevant governmental and non-governmental organizations to ensure the integration of conservation goals into regional development plans and policies.
- ✓ By implementing these conservation strategies, Somali Region can enhance the sustainable management of mammal species, protect their habitats, and ensure their long-term survival.

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Evaluation of the Influence of Tapping Tools and Tree Diameters on Resin Yields of Chomophera Myrrh at Adadle District of Somali Region

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ABSTRACT

The Somali region is one of the few places in Ethiopia endowed with diverse species that yield economically valuable gum and aromatic resin. Most gums and resins, particularly those produced in the Somali Region, are from natural exudates. The output from natural exudates far less than that of the product by tapping trees. This study is conducted with the objectives of evaluation of the influence of tapping tools and tree diameters on resin yields of chomophera myrrh in Adadle district. The study site was selected on the bases of the presence of good population of resin bearing species. Two sites were selected and three Experimental plots sized 20x20 m= 400m^2 were established. Experimental plots were replicated in to two in both sites. Tapping trees were conducted using Mingaf and sunki tools in the first site. Tapping in the second site were also carried out by grouping trees in to large, medium and small diameter class. Untapped trees in control plots were used in both sites. Tapping trees were done for six rounds in 15 days interval during dry periods. Based on the analysis of data gathered, tapping tree with sunki yielded higher compared to yield from mingaf and natural ooze. Total mean yields from sunki 724 g per tree, while yield from mingaf and natural ooze 507.9 & 380.5 respectively. Trees with middle diameter were high yielder as compared to large diameter and small diameter trees when tapped with sunki for six rounds. Total mean yields, middle diameter 701.8 g per tree while 564.3g & 294 g for large and small tree diameter respectively. Therefore, according to our result sunki and middle diameters are recommended tapping tools and tree size for tapping of chomophera myrrh for high resin yields.

Key words: *chomophera myrrh, tree diameter, tapping tools, resin yield*

Introduction

Ethiopia is one of the world's leading producers of incense, notably frankincense (product of Boswelia spp.) and myrrh and myrrh-like resins (products of Commiphora spp.) (Lemenih and Teketa, 2003). Ethiopia's diversity of plants that yield commercial gums and resins is one of the highest in the world. About 13 species of Acacia, 16 species of Commiphora and six species of Boswellia are known as potential yielders of commercial gums (Lemeneh and kassa, 2011). The gum and resin bearing species are much known for their well-recognized actual and potential

socio-economic importance to the local people (Worku, 2006). Many trees produce gum and resin in response to wounding (Langenheim, 2003) and thus seal the wounds and protect themselves against water loss, insect damage and pathogen invasion (Wink, 1988). Three types of frankincense are distinguished in Ethiopia according to their origin: Tigray type, Ogaden type and Borana type. The major Commiphora gums of economic importance in Ethiopia are myrrh, opoponax and hagar. Gum myrrh (heerabol) is a typical name for the gum obtained from C. myrrh (Nees) Engl., which is called true myrrh (FAO, 1995).

The Somali region is one of the few places in Ethiopia endowed with diverse species that yield economically valuable gum and aromatic resin. Among the others, Boswelia Rivae, Boswelia Ngelecta & Boswelia Ogadenisis are the major species that produce frankincense while Myrrh and Gum Arabic yielded by Commiphora myrrh and acacia Senegal. The plants yield these products during dry season of the year for the benefit of local pastoralists in the face of decreased output from livestock. However, most gums and resins, product in the Somali region are produced from natural exudates, the output from natural exudates, far less than that of the product by tapping tree. Tapping is a cyclical operation that is repeated every 15–20 days after the first tapping and carried out during the dry season because it is dictated by the physiology of the tree. Resin yield is increase with the number of incisions (tapping) made along the trunk and the amount of tapping and resin collection rounds, particularly for the larger trees when they indeed have greater resin production capacity (Eshete, 2012). Adadle is one of the kebele in Somali region with dense and diverse gum and incense producing boswelia, chomophera and acacia species. Similar to other area of the region, pastoral communities in Adadle kebele produce gum Arabic, incense and myrrh in traditional way, their benefit is negligible compared to existing potential of the resource. Previously no significant effort has been made to fill the knowledge gaps on how to improve yield and quality of these products. Therefore, this project designed to address this knowledge gap on resin production with the objectives: to investigate effect of tapping tools on resin yield of chomophera myrrh and the influence of tree diameter on resin yield chomophera myrrh species.

Materials and Methods/ Research Methodology

Description of the study area

The study was conducted at one districts of Somali region which is named Adadley. This district is well known in their high production capacity and availability of **gum and resin** producing species, which has regional as well as national production potentials, and hence is selected for this study, Adadley Districts, which is one of the 10 Districts of the Shebelle zone it is located 18 km south Gode and is characterized vast pastoral areas toward Somali republic border, and covers major of large pastoral areas between Kelafo Districts of Shabelle Zone and Barey Districts of Afder Zone. Also geographically it has border with El-kari, Imey and Abaqorow Districts of Afder and Shabelle zone.

Based on the 2007 census conducted by central statistical agency (CSA) this woreda has a total population of 83,260 of whom 48,166 are men and 35,094 women.

Methodology

One hectare of land, dominant with Chomophera Myrrh were selected and demarcated. The area sub divided in to two in Adadle. Two experimental activities were conducted to evaluate influence of tapping tools and tree diameter on resin yield

First experiment: three Experimental plots sized 20x20 m= 400m^2 were established in RCBD design in 3 replications.

In each plot trees for tapping marked with three different colors mingaf (red color), Sunki (blue color) and yellow for control. Trees tapping were conducted in six rounds during dry period in 15 days interval. Resin yield harvested and weighed at the end of each tapping period.

Second experiment: three experimental plots sized 20x20m= 400m^2 were established in RCBD design in 3 replications. Trees grouped in to three diameter class, large (> 20 cm), medium (16–20 cm) and small (10–15 cm) Trees marked and tapped with sunki in six rounds.

2.3. Data collected

- Resin yield from tapping tools such as Mingaf, Sunki and Control.
- Resin yield from tree diameter class by tapping with Sunki.

For the second experiment sunki was selected to make tapping on tree of different size because it's easy tools to use and better for soft bark of chomophera myrrh.

2.4. Data analysis

- The collected resin yield data from both experimented were subjected to Analysis of variance (ANOVA) The means were separated using least significance difference (LSD) for each experiment separately.

Result and discussion

Experiment 1. Influence of tapping on resin yield of chomophera myrrh

The result clearly show that tapping tools has a great influence on resin yield of chomophera myrrh There are highly significant difference between the means of resin yield at $p<0.01$. The result in the table below (table1) shows that sunki yielded higher (724.3gm) in each six round of tapping than mingaf (507.9gm) and control (380.5gm); natural ooze. The reason of high resin yield by sunki may be tapping with sunki was made by scratching the bark of the wood from above unlike Mingaf, which made some depth when tapping. Yield was decreasing from first to last round of tapping in all tapping methods employed. Infect, increasing the number of tapping spots in a tree increases the overall annual yield of myrrh and resulting a decrease in subsequent number of tapping. Because increasing the number of tapping affects the tree's vitality and interferes with its reproductive biology.

Table 1. Influence of tapping tools on resin yield (gm) of chomophera myrrh

Tools	R1	R2	R3	R4	R5	R6	Total	p-value
Sunki	176.2	181.2	127	82.7	80.8	76.4	724.3	
Mingaf	113.8	130.9	83.3	67.7	63.9	48.3	507.9	<0.01
Control	101.1	108.7	64.3	43.9	32	30.5	380.5	
SE+	13.2	13.9	9	6.7	4.4	5.5		

Experiment 2. Influence of tree diameter on resin yield of chomophera myrrh

The results of the study (table 2) clearly show that tree stem diameter showed significant differences ($P \leq 0.05$) in resin yield between the different tree diameters. Trees with middle diameter were high yielder as compared to large diameter and small diameter trees when tapped with sunki for six rounds. The means resin yield in relation to middle diameter of tapping 701.8 g per tree while 564.3g and 294 g mean resin yields for large and small tree diameter respectively. The reason why middle diameter tree yielded higher is that during fruit filling by large diameter trees and during seed collection the yield decreases when compared to trees with middle diameter stem.

Table 2. Influence of tree diameter on mean resin yield in gram per trees of Chomophera myrrh

Middle diameter (16–20 cm)	170.4	175.8	120.6	83.9	79.4	71.7	701.8	
High diameter (> 20 cm)	130.1	111.2	101.9	90.7	69.5	60.9	564.3	<0.05
Low diameter (10–15 cm)	90	83	29	29	24	39	294	
SE+	9	7	4	3	2	4		

Conclusion and recommendation

Tapping tools has a great influence on resin yield of chomophera myrrh. The result of our study showed that sunki yielded higher when compared to mingaf and natural ooze. Tree stem diameter has also influence on resin yield of chomophera myrrh. Tree stem diameter showed significant difference at ($P \leq 0.05$) and higher in tree with middle diameter stem.

Tapping chomophera myrrh with sunki and middle diameter tree gave higher resin yield, therefore according to our result sunki and middle diameters are recommended tapping tools and tree size for tapping of chomophera myrrh for high resin yields. Furthermore, seed collection from old trees and intensively tapped stands should be avoided; otherwise the yield of large diameter stem trees

will dicrease. Instead, seeds must be collected from medium-sized, healthy and untapped trees, if available.

The study recommends that local communities should be aware of the valuable services and benefits of this species. This research technology required to reach the end users through training and capacity building.

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SOCIO-ECONOMIC AND GENDER RESEARCH DIRECTORATE

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Pastoralists and Agro-pastoralists Vulnerability to Drought and their Local Adaptation and Coping Mechanisms: The Case of Fafan Zone, Somali Regional State, Ethiopia, Ethiopia.

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Abstract

This study was conducted in Harshin and Kebribeyah woreda, Somali Regional State of Ethiopia with the objective to understand and evaluate pastoralists and agro pastoralists vulnerability to drought and adaptation mechanisms. The study was conducted in six rural kebeles such as Durwale, Maragajo, Dubur, Lankerta, Afufley and Kam Berwako. Multistage sampling was used to select the study area, due to their drought affected. Simple random sampling was used to select 270 respondents. The study used both qualitative and quantitative data collected through household survey. Also, FGDs and KII were employed to triangulate and substantiate the information from household survey. Data were analyzed using descriptive statistics. The result shows that drought increases from time to time in the kebeles and effects the livelihood of the residents. Though, all pastoral and agro pastoralists in the study are vulnerable to drought, the problem is more acute on the poor, women, large size family, and children, old and disabled persons. Vulnerability is further aggravated by the decline in the crop failure, loss of livestock, unemployment, unavailability and inability of most Agro pastoralists to afford agricultural inputs, and selected variety of crop. Recurrent droughts have negatively impacted on pastoral livelihoods. In order to adapt to or cope with frequently occurring droughts, the study area pastoralists are using a variety indigenous short-term and long-term strategies. Long-term adaptation they use includes mobility to track forage and water sources, herd diversification, regular selling of livestock, diversification of livelihood sources and shifting to agro-pastoralism. The coping mechanisms provided by institutions is very weak and at its early stage in the zone. And the coping mechanisms available in the zone are not equally important and practiced and are insufficient to cope with drought impacts. The study suggests a relentless need to address these challenges both from short and long-term policy perspective. Recurrent drought frequently occurring in the zone have been causing adverse impact on crop and livestock production. Therefore, there is a need to provide drought tolerant and early maturing crops and improved livestock breeds for pastoral households. Water related intervention such as small-scale irrigation farming and water harvesting during good rainy seasons is also paramount to enhance climate resilience of the study area.

Key word: Vulnerability, Drought, Effect of Drought, Adaptation strategies.

INTRODUCTION

Drought is one of the most expensive natural disasters, and it occurs in almost every region of the world as a natural part of the climate (Wilhite 2013). Weather and climate change-related disasters have become a common occurrence on a global scale in recent decades. This has resulted in significant human life loss and socio-economic consequences, jeopardizing socioeconomic growth development, particularly in low income countries. According to the IPCC's Fifth Assessment Report (IPCC, 2010), the frequency and severity of such weather and climate change-related hazards are more likely to increase and will have a greater impact on natural and human systems than a small shift in mean values. Drought is one of the most common natural disasters.

Drought-induced famine was Ethiopia's worst disaster in history, causing immense anguish for millions of people, mostly rural residents, and it continues to be a national policy agenda and problem (Abebe, 2010). Ethiopia has a long history of droughts. Drought has been recorded in Ethiopia since the year 250 BC (Webb *et.al*., 1992). Ethiopia is especially vulnerable to drought, making it the most significant disaster affecting the country over time (Seleshi and Zanke, 2004). Although droughts occur all over the world, their impact is not as severe as it is in Africa, particularly in Ethiopia (Funk *et al*., 2008; Seleshi and Zanke, 2004; Williams and Funk, 2011).

Climate-induced shocks and stressors such as drought, rising temperatures, and irregular rainfall reduce pasture and water availability, resulting in animal loss due to hunger and disease in Ethiopian pastoral communities (Conway, 2000). This results in depleted grassland, a lack of feed and water, and heat stress in livestock. As a result of the long distances they travel in search of pasture and water, herd mortality has increased, as has livestock susceptibility to disease and emaciation (Muluneh and Demeke, 2011).

For nearly a century, Ethiopian pastoralists have faced repeated droughts, which have harmed their livelihoods in specific ways. Drought-affected conditions have worsened, and land productivity is declining, resulting in resource conflict. The scarcity-driven' mobility in search of moist areas persists even as the land area endowed with such conditions shrinks due to climate change and its intensification by local practices. Competition for access to diminishing resources

has resulted in conflicts (Melat, 2008), which have escalated into armed conflicts among the pastoralist population.

According to food aid-related data, highly vulnerable areas with frequent and severe drought impacts exist in peripheral pastoralist areas of the country (Getachew, 2018). Generally, studies focused on pastoral communities and their coping and adaptation strategies to drought are not enough at the country level and in the Somali region. Some of the studies undertaken by Mulu, (2010) and Zigale, (2021) on Somali region pastoralists seem to focus more on Sitti zone pastoralists. Studies focused on drought characterization and indigenous pastoralists' coping and adaptation strategies to drought were scarce in Fafan zone.

Therefore, this project was carried out with the objective to understand the vulnerability of pastoral and agro-pastoral communities to drought, to evaluate the effect of drought to the communities and adaptation strategies practiced by pastoralists and agro-pastoralist to cope with drought.

METHODOLOGY

More than 90% of Harshin and Kebribeyah districts inhabitants depends on livestock and livestock products for their livelihood and the rest, 10% are engaged in agro-pastoralism (both annual and tree crops), livestock production (SC-UK, 2010).

Kebribayeh district will be chosen to represent the arid and semi-arid pastoral and agro-pastoral livelihood using a purposive sampling approach. Kebribayeh is located 50 km away from the regional capital town Jigjiga. It is one of the eleven woredas of Fafan zone of Somali Regional State. It is bounded by Somalia in the North eastern and extends to Western part of the region at the East, shabelley district at the North and Erer zone at the South West. The population of Kebribayeh is 165,422 person with demographic distribution of 89644 men and 75777 women, the population growth is fast and 25491 of its population residences in urban whereas 139,931 lives in rural area. Concerning household size, a rural household has an average size of 6.7 while the urban has 6.3. The average household size for the Fafan Zone is 5.9, less than the average for the Somali Region, which is 6.7 (JZOA, 2001; CSA, 2007).

Geographically it lies 90, 25'and 90, 44', North Latitude and 420, 43 and 430, 32'East Longitude. The total area of the woreda is 407,870 hectares, and it is located in Wabishabele

basin. The population in Kebribayah Woreda is mainly from Somali tribes' which are Muslim in religion and 100% agro-pastoralism in occupation. According to National Meteorological service agency data indicates that temperature variability throughout the year is relatively low. Minimum temperature ranges almost 7C0 and Maximum temperature ranges 36^0C, the mean annual rainfall ranges from700 to 900mm. Altitude ranging from 500 to 1200 m.a.s.l. The farming system in the Worada is characterized by agro-pastoral system The agro-climatic condition of the district is favorable for growing diversified types of crops and different species of animals (BoARD, 2003).

Harshin district was the second district chosen to represent the arid pastoral livelihood zone in Somali region and selected purposively. Harshin is located 730 km far from the capital city of Ethiopia, Addis Ababa. The district covers a total area of 5,120.12 square Km and borders Kebribayah district in the West, Somaliland to the North and East and Aware and Degahbur district to the East and South respectively. The district is geographically located between longitude 9°-21° in the North, 42°-48° in the East, 29°-35° West and 42°-53° South-East. Its altitude ranges from 1302 to 1700 m above sees level. The climate is generally hot and dry with a mean annual temperature ranging from 28℃ to 36℃. The annual rainfall ranges from 300mm to 400mm with limited and unreliable rainfall with two peak rainy seasons of Gu (April-May) and Deyer (October-December). The Gu rains are the most important for pastoralists. Harshin district locates on the boundary between areas in the Somali Region that receive Karan rains in late July to September (Berhanu *et al.*, 2013)

Research Design

For this study, both purposive and random sampling techniques were implemented. The two districts (Kebribayah and Harshin) were selected purposely based on the fact that they suffer from frequent drought and to exemplify the districts most vulnerable to drought in Fafan Zone’s arid and semi-arid pastoral and agro-pastoral districts. Secondly, three rural kebeles (kebele: smallest administrative unit) were selected randomly from each district. Accordingly, Dubur, Maragajo and Durwale kebeles were selected from Kebribayah district and lankerta, Afufley and kam-barwako kebeles were selected from Harshin district. A total of 270 sample households were selected using Yemane's (1967) statistical technique. The formula is presented as follows:

$$n = \frac{20{,}885}{1 + 20{,}885(0.07)^2} = 270$$

Where n is the sample size, N is the population size (total household heads size), and e is the level of precision. Random sampling was employed to select respondents from household lists in each village, while probability proportional to size was utilized to determine the number of respondents from each village.

Data were collected from respondents using interview schedule and by conducting focus group discussions and key informant interviews. The collected data were analyzed by using descriptive statistics.

RESULTS AND DISCUSSIONS

Demographic and other Characteristics of the HHs

The following Table (1) summarized the demographic characteristics of the households.

Table 1. Demographic characteristics of the HHs

Demographic Variables		Respondents					
		Pastoralist (n=**140)**		Agro-pastoralist (n=**130)**		Total (n=270)	
		N	%	N	%	N	%
Sex	Male	94	67	86	66	180	67
	Female	46	33	44	34	90	33
Age grouping	15-24	53	38	42	34	95	35
	25-54	39	28	49	38	88	33
	55-64	27	19	30	23	57	21
	>65	21	15	9	7	30	11
Marital status	Married	68	49	65	50	133	49
	Single	33	24	26	20	59	22
	Divorced	12	9	15	12	27	10
	Widowed	27	19	24	18	45	17
Educational status	Illiterate	84	60	54	42	138	51
	Primary 1-8	32	23	42	16	74	27
	Preparatory/ high school	5	2	9	7	14	5
	Religious knowledge	19	14	25	19	44	16

Source own survey 2023

Sex and Age Structure of the HHs

As indicated in table 1, around 33% of the respondents were female whereas male respondents accounted for 67%. This implies that the surveyed pastoral and agro-pastoral household in the study area were male dominated who determine important decisions as pertains the access and utilization of natural resources within the society.

In accordance Ethiopian age structure (2020), this entry provides the distribution of the population according to age. Information is included by age group as follows: *0-14 years (children), 15-24 years (early working age), 25-54 years (prime working age), 55-64 years (mature working age), 65 years and over (elderly)*. The age structure of a population affects a nation's key socioeconomic issues. Countries with young populations (high percentage under age 15) need to invest more in schools, while countries with older populations (high percentage ages 65 and over) need to invest more in the health sector.

The age structure of the household is an important for pastoralist and agro-pastoral dealing with extreme climatic events for the minimization of the recurrent drought impacts and utilizing their indigenous adaptive and coping response. As shown in table 1, around 35% of the interviewees' ages were ranging from 15 to 24, and around 33% of the interviewees' age were ranging from 25-54, which is prime working/the productive and less vulnerable age class, another 21% of the respondents were the age between 55-64 mature working age, and the rest 11% were older than 65 years.

Marital Status

As indicated in Table 1, the study has revealed that 49% out of the surveyed 270 households were married, while the widowed females and the men who has divorced their wives and husbands were 10% and 17% respectively where as 22% of the respondents were single (unmarried). In spite of polygamy practice of marriage in the study area, means one man may have married more than one wife, most of this households were male dominated, in terms of decisions of family affairs.

Educational Status

This study has revealed that the majority of the respondent pastoral and agro-pastoral households were illiterate and the sum of the formal and informally educated respondents were 33% as indicated the above Table 1. Around 51% of the surveyed pastoral and agro-pastoral households of the study area were illiterate, around 27% of the respondents had reached elementary level and primary education and 5% of the sampled households have reached secondary level where 16% of the respondents has attended informal religious knowledge (*ulimo*).

Livelihood activities of the respondents

As shown in table 2, it can be observed that the agro-pastoral communities has been employed fewer livelihood activities to generate income for their households as compared to the pastoralists. In other words, the agro-pastoral community had additional opportunities in crop productions vegetables production, hand craft, grass and forage productions and land renting. Whereas the principal livelihood activity of the pastoral community seems livestock and livestock products, but it still proportional number of pastoralist and agro-pastoralist community are engaged in the fallowing livelihood activities. Around 54% of the interviewees' selling crop production and 12 to 35% were selling livestock, livestock product and cash crop, and around 4% were selling fuel wood, land rent and petty trade. The principal livelihood activity of the agro-pastoralist community is crop production followed by livestock and their products. While the pastoralists interviewees around 44, 22 and 23% were selling livestock, livestock product, and fuel wood and charcoal respectively. Therefore, Agro pastoralist had more livelihood income compared to pastoralist. This had led agro-pastoralist to have less degree of being vulnerable. Whereas pastoral households livelihood activities were only depends more on the livestock and livestock products. Due to decreasing availability of pasture land and livestock disease their livestock reduced and livestock production decreased. As a result of this pastoralist have faced recurrent drought they loss their livestock and livestock production. This means they don't have other alternative livelihood sources, which leads to the pastoral community more vulnerable to the agro-pastoralist.

Table 2. Livelihood activities of the sample household

	pastoralist (n=140)		Agro-pastoralist (n=130)	
	frequency	Percent %	Frequency	Percent %
Selling of crop productions	7	5	70	54
Selling cash crops	7	5	30	23
Selling of livestock and their product	62	44	16	12
Selling fuel woods	31	22	7	5
Selling charcoals	32	23	-	-
Land renting	-	-	3	2
petty trade	-	-	3	2

Source: own survey

Source of water

Bore holes, dig stream beds, springs, and reservoirs (dams, ponds) are the sources of water for livestock and domestic consumption (SLCRDB, 2019). As indicated by table 3, the pastoralists and agro-pastoralists, the major source of water in the study was *Birka* in which 49% respondents have mentioned, 27% ponds, and 14% motorized well/boreholes, 13% rated for spring/stream.

Most of the motor and traditional hand dug wells, ponds, dams and *Birkas* that take high percentage of the total water coverage are only dependable (to provide water) during and shortly after rainy season, which also usually dry up immediately after the rain. This means only a small share of the population of the zone gets portable water coverage while the remaining struggle for survival for the months outside the two rainy seasons (i.e. six month of *Jilaal* and *Hagaa*).

Table 3: Source of water.

Source of water	**Pastoralist (n=140)**		**Agro pastoralist (n=130)**		**Total (n-270)**	
	N	%	N	%	N	%
Birka	73	45	79	53	152	56
Ponds	36	26	36	28	72	27
Motorized well	13	9	25	19	38	14
Hand dug wells		-	-	-	-	-
Streams	18	13	-	-	18	13

Source: own survey

Local people's Perception on causes of Drought

According table 4, indicated that a slight difference in the perception between pastoralists and agro-pastoralists that curse/worth of Allah is the cause of drought. That is, 71% of the respondents believed that wrath of Allah is the cause of droughts. In the same way, 51% of the respondents perceived that the causes of drought are the result of human actions. 53% of the respondents disagree that drought is the result of natural process, 52% from the respondents believed that the cause of drought is such an activity that is both man-made and natural.

This implies, the pastoralist and agro pastoralist are perceived the major cause of drought is curse/worth Allah. Most of the peoples assume that they face drought impacts as a punishment of Allah as they decreased worshiping of Allah.

Table 4. HH perception of the drought

Perception of drought	**Strongly agree**	**Agree**	**Normal**	**disagree**	**Strongly disagree**
Curse/worth Allah	71	29	-	-	-
Human action	29	51	20	-	-
Natural process	30	-	17	53	-
Human action and natural process	52	-	34	14	-

Source: own survey

Local people Vulnerability to Drought

The pastoralist and agro-pastoralist of the study areas are becoming more vulnerable to drought and the impact been severe and undermining the adaptive capacity of the households. As, one of the major droughts effects is loss of livestock and crop failure which are their main source of livelihood. According to (Mugalavi, 2011), it's reported that there is a positive correlation between drought severity and the magnitude of livestock losses and crop failure. As a result of frequent droughts, a high level of livestock mortality has become a norm in the study area (Respondents cited the 2010 and 2011 drought years as the cause of the highest livestock mortality and the rest of the region was also reported huge loss of livestock (SLCRDB, 2016).

Vulnerability for Pastoral areas

Livestock ownership

The dominant animals reared in the study area include camel, cattle, sheep, goat, and donkeys. Livestock holding of each household was calculated in terms of Tropical livestock unit (TLU) as recommended by Gryseels (1988) and Shiferaw (1991) for local breed animals. According to table 5, the mean livestock size of households is 12.85TLU (± 6.46). The result indicates that average livestock size of agro-pastoral households (9.55 TLU) was relatively less than the pastoralists (16.2TLU). This variation was due to that fact that livestock are a primary source of income in pastoral systems and the latter integrate cultivation as an additional economic activity to improve household income. This result is also in agreement with (Nega *et al*., 2019) who reported that the average livestock holding is relatively larger for pastoral households than agro-pastorals in Borana, Southern Ethiopia.

Table 5. Livestock ownership

S/No	**Description**	**Agro-Pastoralist**	**Pastoralist**	**Overage TLU**
		Mean & SD	Mean & SD	
1.	Livestock size (TLU)	9.5±3.1	16.2±5.0	12.85±6.5

Source own survey 2023

According to the FGD conversation with the kebelle elders, DAs and kebele leaders, the number of livestock in the pastoral kebelle has a decreased trend. In this regard, the participants asked the questions about the trend of animals that they owned and they said from time to time the number of cattle and shoats are decreased in number. One of the reasons for the decline of livestock holding in the study areas was reported to be due to shrinkage of grazing land and restriction of livestock movement to the neighboring regions. This is consistent with the findings of previous studies (Oba 1998; Oba *et al*., 2000; Oba and Kotile, 2001, Desta and Coppock (2004), which showed that Borana pastoralism is under increasing pressure due to shrinkage of grazing lands as a result of wide spread of different unknown weeds like *prosopis,* and demarcation of regional boundaries. Expansion of cultivation is another factor contributing to the decline in livestock holding. Shoats and cattle are the predominant livestock species in all the localities of the study area. However, according to the FGD participants of agro-pastoralist community, alleged that

their livestock production decreased from time to time. Due to the negative effects of climate related shocks, particularly drought. Further complained that the rangeland had become degraded and replaced by unpalatable species as a result of declining rainfall and recurrent droughts leading to scarcity of livestock feed and water. The other major problem that agro pastoralist faced in their locality were spread of invasive weeds, disease and pest that has led agro pastoralist to reduce their crop production and decline range land by covering most of the land for the unwanted species. This has led pastoralist community to be vulnerable.

Feed Availability

Respondents believe that the feed available for different livestock species is decreasing due to the droughts leading to reduction of feed. As indicated in Table 6, 99% of the respondent replied that feed available to the sheep is decreasing, 91% for the feed reduction for cattle, 63 % responded camel feed reduction which less than the previous response for cattle and sheep while 67% of the household responded reduction of feed available to goats. The feed scarcity due to the land degradations and recurrent drought has been reported in different Ethiopian lowlands which are the home of pastoral communities including Somali region (Ruijs *et al*., 2011).

Table 6. Status of feed availability

No	Livestock type	Increasing		Decreasing		No change	
		F	%	F	%	F	%
1.	Cattle	16	6	246	91	8	3
2.	Camel	11	4	170	63	89	33
3.	Sheep	3	1	267	99	-	-
4.	Goat	8	3	181	67	81	30

Source own survey 2023

According to the FGD participant complained that recurrent drought occurring every two interval years has increased, the rangeland degraded and the palatable forages is recently been replaced by non-palatable plants. FGD participants said that before the grazing area recovered from the previous drought, another drought affected the new growth. This situation could cause loss of palatable forage species from the rangeland and reduces forage availability.

Key informants also expressed that as the dry season grazing areas deteriorated due to frequent droughts and unreliable and erratic rains, pastoralists concentrate their livestock around water points, which in turn led to overgrazing of the existing forage resources. Consequently, overgrazing leads to expansion of low forage valued plants or unpalatable species around water points. Invasive plant species was another major problem in the study area. During the Focus group discussion, majority of the participants have agreed that "parthenium, *Shaqshaq* and *Garanwaa*" plants were the major invasive plants which is rapidly spreading and colonizing vast grazing lands. Unwanted plant species is known as *Harame in* Somali is an invasive plant species which is dominating the indigenous vegetation and creates more desertification in the study area.

According FGD a conversation with the kebele elders, DAs and kebele leaders, agro-pastoral kebeles farmers are particularly vulnerable to any reductions in crop productivity for a different of reasons. Observation of the FGD participants discussion were observed farmers from the participants cultivated very small parcels of land (less than one hectar), dedicated most of their land to crop production for household consumption and obtain low crop yields, which are insufficient to meet household needs, let alone provided surplus for sale. On the other hand, participants are characterized as a better-off households as having more than three hectare of cultivated land.

According to Kebribeyah woreda agricultural office report on 2016 stated, that "Even though agro pastoral community of Maragajo kebele cover 9840 hectare of farming land, the community are not used their faming land properly and do not get enough product". Even if, productivity has shown a decreasing trend in the kebeles the declining yields in the study area, the community usage of agricultural inputs are limited (fertilizers, pesticides, improved seed varieties), Shortage of tractors, the use of low technology practices, and land degradation all of which have been identified as constraints to agricultural productivity. In addition to shortage of cultivated land with an increase of population and rainfall variability the community faces declining of agricultural products and availability of water which leads their adaptive capacity to be weak.

Social group vulnerability to Drought

All the interviews similarly reported the existence of repeated serious drought impacts of course with varying degrees between years on the socio-economic activity of the society. Economically, drought forced people to sell their property because in time of repeated drought, the income they derive from crop production and livestock is declined. This makes them to be poor in the future.

Drought also affects people socially. All interviewees reported food deficit, malnutrition cases, educational dropouts, social conflicts, health problems susceptibility to diseases and an increase in the unemployment rate they faced in years of drought. One of the FGD respondents in Harshin district expressed his feeling with regards to health problem he/his family has faced, he said "it is now about three years since I have faced health problem (gastritis), but I did not try anything to save myself from sickness due to lack of property to be sell. Because most of my livestock have been sold in time of drought and I finished all, I don't have any remaining asset.

Table 7. social groups vulnerable to drought

Vulnerable groups	Frequency	Percentage
Poor	81	30
Large size family	21.6	8
Women	62.1	23
Children	70.2	26
Old & Disabled	32.4	12
Men	2.7	1
Total	270	100

Source: own survey 2023

As we can see from the above table 7, on 30%, 26%, 23%t and 12% respondents replied poor, children, women and old and disabled are most vulnerable to drought impacts, respectively whereas respondents who suggested large size family and men are vulnerable to the impacts of drought accounts 8% and 1% respectively.

On the other hand one of the key informant interviewed suggested all agro-pastoral households are disproportionately and are equally vulnerable to the events. The interview held with Harshin and Kebribayah woreda officials and experts found that poor, children, old and disabled, women (divorced, women who have no husband) are most vulnerable than the other groups.

Vulnerability by Poor

As table 7 above shown, 30% of the respondents' poor people are the most vulnerable to drought effects. Poor is also not trusted for credits due to the general perception that poor cannot afford paying it back. From all the studied areas, households were complaining about humanitarian aid corruptions (in place where aid is available) and marginalization of the poor during the aid. It was also understood that the politicians and local representatives usually over report the number of victims, the aid is distributed among all the groups and in most cases poor receive marginal amount of aid.

Vulnerability by gender

As table 7, above shown, 23% of the respondents suggested that women are more vulnerable to the impacts of drought quickly compared to 1% respondent for men. Vulnerability of women was explained from lack of access to property, confinement at home caring for children and family members, worries about feeding the family, poor nutritional status and long distance travel to collect water. According to Nuur Ahmed, one of the development agent from Kebrebeyah district, women have dual responsibility. One is managing the house and the second responsibility is activity outside the home. Their closeness to family members and confinement at home makes them suffer the most because the men can take the breath by being away from home. The impact is intense for divorced or in case of women who have lost husbands. Because divorced or women whose husbands dead take all the responsibilities of caring household by selling local tea shops, leasing land, charcoal, selling particularly, if she is landless and has no elders but more dependent, the situation becomes more difficult to manage the situation, thus she is obliged to face the socio-economic pains of the situation. In case she is old, the change is again more intense.

Vulnerability by Large family size

According to FGD, households have family size of 1 to 8 persons per household and the overall average household size is 6 (table 1, note that around 22% of the respondents are singles).

According to the interview held with officials and households, relatively large size family is most vulnerable to the impacts of drought. Because it is difficult for large size family to feed,

buy clothes and send to school their children even in time of surplus and good seasons. Their assets are not much with the size of their family. If households have small size family, it is retentively easier to send their children to school feed and buy clothes when compared with large size family (households' interview).

Vulnerability by Old and disabled people

Old people, disabled and children are sections of the society who are said to be unproductive and dependent. Unlike youth, old and disabled have no choice at times of drought even to migrate to areas where there are availability of jobs to pass the crisis time unless they have land to be sold on lease which helps to keep the survival of their life. Again, children are also vulnerable to the situations and their vulnerability is apparent from malnutrition cases, school dropout and poor educational achievements. Based on interview, FGD participants, community representatives and experts with pastoral and agro pastoral community in different group has mention, both pastoral and agro-pastoral community kebeles, the elderly groups are vulnerable to drought next to women and children. Meanwhile the elderly people are old, physically weak and face some health problems due to their Ageing. In addition, pastoral elderly group are not working like younger people and can move with their livestock from place to place. At the same time agro pastoralist elderly group also cannot take hard work like farming due to their age and weak health status condition.

Vulnerability by Women and children

According to social assessment report for RPLRP in four region of Ethiopia, (2014) has mention that pastoralist and agro-pastoral communities are more vulnerable to shocks and drought due to the fact that they live in the arid and semi-arid areas where precipitation is erratic. This area is highly vulnerable to natural problems such as; drought RPLRP, (2014). Based on the data conducted from pastoralist and agro pastoralist kebele community the way of life in Kebribeyah and Harshin are making to be vulnerable. Even if all pastoralists and agro-pastoralist groups are vulnerable, women and children are more vulnerable compared to men and elder.

Based on interview, FGD participants, community representatives and experts with pastoral and agro pastoral community in different group has mention, in both pastoral and agro pastoral community kebeles, Women's make the maximum work among the pastoral communities under

pastoralist and agro-pastoralist community. Most of work is both the creative and propagative work mainly on their shoulder. women were active members who were responsible to feed the household members, by collecting water from distance area, collecting fuel wood from forest, preparing food for her family, feeding and keep her children. Whereas children are also vulnerable due to less capacity to have resilience from the occurrences of disease, malnutrition, drought, and also they cannot move long distance to search food or cannot cope from the occurrence of hazards Thus, women and children can be categorized under the vulnerable segment of the population.

Effect and consequence of drought

Perceptions of households on the effect of drought are presented in (Table 8). Pastoral households perceived the top four drought effects as a failure of crop yield, a decrease in livestock asset, lack of food and loss of income. This result corroborates the findings reported by Charles *et al*. (2014) who indicated that climate variability has induced increased crop failure, higher livestock asset losses, migration, food shortages, biodiversity loss, and negative human development effects in the same agro ecology of southern Kenya.

Table 8. Perception consequence of drought in the study area

	Strongly agree	Agree	Normal	disagree	strongly disagree
Decline in crop production	93	7	-	-	-
Livestock reduction	99	1	-	-	-
Food shortage	97	3	-	-	-
Loss of income	90	10	-	-	-

Source own survey 2023

Drought effects on crop production

Local households complained that recurrent droughts, recurrent drought occurring frequently have caused crop failure. Majority of agro pastoral households (93 %) have experienced reduced crop due to climate related shocks and stresses. One of the key informant interview from Afufley kebele said droughts and delays in the onset of rains have made the farm lands drier and difficult to plough, caused stunted growth of crops and slow germination of seeds resulting in early

wilting of the crops and decline in crop yield (or in some cases a loss of the entire crop). Similar result by Melaku *et al*. (2017) and Tsegaye *et al.* (2013) also showed that occurrences of droughts had led crop failure in the region. In discussion with district agricultural office administer extension workers and focus group participant also pointed out that 7-10 years ago the agro pastoral villages were engaged in construction of nursery site for seedling multiplication of multi-purpose trees (pasture, and fruits). However, in recent years due to shortage of rainfall and drying up of private and communal water (*birka*) and ponds, the activity was not successful.

Livestock asset reduction

Livestock has been an important asset of the pastoralists and agro pastoralist in the study area. The major livestock species reared by the respondents were camels, sheep, goats, cattle and donkeys. However, the recurring drought along with increased heat stress affected livestock holdings per household. About 99% of agro pastoral and pastoralists felt drought reduced their livestock in numbers and productivity. KII participants also complained that animal mortality has been increased due to shortage of pasture and water and diseases prevalence especially during drought times. Many livestock owners obliged to use the same water sources to drink their animals and concentration of livestock triggered the spread of disease. They indicated that tick infestation, anthrax, sheep and goat pox, and pneumonia were common diseases observed during the drought and at the beginning of the rainfall after drought in the study area. This result was in line with Desalegn *et al*., (2017) who reported that the rising temperatures and droughts caused the shortage of water and pasture for livestock as well as spread of livestock diseases. Similarly, a study conducted by Akerlof *et al*. (2013) in dry land areas, livestock are becoming weaker and underweight as a result of a steady decline in pasture and water availability, exposing them to infections during the dry season.

Food shortage and loss of income

According to the findings table 8, recurrent droughts and unpredictable precipitation reduced crop and livestock production, resulting in increasing food insecurity and income loss. Food shortages were reported by the majority of agro-pastoral households (97 %) and 90 % of pastoralists due to livestock death and crop failure during droughts. Furthermore, climate-related shocks resulted in a loss of income for 81% of agro-pastoral households and 90 % of pastoralists.

This result corroborates the IPCC (2013) report, which stated that the impact of climate change in East Africa will increase the risk of food insecurity and the collapse of food systems, as well as the risk of loss of rural livelihoods and income due to insufficient access to drinking and irrigation water, as well as decreased crop and livestock productivity, particularly for pastoralists with limited capital in arid and semi-arid areas. Similarly, Zenebe *et al*. (2011) found a decline in average incomes of rural farmers as a result of climate-related shocks, and Gebreegziabher *et al*. (2011) found a 30% loss of income in Ethiopian rural areas as a result of climate change and variability.

Pastoralists' and agro pastoralist's adoption strategies to drought

In the study area, pastoralists have a long history of proving their ability to respond to climate change i.e. drought with their indigenous knowledge, despite the challenges faced with prolonged drought events. This study found that pastoralists and agro-pastoralists used different adaptation and coping strategies for a long time and they are using it today. Based on the respondents' choices most commonly used adaptations strategies were mobility (82.7%), herd diversification (72.7%), livestock off-take (68.0%), increasing puck animals (drought livestock) (60.0%), sending children to school (54.7%), selling livestock (48.7%) and livelihood diversification (46.7%).

Table 9. Adaptation mechanism to drought

Adaptation strategies	**Pastoralist and agro pastoralist (n=270)**
	%
Mobility	82.7
Herd diversification	72.7
Livestock off-take	68.0
Increasing puck animals	60.0
Sending children to school	54.7
Selling livestock	48.7
Livelihood diversification	46.7

Source own survey 2023

Pastoralists practice different adaptation strategies as a long-term response mechanism to drought and to ensure the sustainability of their livelihood. From them, mobility is one of the major adaptation strategies practiced by (82.7%) pastoralists (table 9). It is the movement back and forth between pastureland and settlement villages in search of pasture and water to reduce the adverse effects of drought. According to respondents, it is carried out in nature preserve grazing areas and to use water from permanent water points and utilize the grazing resource properly. During mobility, the total household family members and all livestock owned may not be engaged in mobility. The study found that a group of herds that includes the majority of livestock migrates seasonally while others like milking cows, weak livestock and calves remain to serve women and children at home but adult male herders move with the remaining herd. Women participants in focus group discussion revealed that the herd remained around the home during drought to serve them for fulfilling family needs through selling animal products such as milk and butter. Respondents show that it was not uniform across seasons and nowadays it is not as much as in the past due to a decline in the livestock herd size as a result of recurrent drought. These findings were similar to findings of (Lekapana,, 2013) from studies conducted in the Kenya pastoral community.

Herd diversification is also another drought adaptation strategy that more than (72.7%) of pastoralists used to reduce the adverse effect of drought. Households surveyed from the study areas diversify herd composition and keep a mix of livestock species that include camels, shoats (sheep and goats), cattle and donkeys. According to respondents, there is a preference for camels and goats to cattle during herd diversification because species are perceived to be more resistant to drought, adapt well to harsh arid environments, can withstand drought incidents than cattle and prefer browsers due to changes in vegetation composition and water scarcity. According to them, this was because during drought time woody species with leafy fodder are more reliable than grasses; this encourages pastoralists to prefer browsers over grazers. (Aida *et al*., 2018) and (Pepela *et al*., 2019) also reported that pastoralists diversify their livestock species to secure their livelihood and to use scarce resources. Livestock off-take and selling of different livestock products at different stages of a drought's development are also important adaptation strategies used by (68%) of pastoralists, respectively.

According to FGD participants selling of livestock this practice enabled pastoralists to sell their livestock during drought events because animals were unable to resist long dry periods due to a deficiency of feed and water. According to key informants, in times of drought and food shortage livestock off-take is a solution to reduce livestock losses and fulfill the expense demand of families. They prefer to sell shoats (sheep and goats) on a regular basis for small expenses whereas; they hold camels and cows for milk and calf production and sometimes for big expenses such as selling for marriage and weddings. Responses of women in focus group discussions show that selling different livestock products such as milk, butter, cheese, skin and hides was also becoming a crucial source of income during drought.

Tesema and Musa (2020), also found that income generated from different livestock products sold fulfilled and contributed to family expenses. Sending children to school is also another drought adaptation strategy for (54.7%) of pastoralists as a long-term solution. Respondents exposed that education is the base for knowledge and essential for facilitating income diversification through finding jobs in the modern sector and urban economy. Therefore, they mentioned it as a long-term plan for the response to fear which is expected to happen in the future due to drought occurrence.

Key informants revealed that sending children to school is taken as valuable over other adaptation mechanisms. This is because the family which has educated family members has more ability to adapt to drought through employment both in governmental and non-governmental organizations. Similar findings from (Idris, 2011) confirm that sending children to school is a strategy for adaptation to enable an alternative livelihood for pastoral and agro-pastoral communities. Livelihood diversification is also another drought adaptation strategy that is used for fulfilling family needs, managing drought risks and for easier recovery after the event of drought. Livelihood diversification activities being used in the area were employment, petty trades, being a car driver and daily labor. Key informants and focus group participants revealed that these livelihood diversification activities are not used to substitute for livestock production but they adapted to go to- gather with pastoralism. Similarly, (Opiyo, 2015) found that livelihood diversification is an undertaking of many activities to augment resources from livestock production and it is a major drought adaptation strategy of the pastoral community. Youths in focus group participants revealed that participating in employment activities, petty trades, daily

labor and being a taxi driver help them to get supplementary income for themselves and for supporting their families. Pastoralists feed livestock to those unable to move long distances, milking cows and sick animals stay around home- steads. Respondents revealed that storage of fodder from crop residue; haymaking and livestock grazing reserves are other pastoralists' drought adaptation strategies. For this reason, early matured and drought-resistant crop farming and conservation and feeding on crop residue and enclosing certain open grazing land around the homestead, especially for newly born calves and weak animals are also adapted drought response strategies in the study area. . In addition to pastoralists' response mechanisms water distribution and structural development, emergency aid, safety net, training in livestock health, giving veterinary services and credit services were also available response strategies through NGOs and the government. But, these experienced adaptive and coping strategies to drought being constrained by inadequate capital lack of technical knowledge. Generally, the pastoral development interventions need to recognize and take into account the local knowledge of the pastoral community.

CONCLUSION AND RECOMMENDATIONS

Recurrent droughts had consequently affected the livelihood of pastoralist and agro-pastoralists. The effect of recurrent drought among pastoral and agro pastoral communities normally manifests itself in the form of livestock losses and crop failure, which adversely affects the provision of subsistence, income, and other socio- cultural goods and services to a pastoral and Agro-pastoral household. Along the impact of droughts, pastoralists were also facing a mobility constrains as a result of land enclosure, and expansion of agricultural land use which making them more vulnerable since their existence as a pastoral community needs a free movement with their livestock. Pastoral area are more vulnerable than in agro pastoral area due to the pasture land are becoming more degraded, shortage of pasture and water, livestock diseases particularly during the droughts and the spread of *Prosopis Juliflora* and weed species which are invasive plant species were also challenging their pastoralism. Though, all pastoral and agro pastoralists in the study are vulnerable to drought, the problem is more acute on the poor, women, large size family, and children, old and disabled persons. Vulnerability is further aggravated by the decline

in the crop failure, loss of livestock, unemployment, unavailability and inability of most Agro pastoralists to afford agricultural inputs, and selected variety of crop. Recurrent droughts have negatively impacted on pastoral livelihoods.

The results indicated that the perceived effects of drought included loss of livestock asset, crop failure, water scarcity, food shortage and loss of income. Therefore, there is a need to provide farmers with diseases and drought resistant and early maturing crops and livestock breedsWater related interventions such water harvesting during good rainy seasons and improving small scale irrigation farming are paramount if pastoral households need to climate resilient. Enhancing pastoral communities' access to education and awareness programs will improve their understanding of climate change and their ability to implement environmentally friendly adaption strategies.

Pastoral communities in the study area are using many adaptive and coping strategies as a response to drought. From them, mobility, herd diversification, livestock selling, increasing buck or drought livestock and sending children to school were major adaptations strategies. Herd and household splitting, labor migration to town, selling charcoal and fuel-wood, grain storage and old or weak livestock slaughter were also short-term coping strategies as a response to drought. In addition to pastoralists' response mechanisms water distribution and structural development, emergency aid, safety net, training in livestock health, giving veterinary services and credit services were also available response strategies through NGOs and the government. But, these experienced adaptive and coping strategies to drought being constrained by inadequate capital lack of technical knowledge. Generally, the pastoral development interventions need to recognize and take into account the local knowledge of the pastoral community.

Recommendations

Based on the findings and conclusions, the following recommendations are forwarded;

- ✓ It is a paramount to build an early warning system before occurrence of climate related hazards such as drought, diseases and pests. Enhance communities' awareness and understanding about the drought hazards, its vulnerabilities and response mechanisms.
- ✓ Livelihood diversification for those most vulnerable poor pastoral households using existing opportunities.

- ✓ Establish and implement sustainable natural resource management system such as rotational utilization coupled with rangeland preservation.
- ✓ there is a need to provide farmers with diseases and drought resistant and early maturing crops and livestock breeds
- ✓ Enhancing pastoral communities' access to education and awareness programs will improve their understanding of climate change related shocks i.e. drought and their ability to implement environmentally friendly adaption strategies.
- ✓ Preparing long-term adaptation plans based on the sharing of best practices through community participation, civil society engagement, and the participation of academic and research institutions, with regular monitoring to identify promising practices for scaling up.
- ✓ Promotion of development programs and addressing vulnerable groups through development of better proxy indicators of societal vulnerability, like the way vulnerable groups identified in this study, addressing them from short and long term perspectives.

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Gender Role in Agricultural Activities of Pastoral and Agropastoral Communities in Fafan and Jarar of Somali Regional State

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Abstract

Agricultural activities can be important engine of growth and poverty reduction but sector is under performing in many countries in part because women who are often a crucial resource and the rural economy do not participate them and various socio-economic activities although Ethiopian women have played a traditional role of motherhood and home maker in both rural and urban areas. However, their work has never been limited to the house hold and the family and actively involved in all aspects of social life. Women are producers and procreators and they are active participants in the social and cultural activities of the community but the important role they play have not always been recognized. This study was conducted in Somali regional state and it concerned on the assessment of Gender role in agricultural activities and within this study three objectives were analyzed and interpreted. The data shows that the division of labor between men and women is not fair which shows that (71.2%) of work done by women and also the majority of household headed are male compare to female house headed as well as the age of the respondents were between 31-35 years. However, the majority of the crop activities such as land clearing, preparation and cultivation and other related activities were dominated by male which is (87.2%) while the majority of livestock product activities were dominated by male which are (83.3%) and Finally majority of house headed were male compared to female house headed which were the 87% and the family sizes of the respondents were between 1-6 while the age of the respondents further to that the majority of agricultural activities were done by male compare to female. For Further promotion Gender mainstreaming activities and decisions like resource uses must participate by women and Institutionalizing gender sensitive programmers should be developed by government of the Region.

Key words: Gender role, agriculture, female house headed

INTRODUCTION

Agricultural activities can be important engine of growth and poverty reduction but sector is under performing in many countries in part because women who are often a crucial resource and the rural economy do not participate them and various socio-economic activities performed by people are characterized by certain kind of division of labor among which gender dimension is more apparent in the process of social and economic development. People specialize in particular

tasks and hence it is socially accepted that there are men's tasks and women's tasks (Yaekob, 2011).

Ethiopian women have played a traditional role of motherhood, home maker and agricultural production in both rural and urban areas. However, their work has never been limited to the house hold and the family and actively involved in all aspects of social life. Women are producers and procreators and they are active participants in the social and cultural activities of the community but the important role they play have not always been recognized.

Economic development is unthinkable without men participation; however, their participation in the economy hasn't been valued and hasn't received even their share of the nation (Melese, 2011). Somali pastoralist women have a marginalized position in the household. The Somali society is highly patriarchal and the women have less decision-making power within the home. These women feel undervalued saying themselves as "the half of men "and the aim of this project is to assess gender role in agricultural activities.

With this background and justification, this project was carried out with the objective to identify and investigate gender roles in agricultural activities and access to and control over agricultural resources agro-pastoral communities in the Zone.

METHODOLOGY

Description of the area

This study was conducted Fafan zone and Jarar zone and two district such as Gursum and Degahbur were purposively selected from Fafan zones and Jarar zone respectively. The population of the two district Gursum and Dhegahbour is 100,500 and 115,555 peoples respectively (NMSA, 2008).

Sampling technique and sample size

Yamane formula was used to determine the sample size. Then, total samples of 312 agro-pastoral households were selected, from the two kebele were selected (Hoodale and Halahago), by simple randomly sampling technique.

Sources of Data and Data collection

In this study we used both primary and secondary data sources in order to collect necessary information to this study. Primary data was collected through survey questionnaire and secondary source were used to add support concepts and findings from the primary data. Secondary data were collected from project reports, report and information at Woreda level, institutional and official documents, and records on role of gender in agriculture.

Data Analysis

Based on the nature of objectives the data collected were analyzed by using descriptive statistics such as percentage and frequencies.

RESULT AND DISCUSSIONS

The following Table (1) summarized the demographics of the surveyed agro-pastoral households of in the study areas.

Table 1. Demographic of the respondents

Variables		**Frequency**	**Percent**
Sex	Male	187	60
	Female	125	40
Occupation	Trading	10	6
	Housewife	15	9
	Agro-pastoralist	122	78
	Other specify	9	6
Family size	1-3	69	22
	1-6	173	55
	1-10	70	22
Age	31-35	191	61
	36-46	61	20
	47-60	60	19
Marital Status	Married	121	77
	Single	16	10

	Widowed	19	12

Source own survey 2023

According to table 1, the majority of 187(60%) of the respondents were male household headed and the remaining were female head household. This reveals that male are dominants and the family size of the participants were 173(55%) of the respondents had family size of 1-6 persons. On the hand the demographic characteristics of the marital status, majority of the 121(77%) of the respondents were married, 19(12.2%) were widowed, and 16(10.3%) were single. Therefore, the study concludes that majority of the respondents were married.

Table 2. Male and Female Crop Production activities

Crop activities	Hoodaale	Frequency	Percent	Halahago	Frequency	Percent
Land clearing	Male	110	70	Male	112	71
	Female	20	12	Female	30	19
	Both	26	17	Both	14	8.9
Ploughing	Male	136	87	Male	140	90
	Female	10	6	Female	6	3.8
	Both	10	6	Both	10	6.4
Sowing	Male	80	51	Male	68	44.9
	Female	50	32	Female	30	43.6
	Both	26	16	Both	58	43.5
Weeding	Male	85	54	Male	65	41.6
	Female	35	22	Female	45	28.8
	Both	36	23	Both	46	29
Collecting	Male	90	57	Male	86	55
	Female	30	19	Female	52	33
	Both	36	23	Both	18	11.5
Threshing	Male	130	83	Male	145	92
	Female	10	6	Female	5	3.2
	Both	10	6.	Both	6	3.8
Selling crops	Male	21	13	Male	35	22.4
	Female	120	77	Female	105	67
	Both	15	9.6	Both	35	24.4
Selling chat	Male	20	12.8	Male	112	71.7
	Female	122	78	Female	30	19.2
	Both	14	7.6	Both	14	8.9

Source own survey 2023

According to the gender assessment on the agricultural land preparation, cultivation and related activities, the majority of the study of 110(70%) of the respondents were male for the agricultural land clearing and the remaining were female participants. On the other hand 136 (87%) were male participants who ploughing the agriculture land preparation and related issue, while (10%) female only ploughing and (10%) both (male and female) who ploughing the agricultural land

preparation, cultivation, and related issue. Therefore, it concludes that males are the majority who plough the agricultural land preparation and related issues. As well as the majority of the 80(51%) were male sowing for agricultural preparation and related issues, while 50(32%) were female, and remaining portion of the participants were both sowing on the agricultural preparation, and related issues. On the same, the majority of 66(42%) of participants were weeding both, while 55(35.3%) of the respondents were only males weeding and the least 35(22.4%) were female weeding participants on the agricultural preparation. The majority of male 130(83%) were threshing agricultural products, and 10(6%) were female threshing. Therefore, as indicated on the results of the above showed that male is more dominants than female for the agricultural preparation, cultivation and related issues.

As revealed on the above result, the majority of 120(77%) females were selling crops of the agricultural products, while 15(10%) of both (male and female) are selling crops and the remaining were male only selling crops. Therefore, the results of the above depicts that selling crop were the duties of female participants.

Table3. Male and Female livestock production activities

Activities	**Hoodaale**			**Halahago**		
	Sex	Frequency	Percent	Sex	Frequency	Percent
Barn preparation	Male	102	65	Male	86	55
	Female	25	16	Female	45	29
	Both	29	18.5	Both	25	16
Cleaning of the shed	Male	0	0	Male	4	3.8
	Female	150	96	Female	146	77
	Both	6	3.8	Both	6	3.8
Feeding cattle	Male	25	16	Male	27	17
	Female	125	80	Female	82	53
	Both	6	4	Both	47	30
Milking	Male	87	55.7	Male	102	65
	Female	36	23	Female	20	12.8
	Both	33	21	both	34	21.7

Source own survey 2023

The majority of study in Halahago kebele 86 (55%) respondents were said that barn preparation of livestock production were duties of male participants, while female are fewer participants. On the other hand the researcher of this study were asked cleaning of shed and the majority 150(96%) of the respondents in Hoodaale were female while the remaining are male participants. Hence this result depicts that the majority are female. As indicated on the above table, who was responsible on the feeding of cattle and the majority of 125(80%) of the respondents were answered that male are feeding cattle, while (16%) were both and the least portion of the respondents were both of them female those feeding cattle on them. As shown the majority of (56%) respondents were said that male is milking livestock. According the study for assessment

of gender role in the livestock production activities and related issues were done by males compared to females.

Table 4. Male and Female Gender mainstreaming activities

	Hoodaale			**Halahago**		
	Sex	**F**	**%**	**Sex**	**F**	**%**
Boys and Girls chance of getting equal education	Male	89	57	Male	95	60
	Female	19	12	Female	15	9.6
	Both	48	30.7	Both	46	29
Husband and Wife do they get equal training in your village	Male	111	71	Male	112	71
	Female	5	3.2	Female	16	10
	Both	40	25.6	Both	28	17.9
Do husband and wife attend meeting in your village equally	Male	136	87	Male	145	92
	Female	15	9.6	Female	5	3.2
	Both	5	3.2	Both	6	3.8

Source own survey 2023

The majority of male respondents in Halahago kebele 86 (55%) were conducting barn preparation of livestock production, while female are fewer participants. On the other hand, the majority 150(96%) of the female respondents in Hoodaale were cleaning of shed while the remaining are male participants. Hence this result depicts that the majority are female. As indicated on the above table, who was responsible on the feeding of cattle and the majority of 125(80%) of the respondents were male whom are feeding cattle, while (16%) were both sexes. As shown the majority of (56%) respondents were said that male is milking livestock production, while the remaining are both sexes. According the study for assessment of gender role in the livestock production activities and related issues were done by males compared to females.

Table 5. Male and Female Gender decision making over resources

Description	**Hoodaale**			**Halahago**		
	Sex	**F**	**%**	**Sex**	**Frequency**	Percent
Land	Male	135	86	Male	103	66.0
	Female	7	4.5	Female	5	3.2
	Both	14	8.9	Both	48	31
Livestock	Male	110	70	Male	118	75.6
	Female	17	10.8	Female	27	17
	Both	29	18.5	Both	11	7
Extension and input services	Male	83	53	Male	73	46.7
	Female	47	30	Female	28	18
	Both	26	16.7	Both	55	35
Household income	Male	79	50.6	Male	89	57
	Female	67	42	Female	47	30
	Both	10	6.4	Both	20	12.8

Source own survey 2023

Most of the respondents believed that gender decision affected their social activities which according with the findings of Habiba *et al*. (2012). This indicates that 103(66%), 52(33.3%) and 1(0.6%) of the study participants said that very well, male, both and female high respectively have decision for the resources. while the 118(75.6%) of the study participants had male decision livestock and the remaining 37(24.3%) were also female decision on the resources and gender decision and the social activity. As indicated on the table above extension and input services and household income, the majority of the 83(53%), 79(50.6%) were male participants those making decision on the resources for the study are while the remaining are female participants. As indicated on the extension and input services, land ownership and household income, the

majority of are male participants were those making decision on the resources compared to female.

CONCLUSION AND RECOMMENDATION

Finally, majority of house headed were male compared to female house headed which were the 87% and the family sizes of the respondents were between 1-6 while the age of the respondents were 31-35. It concludes that 86% livestock production activities are male compare are female while the majority of crop activities done by male. As indicated on the extension and input services, credit services and household income then the majority of are male participants those making decision on the resources for the study area compared to female.

- Empowering females to participate in decision making process
- In gender mainstreaming activities, it is important to participate males.
- Institutionalizing gender sensitive programmers should be developed by government of the region.
- Males must participated domestic activities that are burdon for the women.

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Factors Influencing the Adoption of Improved Maize Varieties in Shabelley and Gursum Woreda of Fafen Zone, Somali Region

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ABSTRACT

This study examined factors influencing the adoption of improved maize varieties in agro-pastoral communities in the study areas of Fafan Zone. Improved agricultural technology adoption can positively contribute to the welfare of smallholder farmers' households by increasing crop production and productivity. However, the adoption rates remain extremely low in the majority of agro-pastoral communities in the Somali region. The main objective of the study was to assess factors influencing the adoption of improved maize varieties in Shabelley and Gursum woredas. The methods used for this study included both primary and secondary data collection methods. The primary data for the study was obtained from a random sample of 278 rural farmer households and the collected from these respondents were analyzed using descriptive and inferential statistics. Results of the logit model showed that the educational level of the household head, age, income, distance to market, extension contact, access to credit, and total farmland were significantly affected the adoption of improved varieties. The results from the model indicate how a given variable affects the probability of adoption of improved maize varieties. Findings highlight the importance of these variables in the adoption improved maize. The study concludes that if these variables taken into consideration during technology promotion, the likelihood of adoption of improved maize varieties by farmers will be higher. Therefore, promotion of adult education, working with young farmers, creating access to credit are highly recommended.

Keywords: Improved maize varieties, factors, adoption, agro-pastoral.

INTRODUCTION

Agriculture is essential for inclusive development because it produces food as well as economic wealth for many of the world's poorest people whom practice crop production through small-scale farming. Ethiopia's economy is largely depending on the agriculture sector where 34% of the gross domestic product (GDP) and 71% of the employment emanates from this sector. The Crop production subsector accounts for 72% of total agricultural GDP (ATA, 2019). Various studies have been carried out in the area of technology adoption and most importantly on crop technologies.

Several studies have been conducted on the determinants of agricultural technology adoption in Ethiopia as shown by the increasing number of publications (for example, Admassie and Ayele, 2010; Aweke, 2013; Kassa et al., 2014; Ketema et al., 2016). Their findings revealed that different factors such as; demographic, institutional, socio-economic characteristics hindered adoption of improved and/or new agricultural technologies in Ethiopia. As a result, it had not been possible to benefit from existing/new agricultural technologies which would have been contributed to the achievement of national/regional goals such as eradicating poverty, ensuring food security, and overall economic development. A study conducted by Tura et al. (2010) showed that agricultural technology adoption decision of the farmers is influenced by land ownership, credit access, distance to the nearest market, livestock holding. A study conducted by Gebeyehu (2016) also showed that maize adoption decision of the farmers is influenced by access to credit, access to fertilizer, number of oxen owned, frequency of extension contact, radio ownership and agricultural training. Another study conducted by Masresha et al. (2017) on adoption of improved white haricot beans revealed that the decision to adopt white haricot beans variety was influenced by various factors such as frequency of extension visits, land size allocated, agricultural income, price perception, training obtained, and distant to market. Therefore, this study carried out with objectives of identifying the extent and factors influencing the adoption of improved maize varieties such as Melkassa-2 and Melkassa-4.

METHODOLOGY

Description of the Study Area

The specific study area, Shabelley District, is one of the eleven Districts of the Fafan zone. It is located in the northeastern part of the Somali Region, at an altitude of 1600 to 1700 meters above sea level. The area receives an annual rainfall of 500 to 600 millimeters, which is bimodal, with a short rain season from July to September and a main rain season from March to April. The population of Shabelley District is estimated at 157,461 of whom 79,882 are male and 77,579 female (BoFED, 2022).

Within this area, there are two main seasons: *Gu* (wet season) and *Jilaal* (dry season). Within the *Gu* there are three sub-seasons: *Dira'* (late March - late May), *Hagaa* (late May - late July), and *Karan* (late July - late September). The *Jilaal* (late September - late March) can be further divided into two sub-seasons: *Deyr* (late September - late November) and *Kalil* (late November - late March). The area is dependent upon the *Dira'* rains (mid-March – mid-June) and the *Karan* rains (mid-July – mid-September). The *Karan* rains are normally heavier than the *Dira'*. Both sets of rains are equally important for the cultivation and maturation of crops; availability of water and regeneration of pasture for livestock.

Gursum Woreda is found in Fafan zone of the Somali Regional State covering a total area of 937 square Km and bordered in the north Ajersagora, in the east and south-east Jijiga and K/bayah woredas respectively, in the south Babile woreda and in the north-west, west and south-west Oromiya Region.The population of Gursum district has an estimated total population of 27,400 of whom 14,753 are male and 12,647 female (CSA, 2007). Gursum communities relying on herds of camels, sheep, and goats for their sustenance. Sorghum, maize, and ground nut are the main sources of income and food security.

Sampling Procedure and Sample Size Determination

This study was designed as a multi-stage sampling procedure. In the first stage, two woreda such as Shabelley and Gursum were selected purposively based on their potential in maize production. In the second stage, from the selected woredas, three kebeles from each woreda were selected randomly. Before selecting sample respondnts, sample was calculated based

on the population of the six kebeles selected. The sample size was determined using Yamane's (1967) sample size formula; at 6% Precision Level with the Confidence Level of 95%. The total target population in selected kebeles (367,520).

$$\mathbf{n} = \frac{\mathbf{N}}{\mathbf{1+N(\varepsilon^{2})}} = 278 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\mathbf{n} = \frac{\mathbf{367520}}{\mathbf{1+367520(0.06^{2})}} \mathbf{= 278} \quad \ldots\ldots\ldots (2)$$

Where n is the sample size, N is the total target population, and e (6%= 0.06) is the level of precision at a 95 % confidence level.

Finally, 278 households were selected randomly from sample kebeles using probability proportional to the household size sampling technique.

Table 1. Selected kebeles and sampled households per kebeles.

Shabelley District	Sampled Households	**Gursum District**	Sampled Households
Amadhle	45	Kubi jaro	48
Harre	42	Halahago	43
Hadaw	55	Gollmaroodi	45
Total	142	Total	136
		Grand Total	**278**

Methods of Data Collection and Sources of Data

The study used both primary (survey respondents, and focus group discussion participants) and secondary data sources such as materials were used

A formal survey method was employed and data were collected through interviewing sampled respondents by using a structured questionnaire. The secondary data were collected from annual reports, and published and unpublished documents.

2.4. Data Analysis

The study was used both descriptive and inferential statistics to analyze the data. Descriptive statistics, such as frequencies, percentages, mean and standard deviation were used to summarize the collected data. Inferential statistics such as t-test and logistic regression were used to analyze factors affecting the adoption of improved maize varieties.

Binary Logistic Regression model specification

Table 2. Relationship between the Dependent and Independent Variable

Variable description	**variable type**	**Unit of measurement**	**Expected sign**
Dependent variable			
Improved maize adoption	Dummy	1= Improved maize varieties users 2= Improved maize varieties non-users	
Independent variables			
Sex	Categorical	1=Male, 2=Female	Positives
Age	Continuous	Measured in years	Negative
Education	Categorical	1= Illiterate 2= primary 3= secondary	Positive
Family size	Continuous	In number	Positive
Famer's experience	Continuous	In years	Positive
Distance to market		Km	Negative
Access to Extension Service	Dummy	1=Yes, 2= No	Positive
Land size (hector)	Continuous	Hector	Positive
Livestock (tropical livestock unit)	Continuous	Number of productive ages in the households	Negative
Farm income (Birr)	Continuous	Monthly	Positive
Access to credit	Dummy	1=Yes, 2= No	Positive

Logistic regression is an extension of simple linear regression. Where the dependent variable is dichotomous or binary in nature. Logistic regression is the statistical technique used to predict the relationship between the predictors and response variable where the response variable is binary

$$\text{Logit}\left(P_i\right) = \text{Log}\left(\frac{P_i}{1-P_i}\right) = B_0 + B_1 x_{1i} + B_2 x_{2i} + ...B_k x_{ki} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, $B_0, B_1, ...B_k$ are the model parameters for this study, the dependent and explanatory variables are defined as:

$$Y_i = \begin{bmatrix} 1 & if\ the i^{th}\ Techno\log y\ users \\ 0 & other\ wise \end{bmatrix}$$

And also other explanatory variables may be included in my study based on the data collected from the respondents.

RESULTS AND DISCUSSION

Extent of Improved maize varieties adoption

With regard to the extent of adoption of improved maize varieties, 120 (43.2) respondents were improved maize varieties adopters, while the rest of 158 (56.8) respondents were non-adopters. The results indicate the efforts made by Woreda Agricultural Office and field level extension agents' effort towards technology promotion was higher.

Demographic and socioeconomic of the household

The results of this study shows that, out of the total 278 sample households 239 (86%) were male-headed households and the rest 39 (14%) were female-headed households. The proportion of male-headed households was 38.1% for adopters and 61.9% for non-adopters. Whereas, the proportion of female-headed households of the adopters 38.5% was less than the non-adopters which was 61.5% (Table 3).

Regarding the education level of the household head, about 25.9% of sample households had no schooling years at all (illiterate), 24.1% were primary and finally, 50% were secondary education.

Regarding the proportion of adopters, 20.9% were illiterate, 62.6% were able read and write 6.9% were primary school lvel while 69.2% of non-adopter households were illiterate, 30.8% were able read and write. This indicates that adopters were more educated than non-adopters.

Table 3. Demographic characteristics of sample farmers

Characteristics	Response	Adopters		Non-Adopters		Total	
		No	Percent	No	Percent	No	Percent
Gender	Male	91	38.1%	148	61.9%	239	86%
	Female	15	38.5%	24	61.5%	39	14%
Education	Illiterate	14	20.9%	119	69.2%	72	25.9%
	Read and write	87	62.6%	53	30.8%	67	24.1%
	Primary school	5	6.9%	-	-	139	50%

Source own survey 2023

Table 4. Mean distribution of sample farmers by family size, age, and farming experience.

Characteristics	Adopters		Non-Adopters		Total	
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Family size	8.04	3.491	11.13	2.861	9.95	3.456
Age of the household head	34.53	9.85	41.99	10.593	39.15	10.92
Farming experience	15.0377	3.90817	11.8895	4.1186	13.0899	4.06086

Source own survey 2023

Family Size: as we can see from the results, the average family size of sample households was about 9.95 with a standard deviation of 3.456. The average family size of sample adopter and non-adopter households was 8.04 and 11.13 with standard deviations of 3.49 and 2.81 respectively. Hence, the study showed that the family size of non-adoptions is higher that od adopters.

Age of the household head: As indicated in Table 4, the mean age of the sample household at the time of the survey was 39.15 years with a standard deviation of 10.47 which shows that there is a large variation between the ages of sampled households. The age structure of the sample respondents showed that adopters were younger (average age of 34.53 years with standard deviation of 9.85) than the non-adopters (average age of 41.99 years with standard deviation of 10.59). Regarding the difference between adopters and non-adopters in their age, the results show that the adpoters are younger than non-adopters.

Farming experience of the household heads: The farming experience of the farmer is likely to improve the farmers' skill of crop production. The survey result in Table 3 shows that the average farming experience of sample household heads was about 13.089 years with a standard deviation of 4.06. From the entire sample household heads, the average farming experience of adopters was 15.03 years with a standard deviation whereas for non-adopters it was 11.88 years with a standard deviation of 9.46. Hence, the adopters more experienced in farming than non-adopters.

3.3. Economic variables

Agricultural resources mean the land and on-farm buildings, equipment, manure processing and handling facilities, and processing and handling facilities that contribute to the production, preparation, and marketing of crops, livestock, and livestock products. However, in the section, we see land holding, grazing land, and the number of livestock of the sampled household head.

Table 5. Mean distribution of sample farmers by total farmland, Number of livestock owned and market distance

Characteristics	Adopters		Non-Adopters		Total	
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Total farmland owned	6.36	2.5601	4.6733	2.0998	5.3183	2.42572
Number of livestock owned	23.03	4.521	22.4826	17.0779	22.6942	17.21881
Farm income	3,335	32.1420	2,549	72.7419	2,849	68.8096
Market distance	2.71	0.4929	3.3140	0.59749	3.0863	0.62996

Source own survey 2023

Total farmland: As shown in the table 5 the average total farmland of the sampled household head was 5.31 hector with standard deviation of 2.425 which means that there is a large variation between the sampled households regarding their total land. The average total land of adopters was 6.36 hector with standard deviation of 2.560 whereas non-adopters were 4.6733 hector with standard deviation of 2.42. Regarding the average total land difference between adopters and non-adopters indicated that adopters have larger farmland than non-adopters.

The number of livestock holding: Livestock is the farmers' important source of income and draught power for crop cultivation and is one of the main cash sources to purchase production inputs. As indicated in Table 5, the average number of livestock holding in the sample households was 23.037 TLU with a standard deviation of 4.521. Adopters were found to own more livestock than their counterparts. It was observed that adopters of improved maize varieties had livestock holding 25.314 TLU with a standard deviation of 2.2212 and non-adopters had 21.38 TLU with a standard deviation of 2.12. Regarding the mean difference among adoption categories, adopters have larger livestock number than non-adopters.

Farm income

The average monthly income of the sampled household head was 2,849 Birr with standard deviation of 68.8096 which means that there is a large variation between the sampled households regarding their income. The average monthly income of adopters was 3,335 Birr with standard deviation of 32.1420 whereas non-adopters were 2,549 Birr with standard deviation of 72.7419. Regarding the average monthly income difference between adopters and non-adopters indicated that adopters have higher monthly income than non-adopters.

Market distance: The average nearest market distance to sampled household heads were 3.0863 kilometers with standard deviation 0.62996. The average market distance of adopters was 2.7170 kilometers with the standard deviation of 0.49290 whereas non-adopters was 3.3140 kilometers with standard deviation of 0.59749. Regarding the average market distance difference adopters reside nearer to market when compared to non-adopters.

Institutional characteristics

Table 6. Institutional variables

Characteristics	Response	Adopters		Non-Adopters		Total	
		No	Percent	No	Percent	No	Percent
Access to Credit service	Yes	18	27.3%	48	72.7%	66	23.7%
	No	88	41.5%	124	58.5%	212	76.3%
Access to Extension service	Yes	11	40.7%	16	59.3%	27	9.7%
	No	156	62.2%	95	37.8%	251	90.3%
Access to Market price information	Yes	104	41.4%	147	58.6%	251	90.3%
	No	2	7.4%	25	92.6%	212	9.7%

Source own survey 2023

Access to credit is one way of improving farmers' access to new production technology. Farmers' ability to purchase inputs such as improved seed and fertilizer is particularly important. If appropriate technology is available but not being used by farmers, then the way credit is handled by the government may be part of the problem. The formal sources of credit in Somali microfinance according to the study result only 23.7% of the total sampled households had received credit service from microfinance institutions whereas 76.3% of the sampled households had not received any credit service from any institution. Moreover, no formal credit lending institutions are available. The study result found that 27.3% of adopters and 72.7% of non-adopters of improved sorghum get credit from informal sources. Out of all respondents, 41.5% of adopters and 58.5 % of non-adopters didn't receive credit from formal sources. As indicated in Table 6, non-adopters received more loans than adopters of improved varieties. This was because of those non-adopters received loan for small business enterprise establishment.

One important factor in the adoption of improved varieties is the availability of useful and reliable extension services. In connection to this, the survey result shows that 9.7% of the sampled respondents had been visited by extension agents in the year 2014-2015 main cropping season while 90.3% of the sample respondent had not been visited by extension agents. This was because the majority of extension agents in the study area were not present on their duty during the entire year. This was caused due to restructuring of the regional system.

According to the results, 90.3% of the sample household responded that they got market information while only 9.7% of respondents were not get any information related to market price further the study results show that 41.4% of the adopters and 58.6% of non-adopter had obtained market information while 7.4% of the adopter and 92.6 of non-adopter had not obtained market information which indicates the majority of sample household in the sampled study area had good information access related to the market.

Factors influencing the adoption of improved maize varieties

A total of 11 explanatory variables, of which five categorical and six continuous, were included in the logit model. The maximum likelihood estimate result of the logit model is summarized in Table 7 below. Out of 11 explanatory variables, seven variables were found to be significantly

determined adoption of improved maize varieties. The significant variables were the educational level of the household head, age, income, extension contact, access to credit, distance to market, and total cultivated land. The results from the model indicate how a given variable affects the probability of adoption of improved maize varieties.

Table 7. Results of logistic regression model

Variables in the Equation				
	B	Wald	Sig.	Exp(B)
Age	-0.081	9.175	0.002*	0.922
Sex	1.2	8.589	0.26	0.042
Income	0.018	4.892	0.027*	2.018
education level	0.947	1.464	0.026*	2.578
Farming experience	0.055	3.284	0.20	0.56
Total cultivated land	0.380	11.682	0.001*	1.462
Credit service	1.586	5.243	0.022*	2.05
Extension service	0.859	.748	0.387*	2.362
Market distance	-0.061	8.175	0.001*	0.822
Family size	0.050	6.23	0.62	1.051
Livestock owned	-33.682	9.645	0.789	0.142
Constant	56.559	4.496	0.000	0.34
$\chi 2$			227.276	
-2 Log likelihood			142.294[a]	
Correct prediction of all samples			89.6%	
Correct prediction of adopters			86.8%	
Correct prediction of non-adopters			91.3%	
Nagelkerke R Square			75.9%	

The likelihood ratio of the chi-square result revealed that the overall fitness of the model was found to be significant at a 5% probability level. According to Wooldridge (2002), the logit model coefficient gives signs of the partial effects of each explanatory variable on the response probability of the dependent variable. Detail of significant variables from this model is discussed as follows.

Age of the household head: according to the study result Age had a negative and significant influence on the adoption of improved varieties. Other variables held constant, as the age of the household increases by a year, the adoption of improved varieties decreases by 7.8%. The result implied that younger household heads are optimistic and eager to test new technologies. This result in accordance with the findings of Aman and Tewodros (2016), and Udimal (2017) in that younger farmers are more likely to adopt new technologies compared to older farmers.

Monthly income: monthly income positively and significantly influenced the intensity of using improved maize varieties. Other variables held constant, one birr increase in monthly income of the household, the adoption of the improved verities is increased by 2.018 times. This result showed that households with relatively higher monthly income are able to buy farm inputs to run maize production effectively and/or able to buy household expenditure during crop failure. This result goes along with the previous studies by Aman and Tewodros (2016), Ousmane and Nafiou (2019) and Hawas *et al*. 2023. In their studies, they found that an extra income obtained enhances the farmers' ability to allocate required inputs to improved varieties.

Education level of the household head: The education level of the household head was found to be positive and significantly influenced the adoption of improved varieties. Keeping other variables constant, as the education increases by one unit, the probability of adoption of improved varieties is increased by 2.578. This implied that literate farmers are more likely to adopt improved varieties than those who are illiterate. This might be due to relatively literate farmers having more access to information, being capable of interpreting and analyzing information, and becoming aware of new technology than illiterate farmers. The result could also be due to literate farmers being more rational and analyzing the benefits of the new technology. Alene (2000) Tura *et al*. (2010) and Bayissa (2014) reported that as education level increases the probability of adoption of new agricultural technology by farmers will also increases.

Total cultivated land: According to the study results, total land owned by the household was found to positively and significantly influence the adoption of improved varieties. Other variables held constant, each one hector increase in total cultivated land would result an increase in 1.462 of the probability of adoption of the improved varieties. Farmers who allocate large area of land for maize production will high production of crop and income when compared to those who allocated less area of land. As stated by Yu and Nin-Pratt (2014), Ousmane and Nafiou (2019) and Muluken *et al*. (2021) farmers who allocate a higher proportion of cultivated land for their crops are more likely to use improved technologies and get more amount of production than those farmers with a smaller proportion of cultivated land.

Credit service usage: It positively and significantly influenced the adoption of improved varieties. As households' credit use increases by one unit, the probability of adopting adoption of improved varieties increases by 2.05. The probable reason could be with more financial resources available for crop production, farmers can able to buy required inputs and thereby able to produce more. This result is in agreement with the findings of Gebeyehu (2016), Udimal (2017) and Hawas *et al*. 2023.

Extension service: The result of the logistic estimate concerning extension contact showed that there is a positive and statistically significant influence in the adoption of improved varieties. It was found that household head farmers who more contact with extension agents adopted technologies more than others. More specifically, as one unit increases of contact to extension, the odds in favor of adopting an improved sorghum package increase by a factor of 2.36. This agrees with the findings of Genius et al. (2013), Gebeyehu (2016) and Melese (2018) who found the speed of adoption is greatly influenced by the frequency of technical information received from extension agents.

Market distance: according to the study result market distance had a negative and significant influence on the adoption of improved varieties. Other variables held constant, as the market distance increased by one kilometer, and the probability adoption of improved varieties decreased by 17.8%. The result implied that households with near-distance to markets will access to market information than those reside far from the market. The possible reason might be farmers nearer to the market center have access to a market where they can easily access input for their agricultural production and sell their output for the market than those at a far distance.

Far market forces farmers to incur more costs to travel, and spend more time and energy. The result is in accordance with Aman and Tewodros (2016) and Bekele (2020) households who found at near-distance to market are more likely to adopt improved varieties than those who found at long-distance to market.

CONCLUSION AND RECOMMENDATION

From the results of the study, we found it possible to draw the following conclusions. First, it was found that household characteristics, total cultivated land, and institutional factors are the main determinants of adopting improved agricultural technologies verities. According to the study result Out of 11 explanatory variables, eight variables were found to significantly determine the adoption of improved varieties. The significant variables were the educational level of the household head, age of the household head, monthly income, extension contact, market distance, access to credit, and total cultivated land. The results from the model indicate how a given variable affects the probability of adoption of improved varieties. Second, the study revealed that adoption of improved agricultural technologies verities is found to be less in areas which are located farther distance to the nearest input market and have more farming experience with larger size of land. The area that is far from the market fails to get timely access to inputs and accessibility will become costly. Indeed, farmers cannot visit continuously due to their distance problem. Likewise, households with lots of farm experience are associated with more likelihood of adoption. High monthly income and access to credit are important to reduce the financial shortage of farmers. When there is financial scarcity, financial relief can be made by using income from monthly sell of maize and claiming credit.

Based on the results the following recommendations are forwarded:

- Institutional factors like extension and credit are found the most important factors which increase the likelihood of adoption. Thus, at most attention should be made on the provision of credit service and the frequency of extension workers visits at field as per the plan. Strengthening the technology popularization through demonstration to increase the extent of adoption is also important. Furthermore, the distance to market negatively affects the probability of adoption. Access to information makes farmers to be aware of and get better understanding of improved agricultural technologies, which facilitates change in the behavior of farmers and ultimately leads to decision to take risk for

technology adoption. Farmers who are nearer to market can obtain information regarding agricultural inputs, such as improved sorghum seed, fertilizers and pesticides etc. Hence, alternative ways of providing market information can facilitate the transfer of new agricultural technologies to farmers who reside far from market.

- Farm size is also found to affect the adoption of improved maize varieties positively and significantly. This is due to the fact that farmers owning larger farmlands can allocate a portion of their land to test improved crop production technologies. Therefore, targeting farmers owning larger farm size may enhance the adoption and facilitate the dissemination of new agricultural technologies.
- Since younger farmers have a high rate of maize adoption, for increasing the extent of adoption, the extension agents has to work more with younger farmers.
- Education is one the factors that influenced the adoption of improved maize. Therefore, adult education service has to be delivered, especially at farmers training centers.

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ISBN 978-99990-0-417-6

