Regional Review Workshop on Completed Research Activities

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Preface

Oromia Agricultural Research Institute (IQQO) has six research directorates whose mandate is contributing to the growth of agricultural productivity and hence poverty reduction through generation of suitable agricultural technologies. Livestock research directorate is one these directorates with a general objective of generating and adopting improved livestock technologies the use of which increases the productivity and production of diverse livestock species and hence improve the livelihood of communities.

To fulfill its objective, the directorate has been organized into six research teams, namely Dairy, meat, apiculture, poultry, fisheries, and animal feed resources and rangeland management research teams. Each of these teams generate suitable technologies related to the commodities they address. Currently one or more of these research teams operate in ten of the seventeen research centers of IQQO. Dairy and meat research teams operate in three research centers namely, Adami Tulu and Bako Agricultural Research Centers and in Yabello Pastoral and Dryland Agriculture Research Center. Feed resources and range land management as well as apiculture research teams operate in eight research centers namely, Adami Tulu, Bako, Sinana, Mechara, Fedis, Haro Sabu and Bore Agricultural Research Centers and in Yabello Pastoral and Dryland Agriculture Research Center. In addition, apiculture research is also undertaken in Holeta Bee Research Center. Fishery research team currently operates only in Zeway Fishery and Oher Aquatic Resources Research Center, where as poultry research team operates in Adami Tulu and Bako Agricultural Research Centers.

From each of the above mentioned teams, a number of research activities are annually completed as a result of which physical technologies as well as valuable information are released. Recognizing the importance of reviewing these completed activities at institute level and compiling them as proceeding, the first such proceeding was published last year. This is the second proceeding of the directorate and comprises activitities completed in 2016/17. The proceeding contains a total of 25 research results (3 from dairy research team, 4 from meat research team, 1 from poultry research team, 5 from feed resources and range land management research team, 4 from apiculture research teams and 8 from fisheries resources research team). The information provided in each of these research results are valuable for different beneficiaries depending on the interest, the level of understanding and the resources they have to utilize the technologies or the information provided.

Dairy Research Results

Assessing feed quality and evaluating milk yield and economic profitability of dairy rations formulated from locally available feed resources in Dugda district

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Abstract

The study was conducted in urban and pri-urban areas of Dugda district, East Shoa zone, with the objectives of assessing major available feed resources and evaluating biological and economic benefits of formulated rations prepared based on locally available feed resources. A single visit survey was used to collect data on feed availability and socio economic status of 60 dairy producers. On-farm feeding trial was conducted on fourteen early lactating crossbred cows of uniform parity using Randomized Complete Block Design (2 treatments & seven replications). Average body weight and initial milk yield of cows were 327±14.2kg and 7.89±0.82kg/cow/day, respectively. The treatment groups included 50% wheat bran + 30% linseed cake + 18% molasses + 2% salt + adlib wheat straw (T1) and 68% wheat bran + 15% cotton seed cake + 15% Atela + 2% salt + adlib wheat straw (T2). From the survey, average household size was 6.54±0.41 persons and the average land holding size in the study area was 0.059±0.04ha. The major dairy animal feed resources identified in urban and peri-urban areas were natural pasture, wheat straw, teff straw and maize stover as basal feed, whereas wheat bran, linseed cake, cotton seed cake, molasses and atela are the major concentrate feeds. The on-farm feeding trial result showed a non-significant difference (P>0.05) between two rations formulated from locally available feed resources in terms of total dry matter intake and daily milk yield. The net return/cow/day was high in cows supplemented with T2. In general, the results of this experiment showed that dairy producers can formulate dairy rations from locally available feed resources to improve milk yield and daily income. Finally, cows fed 68% wheat bran, 15% cotton seed cake, 15% atela and 2% salt, produced similar daily milk yield but high net return/cow/day was obtained from cows fed 50% wheat bran, 30% linseed cake, 18% molasses and 2% salt.

Key words: ration formulation, local feeds, dairy cows, economic benefit, Dugda district

Introduction

Milk production on the basis of indigenous cattle is not a fast means to meet the increasing demand for milk and milk products. Thus the use of crossbreds is a suitable option as it combines the adaptability of the indigenous strains to poor nutrition, heat stress and disease challenges with the high milk production potential and better character of the exotic breeds (Beyene, 1992; Ayinalem *et al*., 2009). Keeping crossbred cows at on-farm condition was reported to be profitable (Temesgen and Tadele, 2000). To express their genetic potential however, crossbred cows require a more elaborated feeding including from both roughage and concentrate feeds. Results of previous on-farm studies indicated that adequate level of concentrate supplementation to crossbred cows increased feed intake and milk production (Dejene *et al*., 2009; Efrem *et al*, 2010; Tekeba *et al*., 2013).

Urban and peri-urban dairy producers depend substantially on concentrate feeds to supplement crossbred cows. However, the high cost and lack of knowledge in providing balanced ration is a limiting factor in urban and peri-urban dairy production systems of the country. Hence, previous studies indicated that dairy cows in urban and peri-urban production systems do not meet their energy and protein requirements and hence perform below their genetic potentials (Nega, 2006; Dereje, 2012; Nigusu, 2012; Girma *et. al*, 2014).

In milk production systems which do not rely heavily on pasture grazing and fodder crops to provide cow nutrition, the milk price/concentrate price ratio (MCR) is an important indicator of the economic viability of the dairying (Staal, and Shapiro, 1996). Strategic formulation of different ingredients in a manner to furnish the cow with nutrients in a balanced proportion and to reduce the cost of milk production therefore is desirable (Chilliard, 1999). Most of the research works on the assessment of feed resources in different parts of the country so far conducted only indicated the shortage of feeds without indicating the quality of feeds available to that particular area. This creates a great problem to recommend a possible solution to livestock producers particularly in the extreme drought seasons in Ethiopia. Therefore, it is very much imperative to assess the already existing feed resources so that it would be very easy to suggest either improving the existing feed resources, introduce other feed alternatives or suggest development for each production system. This particular study is therefore, carried out with the following objectives.

Objectives

- To assess major available feed resources in Urban and Peri-urban areas of Dugda district
- To evaluate biological and economic benefits of formulated rations prepared based on locally available feed resources

Materials and Methods

Study area

The study was conducted on urban (Meki) and peri-urban (Weyo Gebriel and Bekele Girissa) dairy farm owners in and around Meki town of Dugda district, Ethiopia. Dugda district lies between $7^{o}58'$ N and $38^{o}43'$E and the altitude ranges from 1600 to 2100masl in the great rift valley of Ethiopia (Deressa, 2013). The district shares boundary line with Bora woreda in the north, Arsi in the east, Adami Tulu Jido Kombolcha district in the south and Southern Nation Nationalities Peoples of Ethiopia (SNNP) in the west. The Capital town of the district is Meki which is located 134km from Addis and 88km west of Adama.

Experimental Procedures

The study had two parts where part I covered extensive assessment (cross sectional survey) to generate baseline information on socio economic situation of dairy farm owners and available feed resources in urban and peri-urban areas, while part II deals with conducting on-farm feeding trial on crossbred dairy cows in Dugda district.

Part I. Cross sectional survey

The cross sectional survey study was conducted to generate baseline information in the study area.
For this study a total of 60 dairy farms, of which 28 from urban and 32 from peri-urban dairy systems were purposively selected.

Sampling methods

A preliminary visit was conducted in the study area to get general picture of the study sites and to identify the target farms. Thus, dairy farms in Meki and two associated peri-urban areas were purposively identified based on their potential to keep crossbred dairy cows.

Data collection procedures

Following identification of dairy farms, semi-structured questionnaires were developed and pre-tested before commencement of the actual survey. Information was gathered by interviewing the household heads. Survey study was conducted from October 15 to November 15, 2016, and each dairy farm was visited once.

Part II. Ration formulation and feeding trial

Selection of farmers and experimental animals

Fourteen volunteer farmers who own early lactating crossbred dairy cows and willing to conduct the experimental procedures were selected for the on-farm feeding trial. The selected farmers and development agents were trained on the experimental procedures and data recording. Five farmers from peri-urban and nine from urban production system were selected based on availability of the required cows (early lactation stage), uniformity of their farms and close proximity to each other.

Fourteen early lactating crossbred cows with average body weight of 327±14.2kg ranging from 235 to 395 kg with an average initial milk yield of 7.89±0.82/cow/day ranging from 6.0 to 11.0kg/cow/day. The animals were divided into two equal groups (7 cows in each groups) based on the level of milk yield, parity, body weight and condition.

Preparation of experimental feeds

Ration formulation was done based on the result obtained from the feed resource assessment carried out in the district. The rations were formulated taking locally available feed resources as main ingredients in such a way that the formulated ration was assumed to fully meet the requirement for major nutrients of target animals as described in NRC (1990). The rations were evaluated through feeding trials having two treatments which compare supplementary dairy ration consisting of 50% wheat bran + 30% linseed cake + 18% Molasses + 2% salt + *adlib* wheat straw (T1) and 68% wheat bran + 15% cotton seed cake + 15% *atela* + 2% salt + *adlib* wheat straw(T2).

The quantity of supplemental feeds offered daily was at the rate of 0.5 kg/liter of milk produced by each cow. The basal feed offer was adjusted daily by allowing 20% of refusal from previous day's intake. The study was done for 105 days including 15 day adaptation period (from December, 2016 to March 2017).

Table1. Experimental treatments

Feed ingredients	% by treatments	
	T1	T2
Wheat bran	50	68
Linseed cake	30	0
Molasses	18	0
Cotton seed cake	0	15
Atela	0	15
Salt	2	2
Total	100	100
CP%	18%	18%
Wheat straw	*Ad-libitum*	*Ad-libitum*

Atela = residue of locally produced beverage
Ad-libitum = free access

Adjustment of the supplemental feed was made weekly based on the milk yield of each cow at the rate of 0.5kg/kg of milk production/day and fed in the morning and evening which is in the milking time by dividing the daily allowance into two equal parts. Farmers followed indoor feeding. The experimental cows were allowed free access to water throughout the experimental duration. The dry matter of the basal and supplemental diet was estimated at the initial stage to feed the animals on dry matter basis.

Management of Experimental Animals

The trial was implemented under farmers' management with full follow-up by trained enumerators. All the cows were drenched with broad-spectrum anti-helminthics (Albendazole2500mg) prior to the start of the experiment. All the farmers' daily routine activities were continued during the experiment period. Milking was performed by the farmers. Before milking, calves were allowed to suckle for about 1 minute to initiate milk let down and after milking for the remaining milk.

Monitoring and data recording

Field visits were carried out every two weeks to monitor the feed intake and milk yield of the animals. The body weight of the cows were measured every month by using heart girth measurement. The enumerators daily recorded the intake of roughage and concentrate and milk yield on pre-designed data recording sheet.

Laboratory analysis of experimental diets

Representative samples of feed resources commonly employed by the farms during the study period were collected monthly and samples of the same feed type were bulked together. They were thoroughly mixed and sub sampled. Wet feed materials were allowed to lose moisture under shed before transportation. The air dried samples were taken to Holetta Agricultural Research Center
nutrition laboratory and dried in an oven at 60^{o}C for 48 hours and ground in Willey mill to pass through 1mm sieve and allowed to equilibrate at room temperature for 24 hrs. The ground samples were kept in air tight containers pending analysis for chemical composition. Feed samples were analyzed for DM and Ash using the standard procedures of AOAC (1990). Nitrogen (N) content was determined by Kjeldahl method and Crude Protein (CP) was calculated as N*6.25 (AOAC, 1995). The organic matter was calculated as difference between 100 DM and ash content. Acid Detergent Fiber (ADF), Acid Detergent

Lignin (ADL), Neutral Detergent Fiber (NDF), and In vitro Digestible Organic Matter in the Dry Matter (IVOMD) was determined by the modified Tilley and Terry method (Van Soest and Robertson, 1985). Metabolizable Energy (ME) content of a particular feed was estimated from IVOMD and as per the following equations:

ME (MJ/kg DM) = 0.15* IVOMD (g/kg) (McDonald *et al*., 1995).

Statistical analysis

Data collected during the survey were analyzed using Statistical Analysis System Software (SAS, 2008). The results were presented as Least Square Means and Standard Error (LS Means ± SE) and significance was declared at ($P<0.05$) unless stated otherwise. The statistical model used for data analysis was:

$Yij = \mu + Fi + eij$

Where, Y = Milk yield and feed intake
μ = over all mean
$Fi = i^{th}$ supplementary feed
eij = random error

The economic evaluation was based on calculations of the total cost of supplemental concentrate and the basal diet. The milk price was fixed, based on the local market price in the study area, which was 13 ETB/liter. The price for the concentrate, wheat straw and milk was obtained from the local market price. To come to the final conclusion of economic analysis, calculation of partial budget analysis was done. This step includes calculation of total cost of production/cow/day, mean milk yield/cow/day, price of milk/cow/day, cost of production/liter of milk and return/cow/day. Return was calculated as the product of mean milk yield/cow/day and price of milk/cow/day. Net return was calculated as the difference of return/cow/day and the cost of production/cow/day.

Results and discussion

Part-I. Cross sectional survey

Socio-economic characteristics

The average household size of the selected respondents was 6.54±0.41 persons. The average household size observed in this study was smaller than reported by Zewudie (2010) who found average value of 10.5±0.6 persons per family in Zeway area. In this regard, the smallest family size reported in this study has a positive effect on the average landholding size of the respondents. On the other hand this result was similar with 6.5±0.3 persons per house hold reported for small scale dairy farms in Shashamane city (Girma *et al*., 2014). Male headed farms accounted for 54% while the rest were headed by females.

Education plays an important role in the adoption of new interventions. In this background, educational level of the targeted households may have important status in identifying and determining the type and method of intervention works needed to be implemented. The result of the current report showed 14% illiterate, 40% and 39% attended primary and secondary school, respectively, while 7% of the household heads completed above secondary school. The result of the current report was lower than 18% illiterate

and much higher than 1.7% above secondary school reported for Zeway area (Zewudie, 2010). This was attributed to better chances of education and establishment of schools in urban and peri-urban areas of Dugda district. This shows the growing of educational coverage which provides better chance to implement improved agricultural practices in the study area.

The average land holding size of the respondents was 0.059±0.04ha which is much less than 3ha reported for the same district (Deressa, 2013) and 2.5ha of the national land holding size. The difference might be due to the reason that the current study focused on urban and peri-urban areas, while the previous study was reported for the whole district. This has negative implications on livestock production and household income. All farmers in peri-urban areas allocated land for crop and livestock production while farmers in urban areas use lands for improved dairy animals' production.

Feeds and feeding

Feeds are the major inputs in dairy animal production activity. Natural pasture, wheat straw, teff straw and maize stover are the most available roughage feed sources noted from this study, whereas wheat bran, linseed cake, cotton seed cake, molasses and *atela* are the major concentrate feeds commonly used in urban and peri-urban areas of the district. This finding is in line with the report of Zewudie (2010) who indicated that the major basal feed resources for cattle in mid-rift valley of Ethiopia. Two major feeding systems were identified in the study area: semi-intensive and stall feeding/zero grazing.

Part II. Ration formulation and feeding trial

Chemical composition of experimental feeds

The chemical composition and IVOMD of treatment feeds given to experimental animals is presented in Table 2. The crop residues are of low nutritional value and below the quality to meet the nutritional requirement of dairy animals (Kearl, 1982). The dry matter (DM) content of all crop residues was above 90%, which corresponds with Zewudie (2010) and Girma *et al*. (2014). All crop residues evaluated had lower CP contents than the minimum level of 7% CP required for optimum rumen microbial function (Van Soest, 1982). Crop residues are normally characterized by low digestibility and energy value, which are both inherent in their chemical composition. The In-vitro organic matter digestibility (IVOMD) for cereal crop residues ranges from 40.2% in wheat straw to 52.6% in teff straw. The lower crude protein and metabolizable energy content for crop residues can be compensated with strategic supplementation of concentrate feeds to improve animal performance.

Metabolizable energy (ME) of wheat bran, molasses and *Atela* varied from 12.22 to 14.97 MJ/kg DM (Table 2). Molasses had the lowest CP content as compared to wheat bran and *Atela*. The nutritional values for the current feeds are compatible with the report of Girma *et al.* (2014); Zewudie (2010) for Shashamane milk shed and mid rift valley, respectively.

Among the protein supplements, *Atela* had slightly lower CP (21.9%) than cotton seed cake (38.7%) and linseed cake (29.4 %). The ME contents of protein supplements were not much different. The energy content, protein content and IVOMD in protein supplements were high though slightly lower than the reported thresholds (Seyoum *et al*., 2007) for good quality protein supplements of (CP = 32.6%), (IVOMD = 65.5%) and (ME = 10.2 MJ/kg DM).

Table 2. Chemical composition of major available feed stuffs in study area

Feed staff	DM (%)	Chemical composition (% DM)						
		Ash	OM	NDF	ADF	CP	IVOMD %	EME (MJ/kg DM)
Wheat straw	92.1	9.5	90.5	79.6	57.4	3.2	40.2	6.03
Teff straw	93	9.2	90.8	81.2	47.8	4.32	49.8	7.47
Maize stover	93.6	9.3	90.7	82.13	51.72	4.5	58.6	8.8
Wheat bran	87.2	4.8	95.2	45.8	8.4	17.2	81.5	12.22
Linseed cake	93.4	8.6	91.4	29.2	9.55	29.4	68.4	10.26
Cotton seedcake	92.1	7.7	92.3	49.2	21.2	38.7	59.6	8.94
Molasses	73.2	19	81	-	-	3.88	99.82	14.97
Atella	18	5.5	94.5	61.5	21.8	21.9	85.92	12.88

DM= dry matter, OM= organic matter, NDF=neutral detergent fiber, ADF= acid detergent fiber, CP= crude protein, IVOMD = In-vitro organic matter digestibility, EME= estimated metabolizabe energy

Dry matter intake (DMI) and daily milk yield of experimental cows

There was no significant difference (P>0.05) between treatments (T1 and T2) in daily concentrate, roughage and total dry matter intake (Table 3). Intake of feed by ruminant can be improved through concentrate supplementation (Quang *et al*., 2015). Addition of CP supplement may stimulate efficient rumen fermentation, more passage rate and intake (Beigh *et al.*, 2017). This implies the presence of direct relationship between CP content of feeds and feed intake. Previous report (Tekeba *et al*., 2013) showed improvement in the daily total DM intake due to supplementation. This may be attributed to the ability of the supplements to provide nitrogen and energy for the cellulolytic microbes upon degradation in the rumen (Martono *et al*., 2016) and increases the nitrogen content of the total diet, which in turn is likely to increase feed intake and the rate of degradation of the basal diet in the rumen (Ranjhan 1997). When the rate of breakdown of digesta increases, feed intake is accordingly increased (Van Soest, 1982).

The average daily milk yield/cow/day is indicated in Table 3. There was no significant difference (P>0.05) between treatments (T1 and T2) on daily milk yield of lactating cows. Cows supplemented with T1 and T2 have had milk yield of 9.3L±1.2 and 9.5± 0.55L, respectively. The similarity in milk yield among treatment groups is attributed to the balanced nutrient contents in the formulated ration particularly crude protein and energy contents (Adebabay, 2009). The milk yield reported in this study is higher than 7.7 ± 0.06 liter of milk reported for HF*Boran crossbred cows fed mixed rations made from locally available feed sources (Rehrahie *et.al*, 2003). The difference might be related to the blood level of crossbred cows.

Table 3. Effect of treatments on daily milk yield, concentrate intake, roughage intake and total feed intake (Mean ±SE)

Independent variables	Dependent variables			
	CDMI (kg)	RDMI (kg)	TDMI (kg)	Daily milk yield (Liter)
Treatment 1	6.6 ± 0.48^{a}	4.3 ± 0.26^{a}	10.9 ± 0.74^{a}	9.3 ± 1.2^{a}
Treatment 2	6.57 ± 0.2^{a}	4.35 ± 0.18^{a}	10.93 ± 0.36^{a}	9.5 ± 0.55^{a}

[aa] Means in the same column sharing similar letters of superscripts are not significantly different (P>0.05); SE=standard error; CDMI= concentrate dry matter intake, RDMI= roughage dry mater intake, TDMI= total dry matter intake

Economic evaluation of treatment feeds

The cost-profit analysis of this study is indicated in Table 4. The economic evaluation was based on calculations of the total cost of supplemental concentrate feed, the basal diet and labor costs. The supplementation of ration formulated from locally available feed in the study area proved to be economically beneficial (Table 4). Though feeding both rations to lactating cows increased net profit to dairy producers, supplementing T2 to lactating cows appeared more cost effective since it had a numerically lower cost/liter of milk and high net return.

The net return obtained from T2 was higher (ETB 73.34/cow/day) than T1 (ETB 67.65/cow/day) due to lower cost of milk production/cow/day. Hence, this study demonstrated that formulation of concentrate feeds from locally available feed source to crossbred cows increased the net profit for farmers. The difference in net profit might be due to low cost of cotton seed cake and *atela* compared to linseed cake and molasses while supplementing higher protein and metabolizable energy to lactating cows.

Table 4. Economic evaluation of feeding two rations formulated from locally available feed sources in lactating crossbred dairy cows

Variables	Treatment 1	Treatment 2
Cost of roughage feed, ETB	1750	1925
Cost of supplement, ETB	3046.07	2528.28
Other costs, ETB	840	840
Total variable cost, ETB	5636.07	5293.28
Cost/cow/day	53.67	50.41
Cost/cow/L of milk, ETB	5.77	5.3
Net return/cow/day, ETB	67.67	73.34
Net return over T1/cow/day, ETB	-	5.67

Conclusion

The results of this experiment showed that dairy producers can formulate dairy rations from locally available feed resources for improved milk yield and economy. Therefore, cows fed 68% wheat bran, 15% cotton seed cake, 15% *atela* and 2% salt, produced similar daily milk yield, but high net return/cow/day was obtained when cows fed 50% wheat bran, 30% linseed cake, 18% molasses and 2% salt. But, there is a need for long-term studies on the response to feeding of the intervention diet on animals' production and reproduction performance under farmers' condition that may provide information beyond the short-term responses observed in the present study.

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Effect of Urea Treated Maize Stover on Voluntary Feed Intake, Milk Yield and Milk Composition of Crossbred Dairy Cows Supplemented With Concentrate Diet

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Abstract

A study was conducted at Bako Agricultural Research Center to evaluate the feeding value of urea treated and untreated when offered as basal diet on voluntary feed intake, milk yield and composition of crossbred dairy cattle. Eight dairy cows (Horro X Friesian) with similar milk yield, early stage of lactation, similar parities were used in a switch over 4X4 double Latin square design. There were four periods each composed of 30 days, 15 days for acclimatization and the remaining 15 days for data collection. Treatments were urea treated and untreated maize stover at install fed and free grazing with supplementation. The basal diets were fed ad libitum. All animals were fed concentrate mix (49.5% maize grain + 49.5% noug seed cake + 1% salt) at a level of 0.5 kg/l of milk. Results of chemical analysis of the experimental feeds indicated that urea treated maize stover (CP=9.97%, ME=9.21 (MJKg^{-1}DM) had better nutritive value than untreated maize stover (CP=5.78% and ME=5.83 (MJKg^{-1} DM). The daily DM, CP, and ME intake were significant (P<0.05) among the treatments with the highest intake observed when cows were fed urea treated maize stover (T3). Daily milk yield was higher (P<0.05) for T3 (7.86) as compared to T1 (5.34 l/d). Composition of all milk constituents were not significantly (P>0.05) different among dietary treatments. Mean daily live weight loss was not significantly (P>0.05) different among treatments. Economic analysis indicates that use of urea treated maize stover as basal diet results to better economic gain than when other treatment is used. Therefore, the result demonstrated that urea treated maize stover had better feeding value as compared to urea untreated maize stover for crossbred lactating dairy cows and can be conserved and used especially in the dry season when conventional roughages are in short supply and low in CP content.

***Key words**: Basal diet, Crossbred, Intake, maize, Stover, Ruminant and urea*

Introduction

In developing countries livestock sector is highly dynamic to meet rapidly increasing demand for livestock products. This demand is largely driven by human population growth, income growth, urbanization and the production response in different livestock systems. The main constraint facing small scale dairy farmers in smallholder mixed farming, pastoral and agro pastoral production systems across East Africa is the inability to provide sufficient quantity and quality feeds to their livestock on a consistent basis (Hall *et al.,* 2008). The major feed resources in Ethiopia for ruminants are natural pasture and crop residues; which are categorized as poor quality roughage with low intake (Berhanu *et al.*, 2009),

due to their tough texture, poor digestibility and nutrient deficiency (Mupangwa *et al.*, 2002). Moreover, the importance of natural pasture as source of feed resource is gradually declining as a result of the expansion of crop production, redistribution of grazing lands to the landless and land degradation (Mulat 1999).

The problem of dry season livestock feeding has directed research efforts towards harnessing and enhancing the utilization of abundant arable by-products and crop residues. Maize is the most common grain cultivated in the western part of Ethiopia. During harvest, farmers are only interested in the maize grain and large quantities of maize stover produced in Ethiopia are wasted year after year. The trend has changed from the situation in which maize stover were considered as waste and are now being converted to animal protein for human consumption (Singh *et al.*, 2004). There is very little information on the actual usage of maize stover residues in the western Ethiopia.

Maize stover consists of the leaves, husks, stalks and cobs of maize plants left in a field after harvest of cereal grain. It makes up about half of the yield of a crop. Maize stover is a very common agricultural product in areas having large acreage under maize cultivation. Maize stover is utilized for animal feeding during the scarcity of green fodder called lean periods. Therefore, it is apparent that the nutritional quality of maize stover is poor and to maintain the health and to increase the milk production potential of milk animals, maize stover should be fed along with concentrates. The concentrates will provide the required concentration of protein as well as other nutrients. The nutritional quality of urea treated maize stover is drastically enhanced compared to untreated stover. The increased microbial biomass in the treated stover may contribute significantly towards higher crude protein content. In countries where dairy industry is well developed, a voluminous work has been done and is being done on maize to increase the protein content of the crop. The addition of protein rich concentrates or chemicals when feeding maize crop residue or its silage are being worked out. Thus efforts were directed to increase the contents of protein in maize stover silage by incorporating non-protein nitrogenous compounds.

The objectives of this study were

- To determine the improvement in chemical composition due to urea treatment of maize stover as compared with the untreated stover
- To determine the potential of urea treated maize stover for milk yield and milk quality of dairy cow during dry season

Materials and Method

Description of the Study Area

BARC is located in Oromia Regional State West Shoa Zone at about 257 Km from the capital city Addis Ababa on the way to Nekmete town. The centercenter is located at 8 km from Bako town. The altitude of the research centercenter is 1650 masl and lies at about 09°6'N latitude and 37°09'E longitude.

The area has a warm sub-humid climate with annual mean minimum and maximum temperature of 13°C and 29.9°C respectively. Mean monthly minimum and maximum temperatures are about 10.4°C and 33.6°C respectively, with an average monthly temperature of 21°C. The daily mean minimum and maximum temperatures are 9.4°C and 31.3°C respectively. The relative humidity of the area was 48.8%

for the year 2013/14 cropping calendar during which the experiment was conducted. The area is known by unimodal type of rainfall and receives annual rainfall of 1431 mm mainly from May to September with maximum precipitation in the month of June to August. Sixty percent of the soil is reddish brown in colour, and clay-loam in texture (Wakene 2001).

Experimental Animals and Management

A total of eight lactating crossbred cows were used for the experiment. Experimental cows with similar lactation performance, same early stage of lactation, similar body weight and similar parities were selected from the total dairy herd available in BARC. All cows were weighed and drenched with broad-spectrum anti-helminthics (Albendazole 500 mg) prior the commencement of the experiment. The calves were separated from their dams five days after parturition and reared according to the standard calf rearing procedures of the research center. The cows were placed in an individual pen in a well-ventilated barn with concrete floor and appropriate drainage slope and gutters and stall-fed. The cows were hand-milked twice daily at approximately 12-hour intervals in milking room.

Feed Preparation and Feeding

The maize stover were chopped into the size of 2-3 cm prior to ensiling process. In 100 liters of water, 5 kg of urea was dissolved and sprinkled uniformly over the 100kg of chaffed maize stover by using sprinkler and buckets. The treated maize stover were mixed by using a fork. All mixtures were firmly packed by trampling to remove as much air as possible and the silo were sealed. The treated maize stover was ensiled for 30 days. Then used for conducting the experiment with lactating crossbred dairy cows. The basal feed offer was adjusted daily by allowing 20% of refusal from previous day's intake. The quantity of concentrate mix offered daily was at the rate of 0.5 kg/liter of milk produced by each cow and offered with equal portions during the morning and evening milking time respectively. Representative and composite samples of all experimental feeds were taken for laboratory analysis.

Eperimental Design, Treatments and Measurements

At the beginning of the experiment, eight lactating crossbred cows were randomly assigned in a double switch over 4X4 Latin square design. There were four periods each consisting 30 days. During the first 15 days of each period, animals were acclimated to the experimental diet and the remaining 15 days were used to collect data. Hence, the experiments took 120 days; being started in December 2015 and finished in March 2016. The experimental animals were initially randomly allotted to one of the four dietary treatments given below. The concentrate mix is (49.5% maize grain + 49.5% noug seed cake + 1% salt). Treatments were:

T1: Untreated maize Stover + grazing +supplement 0.5 kg/litre of milk yield
T2: Untreated maize Stover install feeding + (supplement with 0.5 kg/litre of milk yield
T3: Treated maize Stover install feeding + (supplement 0.5 kg/litre of milk yield
T4: Treated maize Stover + grazing + supplement 0.5 kg/litre of milk yield

Adjustments for concentrate offer was made at the end of each period and for each treatment based on the actual milk produced. Feed offered and refused were measured and recorded for each cow to determine daily feed and nutrient intake. Water was available to the animal all the time throughout the experiment.

The daily milk yield data of individual cows was taken using a Salter balance. About 100 ml milk sample in the morning and afternoon was taken twice every week during the experiment from each cow into a glass measuring cylinder (100ml capacity) after the milk was thoroughly and gently mixed. Body weight was recorded for two consecutive days at the beginning and end of each experimental period for each treatment to monitor body weight change that may occur as a result of dietary treatments.

Metabolizable energy (ME) contents of the feeds were estimated from in-vitro organic matter digestibility (IVOMD) as described by McDonald et al. (2002) as: ME (MJ/kg) = 0.016 DOMD, Where: DOMD = Digestible organic matter in the dry matter.

Chemical Analysis

All samples of feed offered and refusals were analyzed for DM, ash, and N (Kjeldahl-N) according to AOAC (1990). Organic matter (OM) was determined as 100-ash. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined by the methods of Van Soest and Robertson (1985). In vitro organic matter digestibility of feed offered was determined using the procedures outlined by Tilley and Terry (1963). The milk samples were used to determine percentage fat, protein and solid not fat (SNF) by Ultrasonic Ekomilk Analyzer (30w Bulteh 2000, Bulgaria), which have the capacity to measure 20 – 25 samples per hour. Total milk solids (TS) were calculated as TS = SNF+Fat.

Statistical Analysis

Voluntary DM and nutrient intakes, live weight change, milk yield and compositions were subjected to GLM procedure for double Latin Square Design using Statistical Analysis System (SAS, 2002). Treatment means were separated using Least Significant difference (LSD). The models used for the analysis of data were:

$Y_{ijk} = \mu + C_i + P_j + T_k + E_{ijk}$,

Where;

μ = Overall mean

C_i = Cow effect

P_j = Period effect

T_k = Treatment effect

E_{ijk} = Experimental error

3. Results and discussion

Chemical composition of experimental feeds

The maize stover is supposed to be inferior source of nutrients. Hence in order to improve the CP content, it was treated with urea through the process of ensiling. The chemical composition of maize stover and concentrate mixture are presented in the table 1, and it was observed that, there was significant improvement in crude protein content in urea treated maize stover which may be due to impregnation of nitrogen on the particle/pieces of stover.

Table 1. Chemical composition, *in-vitro* organic matter digestibility and metabolizable energy content of experimental feeds **(**% for DM and %DM for other chemical composition values)

Feeds offered	DM (%)	Chemical compositions (and %DM)					IVOMD (%)	ME (MJ Kg^{-1} DM)
	DM	CP	OM	NDF	ADF	ADL		
Treated Maize Stover	92.07	9.97	94.14	81.96	66.33	15.73	57.76	9.21
Untreated Maize Stover	92.94	5.78	95.00	86.35	56.85	10.79	36.44	5.83
Concentrate	92.18	33.33	94.28	33.75	9.06	2.89	78.75	12.6

ADF= acid detergent fiber; ADL= acid detergent lignin; CP= crude protein; DM= dry matter; NDF= neutral detergent fiber; OM= organic matter; IVOMD=Invitro organic matter digestibility,

Dry Matter and Nutrients Intakes

The mean daily DM and nutrient intake of lactating crossbred dairy cows fed urea treated and untreated maize stover and supplemented with concentrate mix are presented in Table 2. The daily DM intake was significant (P<0.05) among treatments. The highest daily dry matter intake was observed when cows were fed with treated maize stover at install feeding (T3) as a basal diet followed by T4 and T2 in that order. There was no significant difference (P>0.05) between T1 and T2 in daily DM intake. The difference could be attributed to the high rumen degradable protein content of the treated maize stover at install feeding compared to untreated one, which might have enhanced the efficiency of rumen microorganisms that increase fiber degradability and digestibility thereby improving feed intake (McDonald *et al.,* 2002). The low CP and high fiber contents of the untreated stover likely depressed both feed intake and digestibility since NDF is negatively correlated with feed intake and its content above 55% can limit DM intake (Arelovich *et al.,* 2008). Animals consuming feeds containing better protein will eat more than those given less protein contain diets (Steinshamn, 2010).

Intake of feed by ruminant can be improved through concentrate supplementation (Gatenby, 2002). Addition of CP supplement may stimulate efficient rumen fermentation, more passage rate and intake (Kempton and Leng, 1979). This implies the presence of direct relationship between CP content of feeds and feed intake (Tesfaye, 2007). Earlier report **(**Mulu, 2005) showed improvement in the daily total DM intake due to supplementation. This may be attributed to the ability of the supplements to provide nitrogen and energy for the cellulolytic microbes upon degradation in the rumen (Wambui *et al*., 2006) and increases the nitrogen content of the total diet, which in turn is likely to increase feed intake and the

rate of degradation of the basal diet in the rumen (Ranjhan, 1997). When the rate of breakdown of digesta increases, feed intake is accordingly increased (Van Soest, 1982). Grovum and Williams (1977) reported that if the ingested feed is retained longer in the rumen, it is expected that the animal would consume less feed, because of the occupied space or 'gut fill'.

Table 2. Means of dry matter and nutrient intake of lactating cross bred dairy cows fed urea treated and untreated maize stover and supplemented with concentrate mix.

Parameter	Treatments				LSD	SL
	1	2	3	4		
Total DMI	1.2282^{c}	4.5306^{b}	6.2220^{a}	1.9169^{c}	1.1742	*
DMI	1.1415^{c}	4.2107^{b}	5.7286^{a}	1.7649^{c}	1.0829	*
CP	0.06598^{c}	0.24338^{b}	0.57114^{a}	0.17596^{c}	0.1008	*
ASH	0.05707^{c}	0.21054^{b}	0.33570^{a}	0.10342^{c}	0.0618	*
OM	1.0844^{c}	4.0002^{b}	5.3929^{a}	1.6614^{c}	1.0212	*
NDF	0.9857^{c}	3.6360^{b}	4.6952^{a}	1.4465^{c}	0.8963	*
ADF	0.12316^{c}	0.45434^{b}	0.90111^{a}	0.27761^{c}	0.1616	*

LSD= Least Significance Difference; LS= Significance Level, T1= ad libitum Untreated maize Stover + grazing + Concentrate mix (0.5 kg/l of milk); T2= ad libitum Untreated maize Stover install feeding *+ Concentrate mix (0.5 kg/l of milk); T3=; ad libitum treated maize Stover* install feeding *+ Concentrate mix (0.5 kg/l of milk);T4= ad libitum treated maize Stover + grazing + Concentrate mix (0.5 kg/l of milk); Concentrate mix = 49.5% maize grain + 49.5% noug seed cake + 1% salt, ADF= acid detergent fiber; CP= crude protein; DM= dry matter; NDF= neutral detergent fiber; OM= organic matter*

Milk Yield and Composition

Table 3. Effect of treated and untreated maize stover on milk yield and composition of crossbred dairy cows supplemented with concentrate mix.

	Treatments				LSD	SL
Parameter	1	2	3	4		
MY	5.3391^{c}	6.2587^{bc}	7.8547^{a}	6.7406^{ab}	1.2401	*
MF	4.83	5.36	5.01	5.05	0.6194	ns
MP	3.47	3.56	3.48	3.46	0.1079	ns
SNF	8.31	8.54	8.32	8.29	0.2883	ns
TS	13.27	13.90	13.33	13.34	0.67	ns

LSD= Least Significance Difference; LS= Significance Level, ns = not significant; T1= ad libitum Untreated maize Stover + grazing + Concentrate mix (0.5 kg/l of milk); T2= ad libitum Untreated maize Stover install feeding + Concentrate mix (0.5 kg/l of milk); T3=; ad libitum treated maize Stover install feeding + Concentrate mix (0.5 kg/l of milk);T4= ad libitum treated maize Stover + grazing + Concentrate mix (0.5 kg/l of milk); Concentrate mix = 49.5% maize grain + 49.5% noug seed cake + 1% salt, MY= Milk Yield, MF= Milk Fat, MP=Milk Protein, SNF= Solid Not Fat, and TS=Total Solid

The results of mean daily milk yield and composition of crossbred dairy cows fed treated and untreated maize stover are shown in Table 3. Daily milk yield were significantly different among treatments ($P<0.05$) and was higher in T3 as compared to T1. Cows fed with treated maize Stover install feeding

with supplementation (T3 produced more milk than those in T2 and T1 basal diets. There was no significant difference among T1 and T2. The difference in milk yield among treatment groups is attributed to the differences in crude protein and energy contents in the diets (Steinshamn, 2010). Adebabay *et al.* (2009) indicated that supplemented cows produced significantly more milk than those grazed on natural pasture alone. Getu (2006) indicated that crossbred dairy cows fed urea treated wheat straw basal diet produced significantly higher milk yield when supplemented with 50% vetch (*Vicia dasycarpa*) diet than the non-supplemented ones because of better nutrient supply. Milk protein, milk fat, solid not fat (SNF) and total solid (TS) contents were not significantly (P>0.05) different among treatments. Results of the present study of milk composition agreed with Promma *et al*. (1994) who reported that feeding lactating Holstein cows with either ammonium sulphate neutralised rice straw or non neutralised rice straw for increased CP intakes did not change milk composition. However, Adebabay *et al.* (2009) and Nega *et al*. (2006) noted differences in milk composition under different concentrate supplementation regimes. The observed lack of differences in milk composition is due to the similar type and same amount per kg milk of concentrate supplementation across the treatments.

3.4. Daily Live Weight Change

Table. 4. Effect of treated and untreated maize stover on mean live weight change of crossbred dairy cows supplemented with concentrate mix.

	Treatments				LSD	SL
	1	2	3	4		
WT	-188.9	-14.7	147.2	38.9	422.96	Ns

LSD= Least Significance Difference; LS= Significance Level, ns = not significant; T1= ad libitum Untreated maize Stover + grazing + Concentrate mix (0.5 kg/l of milk); T2= ad libitum Untreated maize Stover install feeding + Concentrate mix (0.5 kg/l of milk); T3=; ad libitum treated maize Stover install feeding + Concentrate mix (0.5 kg/l of milk);T4= ad libitum treated maize Stover + grazing + Concentrate mix (0.5 kg/l of milk); Concentrate mix = 49.5% maize grain + 49.5% noug seed cake + 1% salt, WT= weight change

The daily mean live weight and periodic weight changes of crossbred dairy cows fed treated and untreated maize stover are shown in Table 3. The result of mean daily live weight loss was not significantly (P>0.05) different. The presence of marked differences in nutrient intake among the dietary treatments did not bring a significant effect in weight change of the cows, which may be due to the utilization of additional nutrients consumed for milk production. During the early lactation (60-90 days after calving) all cows lost body weight, with a declining trend with advance in lactation. Similar amount of body weight loss of 120 g/day with the present study was reported for lactating crossbred cows by Getu (2006). But, body weight loss of cows (60-90 days) in the present study is higher than that reported by Muinga *et al.* (1992, 1995) and Azage (1994). Muinga *et al.* (1992) reported body weight loss of 20 to 90 kg for the entire lactation period for lactating crossbred cows fed *ad libitum* Napier grass fodder and supplemented with 0.4 or 8 kg/d of fresh leucaena forage. However, positive weight changes for dairy cows fed urea treated and untreated low basal feeds (teff and barley straw, maize stover and oats- vetch mixture) supplemented with either conventional concentrate or forage legumes have also been documented by different workers (Lemma *et al.*, 1990; Mpairwe, 1998; Reherahie, 2001). The variation in live weight change between the different studies could be explained by the difference in the stage of lactation and

genetic potential of the animals used in the experiments, the quality of the basal feeds used and the quality and quantity of supplements used in the studies. Garnsworthy (1997) noted that cows in early lactation and those of higher genetic merits partition energy towards milk production at the expense of body fat reserve. This author further noted that cows normally lose 0.5-1.0 kg of body weight each day for the first eight weeks of lactation. Therefore, increased energy intake at this stage of lactation is expected to result in further increases in milk yield, if the cow's genetic potential has not been reached and/or a reduction in the daily amount of body fat mobilized. Cows on all dietary treatments in the present study were losing body weight progressively during the first period of the lactation cycle, which can be solely attributed to peak lactation. Cows were still losing body weight after the first period of the lactation cycle, but with a generally declining trend. However, improvements in body weight condition of cows have also been observed for all dietary treatments during the last period of the experiment. This could probably be associated with more diversion of the available nutrients to body tissue accretion or the decreased milk yield during this period.

Partial Budget Analysis

The economic feasibility of this study was analyzed using partial budget and marginal analysis approaches. According to this analysis, cows in T3 gave the highest net benefit (Birr 67.15 per cow/day), while cows in T1 gave the lowest net benefit (Birr 44.36 per cow/day). The minimum rate of return acceptable by the dairy farmer was assumed to be 50% (CIMMYT 1985). This implies that the dairy farmer expects a minimum rate of return of 50% if he is to adopt a new practice as compared to the practice he used to do.

Table 5. Partial budget analysis for lactating crossbred dairy cows fed urea treated and untreated maize stover with concentrate diet supplementation.

Variable	T1	T2	T3	T4
Milk yield (kg/cow/d)	5.34	6.26[c]	7.86	6.74
Gross field benefit (ETB /cow/d)	96.12	112.68	141.48	121.42
Cost of NGH (ETB/ kg /cow/d)	5.13	18.945	25.785	26.965
Cost of urea utilization (ETB/ kg /cow/d)	-	-	1.15	1.4
Cost for Concentrate mix (ETB/kg/cow/d)	20.98	21.32	21.74	21.56
Cost of Tablet, Mineral and labour (ETB /cow/d)	25.65	25.65	25.65	25.65
Total variable cost (ETB /cow/d)	51.76	65.92	74.33	75.58
Gross income, ETB/head	96.12	112.68	141.48	121.42
Net benefit (ETB cow/d)	44.36	46.76	67.15	65.84
Change in net income	0	2.40	22.79	21.48
Change in total variable cost	0	14.16	22.57	23.82
MRR, %	0	0.17	1.01	0.90

ETB = Ethiopian Birr; MRR = Marginal rate of return

Among the treatments, the largest change in cost that varies was birr 22.57 per day and the change in net benefits was birr 22.79 per day resulting in 100.1% marginal rate of return was recorded for T3. So for each birr invested in input for a cow, the farmer would recover birr 1(one) and an additional birr 22.79 at a given prices. Therefore, on the basis of MRR the technology is recommended for increasing milk productivity of cows. The result of MRR of the present study was in the profitable range like as 158% and

131.85% reported by Shah et al (2009) who worked on an on-farm trial of urea mineral molasses blocks fed to milking cows and buffaloes, respectively.

Generally, those cows fed urea treated maize stover under install feeding was optimized both biological and economic benefits as compared to cows consumed other treatment rations. However, since the cost for most inputs are variable over time, it cannot be taken for granted that the net benefit obtained from this study would be sustainable over years or locations. The increased net benefit obtained for cows in T3 was generally due to the availability of maize stover with low cost and minimum amount of urea utilization. This implies that whether response to feeding treated diet of maize stover is beneficial in economic terms depends on the cost of treatment. In general, it can be understood from the present trial that if farmers conserve and treat maize stover, milk yield from dairy cows can be improved economically

Summary and Conclusion

Feed shortage both in terms of quantity and quality is referred to be a major problem hindering the development of livestock industry in general and dairy production in particular. Ethiopia holds large potential for dairy development. However, milk production is often limited by inadequate supply of feed on a year-round basis. Moreover, there is limited growth of pasture or fodder in many parts of Ethiopia during the dry season. Therefore, livestock do not get enough of high quality feed however maize stover is an important feed resource in the area of maize belt part of western part of Ethiopia, but it is poorly utilized without enhancing nutritional quality. Treating the stover to optimize its utilization by stall-feeding is being required. To fill this gap, a feeding trials was conducted with the objective of evaluating the effect of feeding urea treated maize stover with untreated on voluntary feed intake, and milk yield and milk composition of dairy cattle when supplemented with concentrate diet.

The experiment consisted of feeding trials using eight crossbred lactating cows of similar milk yield, body weight and early stage of lactation in a double 4x4 Latin square design for a lactation period of 120 days. Each period lasts 30 days with the first 15 days for adaptation and the rest 15 days for measurement. Laboratory analysis was conducted for all experimental feeds and data were collected for daily voluntary feed and nutrient intakes, milk yield and milk composition, periodic live weight change. Results from laboratory analysis and *Invitro* digestibility studies of experimental feeds indicated that treated maize stover had better nutritive value than untreated. The CP content of treated maize stover and untreated maize stover was 9.97% and 5.78%, respectively, and the corresponding estimated ME was 9.21MJKg^{-1}DM and 5.83 MJKg^{-1}DM. *In vitro* DM digestibility was 57.76% and 36.44% for treated maize stover and untreated maize stover respectively. The daily DM and CP intakes were significant (P<0.05) among the dietary treatments with the highest intake observed when cows were fed treated maize stover (T3) as a basal diet.

Daily milk yield were significant (P<0.05) with higher mean values for cows fed with T3 basal diet than when they were fed with T1 basal diet. Milk protein, milk fat, solid not fat and total solid contents were not significantly (P>0.05) different among dietary treatments. Therefore, considering milk yield in this study, it can be concluded that cows fed basal diet of treated maize stover with recommended concentrate mix optimize biological benefits as compared to cows consumed other basal diets. In order to verify the importance of the present study at farmer's level, undertaking on-farm trials using the treatment used in the current study is worthwhile.

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In situ conservation of borana cattle through community based breeding scheme

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Abstract

Community based breeding program was performed in the years 2012/13, 2013/14, 2015/16 and 2016/17 in Mega district of Borana Zone, with the objective to improve and conserve Borana cattle breeds through disseminating improved Borana sire to pastoral community of the district. Relevant performance data was collected to check and/or mark the performance of the program in relation to achieving the required goal. The data collected were: Number of females exposed for pregnancy teste (NFEPT), Number of females diagnosed as pregnant (NFDP), Number of females diagnosed as pregnant and failed to calve (NFDPFC), Number of calves born (NCB), Number of live calves born (NLCB), Number of calves dead (NCD), Pregnancy rate (PR), Abortion rate (AR), Calving rate (CR) and Calve death loss based on calves born (CDLBCB). Descriptive statistic procedure of SAS was used to organize the collected data. Accordingly, the result of PR, AR, CR and CDLBCB were 89.18 %, 5.29%, 94.71 and 3.28 %, respectively. The result obtained indicated that community based breeding program can be a best method to improve and conserve Borana cattle breeds through disseminating improved sires. Therefore, extending the mentioned method in broad area through establishing of community ranch will help to keep Borana breed out of danger and maintain it for wellbeing of the community.

***Key words**: Borana Cattle, Breeding Scheme, Community, Conservation, In Situ*

Introduction

Cattle are undoubtedly the most important livestock species in the Borana range land system both for economic and social functions (Coppock, 1994). Borana cattle breed is originated in arid and semi-arid agro-ecologies of Southern Ethiopia. Beyond the home country, the breed are widely distributed in many parts of Africa including Kenya, Tanzania, Uganda, Somalia, Zambia, Zaire and other parts of the world including USA and Australia. The breed is known for their large size, high degree of heat tolerance, resistance to ticks, feeds and water shortage (Albero and Haile Mariam, 1986). They were also considered by FAO to be one of the five breeds, which should be given priority for further development and conservation (Philipsson, 1992).

Due to their better meat quality the Borana cattle were reported as an excellent beef animal both for local and foreign market (Albero and Hailemariam, 1980). The potential of Borana cattle for meat production under ranch condition is also considerable (Trail *et al.*, 1985). They are predominantly serving as dam line in most small holder dairy cross breeding programmes (Hailemariam *et al.*, 1998). However, the

breed have subjected to little artificial selection either for increased milk or meat production particularly in their breeding area. Further, there is a growing concern of genetic erosion of the breed due to blood dilution, recurrent drought, bush encroachment, feed shortage and diseases. These calls for urgent action to carrying out conservation program while improving the breed for beef as well as milk production.

Dida Tiyura ranch has been engaged in improvement, multiplication and distribution of bulls for the communities for over the last two decades and is the only remaining ranch for local cattle genetic improvement currently. The dissemination strategy was in such a way that a bull is sold to selected pastoralists on individual basis. Individual ownership and use of bulls could lead to underutilization of bulls for breeding purpose given that the individual pastoralist owns few breeding cows. Individual ownership (unlike collective ownership) made it easy for pastoralist to sell the bulls for quick-profit benefits rather than long term genetic improvements. Furthermore, there was no feedback on the status of the distributed bulls. Moreover, there have been loose institutional links between pastoral bureaus, multiplication ranch and research centre. Therefore, there is a need to redesign the dissemination strategies, participate and create a link between different stakeholders so as to bring sustainable genetic improvement. Village breeding programmes that are carried out by the communities with involvement of various stakeholders; often at the subsistence level (Solkner *et al.*, 1998) can easily be adapted and contribute sustainably to the improvement of productivity of local breeds. Therefore, this improvement program was designed to conserve Borana cattle breed through disseminating improved Borana sire to the local communities and to evaluate pregnancy, calving and mortality rate under Cooperative/ Communal use of breeding bulls for Mating/breeding.

Materials and Methods

Study Sites

The study was conducted at Danbela Wachu Ranch in Dire district of Borana Zone, Southern Oromia. The area has semi-arid climate with bimodal rainfall distribution during the major wet season, from mid-March to May and the short rainy season extending from September to November. A cool dry period occurs from June to August while warm dry season extends from December to February (Coppock, 1994). The area is characterized by extensive pastoral productions system.

Village/Community based breeding programme

Village based breeding program is placed on the existing system rather than transforming the existing system in to capital or labour intensive and biological or environmental sensitive. It involved less sophisticated methods of measuring and evaluation of animals. Basically it is carried out by local community under unchangeable environment (low feed resource and disease prevalence) where record keeping is difficult and low flow of information was existed. Under low input system of pastoralism the use of good bulls of native breed is the only method of improving milk and meat productivity.

Improved bull dissemination schemes

From lists of available community based breeding program options, Community/Cooperative bull scheme was chosen after severe discussion was made between stake holders. As soon as the decision was made on the appropriate community based breeding program to be used, Pastoralists were organized into groups based on utilization of common grazing areas. A group of cattle owners have been joint owners of the improved bull and were responsible for giving care and maintenance requirement of that particular bull given to them. Depending on the number of breeding cows and availability of large size communal grazing land; Bokosa, Goro Dada and Qersa Denbi PAs were selected for this program. Stud mating was practiced (bringing the cows for mating and return back to their respective base stocks after the end of each breeding season) for four solid years (2012/13, 2013/14, 2015/16 and 2016/17).

Approaches

Stakeholder participation

Since, participation of stakeholders in the designing and implementation of development projects is the key to the success of development projects, particularly in traditional societies with diverse production objectives; Yabello Pastoral and Dry-land Agriculture Research Centre, Pastoral Regional Livestock Laboratory of Yabello, Zonal (Borana Zone) and District (Dire District) Pastoral Development offices were played their fair share for the success of the program.

Site and community selection/group formation

The participating herds consisted of village herds which used the bull for breeding purpose. Selection of cattle owners was performed based on ease of access, possession of common grazing land, willingness to follow appropriate management practices (feeding, housing and health) willingness to use controlled breeding (use of only selected bulls for breeding) and culling of unwanted animals from their herd. Participant pastoralists were selected and organized with an active involvement of local leaders/elders/key informants and development agents.

Training of the community and their roles

The capacity of the cooperative/community in managing and understanding the breeding programme were enhanced through relevant trainings. Training related to breeding, feeding and health management were given for technicians (DA, health technician) that are in charge of the work in village herds by the researchers from Yabello Pastoral and Dry-land Agriculture Research Centre (YBDARC) with active involvement of expertise from the district livestock department office. In turn, they trained and provided assistant to the community regarding handling the breeding strategy. Besides the community were trained by YBDARC researchers how to keep simple but important records that help to make decisions in the breeding programme.

Cooperative/ Communal use of breeding bulls for Mating

Three PAs of Pastoralists (Bokosa, Goro Dada and Qersa Denbi) were organized into groups based on communally possessed grazing areas (Danbela Wachu Ranch). Mating was designed to meet the objective of 1:25 sire to dam ratio during mating season in the years 2012/13, 2013/14, 2015/16 and 2016/17 EC.

Stud mating were practiced (bringing the cows for mating/breeding). However, due to a serious drought occurred in the year 2014/15, mating was not practiced.

Operational aspects and herd managements carried out

The bulls supplied to participant pastoralists were those with relatively greater genetic potential compared to bulls that are available in the study sites herds. For each mating season participatory selection of breeding groups was conducted. All the bulls supplied and the cows/heifers that were brought by pastoralists and passed first round screening were been ear tagged for each subsequent mating and Brucella test were carried out before mating schedule is arranged except for the first year (2012/13).

Due to shortage of good performing sire and the interest of the community to a particular bull, natural mating ranged from 1:33 - 1:50 sire to dam ratio was practiced. Breeding cows were kept with their assigned bull until they give birth based on the condition of the ranch for a given mating year. While bulls remained in the ranch for their entire productive age, withdrawal of dams was performed immediately after parturition. Once mating was commenced, basic health care routines such as vaccination and deworming of animals in the monitored village herds were performed by participant herd owners. Follow-ups and feedbacks on status of breeding herd were practiced by development agents at community level in consultation with district livestock department and research team of Yabello Pastoral and Dry-land Agriculture Research Centre.

Data management and Statistical Analysis

The data collected included, Number of females exposed for pregnancy teste, Number of females diagnosed as pregnant, Number of females diagnosed as pregnant and failed to calve, Number of calves born, Number of live calves born and Number of calves dead (Table 1).

Table 1. Breeding herd structure and status of Danbela Wachu ranch community herd for a given breeding years.

Parameters	Breeding Season/Years			
	2012/13	2013/14	2015/16	2016/17
NFEPT/head	437.00	444.00	332.00	229.00
NFDP/head	398.00	428.00	303.00	157.00
NFDPFC/head	57.00	6.00	3.00	2.00
NCB/head	341.00	422.00	300.00	155.00
NCD/head	11.00	10.00	6.00	13.00
TLCBEF/head	330.00	412.00	294.00	142.00

Number of females exposed for pregnancy teste (NFEPT), Number of females diagnosed as pregnant (NFDP), Number of females diagnosed as pregnant and fail to calve (NFDPFC), Number of calves born (NCB), Number of live calves born (NLCB) and Number of calves dead (NCD).

Descriptive statistics procedure of SAS V.9.2 (2002) was used to organize the collected data and chi-square test (χ^2) was conducted to check the difference existed between mating years for a given reproductive performance such as Pregnancy percentage (PP), Pregnancy loss percentage (PLP), Calving percentage (CP), Calve death loss based on exposed females (CDLBEF) and Calve death loss based on

calves dead (CDLBCB). Accordingly the following equations were used to calculate the given reproductive performance:

$$PR(\%) = \frac{NFEDP}{NFEPT} \times 100.....1$$

Where: PR (%) = Pregnancy percentage, NFEDP = Number of females exposed diagnosed as pregnant and NFEPT = Number of females exposed that are pregnancy tested.

$$CP(\%) = \frac{NCB}{NFEPT} \times 100.....2$$

Where: CP (%) = Calving percentage and NCB = Number of calves born

$$CDLBCB(\%) = \frac{NCD}{NLCB} \times 100.....3$$

Where: CDLBCB (%) = Calve death loss, based on calves dead, NCD = Number of calves dead and NLCB = Number of live calves born

Results and Discussion

Pregnancy rate (PR) of breeding herd for a given mating years is presented in Table 2. The overall pregnancy rate for cows mated in the given breeding years was 89.9%. The result obtained confirmed considerable variation ($\chi^2<0.001$) among breeding years that ranged between 68.56 % and 96.40 in the years 2016/17 and 2013/14, respectively. This result is consistent with the study made by Cruz *et al.* (1976) where pregnancy rate of various tropical breeds was significantly affected by mating year. However, the PR (75.40%) reported by the above mentioned authors for Borana Breed in Zambia is lower than the result obtained from this study. The lower PR observed in 2016/17 compared with the remaining mating years was due to serious drought which resulted in scarcity of green fodder headed to early withdrawal of breeding herd.

Table 2. Pregnancy rate (PR) of breeding herds in Danbele Wachu ranch community herd for the given mating years

Breeding Years	UNIT	Conceived	Not Conceived	Total	χ^2 (df)	Pr > χ^2
2012/13	Head	398	29	427	140.14 (3)	<.0001
	Per cent	27.79	2.03	29.82		
	Row per cent	93.21	6.79			
	Column per cent	30.95	19.86			
2013/14	Head	428	16	444		
	Per cent	29.89	1.12	31.01		
	Row per cent	96.4	3.6			
	Column per cent	33.28	10.96			
2015/16	Head	303	29	332		
	Per cent	21.16	2.03	23.18		
	Row per cent	91.27	8.73			
	Column per cent	23.56	19.86			

2016/17	Head	157	72	229		
	Per cent	10.96	5.03	15.99		
	Row per cent	68.56	31.44			
	Column per cent	12.21	49.32			
Total	Head	1286	146	1432		
	Per cent	89.8	10.2	100		

Table 3 presents calving (CR) and abortion rate (AR) of Borana cows over different breeding years; together with the overall performance of the breeding herds across the given breeding years. Out of the 1286 dams detected pregnant, 94.71% caved live calves and the rest (5.29%) aborted. In comparison to the given breeding years, CR and AR were found to be significantly different ($\chi^2<0.001$). The difference observed is mainly because of higher rate of abortion occurred in 2012/13 breeding year which was attributed by >30 heads of cows that were found infected with Brucella-abortus. The current result is inconsistent with the research output of CR 70.00%, 75.00% and 85.00% for local cows in dry, wet and humid region research stations, respectively reported by Galal *et al* (1981) for local zebu and F_1 crossbreed cows. However, the value reported for humid regions coincided with 85.68% observed in the first breeding year of current study (2012/13). Several research outputs revealed that management of breeding herd is the most important key to confirm higher level performance. In view of that, the current study is coincided with Azage (1989) who reported that CR under a single-sire mating system can be improved to above 80% and in contrast with CR (45%) under pastoral management conditions reported by Coppock (1994). On the other hand, the current result is within the rage of AR (4%) reported by Sabine (2004) for Borana cattle breed.

Table 3. Calving and Abortion rate (%) of breeding herds in Danbela Wachu ranch community herd for the given mating years

Breeding Years	UNIT	Calving Rate	Aborted	Total	χ^2 (df)	$Pr > \chi^2$
2012/13	Head	341	57	398	93.99 (3)	<.0001
	Per cent	26.52	4.43	30.95		
	Row per cent	85.68	14.32			
	Column per cent	28.00	83.82			
2013/14	Head	422	6	428		
	Per cent	32.81	0.47	33.28		
	Row per cent	98.60	1.40			
	Column per cent	34.65	8.82			
2015/16	Head	300	3	303		
	Per cent	23.33	0.23	23.56		
	Row per cent	99.01	0.99			
	Column per cent	24.63	4.41			
2016/17	Head	155	2	157		
	Per cent	12.05	0.16	12.21		
	Row per cent	98.73	1.27			
	Column per cent	12.73	2.94			
Total	Head	1218	68	1286		

	Per cent	94.71	5.29	100.00		

Mortality data based on 1258 calves born over a four year period is presented in table 4. Of all calves born during the given breeding season; 96.82% were born alive and survived to 45 days and 3.18% were born alive but died before 45 days period. Percentages of calves that were born alive and survived to 45 days and born alive but died before mentioned period were not similar ($\chi^2<0.01$) across a given breeding years. The current result is within the range of earlier finding of pre-weaning calf mortality rates of 3.4% in Boran and their Friesian crossbred animals in the Abernossa Ranch (Haile-Mariam *et al.*, 1993) and 5.6% in crossbred animals bred using bull in and around Fitche town, North Shoa Zone of Oromia region (Tesfaye *et al.*, 2017), in the central high land of Ethiopia. However, it is lower than Studies by (Homann *et al.*, 2007) cited smallholder herd mortality rate as high as 18%, with disease accounting for 60% of herd mortality for smallholder cattle in Masvingo district, (Mavedzenge *et al.*, 2007).

Table 4 Mortality rate (%) of breeding herds in Danbela Wachu ranch community herd for a given mating years

Breeding Years	UNIT	Calve Borne	Calf Died	Total	χ^2 (df)	Pr > χ^2
2012/13	Head	341	11	352		
	Per cent	27.11	0.87	27.98		
	Row per cent	96.88	3.13			
	Column per cent	28	27.5			
2013/14	Head	422	10	432		
	Per cent	33.55	0.79	34.34		
	Row per cent	97.69	2.31			
	Column per cent	34.65	25		13.87 (3)	0.0031
2015/16	Head	300	6	306		
	Per cent	23.85	0.48	24.32		
	Row per cent	98.04	1.96			
	Column per cent	24.63	15			
2016/17	Head	155	13	168		
	Per cent	12.32	1.03	13.35		
	Row per cent	92.26	7.74			
	Column per cent	12.73	32.5			
Total	Head	1218	40	1258		
	Per cent	96.82	3.18	100.00		

Conclusion and Recommendations

Livestock production as a whole and cattle in particular are subsistence to the pastoralists of Borana range land. Pure Borana (specially the Qorti ecotype) Breed is threatened by factors like range land degradation, bush encroachment and animal diseases that are attributed by recurrent drought. These aforementioned problems need to be thoughtfully resolved. This study indicated that, community/cooperative bull scheme is one of the best suited breeding programs for conserving Borana breed (both Qorti and Geleba). The reproductive performance of Borana cattle under community breeding scheme relatively found

encouraging one. Thus the government should support and focus on conserving cattle breeds like Borana (both Qorti & Geleba), which have important economic value to the community and the country by training farmers on improved management practices of rearing cattle and also advocate on importance of community/cooperative bull scheme to pastoral community at a broader area. Generally, to succeed in today's cattle business it is vital to understand the comparative position of pastoralists' cattle production operation, to be aware of broader industry trends and issues, and to make use of available resources designed to aid management decisions towards the wellbeing of pastoral community.

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Beef and Small RuminantaResearch Results

On farm Demonstration of urea treated wheat straw based cattle fattening at Arsi-Nagele District of west Arsi zone

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Abstract

The study was carried out in Arsi-Nagele district of west Arsi Zone which is 227km km to the west of Addis Ababa capital city with the aim of demonstration and evaluation of urea treated wheat straw based Arsi cattle fattening under farmers management. The farmers were selected purposely based on their traditional cattle fattening practice and trained on how prepare urea straw treatment, select animals and feeding. 5% of urea was mixed in water and the urea solution was sprinkled over wheat straw with the ratio of 1:1 and buried in silo for fermentation. Then animals were fed this urea treated wheat straw ad libtum and three kilogram concentrate per head per day. The biological and economically data was collected and evaluated by the Microsoft excel sheet. The study revealed that daily weight gain of animal was 0.5kilo gram and the farmers benefited from fattening by getting 1757birr per animal. Therefore, the technology can be scaled up by concerned bodies so that farmers rowing the residues can be benefited.

Key word: Treated Wheat straw, farmer fattening practice

Introduction

The agriculture sector of Ethiopia contributes about 40.6 - 42.8% of GDP (NBE, 2012; MoFED, 2013). The country possesses about 54mln heads of cattle, 25.5mln heads of sheep and 24.1mln heads of goat (FAO stat, 2011; CSA, 2013).The country has huge potential for livestock development due to its large livestock population, favorable climate for improved animal breeds and the relatively disease-free environment for livestock (Mohamed et al 2004). Beside livestock population, the productivity of livestock is extremely low in terms of milk, meat production and draught power output (Azage and Alemu, 1998), mainly because of inadequate quality and quantity of nutrition. The tendency of allocating natural grazing lands for crop cultivation has been increasing from time to time to satisfy the grain production needs of rapidly increasing human population. Because of the expansion of cultivation of food crops and shrinkage of traditional grazing areas, crop residues are getting greater importance as source of roughage than natural pasture. Crop residues from cereals such as wheat straw, teff straw and barley straws constitute the major basal diets of animals. However, crop residues are naturally believed to have low CP and deficient in minerals (Rihirahe, 2001).These characteristics limit intake and digestibility of crop residue. Urea treatment can overcome these limitations. Urea has the ammoniating effect that improves nutrient content and intake of straw (Willie 2001; Kristensen 1984).Urea straw treatment in the country was mainly concentrated on research stations with little on-farm application. Urea wheat straw treatment based Arsi cattle fattening conducted in Adami Tulu Agriculture Research center showed that Ad libtum urea wheat straw plus 3kg concentrate was biologically significant and economically feasible among four treatments (Mieso et al,. unpublished data.) There is a need to demonstrate such technology under farmers' management with intention of developing a system which is both practical and easy for

farmers to adopt. Therefore, the objectives of this study was to demonstrate and evaluate urea wheat straw based Arsi cattle fattening at Arsi-Nagele district of west Arsi Zone of oromia.

Material and methodology

Study site

The study was conducted at kersa Elala and Aliwoyo peasant association of Arsi-Nagele district of west Arsi zone of Oromia. Arsi-Nagele district is located at 227km south of Addis Ababa and is on the main road that stretch from Addis Ababa to Hawasa town. It is classified into low-land (49%), mid-altitude (42%) and high- altitude (19%) agro ecologies. The minimum and maximum temperatures of the area are 10^0C and 27^0C, respectively, while the minimum and the maximum rainfall is 500 mm and 1150 mm, respectively. The crop types of the area include maize, wheat, barley, teff, millet, haricot beans and other crops while the livestock species include cattle, small ruminants, equines, poultry and beehives.

Farmer selection and training

Firstly, situation analysis was done with Arsi Nagele district Livestock and fishery development office, health and marketing agency staff members. Based on situation analysis, the potential peasant association namely Aliy woyo and kersa Elala which have more practice on traditional cattle fattening were identified. The interested farmers which have more practice in traditional cattle fattening were selected purposively. Theoretical and practical training was given to farmers and development agents. The training focus was on procedures of urea treatment of straw; care to be taken while carrying out the treatment process, feeding the treated feed to corresponding animals and how to select the oxen for fattening.

Procedures of straw treatment

Major procedures for straw treatment is shown in Fig 1. Farmers have selected proper site on their backyard and each farmer prepared the silo with a dimension of 2m length, 1m width and 1m height. Polyethylene plastic sheet was properly lined inside the silo. To prepare urea solution, 5% urea was added to 95% of water and stirred very well until urea was dissolved. Wheat straw was weighed using weighing balance and put on the plastic sheet. Urea solution was sprinkled evenly over the straw with the ratio of 1:1 Then the wet wheat straw was put in pit and compacted by trampling. After silo is full it was sealed by plastic sheet and soil to prevent the entrance of oxygen.

Fig. 1. Process of urea treatment: a) covering the silo wall with a plastic sheet, b) compacting straw in silo, c) sealing the full silo with a plastic sheet.

Animal and feeding

Each farmer bought similar age Arsi oxen from the Arsi-Nagele town market according to training given to them, i.e. seven farmers bought two oxen each and four farmers bought one ox each. Animals were injected ivermectein to control external and internal parasites. Multivitamin was also given to animals by our health technician. All farmers kept their animals individually in their own animals shed for fattening. Animals were stayed on adaptation feeding for 15 days before starting the actual fattening period. The treated straw was aerated for few hours. During fattening, ad libitum urea treated straw was given to animals daily.. In addition 3 kg concentrate feed was given to animals per day. Water was given to animals without limitation. The animals were kept on feeding for ninety days.

Statistical analysis

Data like initial body weight and final body weight were taken by heart girth. Total live weight gain (TLWG) = Final weight (kg) – Initial weight (kg). Daily weight gain (DWG) = total gain of animal divided by total number of days. Calculations and statistical analyses were carried out for live weight gain by using Microsoft Excel (spreadsheet). Simple economic evaluation based on calculation of total cost of production (cost of feeds, plastic sheet, health, urea and price of animal purchased) and price of animal sold was explained.

Result and discussion

Farmers' traditional cattle fattening practice

Livestock is mainly used for draught power and also as source of income in Arsi- Nagele district. Famers in the area are highly producing the local drink known as 'Arake' to improve their livelihood. Its byproduct known as 'Atela' is being used for traditional cattle fattening. Wheat is also highly produced in the area and its residue is used as main basal diet for traditional cattle fattening. Generally, in the study site, crop production and traditional cattle fattening are the main activities of the farmers.

Body weight change

Body weight change of the animals by the end of feeding period is given in Table 1. After feeding the urea treated wheat straw and concentrate for ninety days, animals attained a total of 46kg of average body weight gain. The average daily body weight gain of the animals was 0.51kg per day which is similar to the result attained in ATARC on station by Mieso et al. in 2012 (unpublished data).The average daily body weight gain of animals of two peasant association Ali woyo and kersa Elala were similar but the results are numerically different. This difference may be due to variability of farmers' management practice.

Table 1 Both PAs final body weight, average daily weight gain, total weight gains of animals (in kg)

Kebele	Number of farmers	Number of animals	MIBW	MFBW	MTWG	MDWG
Kersa Elala	4	8	295.2	338.4	43.9	0.45
Aliy Woyo	7	10	295.2	343.1	47.9	0.53
Total average	11	18	294.9	341	46.11	0.51

MIBW= mean of initial body weight *MFBW=mean of final body weight*
MTWG=Mean of total weight gain *MDWG= mean of daily weight gain*

Before the demonstration, 14 farmers were selected for fattening the animals but only 11 (78 %) of them have properly fattened their animals, stayed up to the end of the demonstration period and accepted this technology. The other farmers were interrupted due to different reasons. Two farmers told us their animals were reluctant to eat the urea treated wheat straw. Although the farmers were advised as to how to enable the animals to exercise eating the treated straw; they could not having confidence in the technology. One farmer did not start the practice because of his personal problems. Three farmers prepared other Arsi cattle for fattening by local alcohol residue (Atela) and wheat straw. They did not recorded the amount of feed the animals fed. Farmers stated that there is difference in buyer preference while selling fatten animals at the market. The buyer or butcher were preferred urea straw treated based fattened animals than those fattened on local Atela and wheat straw. The buyer easily identify animals that fattened by Atela since their body shines (fig. 2).

Figure 2.Body condition of animal after 90 days of fattening.

Economic analysis

Partial budget analysis of urea treated wheat straw based cattle fattening is shown in Table 2. Simple calculation of the different costs (veterinary cost, feed cost and animal purchasing price) to know the gross profit to be obtained from the fattening.. Estimation of labor cost was difficult since farmers used their family labor and gave little time for feeding, watering and other management. The total cost of feed per animal was 2474 Birr and the average price of an animal purchase was 5111birr. The total cost of production per animal was 7585birr. The farmers sold the fattened animals at local market with a net return of 1758 Birr per animal.

Table 2. Partial economic analysis of urea treated wheat straw based Arsi cattle fattening.

Item	Average cost per head	Gross profit per head	Net return per head
Animal purchased price	5111.11birr		
Wheat straw cost	800birr		
Concentrate cost	1584.05birr		
Urea cost	90birr		
Health cost	9.8birr		
Plastic sheet	80birr		
Total cost per head	7585.16birr		
Gross return per head		9333.33birr	
Net return per head	-	-	1758.17birr

Conclusions and recommendations

The demonstration of treated wheat straw based Arsi cattle fattening was conducted in Arsi-Nagele district in two PAs through participatory approach. The farmers prepared the silo and wheat straws and bought the oxen from market. The fattened animals gained 0.51 kg weight daily which was similar to the on-station result (Mieso et al. 2010 unpublished data). Besides improving body weight of the animals, the farmers got 1758.2 Birr net profit per animal after the ninety days of feeding. These results showed that improved wheat straw by urea treatment increased body weight gain of animals and made farmers profitable. Therefore, this feeding technology can be further scaled up for wider use by our communities where wheat residues are available.

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Evaluation of different dietary rations for growth performance and carcass characteristics of two years old Kereyu bulls for export/local market weight

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Abstract

Growth performance and carcass characteristics evaluation of two years old Kereyu bulls fed on three dietary feed rations was conducted at Adami Tulu Agricultural Research Center during the year of 2014. The objectives of the study were to evaluate the growth performance and carcass characteristics and to identify the most economical feeding rations for export/local market weight gain. Eight experimental bulls were assigned to each of the three dietary treatment groups (T1=Rhodes grass hay ad-lib, molasses 20%, wheat bran 35% and linseed cake 45%, T2= Rhodes grass hay ad-lib, maize grain 20%, wheat bran 45% and Noug cake 35%, T3= G Rhodes grass hay ad-lib, wheat bran 65% and cotton seed cake 35%)in a Randomized complete block design. All the experimental bulls were supplemented with their respective feed rations at 2.5% of their body weight per day during the whole experimental periods. Finally, after 18 hours fasting, 3 bulls from each treatment group were randomly selected and slaughtered for carcass analysis. Data on feed intake, live body weight change, feeds conversion efficiency and carcass parameters were analyzed using general linear model (GLM) of Statistical Analysis System (SAS) version 9.2. Results of the fattening trial revealed that there is no significant difference in daily weight gain, total weight gain, final body weight, feeds conversion ratios and carcass characteristic of bulls fed on treatments 1, 2 and 3 at 168 fattening days (P>0.05). But there was significant difference in feed conversion efficiency and dry mater intake of bulls fed on T1 and T3 (P< 0.05). Even though all the three feeding rations are economical profitable, feeding of bulls with T1 is more profitable as compare to T 2 and T3. Therefore beef cattle fatteners can use T1 for fattening of two years old Kerayu bulls for export/local market weight gain and for better economic return.

Key words= Carcass, Concentrate, Export, Kereyu bulls and market weight

Introduction

Livestock industry is an important and integral part of agricultural sector in Ethiopia. Livestock farming is vital for the supply of meat and milk and serves as a source of additional income both for smallholder farmers and livestock owners (Ehui *et al*, 2002). Ethiopian livestock are fed with diverse feed resources which are very low in quality and quantity. The major feed resources are the crop residues and grass hay which contains poorly digestible nutrients. To ensure better body weight gain of the animals under such situation, it is advisable that additional sources of energy and nitrogen feedstuff should be included in the diet of beef cattle to improve their growth performance and carcass quality. In Ethiopia the effect of many feed ingredients has been tested on body weight change and carcass characteristics of old and culled oxen for domestic consumptions. However, the effect of different feeding rations on different breeds and ages of bulls for export market weight gain is not addressed well. Evaluation of different feeding options on different breeds and different ages of bulls to attain the desired export market weight and carcass quality contributes significant amount of foreign currency to what the country earns from exporting of live

animals and meat. The recent study conducted on different ages of Borana bulls fed on different dietary rations for export market weight gain at Adami Tulu agricultural research center revealed that various feed had played a vital role on growth response and carcass quality of bulls (Mieso G., *et al* 2013 and Girma D. *et al*, 2015). The result indicated that Borana breed have far better potential to attain export market weight at an earlier age than the other breeds so far done in the country Mieso G., *et al* (2013) and Girma D.*et al* (2015). But the effect of different dietary rations on early ages of Kereyu bulls targeted for export/local market weight gain is not studied yet. Hence this feeding trial was designed to evaluate the growth performance, carcass characteristics and to identify the most economical feeding option of Kereyu bulls for export/local market weight gain.

Materials and Methods

Description of the study area

The feeding trial was conducted at Adami Tulu Agricultural Research Center which is located at a distance of 167 kms from the capital city of Ethiopia (Addis Ababa). Its altitude is 1650 meter above sea level in mid rift valley. It lies at latitude of 709'N and 3807'E longitude. The agro-ecological Zone of the area is semi-arid and sub humid. It has a bimodal unevenly distributed rainfall and its mean annual rainfall is 760.9 mm. The mean minimum and maximum temperatures are 12.7^0C and 29.2^0C respectively. The average annual relative humidity is 60%. The soil type is fine, sandy loam with sand: silt: clay in the proportion of 34, 38 and 18% respectively. The average PH is 7.88. The dominant vegetation in the center includes acacia woodland, Pennisetium and Cenchrius grass species (ATARC, 1998).

Description of experimental animals

A total of 24 two-years old Kereyu bulls with an initial mean body weight of 149± 6.49 kg were purchased from local market of Fentale district and transported to Adami Tulu agricultural research center. The Kereyu breed is predominantly found in Fentale district which is located at a distance of 200km east of the capital city of Ethiopia (Addis Ababa). The breed is typically known by their long horn, aggressive behavior, and black and white body color. This breed is commonly kept by Kereyu people/communities. Age dentition and body conformation were used as main criteria to purchase bulls of similar ages and the same body condition from the market. The purchased bulls were kept under quarantine in separate barn at Adami Adami Tulu agricultural research center for about 14 days and they were treated both for external and internal parasites.

Experimental design

The initial body weights of the experimental bulls were used for blocking of the animals into three groups/blocks. Randomized Complete block design was used to assign one of the dietary rations for experimental bulls. Overall a total of 8 Kereyu bulls were randomly assigned to one of the three feeds ration.

Feeds and feeding management

Three feeds ration were formulated from different feeds ingredients to be used for fattening of the experimental bulls. The dietary rations used for this feeding trial were composed of molasses, maize grain, wheat bran, noug seed cake, cotton seed cake and salt. The three different feeds rations formulated from the above listed feeds ingredients were formulated in the way that they contain the same amount of energy and protein contents (table 1). Totally the feeding trail lasted for 168 feeding days to attain the required export/local market weight gain. The dietary treatments used for feeding of experimental bulls during these periods were:

T1 = ad-libitum Rhodes grass hay +20% molasses+ 40% wheat bran+ 40% Noug seed cake
T2 = ad-litum Rhodes grass hay +20% maize grain+45% wheat bran+35% Noug seed cake
T3= ad-litum Rhodes grass hay + 65% wheat bran+ 35% cotton seed cakes.

Table 1. Ingredients and Composition of the formulated experimental ration

Ingredients	**Treatment**	**DM%**	**CP%**	**TDN%**
Molasses	T1	20	1.16	14.4
Wheat bran	T1	40	5.52	26.80
Noug seed cake	T1	40	11.9	26.4
Total		100	18.58	67.6
Maize grain	T2	20	2	17
Wheat bran	T2	45	5.85	30.15
Noug cake	T2	35	10.41	23.1
Total		100	18.26	70.25
Wheat bran	T3	65	8.45	43.55
Cotton seed cake	T3	35	9.8	26.25
Total		100	18.25	69.8

Feeding of Experimental bulls

The experimental bulls were kept in feedlot and they were fed on their respective dietary ration until they attained the desired export/local market weight gain. The bulls were supplemented with the dietary ration at 2.5% of their body weight and feeding of the bull was undertaken in individual basis. Supplementations of bulls at 2.5% of their body weight were gradually changed within two weeks intervals based on the body weight change of the bulls. In addition to supplementary ration, the experimental bulls were also fed on ad-libtum Rhodes grass hay as a basal diet through out the feeding trial. Water was provided for the bulls at free choice/ access. The feeding trial lasted for 168 days including the 14 days of adaption period.

Data collection

Data on daily feed offered and refusal from each treatment group of experimental bulls were collected and weighed every day before the daily feed allowance was provided for the bulls. Data on body weight change of experimental bulls were collected every two weeks (fortnightly) starting from the commencement of the feeding trial to the end of the fattening period.

Partial budget analysis

All costs incurred for feeding of experimental bulls with the three dietary rations were recorded to analyze the profitability of fattening two years old Kereyu bulls for export/local market weight gain. Total variable costs incurred include cost of purchasing the animals, transportation cost, feed cost during the feeding period, labor and veterinary costs. The gross output/revenues of experimental bulls were estimated at the end of the fattening period by the help of three people who have enough knowledge and experience on pricing of fattened bulls. The fixed costs incurred for feeding of these experimental bulls is not included in this cost-benefit analysis. Hence, this partial budget analysis only indicates gross margin of fattened bulls using three dietary rations for 168 feeding day. Gross margin and Total Gross margin per bull was calculated as:

GM = TVC- GO,

TGM = GM multiplied by total number of bulls assigned to one ration/treatment.

Where, GM= gross margin per animal,

TVC= total variable costs incurred for fattening of bulls,
GO= gross out per bull and Total gross margin.

Statistical analysis

Data on feed intake, live body weight change, feeds conversion efficiency and carcass parameters (for each slaughtered bulls) were analyzed using general linear model (GLM) of Statistical Analysis System (SAS). The estimated least squares means were separated by the Duncan's Multiple Range Test at $P< 0.05$. Data on body weight gain of experimental bull were computed by finding the difference of the two weighing periods (initial and final body weight) and regress it over the number of days elapsed.

Result and discussion

The growth performance /body weight change of two years aged Kereyu bulls fed on three feeds rations for 168 days feeding period is indicated in table 2. There was no significant difference ($P > 0.05$) in final body weight, daily weight gain and total weight gain among experimental bulls fed on T1, T2 and T3. This result is similar with the previous finding trial conducted (Girma D. *et al* ,2015). In that study, no-significant difference in final body weight, daily weight gain and total weight gain of two years aged Borana bulls fed on the same type of feeds were reported. Even though there was no significant variation on body weight change of Kereru bulls fed on three feeds ration, experimental bulls fed on T1 had gained higher final body weight, daily weight gain and total weight gain than bulls fed on ration T2 and T3 (table 2).

The mean feeds conversion efficiency of experimental bulls fed on T1, T2 and T3 were 8.1, 8.5, and 6.1 respectively. There is a significant difference (P<0.000) in DMI of bulls fed on T1 and T3 but there is no significant difference (P> 0.05). in DMI of bulls fed on T1 and T2 . But there is a significant difference in FCE of bulls fed on T2 and T3. Experimental bulls fed on T2 had higher feed conversion ratio than bulls fed on T1 and T3 (table 2). There is a significant difference in DMI of experimental bulls fed on T1 and T3, T2 and T3 (P<0.05) but there is no significant difference (P>0.05)in DMI between T1 andT2..

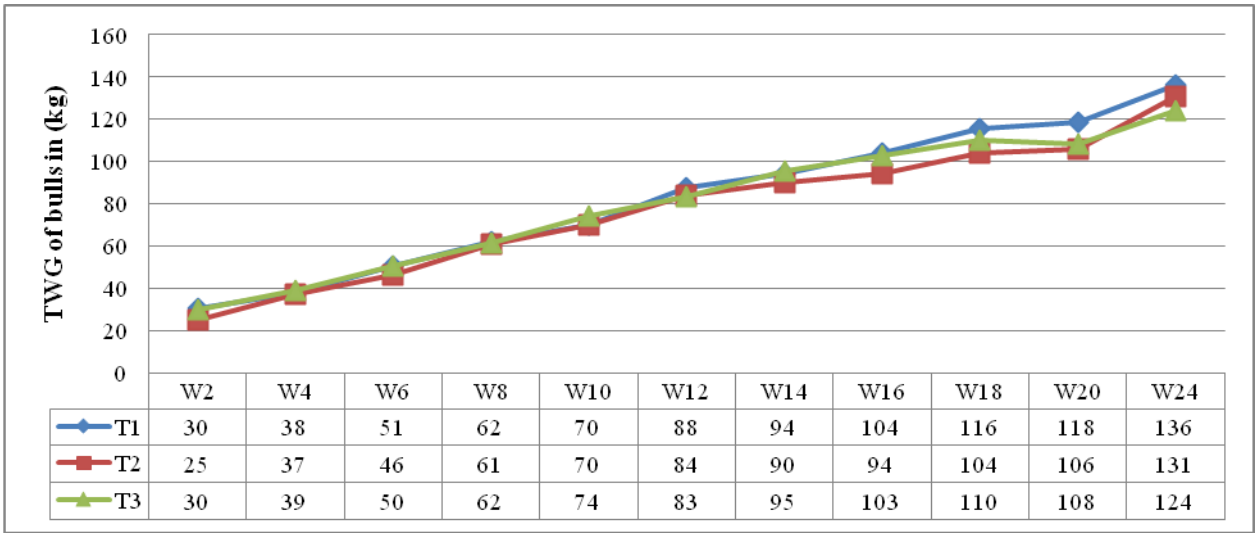
Table 2. Effect of different feeding options on body weight change and feeds conversion ratio of the bulls at 168 feeding days

Variables (kg)	**T1**	**T2**	**T3**	**Grand mean**
IBW	149±6.49[a]	149±6.36[a]	149±5.43[a]	149±6.36
FBW	285.6±11.1[a]	264.8±7.8[a]	274.1±17.0[a]	274.8±7.2
LBWC	136.6±7.3[a]	130.8±17.0[a]	124.38±11.9[a]	130.5±7.1
ADG	0.810±0.07[a]	0.779±0.05[a]	0.740±0.10[a]	0.777±0.04
DMI	6.4±0.20[a]	6.1±0.18[a]	4.2±0.26[b]	5.6±0.24
FCR	8.1±.0.48[a]	8.5±0.81[a]	6.1±0.76[b]	7.6±0.45

IBW=intial body weight, FBW= final body weight, DWG = daily weight gain, LBWC = Live body weight change, DMI= dry matter intak & FCR = feed conversion ratio

The total body weight gain and avergae daily weight gain of bulls fed on T1 in the present study was highere than 69.1and 0.47kg reported for Zebu oxen grazing natural pasture and supplemented with highere level of wheat bran (Tefaye *et al*., 2002). The present ADGs for bulls fed on T1, T2 and T3 were also higher than 0.614 kg/day reported for drought oxen fed on teff straw and supllemented with wheat bran, wheat middlings and cotton seed cake (Osuji and capper 1992). It was also comparable with 0.740 kg/day reported for matured Zebu bulls fed teff straw and supplemented with poultry litter and Noug seed cake (Preston and Leng, 1986). In general, the difference in weight gain might be attributed to difference in quantity and quality of the supplements, type of basal diet and age and the physiological and genetic potential of the animals.

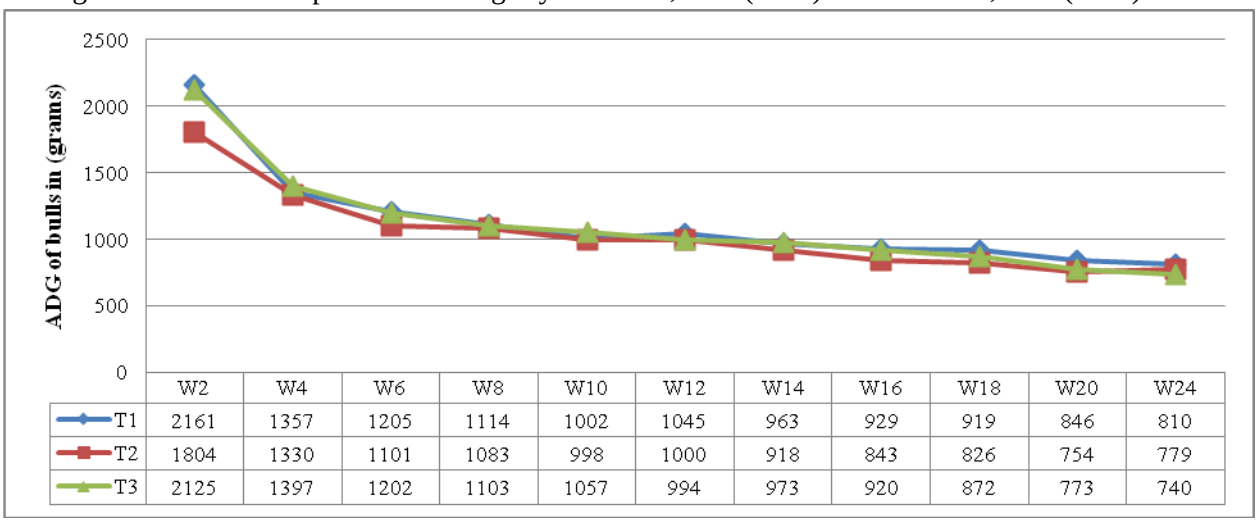
As the number of feeding days increased from 14 to 168 days, the feed conversion efficiency of the experimental bulls also increased. This is because of the increase in dry matter in take of the bulls Howevr, the daily weight gains of the bulls were decreased. The total body weight gain of experimental bulls over 168 days of fattening period is indicated in figure 1. In all dietary treatments the live body weight changes of experimental bulls were steadily increased as the amount of dry matter intake (DMI) of experimental bulls increased. On average the total body weight gain of the experimental bulls increased within the range of 28 kg to 130kg staring from the beginning to the end of the feeding trial



	W2	W4	W6	W8	W10	W12	W14	W16	W18	W20	W24
T1	30	38	51	62	70	88	94	104	116	118	136
T2	25	37	46	61	70	84	90	94	104	106	131
T3	30	39	50	62	74	83	95	103	110	108	124

Figure 1. Trend of total weight gain of two years old kereyu bulls over the fattening period

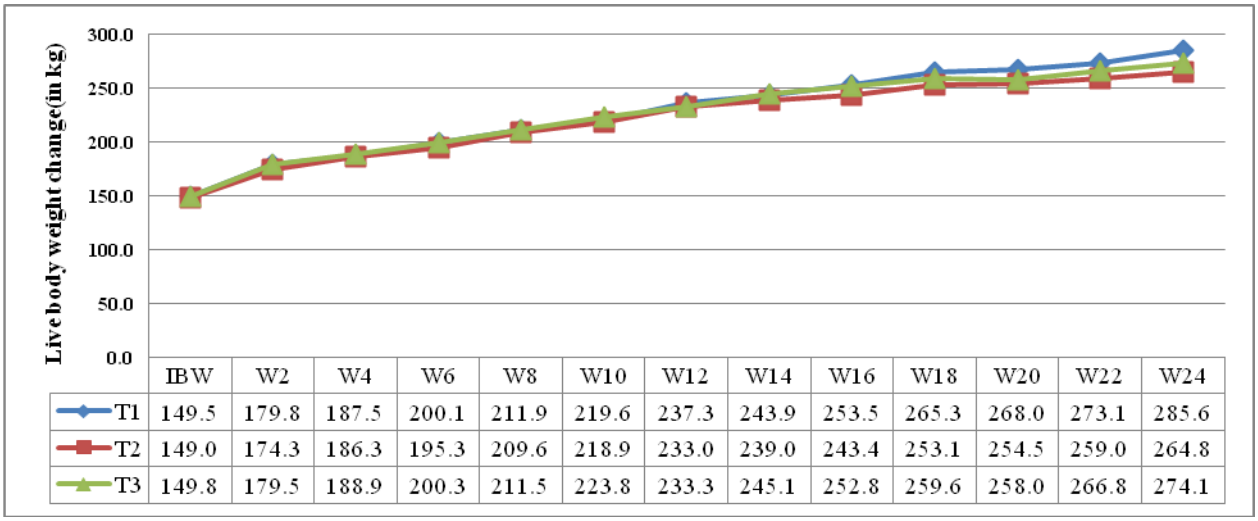
The daily weight gains of the experimental bulls fed for the 168 days are indicated in figure 2. The change in daily body weight gain of experimental bulls also increased/decreased in similar fashion to the live weight change of the bulls. As a result of compensatory growth, the average daily weight gains of experimental bulls were higher at the initial stage of the feeding period. But later on as the experimental bulls finished their compensatory growth, their average daily weight gains decreased steadily. This finding is similar with the previous findings by Mieso G., *et al* (2013) and Girma D., *et al* (2015).



	W2	W4	W6	W8	W10	W12	W14	W16	W18	W20	W24
T1	2161	1357	1205	1114	1002	1045	963	929	919	846	810
T2	1804	1330	1101	1083	998	1000	918	843	826	754	779
T3	2125	1397	1202	1103	1057	994	973	920	872	773	740

Figure 2: Trend of daily weight gain of two years old kereyu bulls over the fattening period

The dry matter intake (DMI), daily weight gain (DWG) and feeds conversion efficiency (FCE) of experimental bulls are indicated in table 3. The feed conversion ratio/efficiency indicates the amount of feed needed to produce one kg gain in live weight. The dry matter intake and daily weight gain of experimental bulls fed on three dietary rations were steadily increased throughout the feeding period. The feed conversion ratio of the experimental bulls fed on the three treatment groups steadily increased starting from day one to the end of feeding period (168 days).



	IBW	W2	W4	W6	W8	W10	W12	W14	W16	W18	W20	W22	W24
T1	149.5	179.8	187.5	200.1	211.9	219.6	237.3	243.9	253.5	265.3	268.0	273.1	285.6
T2	149.0	174.3	186.3	195.3	209.6	218.9	233.0	239.0	243.4	253.1	254.5	259.0	264.8
T3	149.8	179.5	188.9	200.3	211.5	223.8	233.3	245.1	252.8	259.6	258.0	266.8	274.1

Figure 3. Live weight change of experimental bulls over the feeding period.

Table 3 Dry matter intake, daily weight gain and feeds conversion efficiency of Kereyu bulls

Feeding days	Treatment 1			Treatment 2			Treatment 3		
	DMI (gm)	DWG (gm)	FCE	DMI (gm)	DWG (gm)	FCE	DMI (gm)	DWG (gm)	FCE
0-14	4200	2161	2	4000	1804	2	4300	2125	2
14-28	4400	1357	3	4300	1330	3	4400	1397	3
28-42	4700	1205	4	4600	1101	4	4300	1202	4
42-56	4900	1114	4	4900	1083	5	4400	1103	4
56-70	5300	1002	5	5200	998	5	4700	1057	4
70-84	5400	1045	5	5400	1000	5	4700	994	5
84-98	5800	963	6	5800	918	6	4500	973	5
98-112	6100	929	7	5700	843	7	4900	920	5
112-126	6300	919	7	6100	826	7	4900	872	6
126-140	6400	846	8	6100	754	8	4700	773	6
140-168	6400	810	8	6100	779	8	4300	740	6

DMI= Dry Matter Intake, DWG=Daily Weight Gain, FCE=Feeds Conversion Efficiency and gm=gram

Effect of dietary rations on carcass parameters of experimental bulls

The effects of dietary rations on dressing percentage and lean to fat ratio of bulls fed on the three treatment groups were indicated in table 4. In this experiment there was no significant difference ($p>0.05$) in dressing percentage, lean to fat ratio, fat to bone ratio and bone to lean ratio among the three dietary treatments. However, experimental bulls fed on dietary ration T2 had higher dressing percentage and lean to fat ratio than bulls fed on treatment one and two. The current dressing percentage of Kereyu bulls (57%) obtained by feeding with T2 (adi-libitum Rhodes grass hay, 20% maize grain, 45% wheat bran and 35% Noug cake) is similar with the report of Girma D. *et al* (2015) who reported the dressing percentage of 59% for two years old Borana bulls fed on grazing + 20% molasses + 40% wheat bran and 40% Noug seed cake. Mekasha., *et al* (2011) also reported similar dressing percentage (56%) for Ogaden bulls

grazing on native tropical pasture supplemented with different levels of agro industrial by-products. The dressing percentage found in this feeding trial is higher compare to the dressing percentage of 52.5% reported for Sudan Baggara Zebu bulls maintained under *ad libitum* feeding management (Fadol and Babiker, 2010; Talib and Ahmed, 2008). The lean to fat ratio found in this trail is also comparable with the report of Girma D. *et al* (2015) who reported the lean to fat ratio of 2.6 for two years old Borana bull. The higher lean to fat ratio obtained in this feeding trial than the previous result of Borana bulls indicates that Kereyu bulls had accumulated less fat than Borana bulls.

Table 4 . Effect of different feeding options on dressing percentage, lean to fat, lean to bone and fat to bone ratios of the bulls

Parameters	T1	T2	T3	Mean
Dressing percentage	54.4	57.4	57.1	56.3
Lean meat to cold carcass weight ratio	2.43	2.53	2.42	2.46
Fat to cold carcass weight ratio	0.79	0.69	0.74	0.74
Bone to cold carcass weight ratio	0.72	0.72	0.76	0.73
Lean to fat ratio	3.08	3.67	3.25	3.3
Bone to lean ratio	0.3	0.28	0.31	0.3
Fat to bone ratio	1.09	0.96	0.98	1.01

The effects of different feeding options on non-edible organs and different parts of slaughtered bulls are indicated in table 5. There was no statistically significant difference in non-edible organs of experimental bulls fed on T1, T2 and T3. Even though the differences among the treatment groups were not statistically significant,, experimental bulls fed on T3 had higher skin and small intestine than bulls fed on T2 and T1.

Table 5. Effect of different feeding options on non-edible organs of the bulls

Non-edible organs (in kg)	T1	T2	T3	Overall mean
Tail	0.8	0.6	0.8	0.7
Skin	22.7	21.7	23.9	22.8
Feet	5.1	4.5	5	4.8
Lung	2.5	2.5	2.8	2.6
Spleen	0.8	0.8	1	0.8
Pancreas	0.2	0.2	0.2	0.2
Bladder	0.1	0.1	0.1	0.1
Pensi	0.4	0.5	0.5	0.5
Full gut	31.8	28.5	34.2	31.5
Small intestine	9.6	10.9	13.1	11.2
Large intestine	6.4	5.3	5.6	5.8

The effect of different dietary rations on carcass parameters of experimental bulls fed on T1, T2 and T3 were depicted in table 6. There was no significant difference in hot carcass weight, cold carcass weight, heart, kidney, hump and empty gut of experimental bulls fed on T1, T2 and T3.

Table 6. Effect of different feeding options on carcass and edible organs of the bulls

Carcass parameters(in kg)	T1	T2	T3	Overall mean
Hot carcass weight	155.4±6.4	152±8.2	156.5±8.8	154.6±4.2
Right side hot carcass weight	77.5±2.6	76.1±4.2	77.3±3.9	76.9±1.9
Left side hot carcass weight	77.8±3.9	75.8±4.0	78.8±5.3	77.54±2.4
Right cold carcass weight	76.3±3.3	74.4±3.9	74.3±4.4	75.0±2.0
Tongue	0.85±0.07	0.74±0.16	0.73±0.07	0.77±0.06
Heart	0.95±0.5	0.96±0.06	0.96±0.10	0.96±0.04
Heart fat	0.75±0.05	0.80±0.06	0.65±0.12	0.73±0.48
Kidney	0.55±0.05	0.54±0.02	0.65±0.03	0.56±0.23
Kidney fat	3.2±0.45	3.7±0.0.45	4.2±0.57	3.7±0.27
Liver	5.95±0.36	3.9±0.35	4.1±0.27	3.98±0.17
Pelvic fat	1.56±0.37	1.4±0.07	1.2±0.09	1.4±0.13
Hump	2.96±0.53	3.7±0.26	3.6±0.59	3.4±0.27
Omental fat	2.6±0.4	3.0±0.35	3.3±0.30	3.0±0.20
Head	13.5	11.9	13.4	12.9
Empty gut	7.4	6.7	6.8	6.9

The effect of feed rations on lean meat, fat content and bone of the slaughtered bulls were indicated in figure 3. There was no statistically significant difference in lean meat and fat accumulation of experimental bulls fed on ration 1, ration 2 and ration 3. Hence, in this trial lean meat proportion was not significantly affected by dietary rations. But experimental bulls fed on T2 had developed higher lean meat than bulls fed on T1 and T3. While bulls fed on T1 had accumulated higher fat proportion than bulls fed on T2 and T3. Experimental bulls developed higher lean meat and lower proportion of fat and bones. On the other hand experimental bulls' accumulated higher fat percentage (T2) and developed lower lean meat as compare to other experimental bulls fed on other rations (T1 and T3).

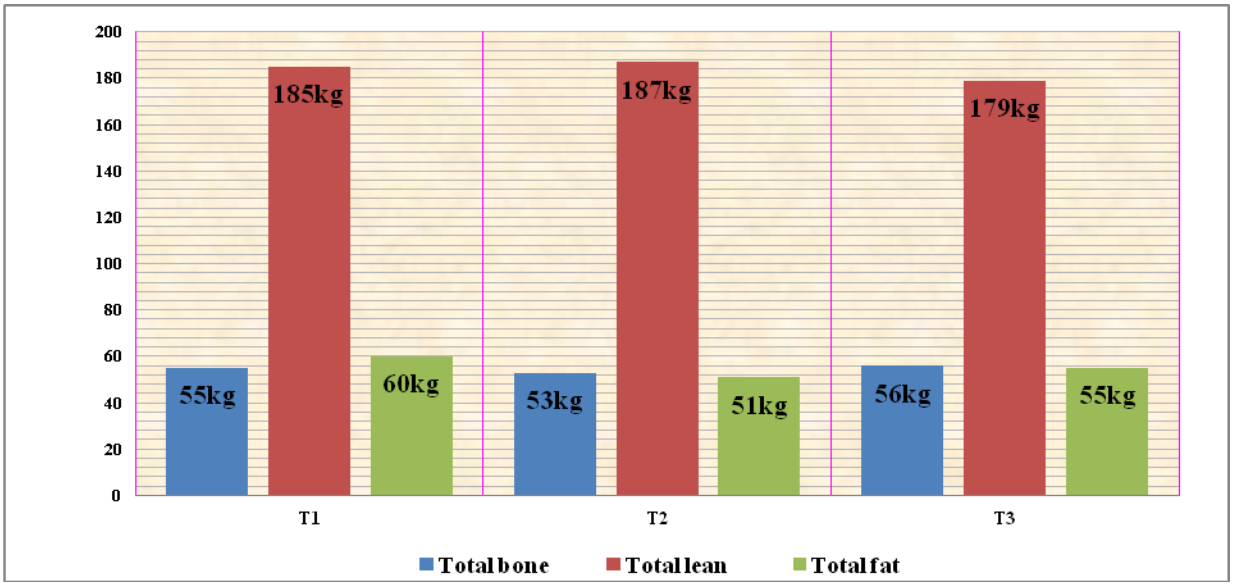


Figure 3. Effect of feeding rations on lean meat, fat percentage and bones of the bulls

Effect of different feeding options on hot and cold carcass weight of experimental bulls was depicted in figure 2. There was no significant difference in hot carcass weight and cold carcass weight of experimental bulls fed on T1, T2 and T3. However, bulls fed on dietary ration 1 had higher hot carcass and cold carcass weight than experimental bulls fed on dietary rations 2 and 3. The effect of dietary rations on hot and cold carcass weight of the bulls found in this trial is lower than the report of Mekasha Y., *et al* (2011) for Ogaden bulls grazing on native tropical pasture plus different levels of agro industrial by-products. This difference might be due to the breed difference and type of feeds used for fattening of the bulls.

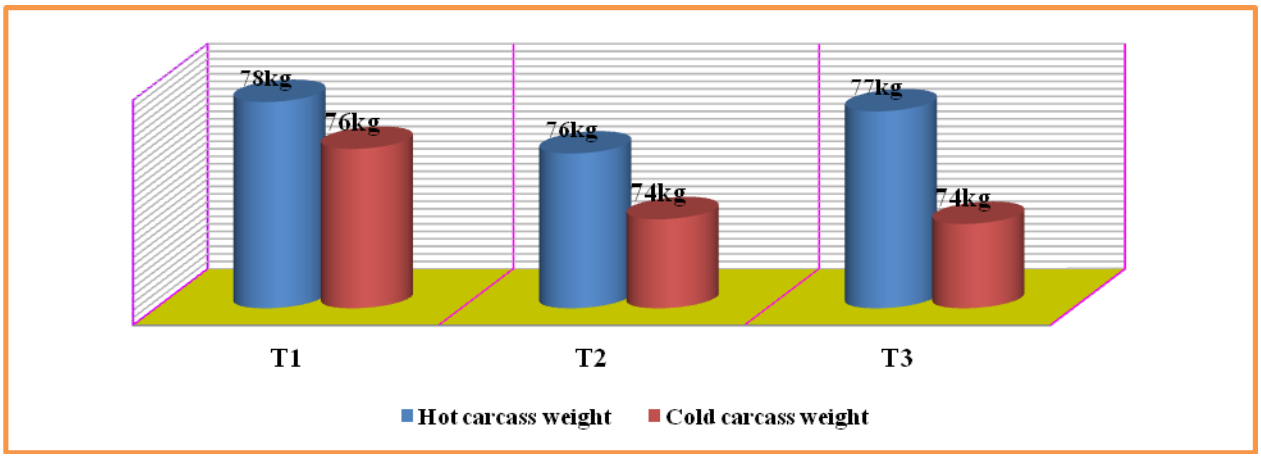


Figure 4. Effect of feeding rations on hot and cold carcass weight of the Kereyu bulls

Economic return on fattening the Kereyu Bulls

The result of partial budget analysis of fattening the Kereyu bulls fed on three different rations for about 168 days is indicated in table 7. Its result showed that experimental bulls fed with T1 had higher gross margin (42704.00 Birr for the 8 bulls) than bulls fed on T2 and T3 which resulted in a gross margin of 37330.25 and 38728.30 Birr respectively each of them for the same number of bulls as T!.). Feeding of bulls with T2 is less profitable as compare to T1 and T3. This is because of the high cost of maize grain used in T2. Hence, fattening of two years old Kereyu bulls for 168 days by using three different feeding rations for export market weight gain of 275kg is profitable for all the three feeding rations in general.

Table 7 Partial budget analysis of Kereyu bulls fed on different feeds rations for 168 feeding days

List of items	T1	T2	T3
Feeds costs per bull	5933	6605	6479.96
Purchasing price and transportation coats per bull	2400	2400	2400
Labor cost per bull	294	294	294
Vet cost per bull	35	35	35
Total variable costs per animals	8662	9334	9208.96
Total gross output per bull	14000	14000	14050
Gross margin per bull	5338	4666.3	4841
Total gross margin (8 bulls)	42704	37330.25	38728.3

Conclusion and recommendations

There was no significant difference (P>0.05) in ADG, TWG, FBW, FCE and carcass parameters evaluation of two year old Kereyu bulls fed on T1, T2 and T3 for 168 feeding days. This may be because of the similarity in ages and breed of the bulls which had brought the same effect on body weight gains and carcass characteristics of the bulls. Moreover the same percent of total CP and TDN had been provided for experimental bulls which might have produced the same effect on body weight change and carcass characteristics of experimental bulls. The dressing percentage of experimental bulls fed on T3 was higher than those fed on T2 and T1. But in case of final body weight gain, hot carcass weight, clod carcass weight, bulls fed on T1 had higher values than those fed on T3 and T2. Lean meat to fat ratio of experimental bulls fed on T2 was the highest followed by those fed on T3. Experimental bulls fed on T1 had least lean to fat ratio. This might be because of the energy in dietary ration T2 and T3 had relatively lower digestibile energy than ration 1. This plays a great role in accumulation of fat in muscles. Feeding of two years aged Kereyu for export/local market weight gain of about 300kg took very long time and may not be profitable. Because of this, feeding of the bulls was stopped on average at 275 kg live weight. Feeding of two years old Kereyu bulls with T2 and T3 for 168 days is less profitable as compare to feeding of the bulls with T1. Hence, feeding on T1 is very feasible both economically and biologically as compare to feeding on T2 and T3. Therefore beef cattle fatteners can use T1 for fattening of two years old Kereyu bulls for export/local market weight gain.

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Analysis of community breeding objectives and practices for goats in Fentale district, East Shawa Zone of Oromia Regional State

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Abstract

A survey work was conducted in Fantale District of East Shoa Zone of Oromia regional State to define farmers' goats breeding objectives, their trait preferences, characterizing of their breeding practices and to describe traditional individual animal identification system in the study areas. Purposive and simple random sampling was employed to select the study PAs and all the respondents in the study sites. Semi-structure questionnaire survey was implemented to collect the required information by interviewing the selected respondents in each selected PA. The survey result indicated that about 9.7% were involved in goats' breeding activities to produce meat, 21.2% to produce milk, 28.3% to produce both milk and meat, 7.1% for other purposes while 33.6% to produce milk & for other purposes. About 76.7% of the respondent farmers select goats for breeding purpose, while the rest 23.3% do not select goats for breeding purpose. From the total interviewed farmers and pastoralists about 92.5% were involved in goats breeding activities to produce meat and milk. During the survey time the reproductive performance of goats was also assessed and its result indicated that the mean age at first kidding in the study areas is 13±0.67 months. The average kidding interval in the study PAs was 7.24 month, while the mean litter size of doe in study PAs was 1.07±0.02 kids. In general the farmers /pastoralists in Fantale area need awareness creation on use of selection criteria and breeding objectives for breeding of their goats.

Introduction

Farm animals as a whole are an integral part of the country's agricultural system and are raised both in the highland and lowland areas. Similarly, the habitats of the indigenous goat breeds extend from the arid lowlands (the pastoral and agro-pastoral production system) to the humid highlands (mixed farming systems) covering even the extreme tsetse-infested areas of the country (Workneh, 1992). Fentale is endowed with large population of livestock with an estimated number of 104,858 cattle, 109,113 goats, 96,245 sheep and 89,652 camels. Pastoralists in this district are mainly dependent on livestock for their livelihood both before and after introduction of irrigation scheme.

However, livestock production is constrained by different factors such as sever animal health related problems, less productivity of animals, absence of improved breeds, marketing of livestock and lack of information on the actual performance of animals under their natural habitat and these needs to be addressed to improve the livelihood of the producers.

The design of sustainable genetic improvement schemes under smallholder situations requires indigenous knowledge on traditional breeding practices which is structured differently from scientific knowledge (Mbuku *et al.,* 2006). Lack of such knowledge leads to the setting up of unrealistic breeding goals in the design of livestock genetic improvement programs and the consequence of which can put in danger the conservation of indigenous animal genetic resources (Zewdu *et al*., 2006). Pastoralists or smallholder

farmers have very valuable knowledge about animal management and desirable traits, but less knowledge on how genes are transmitted to the next generation and how to use information from relatives (Mbuku *et al.*, 2006). When defining the selection criteria, they consider not only the individual's own features, but also, for example, the features of the individual's parents and grandparents. Presently, community-based genetic improvement strategies are being advocated for pastoral production (Kahi *et al*., 2005). Among the important subjects are the breeding practices, description of production environment, definition of breeding goals/objectives and traits to be selected for (traits preference). These strategies would require a good understanding of the community's indigenous knowledge of their animals. However, information on indigenous knowledge of traditional animal breeding practices is hardly available for goats' populations in Fentale district despite the current emphasis given for on-farm participatory research.

Moreover, on-farm flocks productivity monitoring clearly revealed the potentiality of the population for their future improvements (unpublished). A given breed can perform differently under different production system because animal's performance is the combined result of genotype and environment. Performance evaluation of goats under their natural habitat is vital for insight decision and development of sustainable breeding scheme under smallholder/pastoralists situations. Therefore, this study was designed to address all above mentioned issues with the following objectives.

Objectives

- To define farmers' goats breeding objectives, identify their trait preferences, and characterize their breeding practices.
- To describe traditional individual animal identification system and flock management practices

Materials and methods

Sampling techniques

Potential PAs were purposively selected based on criteria such as small ruminant population, production system and accessibility of the area in the study sites. To have holistic view of smallholders/pastoralists breeding practices, 6 PAs namely Banti, Haro, Kersa, Elela, Kobo and Gola found in different production systems at Fentale district were selected. Accordingly, a total of 120 farmers (20 respondents from each selected PAs) were randomly selected

Type of data and methods of data collection

Both primary and secondary data were collected from the study sites. Primary data was collected on general household and farm characteristics, reproductive problems, breeding management practices, breeding objectives, flock, purpose of keeping of goats, individual animal identification system and selection criteria for male and female goats. Moreover, data on mortality trend and causes of mortality and its relationship with season, kids' birth type, and dam parity were collected. Husbandry practices such as housing and feeding as well as adaptation traits like level of resistance to disease and parasite, tolerance to heat and drought were also assessed during the study time.

Primary data was collected through survey by use of semi-structured questionnaire administered to selected sample households. The questionnaire survey was first pre-tested and modified before the execution of the actual survey. One focused group discussion at each production system was also employed to clarify issues not well addressed through individual interview and to validate/triangulate some information collected by individual interview. Development agents, key informants (Elders, PA leaders), district livestock experts were participated on the discussion.

Data management and statistical analysis

Both primary and secondary data were coded, screened and entered into computer on Microsoft excel and analyzed using Statistical Package for Social Science (SPSS version 19) to describe them in terms of proportions.

4. Result and Discussion

4.1. Sex and age of the respondents in the study sites

From the total interviewed respondents about 72.5% and 27.5% were males and females respectively. In this study sites more males were interviewed to generate base line data on goats' breeding objectives and practices. The result of the survey showed that the mean average age of the interviewed farmers and pastoralists in the study PAs is 34.42 years. The maximum and minimum age of the interviewed respondents during the study time was 81 and 17 years old respectively. The frequency of age distribution of the respondents in the study PAs were indicated in figure1.

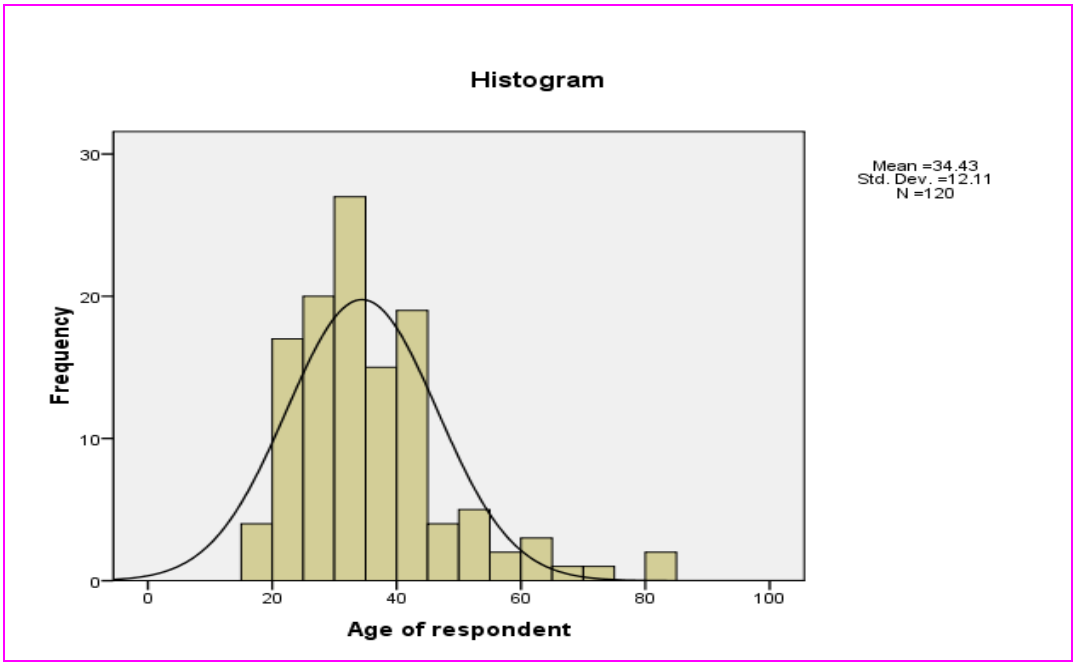


Figure 1. Age of respondents in the study PAs

Purpose of goat keeping

From the total interviewed farmers/pastoralists about 9.7% were involved in goats' breeding activities to produce meat, 21.2% to produce milk, 28.3% to produce both and 7.1% for other purposes while 33.6% to produce milk & for other purposes.To get the intended purposes about 71.6% of the interviewed respondents started the goats' breeding activity before 10 years, 13.8% of the respondents started it before five year, whereas about 14.7% of the respondents started the work during the past five years. Milk production is the primary reason of keeping goats by pastoralists in study sites. From this it was observed that most of the pastoralists in the study PAs produce goats for milk production. This result is in line with those of Gatenby (2002), Chipman (2003), Adugna and Aster (2007), Belete (2009), Tesfaye K (2010) and Mengistie *et al.* (2010).

Selection of goats for breeding purposes

From the study it was observed that about 86.7% of the respondents have their own breeding objectives, while the remaining 13.3% do not have any breeding objective. From the total interviewed respondents about 76.7% of the respondent farmers select goats for breeding purpose, while the remaining 23.3% do not select goats for breeding purpose. Some of the bucks' selection criteria used by the farmers and pastoralists in the study sites are indicated in figures 2. 69.2%, 51.7% and 50.8% of the respondents in the study PAs used body conformation, pedigree and color respectively as selection criteria to select breeding bucks. Others do not use any selection criteria for selecting breeding bucks; instead, they simply carry out the breeding activities without considering these criteria. This result was in agreement with Tesfaye K. (2010), who reported that selection of bucks based on body morphology/ condition was rated to be of great importance to farmers/pastoralists, while character of bucks was considered the least important. The respondents indicated that meat production potential of goats observed in terms of market values of goats rather than for consumption at home i.e. the contribution of goat meat for diet of farmers was very low as compared to milk which was part of their diet mainly for children almost every day. In general, the results of this study suggested that the farmers have multiple breeding objectives. These include milk production, growth/meat production, body size, and reproduction in order of their importance. Majority of the farmers emphasized breeding goats for milk production in order to produce and maintain high milk producing Does.

As farmers mentioned, their goats have good reproductive performance and Does which give frequently multiple birth especially twins and those which have high rate of kidding are more preferred by the owners because such Does contributed more to the diet and income of farmers. Generally, farmers want to own breeding goats adaptive to their environment and have better milk production potential with large body size, fast growth rate and better reproductive performance in terms of kidding interval and prolificacy.

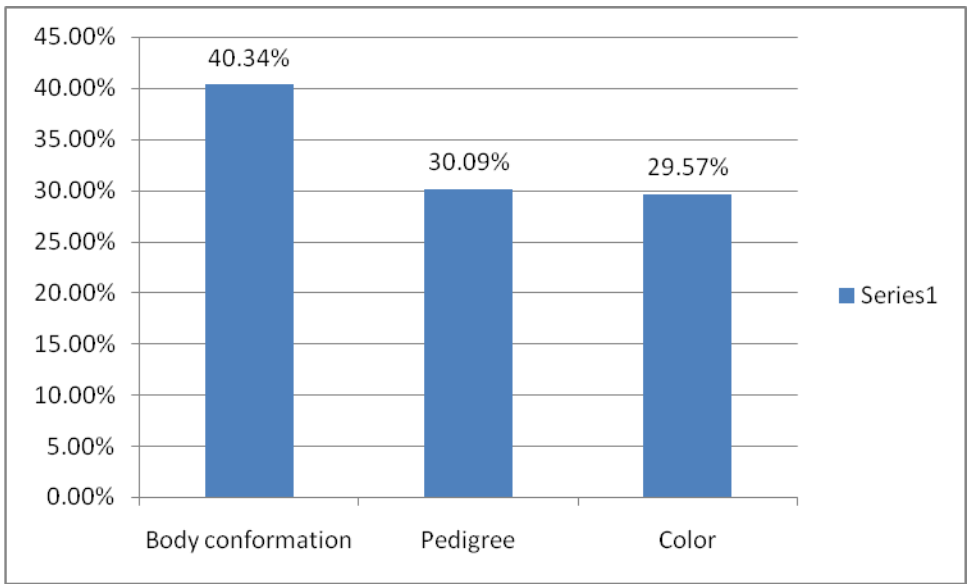
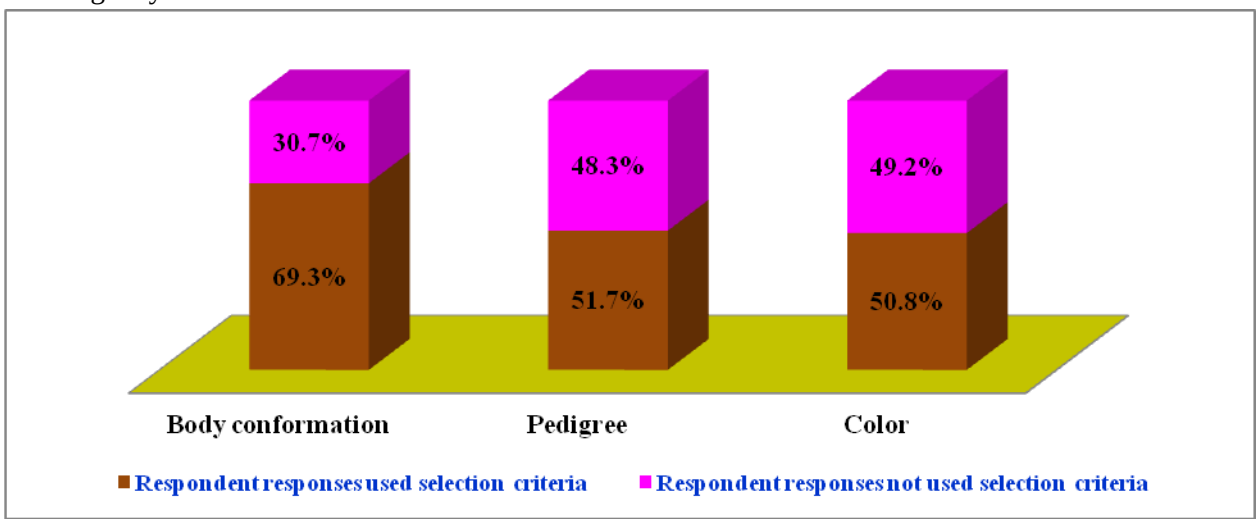


Figure 2. Percentages of respondents using different selection criteria to select breeding Bucks

The selection criteria used by the interviewed farmers/pastoralists in the study sites to select breeding Does was showed in figure 3. From the selection criteria indicated here about 73.3 % of the respondents do not use mothering ability as criteria to select breeding Does. But majority of the respondents (53.4%) use body conformation of female goats as selection criteria to select breeding Doe's for reproduction purposes followed by milk production (49.2%) and pedigree (45.8%). This result was in agreement with Tabbaa and Al-Atiyat (2009) in Jordan, who reported that majority of farmers (84%) emphasized on breeding goats for milk production in order to produce and maintain high milk producing Does. This result was also in agreement with the finding of Muller (2005), who reported selection for body conformation traits, such as feet and leg as well as udder traits, to be considered to to sustain milk yield and longevity.



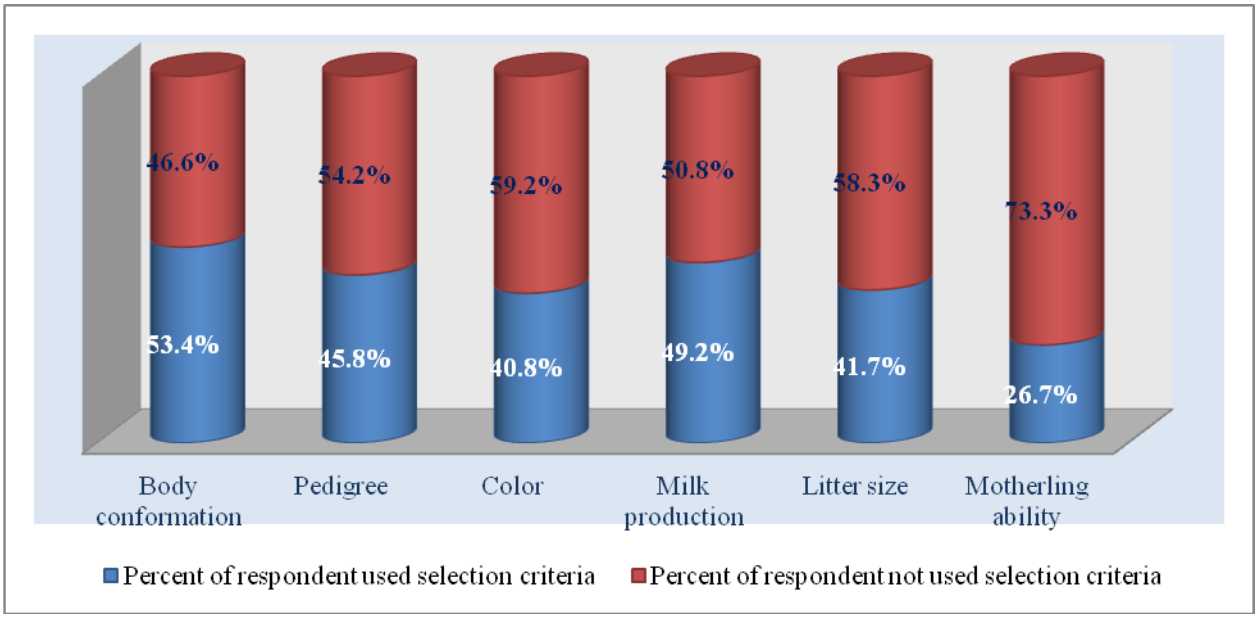


Figure 3. Percentage of the interviewed respondents used different selection criteria for selection of breeding Does

Reproductive performance of goats

During the survey work all the reproductive performances of goats in the selected PAs were assessed and results are presented under the following sections.

Age at first kidding

Age at first kidding can be defined as the age at which Does give birth for the first time. It is a function of puberty, age at first breeding and conception and successful completeness of pregnancy. These reproductive characteristics including age at first kidding (AFK) are influenced by many factors such as genetic make up of an individual, physical environment, nutrition and time of birth (Alexander *et al.*, 1999; Awemu *et al.*, 1999). Age at first kidding is highly variable and dependent on the growth rate and management system used (Song *et al*., 2006).

The mean age at first kidding of goats in the study areas was 13±0.67SE months. This survey report is similar with the finding of Samuel (2005) who reported 13 months as the age at first kidding for Arsi-Bale goats. The current result is also in close agreement with that of Belete (2009), who reported, Getahun (2008), and Tsedeke (2007) who reported, respectively, 12.5 months for Keffa goats, 12.5 for Adilo goats and 12.1 for Arsi-Bale goats under traditional management systems. However, the mean values are lower than those reported by Fikerte (2008), Mengestie *et al* (2011) and Zewdu (2008). The average AFK reported by Tesfaye (2008) was higher than the present finding. This is attributed to the different management practices provided for different breeds of goats.

Kidding interval

Kidding interval is one of the most important reproductive components affecting the lifetime productivity of the Doe in goats' breeding activities. Reproductive efficiency is related to the length of parturition interval of Doe, where long kidding interval has lower reproductive efficiency (Ibrahim, 1998). The mean

kidding interval of goats in the study areas was 7.25±0.24 SE months, which agrees with findings of Tesfaye K(2010), who reported KI of 9.33±0.46 and 7.74±0.1 months at on-station and on-farm respectively which is nearly the theoretically expected three times kidding per two years under normal circumstances (Girma, 2008). Tatek *et al.* (2005) also reported 8.07 months from on-farm monitoring study conducted in Arsi-Negelle district on Arsi-Bale goat breed.

Litter size at birth (LSB)

Litter size is a combination of ovulation rate and embryo survival, number of lambs or kids born per parturition. There is a positive relationship between litter size and age and parity (Getahun, 2008; Girma, 2008). About 93.3% of the respondents in the study sites indicated that majority of their goat flocks give single birth, while only 6.7% responded that their goats give twin birth. This finding contradicts with the result of Tesfaye k., *et al* (2010), who reported that majority (61.5% at on-farm and 50.68% at on-station) of Arsi-Bale goats give twin births. The mean litter size of Does in the study PAs was 1.07, which is lower than the result of Tesfaye k., *et al* (2010) in which an overall mean liter size at birth of 1.6 and 1.65 kids at on station and on-farm conditions, respectively was reported for Arsi-Bale goats.

Heat (sign) detection

In the study sites about 93.3% of the respondents know when their flocks show heat sign, while 6.7% of them do not know when their goat flocks show heat sign. From the total interviewed respondents 80.8%, 79.2%, 73.3%, 30.8% and 20.8% know when their flock show heat by sign of restlessness, uprising of tail, mounting of other goats, vaginal discharge and reduced appetite respectively (fig. 4)..

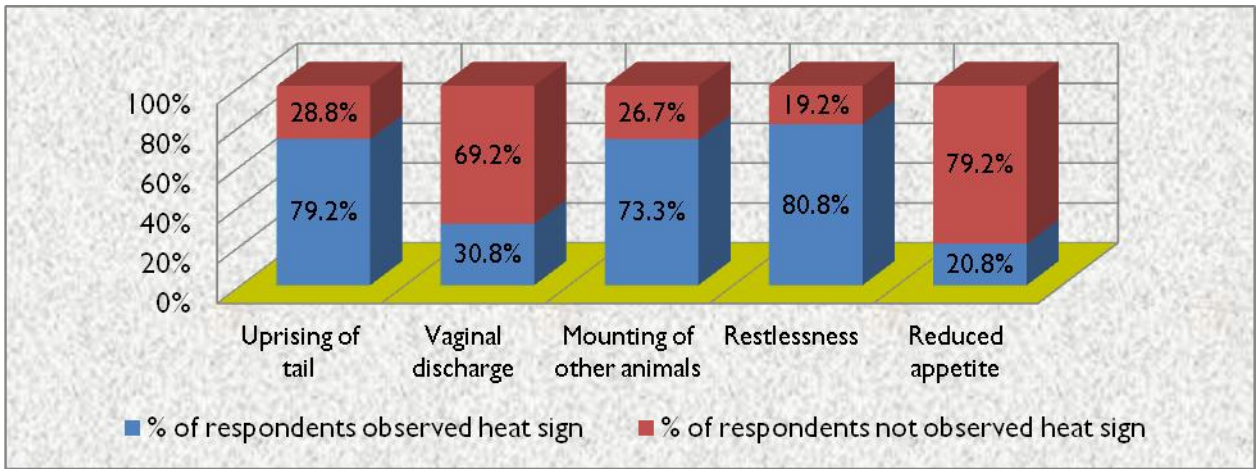


Fig. 4. Percentage of the interviewed respondents using different heat detection signs for breeding of their Does

Breeding/mating system

About 77% of the respondents in the study site bring breeding bucks to their breeding flocks at time when their Does show heat sign, while 6.2% of the respondents bring breeding bucks to breeding flocks 12 hours after they observed the breeding Does in heat sign. However, 16.8% of the respondents do not care about bringing the breeding bucks to breeding Does at all; they leave it to their natural behavior. To undertake this breeding activity about 81.4% of the respondents follow uncontrolled natural mating

system. But only 18.6% of the respondents who do not have personal breeding bucks use natural controlled mating system.

Goats' identification system in the areas

From the survey result it was observed that about 91.7% of the respondent in the study areas recognize their goats' flock individually by their names and the remaining 8.3% of the interviewed pastoralist did not recognize their flocks individually.. From the total interviewed respondents about 94.2% give individual name for their goats to identify each of them within the flock, while only 5.8% of the respondents do not give any name for their individual goats in the flocks. It was noted that almost all the respondents in the study PAs give names to their flocks based on the source of the flocks they acquired. Some of the names given for goats by pastoralists in the study areas are indicated in table 1 below:

Name given	Reason for the naming
Abbee	If the goat is obtained from father
Ayyee	If the goat is obtained from their mothers
Obblee	If the goat is obtained from brothers
Qarsho	If the goat is purchase by cash
Tiko	If the goat is obtained by keeping/goat herding

Small ruminant management practices

Feeding system

From the total interviewed respondents about 96.6% use natural grazing 2.6% use stall feeding around their shelter and only 0.9% provide supplementation. This kind of feeding system is used for goats, which cannot go long distance in search of feeds and water due to age and health problems. During the study time majority of the respondents indicated that there is availability of communal grazing lands, which the pastoralists use during the summer season of the year.

Housing system

About 68.3% of the respondents in the study areas use separate housing for keeping their goats during the night time, while about 30.8% use common shade/enclosure together with other species for keeping their goats during the night time. Very few respondents use part of family house for housing their goats during the night time.

Constraints and challenges of small ruminant production in the study areas

Majority of the respondents in the study area mentioned that shortage of livestock feeds, erratic rain fall, recurrent drought and frequent death of goats as a result of epidemic diseases; drought and inadequate veterinary services are the main challenges of goat production. On the top of the above mentioned constraints, shortage of water as a result of recurrent drought is also among the main constraints which contribute to inadequate feed resources and which cause frequent migration of pastoralists in search of water and feeds. Absence of on-time vaccination of goats to control outbreak diseases is also pinpointed by the respondents as one of the main challenges.

Conclusion and recommendation

From the study it was concluded that shortage of animal feeds and water are major causes of reduction in goat production. The pastoralists in the study areas have indigenous knowledge on individual flock identification system by giving specific names for individual goats. The farmers/pastoralists' goats breeding objectives, their traits of preference and their management practices in the study areas are differing from each other. Some pastoralists do not use any selection criteria for breeding of their goats and their breeding objectives are mainly targeted for milk production just for family consumption. Their goats' management practices mainly focused on natural vegetation for feeding of their flocks, using of common house /enclosure for keeping of goats during night time. But during the dry season they frequently migrate in search for of feeds and water. The average kidding interval in the study PAs was 7.24 month, while the mean litter size of doe in study PAs was 1.07±0.02 kids. Therefore, in general the farmers /pastoralists in Fantale area need awareness creation on use of selection criteria and breeding objectives for breeding of their goats.

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Evaluation of production parameters in three indigenous goat breeds under smallholder production systems in Ethiopia

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Abstract

Evaluation of production parameters in Abergelle (AB), Central Highland (CH) and Woyto-Guji (WG) indigenous goat breeds was conducted under smallholder production systems in Ethiopia. The objectives were (1) to evaluate three month (3mw) weight and average daily milk yield (DMY) (AB only) and (2) to evaluate kidding interval (KI), litter sizes at birth (LSB) & three months (LS3M). Over all means of 3mw were 7.44±1.41 kg, 10.96±2.30 kg and 9.38±1.44 kg for AB, CH and WG, respectively. The overall means of KI for these breeds, in respective order, were 362±82, 268.11±72.21 and 309.47±89.42 days. The overall means LSB and LS3M for the three goat breeds, in respective order, were 1.028, 1.40 and 1.09 and 0.79, 1.09 and 0.84. The overall mean of ADY (for AB only) was 380.74±6.33 ml. In most cases, all the fitted fixed factors significantly influenced the production parameters in the three indigenous goat breeds. Locations with favorable environmental factors, 2013 year of birth or kidding, wet months of birth, male kids, smaller/ medium flock sizes and single born kids were associated with higher live weights (3mw), shorter KI, higher LSB, LS3M and DMY. In general, CH goat breed was characterized by havening highest 3mw, KI, LSB and LS3M. The production parameters presented in this paper could be used as benchmark for the planned community based breeding program on the breeds. The parameters could also be used as inputs, where necessary, for the optimization of the breeding scenarios for the breeds.

Keywords: Kidding interval; Litter size; Milk yield; Live weight

Introduction

In developing countries, indigenous goats make valuable contribution, especially to the poor in the rural areas (Peacock, 2005). They are important sources of meat, milk, manure, fibers & skins, and satisfy various cultural and religious functions (Tesfaye, 2004; Kosgey and Okeyo, 2007; Kanani, 2009; Aziz, 2010; Devendra, 2012). The various institutions conducting research on livestock in Ethiopia could not yield significant impact at farm level (Duguma *et al*., 2010), in which the cases goats was not exceptional.

Alternative to on-station researches, community based breeding program (CBBP), more frequent with keepers of local breed small ruminants (Mueller *et al*., 2015), has emerged for developing countries (Aynalem *et al.*, 2011; Duguma, 2010; Mirkena, 2010). Monitoring based benchmarks are required in any breeding activity though former benchmarks for CBBP were based on survey reports (Mirkena *et al.*, 2010; Getachew *et al*., 2009; Edea et al., 2009).

The present study was part of BecA-ILRI (Bioscience for eastern and central Africa-International Livestock Research Institute) goat project funded by Swedish government and implemented in Ethiopia and Cameroon. As preliminary result for the component in Ethiopia, Alubel (2015) reported live weight and milk parameters for Abergelle (AB) and Central Highland (CH) goat breeds using smaller data size and without addressing fixed effect of year, season and location of birth properly. Information on the reproduction parameters were not addressed in the former works for AB and CH while estimates production parameters were totally lacking for Woyto-Guji (WG) goat breed.

Therefore, this paper was designed with the following four objectives: (1) to evaluate three month (3mw) weights and average daily milk yield (DMY) (AB only) and (2) to evaluate kidding interval (KI), litter sizes at birth (LSB) and three months (LS3M) for the three. The estimated parameters could be used as benchmark for the planned CBBP for the named goat breeds and used as input parameters for the alternative breeding scenarios to be optimized for the respective goat breeds.

Materials and Methods

Description of the study sites

The study was conducted in four national regional states of Ethiopia: in Tigray and Amhara regions for AB, in Amhara and Oromia regions for CH and in and Southern Nations, Nationalities, and People's (SNNP's) region for WG goat breeds. Descriptions of the study sites were detailed in Alubel (2015) and Netsanet (2014). Districts were Tanqua Abergelle (Tigray region) and Ziquala (Amhara region) for AB, Lay Armachiho (Amhara region) and Meta-Robi (Oromia region; while writing this paper Meta-Robi district was divided into two districts as Meta-Robi and Meta-Welkite; the specific site for the current work fallen in Meta-Welkite) for CH and Konso (SNNP's region) for WG breeds. Specific villages by goat breeds were *Dingur* (in Tanqua Abergelle district) *and Blaku* (in Ziquala district) for AB, *Waykaw* (in Lay Armachiho district) *and Tatessa* (in Meta-Welkite district) for CH and *Messale* and *Arkisha* (both in Konso district) for WG. Hereafter, *Dingur*, *Blaku*, *Waykaw*, *Tatessa*, *Massale* and *Arkisha* means, in respective order, *Dingur* village, *Blaku* village, *Waykaw* village, *Tatessa* village, *Massale* village and *Arkisha* village. Latitude, longitude, altitude and rainfall of the study villages is given in Table 1. Village identifications were guided by the respective district agricultural sectors and was systematic in that the villages were where other projects were supposed to take over the initiatives if in case, the BecA-ILRI goat project phases out. Farmers were trained on different aspects of CBBP of goats and finally engaged in the work.

Table 1. Latitude, longitude, altitude and rainfall of the study villages

	Abergelle		Centeral Highland		Woyto-Guji	
Parameters	*Dingur*	*Blaku*	*Waykaw*	*Tatessa*	*Massale*	*Arkisha*
Latitude						
Longitude						
Altitude[#]	1731	1405	1192	2176	1383	1326
Rainfall (ml)*	710.65	546.95	1879.3	910.85	510.75	510.75

**=average rainfall of 2013 and 2014 (national Meteorology agency of Ethiopia) and meteorology stations for rainfall were AbiAdi, Sekota, TikilDingay, Ambo Agriculture, and Konso, from left to right, respectively; #= meters above sea level.*

Data Collection

Ad hoc enumerators were hired, two to four per village, for the data collection. The data collection duration was from mid July 2013 to Mid April 2015 for all the three breeds. The following traits were monitored: live weight at three months (3mw) from date of birth; and average daily milk yield (DMY) (AB only. The following traits were derived from the already collected data: kidding interval (KI) and litter size at birth (LSB) and three month (LS3M). DMY was collected from Abergelle breed for 12 weeks starting at a week after kidding. A doe was milked one day in a week and two times per day: in the evening and in the morning. Night time suckling of kids was prevented by housing kids separately from their mothers and day time suckling was prevented by farmers' traditional practice of tying teats and lubricating the teats with dung (Figure 1). When milk measurement was taken from a doe, her kid(s) was (were) assigned to another doe from which data were not taken on the day in order to ensure complete milking. LW3M were calculated as the sum of weights per parturition per doe at three months. KI, difference between the two successive kidding dates, was calculated for does that kidded at least two times during the data collection time. LSB and LS3M were taken as number of kids per kidding per doe at birth and three months, respectively.

Figure 1. Traditional farmers' practice of preventing kidds from succling teat (Dingur village, Tigray).

Data Analyses

General linear model procedure in the SAS (2004) was used to analyze all the production parameters trait. For the latter trait logistic procedure in the same software was used. Normality of data was checked for all trait and extreme values that could be due to typing errors were removed before embarking to analyses. The following general model was used for the dependent variables of three months weight, KI and DMY analyses:

$$\mathbf{Y_{ijklmnopq}=\mu+S_j+Pr_k+B_l+R_m+V_n+Y_o+F_p+W_q+E_{ijklmnopq}}$$

$Y_{ijklmnop}$ = an observation of dependent variable from i^{th} animal, j^{th} sex, k^{th} parity, l^{th} birth type, m^{th} season, n^{th} village, o^{th} year, p^{th} flock and q^{th} postpartum weight.

μ= Over all mean;

S_j=sex effect (male, female);

P_k= Parity effect (1 – 6);

B_l =birth type effect (single, twin);

R_m =season effect (dry, wet)

V_n= Village effect (1, 2)

Y_o= Year effect (2013, 2014)

F_p=Flock size efeect (<10, ≥10 &<20 and ≥20)

W_q=Post-partum weight effect and

$E_{ijklmnopq}$ = random error.

In the model for the analyses of LSB, 3mw, LS3M all the above fixed were fitted; in analysis KI, fixed effects of sex and post-partum weight (PPW) were not fitted; in the analysis of DMY fixed effects of village, year, season and parity were fitted.

Assessing fixed factors for their effects

Fixed effects of villages where kids were born and reared, years of kids' birth, season of kids' birth, six of kid, birth type of kid, flock size as number of goats per household, parity of kids' birth and covariate postpartum weight of does were fitted in most of the analyses.

Records of kids' birth were made during 2013 to 2015; however, due to small number of observations in 2015, records in 2014 and 2015 were merged. Seasons were categorized into dry and wet based on 2013 and 2014 rain fall data purchased from the national meteorology agency of Ethiopia. Accordingly, in this particular paper, 'wet' months were July, August and October in *Dingur*; July, August and September in *Blaku*; June, August, September, October and November in *Waykaw*; April – October in *Tatessa*; and January, March, June, August, September, October and November in *Massale* and *Arkisha*. Unmentioned months were assigned as 'dry' season. Kid birth type ranged from one to three per parturition per doe especially in the case of CH goat breeds. However, due to small number of records of triplet, kids born twin and triplets were treated as twins. With the assumption that the productivity parameters could be affected by number goats reared per household, three categories based on number of goats per household, were created as <10 goats/household (HH), ≥10 &<20/HH and ≥20/HH. Parity of kids' birth was assigned to be from one to six. Actually, parities were measured up to eight to nine. However, numbers of observations per parity above six was considerably small; hence parities six and above were considered as parity six. Parity of doe was captured from owners at beginning of monitoring work for the base flock. Doe PPW were fitted as linear covariate for the analysis of 3mw.

Results and Discussion

Three month weights (3mw)

Least squares means of three month weight (3mw) are given in Table 2 for AB, CH and WG breeds. Over all means were 7.44±1.41 kg, 10.96±2.30 kg and 9.38±1.44 kg for the breeds in respective order. The effect of village was significant on the trait for AB ($p<0.05$) and WG ($p<0.001$). AB goat breeds reared in *Dingur* had higher 3mw than those reared in *Blaku*. Year of birth had significant ($p<0.001$) effect on 3mw in all breeds. AB and WG kids born in 2013 had higher 3mw (7.20 kg versus 6.98 kg and 9.33 kg versus8.70 kg for AB and CH, respectively) and CH kids born in 2013 had lighter 3mw than those born in 2014 (10.23 kg versus11.35 kg). The effect of season of birth on 3mw was significant ($p<0.05$) for AB and CH. Kids born in 'wet' months had heavier 3mw than those born in the 'dry' months (7.72 kg versus7.20 kg and 10.98 kg versus10.59 kg for AB and CH, respectively). The effect of sex of kids on 3mw was significant ($p<0.01$) for CH breed only where male kids had higher 3mw than female kids (11.02 kg versus10.56 kg). The effect of flock size on 3mw was significant for CH ($P<0.01$) and WG ($p<0.001$). In both breeds higher 3mw was from small (<10 goats per household) and medium (≥10 to <20) flock sizes per household than dense animals per household (≥20). Regarding the effect of birth type, singletons of CH breed only had significantly ($p<0.001$) higher 3mw than twin born kids (11.56 kg versus10.01 kg). The PPW was significant ($p<0.001$) covariate of 3mw for the three breed and there was 0.05, 0.09 and 0.06 kg improvements per kg increment of PPW of does, in AB, CH and WG breeds, respectively. Fixed effect of parity of birth did not have significant effect ($p>0.05$) on 3mw in all the three breeds. Fixed effects of sex and birth type on 3mw was not significant ($p>0.05$) in AB and WG and the fixed effect of village was not significant ($p>0.05$) on 3mw in CH.

For the evaluated 3mw in the three breeds location (village) had significant effect reflecting differences in the level of management and other environmental conditions like temperature, humidity and rains in the area which naturally affects the fodder production (Hailu *et al*., 2005). Even though both villages (*Blaku* and *Dingur*) are moisture constrained areas, better rainfall and hence feed availabilities were in *Dingur* than *Blaku*.CH breed born and reared in *Tatessa* had heavier 3mw than those born and reared in *Waykaw*. This may indicate that good mothering ability of does in *Tatessa* than *Waykaw*. Maternal effects are more pronounced in early life of animals.WG breed born and reared in *Massale* were inferior to those born and reared in *Arkisha* at 3mw. Smallholder farmers in *Arkisha* had vast communal browsing areas compared to smallholder farmers in *Massale* and does or kids in the former villages were having more access to feed compared to goats in the latter village. This might gave chance to does in *Arkisha* village to enjoy feeds.

Effect of year of birth was also significant ($p<0.05$) on 3mw in all the three breeds. Kids born in 2013, in most cases, were higher than or similar to live weights of kids born in 2014. The only exception was that 3mw of CH breed where the kids born in 2014 had heavier than kids born in 2013. Environmental conditions like temperature, humidity and rains might be more favorable in the areas (Hailu *et al*., 2005) and positively influenced the fodder production in years when live weights were favored. Three month weight of kids born in 'wet' months was significantly heavier than 3mw of kids born in 'dry'months in the three breeds. At three months, male kids were heavier than female kids. In relation to endocrinal system, estrogen hormone has a limited effect on the growth of long bones in females. That could be one of the reason in which females have smaller body and lighter weight against males (Rashidi *et al*., 2008). Regardless of the direct effect of flock size kept per house hold on production parameter, insufficient

reports are available. When smaller numbers of animals are kept per household, individual animals may get attention in terms of feeding, housing and medication. This is evidenced on 3mw in the case of CH and WG goat breeds. The non-significant effect (p>0.05) of flock size on 3mw of ABgoat breed may indicate that the relative importance of the breed to the community and their special close follow-up to their goat.

Compensatory growth exerted by multiple born kids compared to single born ones were reported but not in the present study on 3mw in all the three breeds. This may be due to the fact that kids were not separated from their mothers at the age of three months. Parity of birth did not significantly (p>0.05) affected 3mw in all the cases. In study of Mahal *et al.* (2013), in agreement with this study, on live weights of Black Bengal goats at birth and every three months thereafter up to 12 months, parity of birth could affect birth weight only.

Table 2. Least squares means (± standard errors (SE) of three month weight (3mw) (kg) by fixed factors in three indigenous Ethiopian goat breeds under farmers' production practices.

Factors℃	Abergelle		Central Highland		Woyto-Guji	
	n	±SE	N	±SE	n	±SE
Overall	885	7.44±1.41	779	10.96±2.30	504	9.38±1.44
Village¥	*		ns		***	
1	351	7.58±0.16a	376	10.63±0.16	199	7.39±0.14b
2	534	7.34±0.18b	403	10.94±0.16	305	10.64±0.11a
Year	***		***		***	
2013	539	7.94±0.17a	198	10.23±0.19b	157	9.33±0.14a
2014	346	6.98±0.16b	581	11.35±0.11a	347	8.70±0.10b
Season	*		*		Ns	
Dry	829	7.20±0.14b	250	10.59±0.17b	243	8.98±0.12
Wet	56	7.72±0.24a	529	10.98±0.11a	261	9.05±0.11
Sex	Ns		**		Ns	
Male	447	7.51±0.17	394	11.02±0.13a	280	9.14±0.11
Female	438	7.40±0.17	385	10.56±0.14b	224	8.90±0.11
Flockϕ	Ns		**		***	
<10	32	7.47±030	158	10.97±0.20a	205	9.30±0.12a
≥10 to<20	221	7.43±0.16	296	11.02±0.15a	137	9.22±0.13a
≥20	632	7.49±0.14	325	10.37±0.15b	162	8.53±0.15b
Birth type	Ns		***		Ns	
Single	837	7.58±0.12	315	11.56±0.17a	419	9.19±0.08
Twin	48	7.35±0.25	464	10.01±0.13b	85	8.84±0.17
PPW	0.05±0.01		0.09±0.02		0.06±0.02	

n= number of observations; *** = p<0.001; **=p<0.01; *p<0.05; ns=p>0.05; ℃= least squares means with different letter are significantly different; ¥=1=*Dingur*, *Waykaw* and *Massale* for AB, CH andWG breeds, respectively and 2=*Blaku*, *Tatessa* and *Arkisha* for AB, CH and WG, respectively; ϕ=average number of animals per household; PPW=Post-partum weight.

Kidding intervals (KI)

The least squares means of KI are given in Table 3 for AB, CH and WG goat breeds. The overall means of KI for these breeds, in respective order, were 362±82, 268.11±72.21 and 309.47±89.42 days. None of the fixed effects had significant (p>0.05) effect on KI of WG breed probably due to the small number of

observations compared to others. For the other two breeds, fixed effects of village and year of previous parturition in AB and year of previous parturition in CH breed had significant ($p<0.001$) effect on the KI. Does that had their previous parturition in *Dingur* had shorter KI than those had their previous parturition in *Blaku* for AB. KI was found to be shorter for does that had their previous parturition in 2014 compared to does that had their previous parturition in 2013 for AB. Similarly, does having their previous parturition in 2014, had shorter KI than does had their previous parturition in 2013 for CH. However, season of previous parturition, flock size, birth type and parity of previous parturition did not significantly ($p>0.05$) affected KI both in AB and CH. Village of previous parturition did not significantly ($p>0.05$) affect KI of CH.

The present values of KI for CH and WG were in agreement with values reported by Đuričić *et al.* (2012) for Boer goat. However, KI of AB breed were a bit longer than the reported ones. AB and CH does that had their previous kidding in 2014 had significantly shorter KI than those had in the other year. Does having their previous kidding in *Dingur* had shorter KI compared to does having their previous parturition in *Blaku*. Conditions favoring greater ovarian activities most likely lead to shorter postpartum anestrus and hence shorter kidding interval. Shorter KI in *Dingur* compared to *Blaku* could be due to the availability of green folder grasses and forages. Availability of feeds have direct influence on ovulation rate and fertility, since the nutritional stress appears to be a prime probable cause of cyclist and long kidding interval in goats (Bushara *et al.,* 2013). Another possible explanation may be due to the presence of the male in the flock running with the female all the time.

Table 3. Least squares means (±standard errors (SE) of kidding intervals (days) in three indigenous Ethiopian goat breed under farmers' production practices

Factors¢	Abergelle		Central Highland		Woyto-Guji	
	n	±SE	N	±SE	n	±SE
Overall	229	362±82	162	268.11±72.21	59	309.47±89.42
Village¥	***		ns		Ns	
1	98	304.77±21.08b	72	252.10±11.06	-	-
2	131	348.39±20.34a	90	276.20±9.31	-	-
Year	***		***		Ns	
2013	203	371.88±18.55a	101	293.98±9.94	36	312.63±28.94
2014	26	281.28±24.29b	61	234.233±10.48	23	268.79±34.12

n= number of observations; *** = $p<0.001$; **=$p<0.01$; *$p<0.05$; ns=$p>0.05$; ¢= least squares means with different letter are significantly different; ¥=1=*Dingur, Waykaw* and *Massale* for AB, CH and WG breeds, respectively and 2=*Blaku*, *Tatessa* and *Arkisha* for AB, CH and WG, respectively; ϕ=average number of animals per household.

Least square means of LSB and LS3M in AB, CH and WG goat breeds are given in Table 4. The overall means LSB and LS3M for the three goat breeds, in respective order, were 1.028, 1.40 and 1.09; and 0.79, 1.09 and 0.84. The values of LSB in the present study were smaller than 2.9 for Zaraibi goat Marai et al. (2002) and 1.8 for Red Sokoto goat (Awemu *et al*., 1999). The overall values of LSB of CH goat breed (1.40) in the present study was higher than that of Sudan Nilotic goat that was 1.2 (Atta *et al*., 2012) and the overall value of LSB from WG goat breed (1.09) was lower than this report.

Parity of birth had significant effect on LSB in all the breeds ($p<0.01$ in AB; $p<0.001$ in CH and WG). In agreement with the present report parity of birth affected LSB of kids in Red Sokoto (Awemu, et al., 1999) where LSB increased with parities. Village (location) of birth ($p<0.001$) and season of birth ($p<0.05$) significantly affected LSB of CH. LSB from the first and the second parities were significantly

($p<0.05$) lower than that from the latter parities in all cases. In the case of CH, LSB from *Waykaw* village was higher than that of *Tatessa* (1.56 versus 1.34) and LSB in dry months (1.49) was higher than LSB in wet months (1.41). The fixed effect of year of birth did not have significant ($p>0.05$) effect on LSB in all cases and fixed effects of village (location) and season of birth did not have significant ($p>0.05$) effect on LSB in AB and WG goat breeds. In general, LSB is largely influenced by ovulation rate which was in turn substantially controlled by genotype and environment and can definitelybe increased by the premating nutrition management in the case of ewes (Mukasa-Mugerwa and Lahlou-Kassi, 1995) which may also hold true in does.

The effect of type of birth on LS3M was significant ($p<0.001$) in all the three breeds whereas the effect of village (location) was significant ($p<0.001$) on LS3M in AB and CH. Fixed effect of season had also significant effect on LS3M in AB ($p<0.001$) and CH ($p<0.01$). Year of birth had significant effect ($p<0.001$) on LS3M in AB and WG. The LS3M of twin born kids was 1.45, 1.55, and 1.52 in AB, CH and WG goat breeds, respectively compared to 0.658, 0.73 and 0.82 for single born kids, in respective order. LS3M in *Blaku* was higher than that of *Dingur* (1.146 versus 0.963) for AB and LS3M in *Waykaw* was higher than that of *Tatessa* for CH goat breed. Kids born in dry months had higher LS3M compared to those born in wet months (1.19 versus 0.963; $p<0.001$ for AB) and those born in wet months had significantly higher (1.21 versus 1.08; $p<0.001$) LS3M in CH). Kids born in 2013 had higher LS3M compared to those born in 2014 (1.18 versus 0.93; $p<0.001$ for AB and 1.25 versus 1.09; $p<0.001$ for WG). Parity of birth had no significant effect ($p>0.05$) on LS3M in all cases and season of birth did not significantly affected ($p>0.05$) LS3M of WG goat breed. The overall LS3M in the present study (0.79 (AB) – 1.09 (CH)) were lower than values reported as letter size at weaning for Red Sokoto goats as 1.7 (Awemu *et al*., 1999) and Zaraibi goats as 2.3 (Marai *et al*., 2002) probably due to the inclusion of kids that not survived at three months of age in the calculation of LS3M in the present study. As exclusion of kids that did not survive at three months of age from calculation of LS3M over estimates the value, inclusion of dead kids in the calculation of LS3M is characterized by large standard error.

Average daily milk yield (DMY)

Least squares means of ADM is given in Figure 2 for AB. The overall mean of the trait was 380.74±6.33 ml. Villages in which does kidded and milked had significant ($p<0.001$) effect on DMY where does kidded and milked in *Dingur* had higher DMY compared to the other village. Year and season of kidding did not significantly ($p>0.05$) affected DMY. On the other hand, parity of does significantly ($p<0.05$) affected DMY where DMY from the first parity was significantly lower than DMY from the latter parties.

The DMY in the present study is lower than values reported by Alsheikh (2013) and comparable with reports of Mahal *et al* (2013). As in the case of the present study parity had significant effect on milk production of Black Bengal goat. Milk production generally reaches peak in mid parities and decrease thereafter. Similar to the present study, season of kidding did not significantly affect milk yield of goat (Mahal et al., 2013; Bushara *et al*., 2013). However, amount of daily milk yield was high in the rainy season probably due to the effect of quantity and quality of feedstuffs provided by pasture in the rainy season, or due to presumably benefitted nutritionally from leaf development by some browse species (Bushara *et al.*, 2013).

Table 4. Least squares means of litter size at birth (LSB) and three month (LS3M) in Abergelle (AB), Central highland and Woyto-Guji (WG) breeds

Fixed factors	Litter size at birth						Litter size at three month weight		
		AB	CH		WG		AB	CH	WG
	n		n		n				
Overall	1159	1.028±0.17	714	1.40±0.45	601	1.09±0.29	0.791±0.379	1.09±0.58	0.84±0.46
Village¥		ns		***		ns	***	***	ns
1	541	1.029±0.008	290	1.56±0.03a	245	1.10±0.02	0.963±0.037b	1.22±0.04a	1.14±0.04
2	618	1.023±0.009	424	1.34±0.03b	356	1.14±0.02	1.146±0.040a	1.06±0.03b	1.20±0.04
Year		Ns		Ns		Ns	***	ns	***
2013	590	1.017±0.009	204	1.42±0.04	172	1.12±0.02	1.178±0.039a	1.10±0.05	1.25±0.05a
2014	569	1.035±0.009	510	1.48±0.02	492	1.11±0.02	0.931±0.037b	1.18±0.03	1.09±0.04b
Season		ns		*		ns	***	**	ns
Dry	1009	1.032±0.005	216	1.49±0.03a	284	1.11±0.02	1.189±0.034a	1.08±0.04b	1.21±0.04
Wet	150	1.020±0.014	498	1.41±0.02b	317	1.13±0.02	0.920±0.046b	1.21±0.03a	1.14±0.04
Birth type		-		-		-	***	***	***
Single	1126	-	423	-	544	-	0.658±0.017b	0.73±0.04b	0.82±0.02
Twin	33	-	291	-	57	-	1.451±0.068a	1.55±0.04a	1.52±0.06
Parity		**		***		***	ns	ns	ns
1	247	0.999±0.012b	135	1.17±0.04b	146	1.02±0.02b	1.080±0.044	1.15±0.06	1.14±0.05
2	157	1.00±0.014b	136	1.25±0.04b	137	1.02±0.03b	1.029±0.044	1.18±0.05	1.09±0.05
3	204	1.027±0.013ab	135	1.45±0.04a	107	1.08±0.03b	1.088±0.044	1.19±0.05	1.17±0.05
4	223	1.028±0.012ab	124	1.60±0.04a	97	1.18±0.03a	1.047±0.042	1.05±0.06	1.18±0.05
5	190	1.049±0.013a	81	1.62±0.05a	63	1.18±0.03a	1.055±0.043	1.14±0.06	1.28±0.06
≥6	138	1.053±0.015a	103	1.60±0.05a	51	1.21±0.04a	1.030±0.046	1.13±0.06	1.18±0.07

*N=number of observations (observations in LS3M were equal to observations in LSB in respective breeds and factors); ***=p<0.001; **=p<0.01; *=p<0.05; ns=p>0.05; z=least square means with different letters are significantly different. ¥=1=Dingur, Waykaw and Massale for AB, CH and WG breeds, respectively and 2=Blaku, Tatessa and Arkisha for AB, CH and WG, respectively.*

Conclusion

In most cases, all the fitted factors significantly influenced the production parameters in the three indigenous goat breeds of Ethiopia. Locations with favorable environmental factors, 2013year of birth or kidding, wet months of birth, male kids, smaller or medium flock sizes and single born animals were associated with higher live weights (3mw), shorter KI, higher LSB, LS3M and DMY. On the other hand, parity and the covariate PPW had non-significant effect on 3mw. KI in AB breed was longest compared to the other two breeds due to harsh environments not favoring quicker onset of subsequent parturitions. The production parameters presented in this paper could be used as benchmark for the planned community based breeding program on the breeds. The parameters could also be used as inputs, where necessary, for the optimization of the breeding scenarios for the breeds.

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Assessment of major diseases of sheep and associated risk factors in fentale district (phase i)

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Abstract

A survey was conducted in six PAs of Fentale district of East Shoa zone to assess and prioritize the major sheep diseases and associated risk factors. Cross-sectional assessments of major sheep diseases were carried out. From each PAs twenty pastoralists were selected. The selected pastoralists were interviewed using a semi-structured questionnaire (SSI). For tentative diagnosis of the clinical symptoms of the particular disease mentioned by owners and responses for oral questions forwarded by experienced animal health professionals were used. In addition, different epidemiological tools were used to generate data on livestock information. From 120 respondents interviewed, 58%, 44.6%, 34.5%, 33.9% and 24.1% have history of Coenerosis, CCPP, Sheep and goat pox, PPR and CU deficiency, respectively in their flock. From this study it was concluded that majority of the lambs were died during winter (78.3%) followed by summer (13%) and spring (2.6%) seasons. This might be due to the variation in incidence of diseases and feed and water availability among seasons. Major causes of lamb mortality in the study areas were diseases (72.6%) and feed and water shortage (27.4%). In conclusion further detail investigation and identification of diseases should be done using laboratory analysis and systemic disease prevention and control schemes/ strategies should be designed.

Introduction

Ethiopia is believed to have the largest livestock population in Africa. This livestock sector has been contributing considerable portion to the economy of the country, and still promising to rally round the economic development of the country. Agriculture accounts for 90% of the total export and 47.7% of GDP. Livestock and their products account for about 20% of agricultural GDP and 12 to 15% of the total agricultural export earnings (Metaferia *et al.* 2011). However, this contribution is low compared to the potential. It is eminent that livestock products and by-products such as meat, milk, honey, eggs, cheese, and butter provide the needed for animal proteins that contribute to the improvement of the nutritional status of the people. Livestock also plays an important role in providing export commodities, such as live animals, hides, and skins to earn foreign exchanges to the country (CSA, 2013).

There are many sheep production constraints that affect the production and productivity of sheep in Ethiopia. Among these factors infectious disease and parasites are the major ones that limit the benefit expected from sheep production. Fentale district is endowed with large population of livestock with an estimated number of 104,858 cattle, 109,113 goats, 96,245 sheep and 89.652 camels. Pastoralists in this district are mainly dependent on livestock for their livelihood both before and after introduction of irrigation scheme.

In spite of the presence of large number of sheep population; the district fails to optimally utilize this resource as the sector is suffering from lower productivity. Among many factors that limit the economic return from sheep production disease stands in the front line. Sheep disease of major economic and

international significance persist in pastoral areas because of poor veterinary interventions being rendered. There is also lack of basic epidemiological information that enables diseases to be prioritized at local level. Therefore, assessment and identification of the prevailing sheep health problems in the study area is very important to design and develop strategies for prevention and control of the prevalent sheep diseases. The objective of this study was to assess and prioritize major sheep diseases and associated risk factors.

Material and methods

Study area and population

The study was conducted in Fentale district (Fig. 1) which is located in East Showa zone of Oromia regional state. The district is found at a distance of about 200km from the capital city of Ethiopia. Its agro-ecology is semi arid and it receives an annual rainfall ranging from 400-700mm.Its temperature ranges from 29 to 38^0c (Shiferaw, 2007). In altitude, most parts of this district range from 900 to 1000 meters above sea level; Mount Fentale being the highest point (2400 meters). Rivers in the area include the Awash and the Germama river. Lake Basaka is an important water body in the district. Of the total land of the district, 8.2% is arable or cultivable, 7.6% pasture, 28.8% forest, and the remaining 55.4% is considered degraded or otherwise unusable. The Metehara Sugar Cane Plantation covers 100 square km. In 11 of the 18 kebeles of Fentale, the predominant agricultural practice is pastoralism. Camels, goats and cattle are the most common livestock species. Migration to the border areas of Boset woreda for grazing during normal years is a common practice in the area. In years of low rainfall, herdsmen migrate as far as Arsi area. The vegetation is primarily acacia trees with bushes and shrubs.

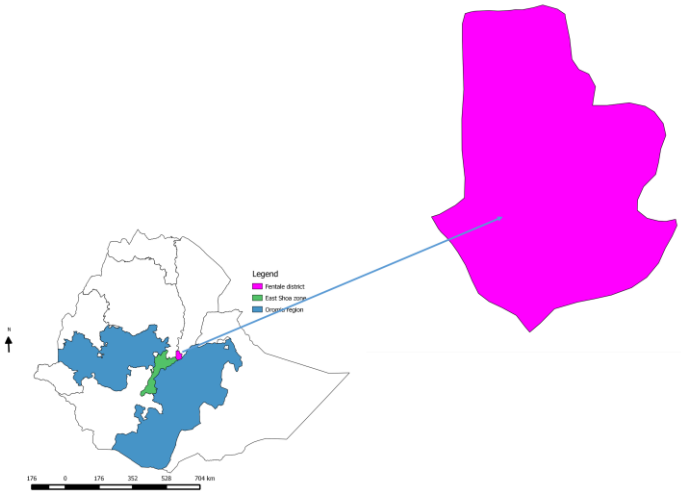

Fig 1. Map of study area

Study design and sampling method

A cross-sectional assessment of major sheep diseases was carried out in purposively selected six peasant associations namely Kobo, Elala, Banti, Turo, Gola and Harokersa of Fentale district These areas are known to have large sheep population. From each PA twenty respondents were selected and interviewed using semi-structure questionnaire. For tentative diagnosis of the particular disease clinical symptoms mentioned by sheep owners and responses for oral questions forwarded by experienced animal health

professionals were used. In addition, different epidemiological tools were used to generate livestock information data.

Data management and statistical analysis

The collected data entered in to excel spread sheet and transferred to Statistical Package for Social Science (SPSS version 20). Descriptive statistics was used to analyse the data.

Result and discussion

Survey was under taken to assess the major diseases and associated risk factors of sheep in six PAs of Fentale district of East Shoa zone. From 120 respondents interviewed 58% have history of Coenerosis, 44.6% have history of CCPP, 34.5% have history of Sheep and goat pox, 33.9% have history of PPR and 24.1% have history of CU deficiency in their flock (Table 1).

Table 1. Major diseases that affect sheep in the study area

Local name of the disease	**Scientific name of the disease**	**Farmers response**		**Seasonality**
		YES	NO	
Jini/ Martoo	Coenerosis	58	42	Not seasonal
Dhibee somba	CCPP	44.6	55.4	Not seasonal
Kodhobo/Hodhobo	Sheep and goat pox	34.5	65.5	Winter
Michiisaa/buchansiisa	PPR	33.9	66.1	Not seasonal
Degamakaa/wurroo	CU deficiency	24.1	75.9	Not seasonal
Dhibee tiruu	Fasciolosis	17.9	82.1	_
Maxxantuu alaa	External parasite	13.4	86.6	_
Masa	FMD	10.7	89.3	_
Halaa	Babesiosis	9.8	90.2	_
Furii	Pneumonia	9.8	90.2	_
Maxxantuu keessaa/ Raammo	Internal parasite	8	92	_
Hirkii	ORF	6.3	93.7	Not seasonal
Abasangaa	Anthrax	4.6	96.4	Winter
Bokoksaa	Bloat	1.8	98.2	_

From this study it was found that majority of the lambs were died during winter (78.3%) followed by summer (13%) and spring (2.6%). This might be due to the variation of incidence of diseases and feed and water availability among seasons. Major causes of lamb mortality in the study areas were diseases (72.6%) and feed and water shortage (27.4%). The result observed in this study in agreement with the report of Oromia livelihood zone Fentale woreda, East Shewa administrative zone 2006. According to this report the major diseases infecting livestock in the district are PPR, goat and sheep pox, CCPP and blackleg. Faris et al, 2011 also reported positive case of PPR.

Conclusion and recommendation

Assessment of the major diseases and their risk factors in areas where livestock production is predominant is important. Disease and related risk factors negatively affect production and productivity of sheep in the study area. Therefore, further detail investigation and identification of diseases should be done using laboratory analysis and systemic disease prevention and control schemes/ strategies should be designed for identified diseases.

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Epidemiological investigations of contagious caprine pleuropneumonia in selected districts of Borana Zone, Southern Oromia, Ethiopia

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Abstract

A cross - sectional study to determine the sero-prevalence of caprine contagious caprine pleuropneumonia (CCPP) was conducted from November 2016 to April 2017 in selected districts of Borana zone, Southern Oromia, Ethiopia. The objectives of the study were to investigate the epidemiology and characterize the causative agent using molecular techniques. A multistage random sampling was implemented to select districts, Pastoral associationsand households. A total of 890 serum samples (goats n=789 and sheep n=101) were collected andscreened for the presence of specific antibodies against Mycoplasmacapricolum subspecies capripneumoniae using competitive enzyme linked immunosorbent assay. Lung tissues and pleural fluid samples were collected from 8 sero-positive and clinically suspected goats for isolationof Mycoplasmacapricolum subspecies capripneumoniae.Serology showed that overall 31.2% (246/789) of goats and 12.9% (13/101) of sheep were positive with statistically significant differences between districts. (p= 0.001).Logistic regression analysis revealed that goats from Moyale district had twice the odds of being positive than goats from Elwoya district (OR=2.05, CI 95%: 1.4 - 2.99). Goats from Yabello had 1.61 times higher odds of being infected than goats from Elwoya (OR=1.61, CI 95%: 1.058 - 2.45). Age of goats was also was also significantly associated with sero-positivity (OR=1.47; CI 95%: 1.2 - 1.8). Mycoplasmacapricolum subspecies capripneumoniaewas identified in 7 (87.5%) of the tissue samples using species specific primer of PCR. Besides improving the understanding of the epidemiology of CCPP in the studies region and demonstrating the wide distribution, the study highly also sighted the possible role of sheep in the maintenance of the disease.

Key words: *CCPP, cELISA, Goats, Sero-prevalence, Risk factors, Borana, Ethiopia*

Introduction

Contagious caprine pleuropneumonia (CCPP) caused by *Mycoplasma capricolum* subspecies *capripneumoniae* (*Mccp*) is a severe and devastating respiratory disease with high morbidity and mortality in goats (Sadique *et al*., 2012; Tsehay *et al*., 2014) causing considerable economic losses (Asmare *et al*., 2016).It occurs in many countries in Africa, Asia and Middle East (Prats-van der Ham *et al*., 2015) and is a classical trans-boundary animal disease (Shahzad *et al*., 2016). Moreover, the disease is included in the list of notifiable diseases of the World Organization for Animal Health (OIE) as it threatens a significant number of goat populations throughout the world and has a considerable socioeconomic impact in infected territories (Atim *et al*., 2016). Though the disease is confined to goats, subclinical cases were reported in sheep and some wild ruminant species (Asmare *et al*., 2016).

In Ethiopia goats play a unique role in the livelihood of pastoral communities, including in the Borana pastoral area, as they provide milk and dairy products and a source of incomefor the family which is used to cover school fees for children and other family expenses. Despite the presence of a massive goat population and their important socio-economic role, health of small ruminants in general and goats in particular has received little attention so far (Lakew *et al*., 2014). Few studies carried out in the area showed that CCPP is prevalent and causesconsiderable mortality in goats in the area. For instance, between 2011 and 2015 83 outbreaks affecting 23950 goats was reported. Hence, reliable epidemiological information is needed in order to devise effective control measures. Specifically, antigen detection of *Mccp* and the role of sheep in the maintenance of the disease need to be explored. The objectives of the study were to assess the epidemiology of contagious caprine pleuropneumonia and to characterize the causative agent using molecular techniques.

Materials and Methods

This study was conducted in of the Borana which is predominantly inhabited by the Borana community, extends to the Kenyan border in the South, Somali region in the South East, Southern Nation, Nationalities and People Region (SNNPR) in the West and North, and Guji zone in the North East. Borana rangeland is characterized by a semiarid to arid climate (Kamara *et al*., 2005; Haile *et al*., 2011). Geographically the area is located between from 4° to 6°N latitude and 36° to 42°E longitude with altitude ranging from 1,000 to 1,700 meters above sea level.The mean annual rainfall of the area ranges from 250 to 700 mm. The annual mean temperature varies from 19 to over 25°C. Extensive pastoralism is the main means of livelihoods for the Borana people (Gelagay *et al*., 2007).

Multistage random sampling coupled with systematic sampling method was applied to select the study animals. The sampling frame comprised a list of all districts in the zone and pastoral associations (PAs) or villages. Once the three districts were selected randomly, in each 2 PAs where no CCPP vaccinations had not been used selected purposively.The resulting 6 PAs/villages wereAreri and Adegalchet from Elwoya, Tile mado and Dambi from Moyale, and Dida Yabello and Harwoyu from Yabello (Figure 1).

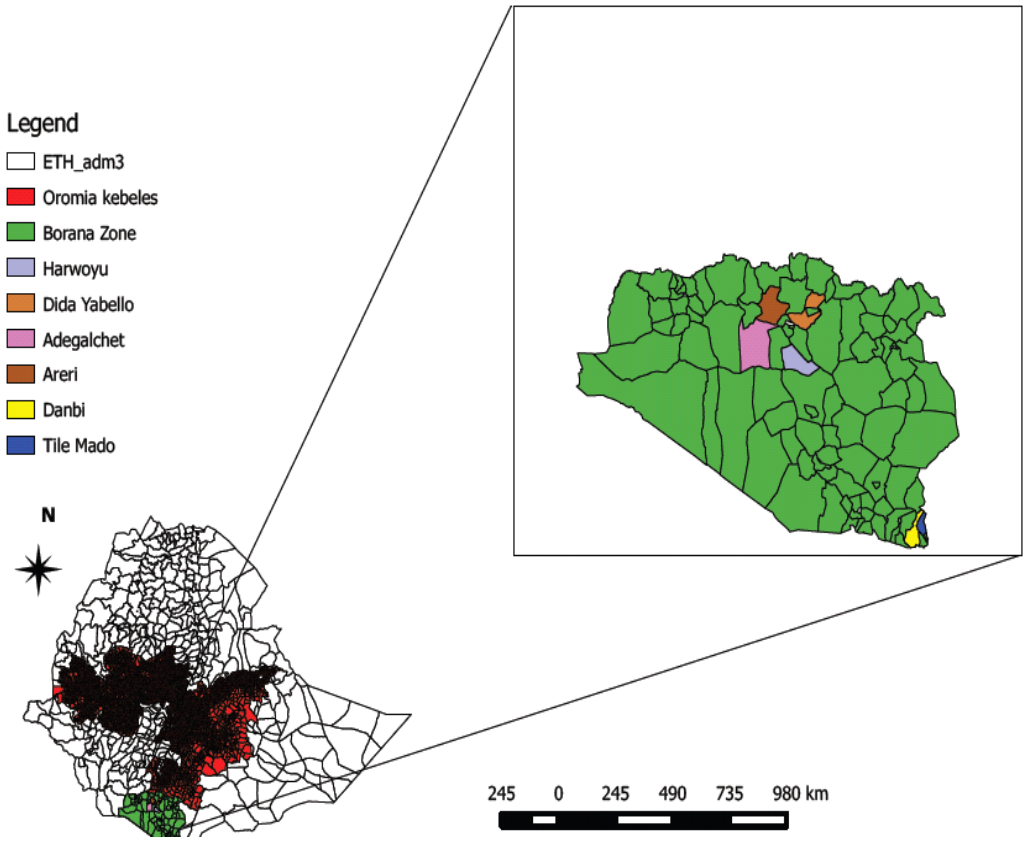

Figure 1. Map of Ethiopia showing study areas.

Finally, goats owned by the households in the selected Pas were selected systematically. If the flock size of a household was greater than five, 4 to 9 goats were systematically selected from each flock whereas all goats per household were sampled if the flock size is less than or equal to five. In addition, 101 in contact sheep were selected purposively.The goats selected were identified with ear tags and information on household profiles and attributes of animals was collected before sampling. The age of animals was estimated using information from owner and dentition. Besides sero-samples, blood samples and lung tissues were collected from sero-positive and clinically affected goats for molecular and bacteriological investigations. During sampling, recently introduced animals were excluded to avoid the risk of including vaccinated animals.

To categorize flock size into small, medium and large, five key informants were used from each district.

Sample size estimation

The estimation of sample size for epidemiological investigation using serological assay was done using the formula given by Thrusfield (2005) considering 95% confidence level,expected prevalence of 31.6% (Lakew *et al*., 2014) and 5% absolute precision.

$$n = \frac{1.96^2 P_{exp} (1-P_{exp})}{d^2}$$

Where, n = required sample size

P_{exp} = expected prevalence
d = desired absolute precision (5%)

Accordingly, a minimum of 332 goats was obtained. However, we obtained 789 goats for this study to account for clustering at PA and district level.

Blood sample collection

Approximately 5-7 mL of blood was collected from jugular vein of goats and sheep for serological examination using sterile vacutainer tubes and needles. Samples were then transported in an icebox to the microbiology laboratory of the Yabello Pastoral and Dryland Agriculture Research Center. The blood samples were kept in a slant position overnight to allow serum separation. The sera were separated after centrifugation at 1500rpm for 10min. The sera samples were collected into sterile cryogenic tubes and stored at -20^0C until the sampleswere transported to the National Animal Health Diagnostic and Investigation Center (NAHDIC), Sebeta, Ethiopia for analysis.

Collection of tissue samples

Three goats that werepositive in the cELISA test or which were suspected to be clinically affected by CCPP after thorough clinical examination were purchased and sacrificed for post-mortem examination. Gross pathological lesions were observed and samples of lung at the interface between the consolidated and unconsolidated healthy tissues and pleural fluids were collected and transported to the National Veterinary Institute (NVI), Bishoftu, Ethiopia for molecular analysis using polymerase chain reaction (PCR) as described by Woubit *et al*. (2004).

Laboratory Analysis of Samples

The serum samples were examined for the presence of specific antibodies against *Mccp* by using a commercial cELISA (Idexx, France) according to the instructions of the manufacturer. Briefly, test samples and controls were pre-diluted on the uncoated plate. Samples to be tested were premixed with a specific monoclonal anti-*Mccp* antibody (Mab 4.52) in to uncoated plate and homogenized contents of the plate were transferred into the *Mccp* antigen coated microplate. The contents were incubated for 1 hour at 37°C with gentle agitation, washed two times, dried and then enzyme conjugate was dispensed and incubated for 30 minutes at 37°C. Then, after three times washing enzyme substrate (N.9) was added and incubated for 20 minutes 37°C in dark place. Finally, stop solution (N.3) was added and color development was observed and read at 450 nm by BioTek ELx800 ELISA readerto determine the optical density and percentage of inhibition was calculated. For the assay to be valid, results of internal quality control sera were first checked to make sure they were within the acceptable ranges. Samples with percentage of inhibition greater than or equal to 55% were considered positive for presence of *Mccp* antibodies (Peyraud *et al*., 2014).

Polymerase Chain Reaction (PCR)

Samples for PCR were prepared as described by Woubit *et al*. (2004). About one gram samples from each lung tissue and bronchial lymph nodes were taken and chopped with scissors and then grinded by pistil and mortar; mixed with 9mL phosphate buffer solutions (PBS) and transferred to test tubes. For pleural fluids,1mL of pleural fluid was taken and mixed with 9mL PBS and subjected for DNA extraction. Master Mix and PCR were done as described by Woubit *et al*. (2004).

Data Analysis

Disease prevalence and odds ratio were calculated using STATA 13.0 (Stata corp.1985-2013) statistical software. Logistic regression analysis was used to measure association between potential risk factors and sero-prevalence. Associations between the outcome variable and its potential risk factors were quantified using multivariable logistic regression analysis. Finally, odd ratios and 95% confidence interval were calculated and disease associated risk factors with a p-value less than 0.05 considered significant.

Results

Sero-prevalence and Associated Risk Factors of CCPP in Goats

.Out of a total of 789 sera samples examined, 246 (31.2%) were found positive for anti-*MCCP* antibodies. The highest prevalence (36.70%) was observed in Moyale district, followed by Yabello (32.7%) and Elwoya (22.6%)(Table 1). The difference in sero-prevalencebetween districts was statistically significant (P = 0.001). There was also a significant difference in the sero-prevalence CCPP between different age groups (P< 0.001) in which adult goats (37.3%) were more likely to test positive than young goats (24.7%). Higher sero-prevalence was recorded in female goats (32.1%) than males (29.1%) although this difference was not statistically significant. Similarlysero-prevalence of CCPP was 34.3%, 32.2% and 28.8% in small, medium and large flock size, respectively. However, the difference in prevalence among various flock sizes was not statistically significant. Sero-positivity was detected in all localities surveyed as depicted in figure 2.

Table 1. Results of descriptive analysis to identify risk factors of sero-prevalence of CCPP in goats in Borana Zone, Oromia, Ethiopia

Risk factors	N	Test Positive	Prevalence	X^2	P -Value
District				13.618	0.001
Elwoya	252	57	22.6		
Moyale	332	122	36.7		
Yabello	205	67	32.7		
Sex				0.73	0.393
Female	535	172	32.1		
Male	254	74	29.1		
Age				14.455	<0.001
Adult	405	151	37.3		
Young	384	95	24.7		
Flock Size					0.402
Small	175	60	34.3	1.82	
Medium	267	86	32.2		
Large	347	100	28.8		
Overall	789	246	31.2		

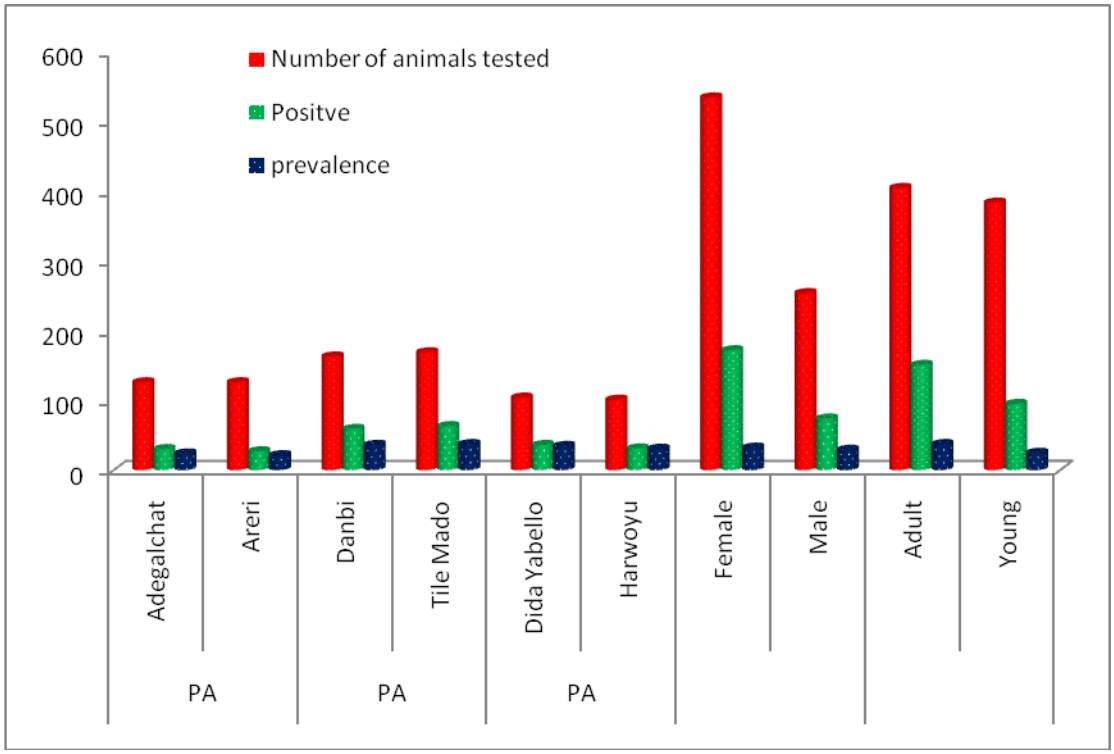

Figure 2. Proportion of Sero-positivity in goats by locality

The results of logistic regression analysis revealed that among the risk factors considered in the analysis (Table 2), district and age had statistically significant effect on sero-positivity whereas sex and flock size had no statistically significant effect. The results showed that animals in Moyale and Yabello district had about twice and 1.6 times higher odds of being positive for CCPP, respectively than those animals reared in Elwoya district. Similarly, the odds of CCPP sero-prevalence was observed to significantly increase by 1.5 times as age of animals increase by one year.

Table 2. Results of multivariable logistic regression analysis of sero-prevalence of CCPP in goats

Risk Factor	Odds Ratio	Std. Err.	Z	P>|z|	[95% Confidence Interval]
District					
Moyale	2.050	0.3982	3.7	<0.001	(1.401 - 2.999)
Yabello	1.611	0.3457	2.22	0.026	(1.058 - 2.453)
Sex					
Male	0.924	0.157	-0.47	0.64	(0.662 - 1.289)
Age in year	1.472	0.157	3.64	<0.001	(1.195 - 1.814)
Flock size					
Medium	1.172	0.211	0.88	0.378	(0.823 - 1.669)
Small	1.429	0.297	1.72	0.086	(0.951 - 2.146)
_cons	0.137	0.036	-7.55	0.000	(0.081 - 0.229)

Sero-prevalence and Associated Risk Factors of CCPP in Sheep

From a total of 101 sera samples collected from sheep and tested by cELISA, 13 (12.9%) were found positive. The differences in sero-prevalence between age groups, sex and districts examined were not statistically significant (P>0.05) as presented in Table 3. The proportion of sheep tested positive by sex, age and PAs was shown in Figure 3.

Table 3. Results of Multi variable logistic regression analysis of associated risk factors of CCPPin sheep in the study area.

Risk Factors	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf. Interval]
Age in year	1.185	0.603	0.33	0.738	(0.437 - 3.213)
Sex					
Male	0.320	0.274	-1.33	0.184	(0.059 - 1.715)
District					
Moyale	1.015	0.751	0.02	0.984	(0.238 - 4.329)
Yabello	0.885	0.697	-0.15	0.877	(0.189 - 4.138)
_cons	0.150	0.163	-1.74	0.081	(0.018 - 1.264)

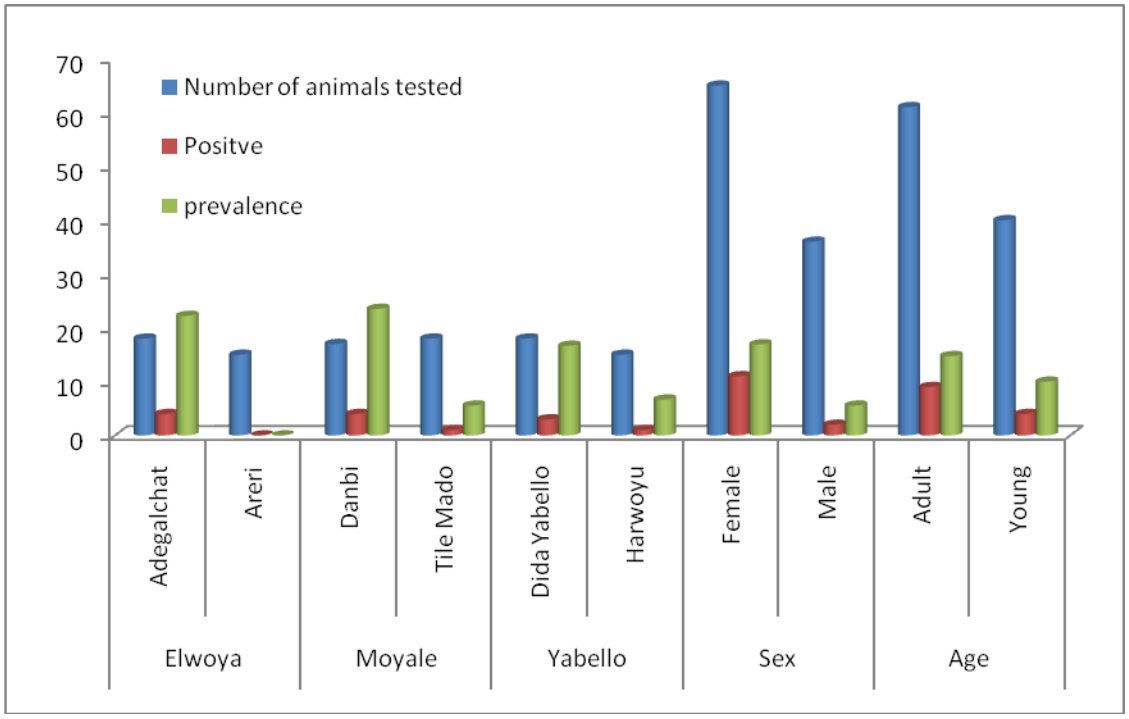

Figure 3. Proportion of sero-positivity in sheep by locality.

Results of gross pathological examination

Gross pathological changes observed in goats showing clinical signs of CCPP include accumulation of fluids in the pleural cavities, adhesion of lungs to the thoracic wall, frothy discharge in the trachea, enlarged bronchial lymph nodes, pneumonic lung tissues and pleural fluids containing large clots of fibrin (Figure 4).

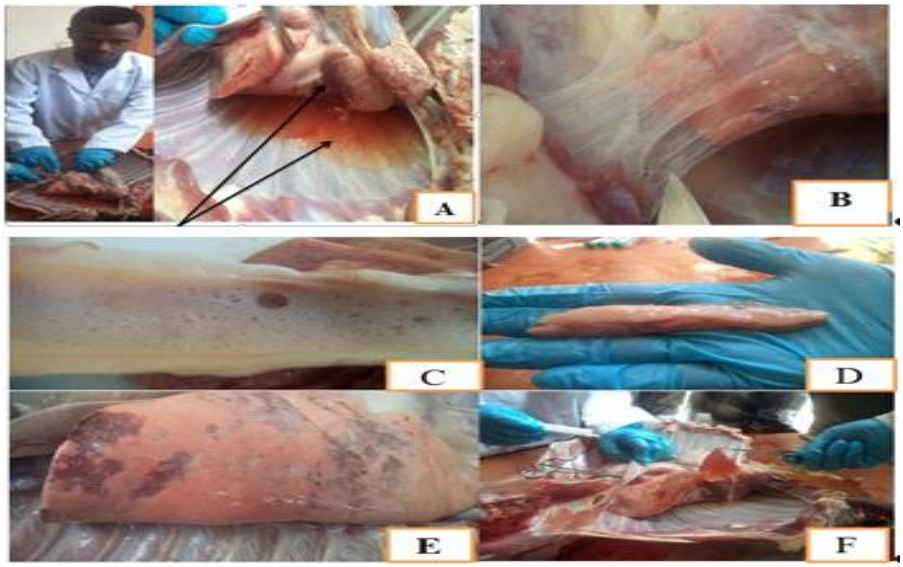

Fig 4. A) accumulation of lung exudate in thorax cavity; B) adhesion of lungs to the thoracic wall; C) froth in the trachea; D) enlarged tracheo-bronchial lymph node; E) lung with areas of pneumonia and F) lung exudate containing large clots of fibrin.

Molecular Test Result

Mccp detection and confirmation using conventional PCR

From a total of 8 samples (three lung tissues, three pleural fluids and two bronchial lymph node samples) collected from three goats that tested positive in cELISA and from clinical affected goats and analyzed by conventional PCR, 7 (87.5%) of them gave positive signals for *MCCP*. The specimens that tested positive include three lung tissues, Lane 1-3; three pleural fluids, Lane 5, 6 and 8 and one bronchial lymph node, Lane 7), whereas the samples of the other bronchial lymph node (Lane 4) did not give positive signal. The results of PCR analysis is depicted in Figure 5. The fragment size of the amplified products was 316 bp.

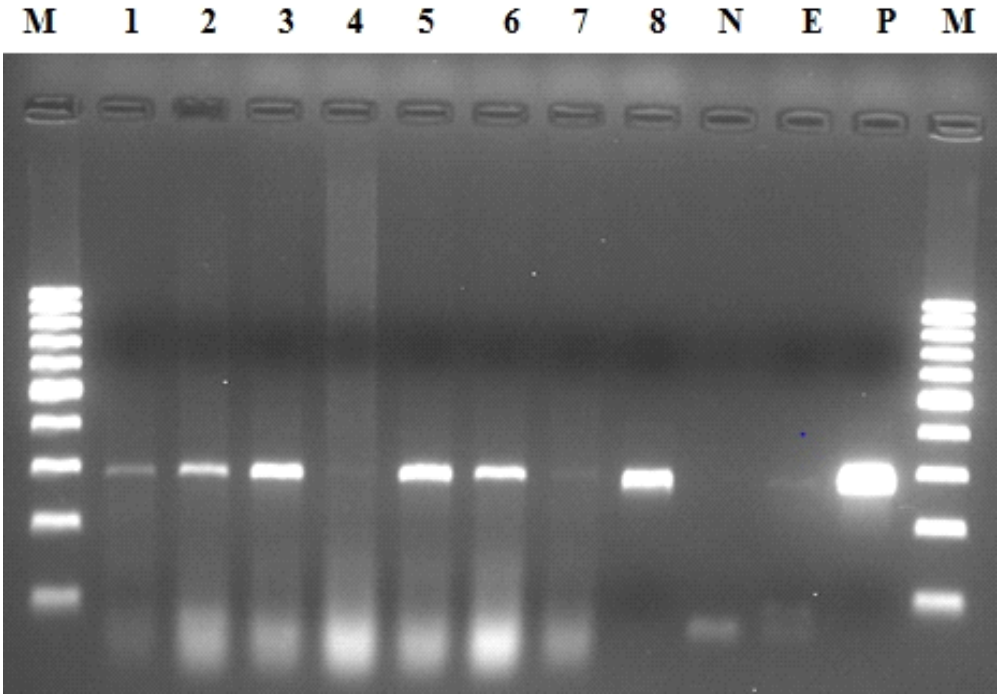

Figure 5. Agarose gel electrophoresis of PCR products (316 bp) amplified with *Mccp* specific primers. **Lane M:** 100bp DNA molecular weight marker; **Lane P**: Positive control; **Lane N**: Negative control; **Lane E**: Extraction control; Lane 1-8 are samples.

Discussion

The main objective of this study was to estimate the prevalence of CCPP in selected districts of Borana zone. The study revealed that CCPP is a major health constraint of goats in Borana pastoral areas. This was revealed by a general sero-prevalence of 31.2% and by the detection of *Mccp* in the samples collected from the three suspected cases. It has been shown previously that several outbreaks of CCPP reported in the country were from Oromia, the majority of which were from Borana (MoLF, 2016). The previous reports of outbreaks were based on the clinical signs. This study, however, provided confirmation of CCPP cases with molecular techniques and provided reliable information on the occurrence of *Mccp* in Borana area. This has important implication for the wellbeing of the pastoral community.

The overall sero-prevalence of 31.2% reported in unvaccinated goats in this study shows that *Mccp* has been established and is circulating in the area. For anunvaccinated population of goats this figure is high and requires attention of the veterinary and livestock authority of the area to minimizethe effect CCPP has on livelihoods in the community. The overall prevalence of CCPP in the present study was higher than the national prevalence estimated from pooled sero-prevalence (25.7%) through a systematic review by Asmare *et al*. (2016) and is largely in agreement with the previous findings from Ethiopia (Lakew *et al*., 2014) in which 31.6% of goats in Borana were found to be positive to CCPP. Similar observations were also made earlier by Eshetu *et al*. (2007) in goats at an export abattoir at Bishoftu, Ethiopia and Southern Ethiopia, Hadush *et al*. (2009) in Tigray and Afar, Sherif *et al*. (2012) and Hussain *et al*. (2012) in Beetal goats in Pakistan. Similar prevalence was also observed in Southern Darfuor state, Khartoum state,

Kassala state and Red Sea state, of Sudan by Abbass (2006). Thus our findings show that little has changed over the years, and the efforts made to control the disease with vaccinations have not resulted in sufficient vaccination coverage to prevent spreador contain the disease. This was also reflected by the fact, that it was easy to find villages in which goats had not been vaccinated against CCPP.

In contrast to our findings lower prevalence of CCPP has been reported earlier by Yousuf *et al*. (2012), Bekele *et al*. (2011), Mekuria *et al*. (2008), Mekuria and Asmare, (2010), Fasil *et al*. (2015) and Regassa *et al.* (2010) from different parts of Ethiopia. Elsewhere in the globe prevalence of CCPP is lower as reported by Shahzad *et al*. (2016) from Pakistan and Wazir *et al*. (2016) from Pakistan. On the other hand higher sero-prevalence of 44.5%, 47.3%, and 51.8% were reported from Dire Dawa, Afar, and Oromia regions of Ethiopia, respectively by Gizawu *et al*. (2009). Hadush *et al*. (2009) also reported higher prevalence 38.6 % and 43.9 % from Afar and Tigray regions of Ethiopia, respectively. In other parts of the world higher prevalence than our observation has been documented by Shahzad *et al* (2012) from Beetal, Pakistan, Mbyuzi *et al*. (2014) and Nyanja *et al*. (2013) from Tanzania, Kipronoh *et al*. (2016) from Kenya, Atim *et al*.(2016) from Uganda and Cetinkaya *et al*. (2009) from Turkey. An international collaborative study done by Peyraud *et al*. (2014) also reported sero-prevalence of 6 to 90%, 14.6%, 16%, 10.1%, 0% and (2.7%, 44.2%) from Kenya, Ethiopia, Mauritius, Tajikistan, Afghanistan, and Pakistan, respectively using monoclonal antibody based cELISA. The observed variation in sero-prevalence reported from different studies may be due to differences in the husbandry practices, agro-ecology, the antibody detection techniques used and the sampling methods followed and sample size used.

The sero-prevalence of CCPPwas significantly lower in Elwoya than in Moyaleand Yabello. This observation agrees with the reports of Wazir *et al*. (2016) who reported significantly different prevalence among geographical areas. However it is contrary to the findings of Eshetu *et al*. (2007), Hadush *et al*. (2009) and Sherif *et al*. (2012). The higher prevalence in Moyale and Yabello compared to Elwoya observed in this study could be due to frequency of animal movement in the districts. Moyale is a district bordering Kenya. There is free movement of animals between the two countries in search of market and pastures. Pastoralists in the area often cross the border for marketing purposes as well as in search of feed and water mostly during the dry season and during droughts. There is also free movement and contact with animals from neighboring Somali pastoralists in Moyale. Yabello is the center of Borana zone, where animals from surrounding PAs are being moved to for veterinary services and marketing. Therefore, the higher prevalence of CCPP in these two districts is probably due to animal movement for marketing and in search of water and pasture.

The serological test results showed the presence of anti-*Mccp* antibodies in all age groups of goats and sheep. However, the results of sero-prevalence study showed that age had significant effect on the occurrence of infection with *Mccp* in Borana zone. The higher odds of infection as age increases are due to increased chance of contact with carrier animals and then higher chance of infection in life time. As time goes, the chance of animals to come in contact with carrier animals becomes high. In addition, the higher prevalence of CCPP in adult animals compared to young ones might be explained by the fact that humoral immunity to CCPP is influenced by age as discussed by Sherif *et al*. (2012). This observation is in consent with the findings of Fasil *et al*. (2015) who reported that adult goats were 1.84 times more likely to be sero-positive than kids. Our findings also agrees with the report of Mekuria and Asmare (2010), Bekele *et al*. (2011), Yousuf *et al*. (2012), Sherif *et al*. (2012),Nyanja*et al*.(2013) and Lakew *et al*.

(2014) who observed the presence of significant variation among age groups. However the finding of this study contradicts with the works of Gizawu *et al.* (2009), Nicholas, (2002), Eshetu *et al.* (2007) and Hadush *et al*. (2009) who observed absence of association between age and occurrence of CCPP.

In this study sheep kept along with goats were found to be sero-positive in all PAs except in Areri. That is, sheep in contact with infected goats were sero-positive. In consent with our observation previous authors showed that sheep were sero-positive from different parts of Ethiopia. For instance 13% of sheep were found sero-positive by Dawit (1996), 7.14% by Gelagay *et al*. (2007), and 47.6% by Hadush *et al*. (2009). In Africa sero-prevalence of 36.7% and 22.9% from sheep serum was also reported from Tanzania by Mbyuzi *et al*. (2014). In addition to this there are reports describing the isolation of *Mcpp* from sheep with respiratory disease returning to Eritrea with refugees from Sudan (Houshaymi *et al*., 2002), from healthy sheep in Kenya that have been in contact with goat herds affected by CCPP (Litamoi *et al*., 1990), from sick sheep mixed with goats in Uganda (Bolske *et al*., 1995) and elsewhere in the globe by Cetinkaya *et al*. (2009) from lung and nasal swab of sheep. This raises questions on the role of sheep as a reservoir and contributing to maintaining transmission of*Mccp*. The exact role of sheep in the maintenance and spread of *Mccp* to goats needs to be further investigated

Our finding of CCPP gross lesions at postmortem which revealed lung exudate containing large clots of fibrin, adhesion of lungs to the thoracic wall, froth in the trachea, enlarged bronchial lymph nodes, pneumonic lung tissues, are similar with the previous study of Wesonga *et al*. (2004) who reported the lesions of classical CCPP caused by *Mccp*. These observations are also matched with the findings of others (OIE, 2008; Sadique *et al*., 2012). In conclusion the present study revealed that CCPP is prevalent in the Borana pastoral area. The causative agent of CCPP*Mycoplasma capricolum* subspecies *capripneumoniae* was identified and confirmed by PCR. The study also showed that sheep were infected with *Mccp*with asero-prevalence of 12.9%. Age of goats and district of origin were found to be risk factors of sero-prevalence of CCPP in the area. Therefore, more coordinated efforts are needed to prevent the disease and mitigate its impact.

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Dissemination and On-Farm Evaluation of Crossbred Goats at Yabello District

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Abstract

The study was conducted in different PAs of Yabello district, Borana zone aiming to improve the growth performance of Borana goats without losing adaptive traits, reduce age at marketing and evaluate and develop crossbred animals dissemination schemes. GLM procedure of SAS V. 9 was used to analyze the effect of sex, season and year on growth performance regarding birth (BWT), weaning (WWT), six month (SMWT), nine month (NMWT), yearling weight (YWT) and pre (PreDG) and post (PoADG) weaning average daily gain. Crosses were performed better with an average 3.32±0.04kg, 9.05±0.09kg, 71.48±1.06gm, 15.30±0.13kg, 20.53±0.14kg, 25.50±0.15kg and 68.29±0.55, respectively for BWT, WWT, PADG, SMWT, NMWT, PoADG and YWT. All growth parameters were significantly affected (P<0.05) by sex, season and year. Overall, the performance of crossbred can be considered as better one compared to some indigenous breeds. But, failed to satisfy goat producer regarding some important parameters like horn structure and survival, which are related to the prevailing management. However, they can be a good opportunity for commercial producers with some improved management. Generally, the crosses are significantly outperformed the indigenous goats while compared to growth performance and attaining heavier weight at early age for market. Therefore, if minor improvement is made on management Boer x Borana Goat can be one option for goat producers of the study area

Key words: Dissemination, Crossbred Goats, On-Farm Evaluation, Yabello District

Introduction

The lowland areas are the home for about 10 million pastoral people who are highly dependent on livestock for their economy and social well-being. Apart from subsistence, livestock also play economic and cultural roles. The majority (75%) of the goats in the country are raised in arid and semi-arid zones. In this system small ruminant have a very important role in contributing to the food security as well as in mitigating environmental risk due to their unique adaptation to arid and semi- arid areas. Goats are primarily used for milk consumption and sheep are kept for meat production. They also play significant role in socio-cultural values.

Small ruminant production systems in arid and semi-arid areas undergoing a course of production as a result of growing demand for meat both in the local and foreign markets. Geographic proximity of Ethiopia to high goat meat importing countries of Middle East and neighbouring countries offers opportunity for goat producers to enhance in exploiting the organic meat demanding markets. Increasing human population, urbanization and incomes, coupled with changing consumer preferences are creating more demand for goat and their products. This demand can effectively be met by substantially increasing goats' productivity. However, productivity of goat in Ethiopia is lower than the African average. Total off take of goat is estimated to be 37% (Beyene, 1991), carcasses usually weighing 9-10 kg giving a mean yield of 3 kg (Galal, 1980). The price of meat is almost entirely determined by the animals live weight

that reasonably varies with demand and price. But their merit to survive and reproduce in harsh and unpredicted environment is remarkable. The small size of indigenous breeds of small ruminant is one of the main problems both in the local and foreign markets. The export markets demands goats that weigh up to 30-35 kg at yearling age (Yibrah, 2008). Most of the local breeds slaughtered/marketed at round yearling age when their body weight are 18-25 kg. Low genetic potential of local breed is often assumed as a major constraint to meat and milk production in SSA.

Studies illustrated that improvement of production management are not cost effective when used with unimproved stock, in the absence of systems that allow farmers improved genotype (Tibbo, 2006). Thus, to improve goats' productivity, breeding intervention should receive similar priority as other feeding and health management. Efficient genetic improvement programs can boost output and profitability for the smallholders. Therefore, there is a need to study on how to deliver genetic improvement of indigenous goat under traditional circumstances to enhance food security, combat rural poverty, and meet needs of human population and foreign market demands. Cross breeding could be one of the options to improve production and productivity of goats. Cross breeding involving an adapted tropical goat breeds can make a huge contribution to sustainable and competitive production system. Cross breeding enables use of complementary of breed difference, exploit heterosis and utilization of adapted and specialized breeds to different environments.

Consequently, improved goat breed such as Boer are recognized and identified as the most potential and promising resources for arid and semi-arid agro-ecologies of the world. There is an on-going effort by Ethiopian government with the support obtained from USAID to at the start and proceeded with budget released from Government later on to improve goat productivity both through improving the environment and the genotype. Improved Boer goat have been already introduced and being used as sire/buck line to improve growth performance of indigenous goat breeds. Hence, this work is a continuation of the program and initiated to address the following objectives.

Objectives

- To improve the growth performance of Borana goats without losing adaptive traits.
- To improve marketable weight and reduce age at marketing.
- To evaluate and develop crossbred animals dissemination schemes

Material and Methods

Evaluation crossbred genotype

The cross breeding scheme involves production of 50% Boer 50% Borana bucks in the centre (figure 1). Crossbred animals were evaluated for their growth production performance. Selection takes placed at different stage of growth which is started at weaning (3-4 months) to include the maternity performance of the doe indirectly. Due to the prevailing low management level (poor housing, disease prevalence) and low drug availability, lack of animal health technician; F_1 crossbred males were used for dissemination to goat producing pastoralists.

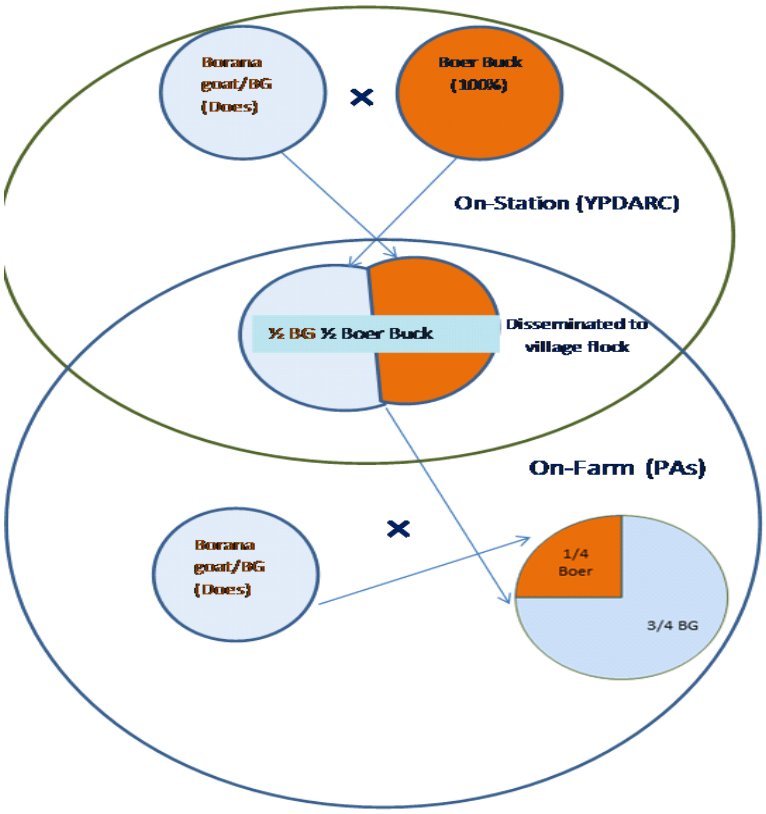

Figure 1: Schematic presentation of the Boer x Borana goat cross breeding scheme at Yabello station (1st step) and on-farm (2nd step) level

Site and community selection and group formation

The participating flocks consisted village flocks, which use the crossbred bucks to up-grade their indigenous flocks. Targeted participants were private large to medium scale goat producing pastoralists and agro-pastoralists. Participant villagers and pastoralists were selected in consultation with expertise at the district and Development Agents at community level. Meeting was made with participants and livestock development workers focusing on the project concept. Participants/pastoralists were aware on the long-term benefits of goat production genetic improvement. To reduce indiscriminate crossing and chance of blood dilution of the local breed, cross breed males/bucks were distributed and restricted to be used only within the project areas. Selection of goat breeders was made based on ease of access, potential for goat production, interest to keep crossbred animals, willingness to follow appropriate management practices, willingness to use controlled breeding (use of cross bred bucks only for breeding purpose and culling of unwanted animals from their flock), keep minimum records and allow their animals for monitoring and evaluation. Considering ease of follow-up and proximity from the station only Yabello district was targeted as pilot test of first phase. Potential PAs (Dida Yabello, Dhedim, Cheri, Elweya and – were selected to participate in the breeding program.

Training and role of participant small ruminant owners

Discussion was held with the participant pastoralists and local concerned government officials before the dissemination of the crossbred bucks. Relevant training related to breeding management, feeding and health management were given for technicians in charge of the work in the village flocks by the researchers from Yabello station with active involvement of development agents. The capacity of the participants in managing the breeding program was boosted through relevant trainings. Participants were trained how to keep simple but important records that help to make decisions in the breeding program. Participants shared the cost and agreed to provide minimal level of management to realize the benefits of genetic improvement program and paid for the improved buck they obtained to sustain the scheme. The improved genotypes were accompanied by improved management practices (improved housing, feeding and health care). Basic health care routines such as vaccination and deworming of animals in the monitored village flocks were attained by participant goat owners.

Dissemination strategies for crossbred bucks

Due to the reproductive rates of males, crossbred bucks were used for dissemination. To develop sense of communality, to discourage disposal of breeding bucks for market, to facilitate efficient utilization; crossbred bucks were sold/distributed to individual goat owners depending on the number of breeding Does they own. Mating was designed in a way that a buck is assigned with 25 to 30 breeding females during mating season. The participating individuals were responsible for use and care of the bucks**.** The bucks were checked for disease such as brucellosis prior to mating. Bucks unwanted for breeding were disposed before they reached breeding age to avoid indiscriminate mating.

Monitoring and Evaluation

Progenies of distributed bucks were carefully measured, tested and monitored with involvement of extension staffs at district and community level. Continuous follow-up by the research team, development agents, record keeping and monitoring was carried out. The development agents at the community level were responsible for facilitating communal record keeping and assisting pastoralists in technical aspects in consultation with the research team. Animals were evaluated based up on their phenotypic performances for production traits. The impact of improved genotype on livelihood of the household income and performance of goats in terms of growth was assessed.

Data collection at on farm level

Growth data collected from on farm included, BWT=Birth Weight, WWT=Weaning Weight, PreADG=Pre weaning average daily gain, SMWT=six month Weight; NMWT=Nine month Weight, PoADG=Post weaning average daily gain and YWT=Yearling weight

Data management and Statistical Analysis

The General Linear Model (GLM) procedures of SAS (2003) were employed to determine effects of class variables genotype, type of birth, age and sex on production. The effects of class variables and their interaction is expressed as Least Square Means (LSM) ± SE.

Model for the least - squares analysis:

$$Y_{ijkl} = \mu + S_i + Y_k + P_l + e_{ijkl}$$

Where: Y_{ijkl}= Observed (BWT=Birth Weight, WWT=Weaning Weight, PreADG=Pre weaning average daily gain, SMWT=six month Weight; NMWT=Nine month Weight, PoADG=Post weaning average daily gain and YWT=Yearling weight)

μ = Overall mean

S_i = the fixed effect of i^{th} sex (i = female, male)

Y_j = the fixed effect of j^{th} birth type (j= 2012, 2013, 2014, 2015 and 2016)

P_k = the fixed effect of k^{th} season (k=Long rainy, Cool dry, Short rainy, Long Dry)

e_{ijkl}= random error

Result and Discussion

Pre-weaning Growth Performance:

LS means of pre-weaning growth performance of crossbred goats (50% Boer × 50% Borana Goat) is presented in table 2. The result from GLM showed that growth performance of crossbred is affected significantly (*P<0.05*) by sex of the kid, year and season. Male kids were found 20% heavier than their female counter part. On the other hand, the kids that were born in the year 2016 were found 26.37% to 34.25% lighter than the one that born in the remaining years (2012 to 2015). Similarly, kids those born in long dry season were smaller in weight and out performed by those that were born in the rest season.

Table 2: LS mean of pre weaning growth performance (Birth weight, weaning weight and pre weaning average daily gain of (25%Boer5%Borana goat)

Factors	**BWT (kg)**	**PreADG (gm/day)**	WWT(kg)
Overall Mean ±SE	3.32±0.04	71.48±1.06	9.05±0.09
CV (%)	20.33	24.46	16.24
Sex			
Male	3.51±0.08a	72.82±2.10a	9.32±0.18a
Female	2.92±0.07b	67.83±2.15b	8.35±0.19b
Years			
2012	3.41±0.06a	71.06±1.52a	8.92±0.13b
2013	3.30±0.16a	74.84±5.93a	8.82±0.50b
2014	3.53±0.07a	72.76±2.31a	8.90±0.19b
2015	3.31±0.13a	74.34±2.73a	9.82±0.23c
2016	2.53±0.23b	58.62±5.37b	7.71±0.50b
Season			
Long Dry	2.94±0.09c	61.96±2.37b	8.74±0.21bc
Long Rainy	3.29±0.08a	75.43±2.90a	8.07±0.23c
Cool Dry	3.08±0.08bc	73.89±2.11a	9.16±0.18ab
Short Rainy	3.54±0.16a	70.02±3.68ab	9.37±0.31a

[a]BWT=Birth Weight, WWT=Weaning Weight, PreADG=Pre weaning average daily gain

[b]Values with different letters are significantly different (at least at $P < 0.05$)

The overall mean (9.05 ± 0.09 kg) weaning weight of 75% Borana and 25% Boer cross kids obtained in the current study (Table 1), was within the same range with 9.02±0.18 kg Arsi Bale goats (Tatek *et al*., 2004) and Highland kids (Tucho *et al.*, 2000). However, heavier than 7.2 kg the value reported for Boran-Somali kids (Tucho *et al.*, 2000), Abergele weaner kids (Belay and Mengistie, 2013), Mid Rift Valley kids and Highland goats (Tucho *et al*., 2000). On the other hand, the overall average pre-weaning daily weight gains obtained in this study was found lower than pre-weaning (76.6±2.27g/day) weight obtained and pre-weaning growth rate under traditional managements (104 g/day) of Ethiopian goats reported by Mukassa-Mugerwa *et al*. (1989). The differences in the pre-weaning weight gains are closely associated with the differences in level of milk intake during milk feeding period and the nutritional status of the doe (Negi *et al*., 1987; Singh *et al*., 1987).

The incidence of heavier (P<0.05) birth and weaning weight for male kids when compared to females found in the current study is in agreement with past research outputs reported by Wenzhong *et al.* (2005), Zeleke (2007) and Ali and Khan (2008) in Angora, Somali, Beetal and Tellicherry goat breeds, respectively. Season of birth and weaning produced significant effect on body weights of Borana × Boer goats (75:25) at birth, weaning and pre-weaning average daily gain. The current result coincides with study result reported for Angora goats by Wenzhbong *et al.* (2005) and Ontario goat herd by Nadarajah *et al.* (1995) where they explained as season influenced the pre-weaning growth performance of the mentioned goats. Seasonal variation of growth performance observed is the result of different feeding conditions created in each season in response to irregular climatic conditions, specifically in arid areas (Gaddour *et al.*, 2007). As a result, pastoral areas feed resources change very much from one month to another, and for the same month from one year to another, which directly affects the intake of any kids and milk production of dam (Najari *et al.*, 2007).

Post-Weaning Growth Performance:

Male kids weight at six, nine and twelve months of age was significantly different (P<0.05) as compared to female groups (Table 2). Similarly, male kids exhibited > 4.50% faster growth (P<0.05) when compared to their female counter parts. Likewise Kids that were reared in different years were performed in a different way (P<0.05) and those that reared in 2014 showed better performance regarding SMWT (15.80 ± 0.34 kg), NMWT (21.07 ± 0.39 kg), YWT (27.01±0.38 kg) and PoADG (70.96 ± 1.85 gm). In the contrary, Kids that were reared in 2016 were significantly lighter (P<0.05) than those that were reared in the other years. The difference observed was strongly associated with forage and water availability which is linked to a rainfall pattern and amount rained within a particular year. Accordingly, the year 2016/17 was registered as one of the serious drought period occurred in the area.

Table 2. LS mean of six and nine month, post weaning average daily gain and yearling weight of cross breed goat (25%Boer5%Borana goat)

Factors	**SMWT (kg)**	**NMWT(kg)**	PoADG (g/day)	YWT(kg)
Overall Mean ±SE	15.30±0.13	20.53±0.14	68.29±0.55	25.50±0.15
CV (%)	14.22	10.83	12.30	9.73
Sex				
Male	15.65±0.26a	20.74±0.19a	67.70±0.87a	25.17±0.17a
Female	14.70±0.25b	19.99±0.20b	64.74±0.87b	24.72±0.18b
Years				
2012	14.92±0.24bc	20.74±0.24ab	64.42±1.24b	24.40±0.26c
2013	16.06±0.35a	20.06±0.30bc	69.99±0.80a	25.70±0.16b
2014	15.80±0.34a	21.07±0.39a	70.96±1.85a	27.01±0.38a
2015	15.46±0.27ab	21.15±0.31a	68.99±0.84a	26.00±0.17b
2016	13.61±0.80c	18.96±0.49c	56.73±2.51c	21.59±5.51c
Season				
Long Dry	13.98±0.33c	19.83±0.25bc	62.87±1.19c	23.04±0.22d
Long Rainy	16.26±0.50a	20.68±0.35ab	67.31±1.03b	25.70±0.21b
Cool Dry	15.49±0.23ab	19.81±0.31c	64.18±1.03c	24.72±0.24c
Short Rainy	14.97±0.39b	21.27±0.29a	70.52±1.22a	26.31±0.25a

[a]*SMWT=Six Month weight, NMWT=Nine month weight, YWT=Yearling weight and PoADG= Post weaning average daily gain*

[b]*Values with different letters are significantly different (at least at $P < 0.05$)*

Six month and yearling weights of 75% Borana and 25% Boer goats 15.30 ± 0.13 kg and 25.50±0.14 kg were by far most larger than values 7.87 ± 1.62 kg and 12.85 ± 2.55 kg reported for local Mid Rift Valley goats (Tucho *et al*., 2000) and fairly greater than 13.61±0.40 and 20.15±0.67 reported for local central-highland goat breed at Debre Berhan area (Tesfaye *et al*., 2006). The average nine month weight 25.50 ± 0.14 kg obtained in the current study is somewhat comparable with the average values reported for central-highland local goat breed. On the other hand, post-weaning growth rate obtained in the current study (68.29 ± 0.55 g/day) is larger than those reported for Abergelle goats (Belay and Mengistie, 2013).

Conclusions and Recommendations

The result obtained over the five years of the 50% crossbred bucks (Boer × Borana goat) has shown substantially evidence that small ruminant growth performance can be improved through terminal buck breeding program. However, there is evidence that with the current extensive production system, it is very difficult to lead productivity of goats to advanced level in the study area. Social and organizational constraints need to be overcome with a purposeful effort in changing the goat production system to some degree. Because, genetic change in animal production results in biological change of the animal, which often requires corresponding changes in nutritional and management inputs for optimal genetic expression.

However, the result indicated as 50% crossbred buck (Boer × Borana goat) can perform well for commercial goat keepers with a little health and feed intervention. But, the Zonal pastoral development agencies in Borana zone should foster channels of communication with zonal and regional research centres to ensure access to new information of possible applicability. Moreover, if more biological data regarding reproductive and mortality incorporated, detail information about the breed in association with the prevailing production environment will be met.

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Dissemination and On-Farm Evaluation of Crossbred Sheep at Yabello District

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Abstract

Dissemination and On-farm evaluation of crossbred sheep between Dorper and Black Head Sheep (BHSh) was carried out in Potential PAs Dida Yabello, Dhedim, Cheri, Gocheme, Elweya and Did-hara of Yabello district. Growth performance data birth (BWT), weaning (WWT), six month (SMWT), nine month (NMWT), yearling weight (YWT) and pre (PreDG) and post (PoADG) weaning average daily gain were collected and fitted in GLM of SAS procedure to identify the performance of 25%Dorper 75% Black head cross-breds associated with Lamb sex, Season and Year. The result obtained indicated as cross-breds growth performances significantly ($p<0.05$) influenced by these factors. The overall average performances of the cross-breds for the considered traits were 3.09±0.04kg, 11.84±0.01kg, 95.00±1.37g, 17.11±0.22kg, 20.79±0.36kg, 73.12±1.36g, and 26.55±0.28kg. Generally growth performance evaluation studies as demonstrated in the results of current on-farm research reveals tremendous potential of crossing indigenous Black head sheep with Dorper breed for improved productivity at on-farm level. However, comparative research related to reproductive potential, survival rate, mutton quality and profits need to be performed considering the pure and cross-breds of black head sheep.

Key words: Dissemination, On-Farm Evaluation, Crossbred Sheep, Yabello District

Introduction

The lowland areas are the home for about 10 million pastoral people who are highly dependent on livestock for their economy and social well-being. Apart from subsistence, livestock also play economic and cultural roles. The majority (75%) of the small ruminates are raised in arid and semi-arid zones. In this system small ruminant have a very important role in contributing to the food security as well as in mitigating environmental risk due to their unique adaptation to arid and semi- arid areas. Sheep are primarily kept for meat production. They also play significant role in socio-cultural values.

Small ruminant production systems in arid and semi-arid areas are experiencing a process of production as a result of growing demand for meat both in the local and foreign markets. Geographic proximity of Ethiopia to high mutton importing countries of the Middle East and neighbouring countries offers opportunity for small ruminant producers to enhance in exploiting organic mutton demanding markets. Increasing human population, urbanization and incomes, coupled with changing consumer preferences are creating more demand for these animals and their products. This demand can effectively be met by substantially increasing the productivity of sheep. However, their productivity is lower than the African average, in Ethiopia total off take rate of sheep is estimated at 33% (Beyene, 1991), carcasses usually weighing 9-10 kg giving a mean yield of 3 kg (Galal, 1980). The price of meat is almost entirely determined by the animals live weight that reasonably varies with demand and price. But their merit to survive and reproduce in harsh and unpredicted environment is remarkable. The small size of indigenous breeds of small ruminant is one of the main problems both in the local and foreign markets (Yibrah,

2008). Low genetic potential of local breed is often assumed as a major constraints to meat production in SSA.

Studies illustrated that improvement of production management are not cost effective when used with unimproved stock, in the absence of systems that allow farmers improved genotype (Tibbo, 2006). Thus, to improve small ruminant productivity, breeding intervention should receive similar priority as other feeding and health management. Efficient genetic improvement programs can boost output and profitability for the smallholders. Therefore, there is a need to study on how to deliver genetic improvement of indigenous sheep under traditional circumstances to enhance food security, combating rural poverty and to meet demands of sheep keepers and foreign markets. Cross breeding could be one of the options to improve production and productivity of the small ruminant. Cross breeding involving an adapted tropical sheep breeds can make a huge contribution to sustainable and competitive production system (Yapi-Gnoaré, 2000). Cross breeding enables the use of complementary breed difference, exploit heterosis and utilization of adapted and specialized breeds to different environments.

Improved sheep breed such as Dorper are recognized and identified as the most potential and promising resources for arid and semi-arid agro-ecologies of the world. There is an on-going effort by Ethiopian government with the support from USAID to improve sheep productivity both through improving the environment and the genotype to progress marketable weight and reduce age at marketing. Improved Dorper have been already introduced and being used as sire/ram line to improve growth performance of indigenous seep breeds. Hence, this work is a continuation of the program and initiated to address the following objectives.

Objectives

- Evaluate and disseminate cross-bred rams to pastoral sheep producers
- Improve the mutton production of Blackhead sheep without losing adaptive traits.
- Evaluate and develop cross-bred animals dissemination schemes

Materials and Methods

Study Sites

The current research was conducted in Yabello district of Borana zone, southern Oromia. Borana zone of pastoral system has been one of the long ever known wider lowland range land area in southern Ethiopia covering around 95,000Km², that is located 567Km from the capital Addis Ababa between 03°37' 23.8" to 05°02'52.4" North and 37°56'49.4" to 39°01'101" East, with an altitude ranges from 970 masl in the south bordering Kenya to 1693 masl in the North east (Coppock, 1994). The area receives mean annual rainfall of 600mm³ with mean minimum and maximum annual temperatures of 19°c and 24°c respectively.

Evaluation of cross-bred genotype

Cross breeding scheme involved production of cross-bred rams with blood level of 50% Dorper and 50% Blackhead at Yabello Pastoral and Dry-land Agriculture Research Centre (YPDARC). Cross-bred sheep were evaluated for their growth and survival performance. First selection held at weaning (3-4 months) based on their growth rate performance in response to maternal, maternal permanent environmental effect and the management level applied. Due to the prevailing low management level (poor housing, disease prevalence) and shortage of drugs, lack of animal health technician; F_1 cross-bred males were disseminated to pastoralists.

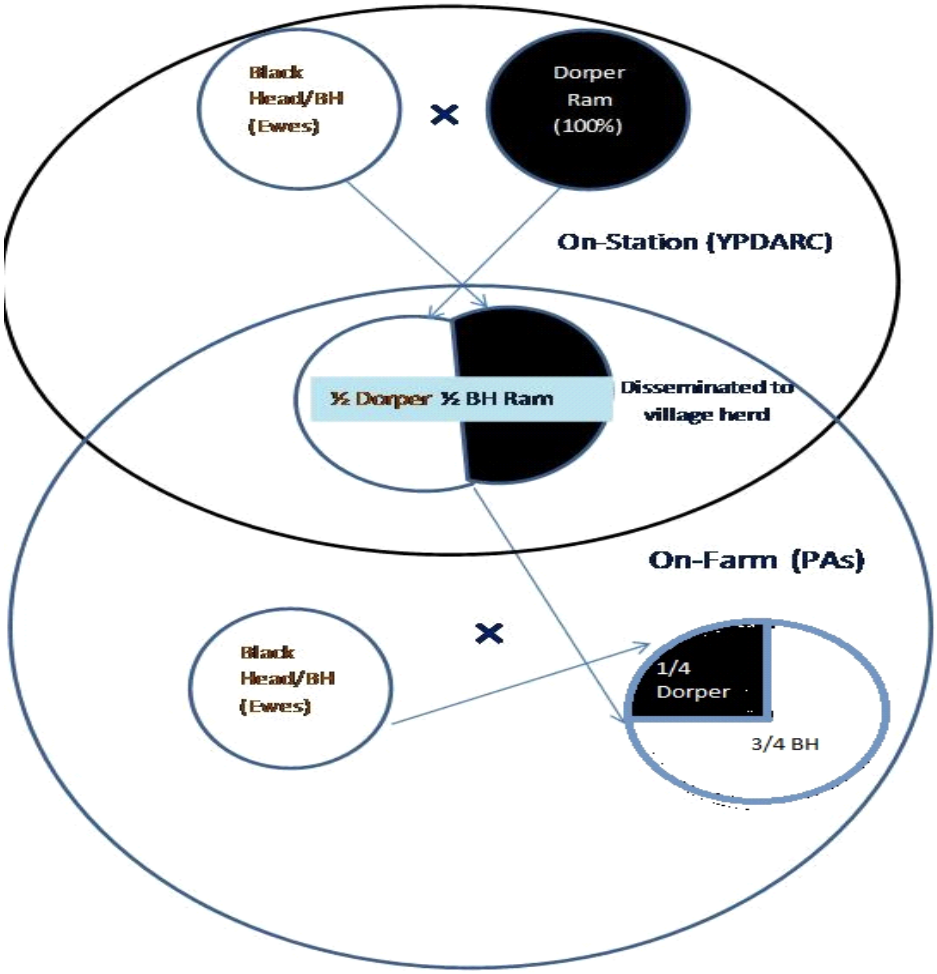

Figure 1 Schematic presentation of the Dorper x Blackhead Somali sheep cross breeding scheme at station level

Site and community selection and group formation

The participating herd consisted village flocks that used the cross-bred rams to up-grade their indigenous sheep breed. Targeted participant were private large to medium scale sheep producing pastoralists and

agro-pastoralists. Participant villagers and pastoralists were selected in consultation with expertise at the district and Development Agents at community level. Meeting was made with participants and livestock development workers focusing on the project concept. Participants/pastoralists were aware on the long-term benefits of sheep production genetic improvement. To reduce indiscriminate crossing and chance of blood dilution of the local breed, cross breed males/rams were distributed and restricted to be used only within the project areas. Selection of sheep breeders was made based on ease of access, potential for sheep production, interest to keep cross-bred animals, willingness to follow appropriate management practices, willingness to use controlled breeding (use of cross bred rams only for breeding purpose and culling of unwanted animals from their herd), keep minimum records and allow their sheep for monitoring and evaluation. Considering ease of follow-up and proximity from the station only Yabello district were targeted as pilot test of first phase. Potential PAs (Dida Yabello, Dhedim, Cheri, Gocheme, Elweya and Did-hara) were selected to participate in the breeding program.

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Discussion was held with the participant pastoralist and local concerned government officials before the dissemination of the cross-bred rams. Relevant training related to breeding management, feeding and health management were given for technicians in charge of the work in the village herds by the researchers from Yabello station with active involvement of development agents. The capacity of the participant in managing the breeding program was boosted through relevant trainings. Participants were trained how to keep simple but important records that help to make decisions in the breeding program. Participants shared the cost and agreed to provide minimal level of management to realize the benefits of genetic improvement program and paid for the improved ram they obtained to sustain the scheme. The improved genotypes were accompanied by improved management practices (improved housing, feeding and health care). Basic health care routines such as vaccination and de-worming of animals in the monitored village flocks were attained by participant sheep owners.

Dissemination strategies for cross-bred rams

Due to the reproductive rates of males, cross-bred rams are used for dissemination. To develop sense of communality, to discourage disposal of breeding rams for market, to facilitate efficient utilization; cross-bred rams were sold/distributed to individual sheep owners depending on the number of breeding Does they owned. Mating was designed in a way that a ram is assigned to 25 to 30 breeding females during mating season. The participating individuals were responsible for use and care of the rams**.** The rams were checked for disease such as brucellosis prior to mating. Rams unwanted for breeding were disposed before they reached breeding age to avoid indiscriminate mating.

Monitoring and Evaluation

Progenies of distributed rams were carefully measured, tested and monitored with involvement of extension staffs at district and community level. Continuous follow-up by research team and development agents regarding record keeping and breeding was carried out. Development agents at community level were responsible on facilitating communal record keeping and assisting pastoralists in technical aspects in consultation with research team. Animals were evaluated based on their phenotypic performances for production traits.

Data collected at on farm level

Growth data collected from the research sites included, birth weight (BWT), weaning weight (WWT), Six Month weight (SMWT), Nine Month weight (NMWT) yearling weight (YWT), pre (PreADG) and post-weaning growth (PoADG)

Data management and Statistical Analysis

The General Linear Model (GLM) procedures of SAS (2003) were employed to determine effects of class variables genotype, type of birth, age and sex on production. The effects of class variables and their interaction is expressed as Least Square Means (LSM) ± SE.

Model for the least - squares analysis

$Y_{ijkl} = \mu + S_i + Y_j + P_k + e_{ijkl}$

Where: Y_{ijkl} = Observed BWT=Birth Weight, WWT=Weaning Weight, PreDG=Pre weaning average daily gain, SMWT=six month Weight; NMWT=Nine month Weight, PoADG=Post weaning average daily gain and YWT=Yearling weight

μ = Overall mean

S_i = the fixed effect of i^{th} sex (i = male, female)

Y_j= the fixed effect of j^{th} yaers (j = 2012, 1013, 2014, 2015 and 2016)

P_k = the fixed effect of k^{th}season (k=Long rainy, Cool dry, Short rainy, Long Dry)

e_{ijkl} = random error

Results and Discussion

Pre-weaning Growth: Overall mean (±SE) and LS means for pre-weaning growth performance of 25%Dorper and 75%Black head cross-bred sheep is presented in table 2. The result from GLM showed that factors like sex of the sheep, year and season significantly (*P<0.05*) affected pre-weaning growth performance of cross-bred sheep. Accordingly, male lambs were found 270g and 560g, respectively heavier at birth and weaning than their female counter part. On the other hand, the lambs that were born in the year 2016 were found 240gm to 590g and 530g to 1740g respectively lighter at birth and weaning than those born in the remaining years (2012 to 2015). Similarly, those lambs born in long dry season were smaller in weight and out performed by those born and weaned in the other season.

Table 1: LS mean of pre weaning growth performance of 25%Dorper and 75%Black head crossbred sheep

Factors	BWT (kg)	WWT(kg)	PreADG (g/day)
Overall Mean ±SE	3.09±0.04	11.84±0.01	95.00±1.37
CV (%)	18.45	16.69	20.39
Sex			
Male	3.26±0.10[a]	11.99±0.24[a]	94.27±2.32[a]
Female	2.99±0.11[b]	11.43±0.22[b]	89.03±2.14[b]
Years			
2012	3.12±0.08[a]	11.54±0.42[ab]	88.15±4.13[bc]
2013	3.06±0.33[ab]	12.31±0.43[b]	93.01±4.18[abc]
2014	3.23±0.11[a]	12.35±0.20[a]	100.76±1.95[a]
2015	3.41±0.29[a]	11.10±0.25[ab]	95.35±2.48[ab]
2016	2.82±0.10[b]	10.57±0.57[b]	80.98±5.65[c]
Season			
Long Dry	2.90±0.13[b]	10.40±0.28[b]	77.86±3.24[b]
Long Rainy	3.19±0.15[a]	12.42±0.40[a]	94.92±2.77[a]
Cool Dry	3.13±0.11[ab]	11.72±0.33[ab]	93.48±3.24[a]
Short Rainy	3.27±0.14[a]	12.31±0.23[a]	100.33±2.23[ab]

[a]BWT=Birth Weight, WWT=Weaning Weight, PreADG=Pre weaning average daily gain
[b]Values with different letters are significantly different (at least at $P < 0.05$)

The current overall mean birth weight (BWT) value (3.09±0.04) observed for 25%Dorper and 75%Black head cross-bred sheep is 27.16 and 42.40% heavier than the birth weight estimate reported by Awgichew (2000) for two Ethiopian indigenous breeds Horro (2.43kg) and Menz lambs (2.17kg), respectively. Moreover, the current BWT value was larger than the reported 2.83kg for F1 Awassi x Menz lambs (Gizaw *et al*., 2012) and 2.57+0.06 kg and 2.77+0.04 kg reported by Abebe *et al.* (2015) for Dorper x Afar (50%) and Dorper x Menz (50%). The difference observed attributed to the fact that the current observation was associated from single born lambs. On the other hand, 11.84±0.01kg and 95.00±1.37g day^{-1} observed in the current study was higher than 9.45+0.87kg and 73.19+10.89g day^{-1} for Dorper x Afar (50%) and slightly lower than 12.34+0.25kg and 106.24+2.61g day^{-1} for Dorper x Menz (50%) reported by Abebe *et al.* (2015), respectively for weaning and pre-weaning average daily gain. The significant difference (P<0.05) over pre-weaning growth associated with sex, season and year observed in current study, agrees with previous studies (Abebe *et al.,* 2015; Negussie et al., 2004; Ermias et al., 2002; Nawaz and Ahmed, 1998; Teferawork, 1990) that confirmed the significant effects of the mentioned factors on pre-weaning growth traits. Whenever the effect of sex on growth can be associated with the variation of crinological and physiological hormones existed between male and female (Ebangi *et al.,* 1996); the difference of growth performance in various season and year is attributed to the availability of pasture for the ewes and growing lambs in a particular period (Tibbo, 2006; Mekuriaw, 2011).

Post-weaning Growth:

Male lambs weight at six, nine and twelve months of age was significantly different (P<0.05) as compared to female groups (Table 2). Similarly, male lambs exhibited 6.47g day^{-1} faster growth (P<0.05) when compared to their female counter parts. Likewise lambs that were raised in different years were performed in a different way (P<0.05) and those that raised in 2014 showed better performance regarding SMWT (17.24 ± 0.29 kg), NMWT (22.88 ± 0.73kg), YWT (27.90±0.82kg) and PoADG (83.78 ± 3.89g day^{-1}). In the contrary, lambs that were measured in 2016 were significantly lighter (P<0.05) than those raised in the other years. The difference observed was strongly associated with forage and water availability which is attributed to a rainfall pattern and amount rained in the particular year which is seriously affected availability of water and feed, particularly in 2016.

Table 2 LS mean of six and nine month weight, post weaning average daily gain and yearling weight of 25%Dorper 75%Black head cross-bred sheep

Factors	**SMWT (kg)**	**NMWT(kg)**	**PoADG (g/day)**	**YWT(kg)**
Overall Mean ±SE	17.11±0.22	20.79±0.36	73.12±1.36	26.55±0.28
CV (%)	12.35	15.86	28.30	16.41
Sex				
Male	17.34±0.30^{a}	21.42±0.36^{a}	77.75±2.23^{a}	27.76±0.44^{a}
Female	16.31±0.29^{b}	20.59±0.34^{b}	71.28±2.17^{b}	25.97±0.41^{b}
Years				
2012	16.90±0.68^{ab}	21.73±0.75^{ab}	73.02±5.29^{bc}	27.16±1.01^{a}
2013	17.12±0.48^{a}	20.94±0.57^{b}	77.22±4.57^{ab}	27.89±0.81^{a}
2014	17.24±0.29^{a}	22.88±0.73^{a}	83.78±3.89^{a}	27.90±0.82^{a}
2015	17.33±0.40^{a}	20.60±0.30^{b}	73.52±1.96^{b}	26.44±0.38^{a}
2016	15.51±0.60^{b}	18.90±0.63^{c}	65.03±3.08^{c}	24.92±0.64^{b}
Season				
Long Dry	15.43±0.35^{c}	19.58±0.45^{c}	67.48±3.94^{b}	24.64±0.57^{c}
Long Rainy	18.12±0.41^{a}	22.20±0.41^{a}	79.11±2.46^{a}	28.51±0.47^{a}
Cool Dry	16.44±0.36^{b}	20.48±0.49^{bc}	72.48±3.07^{ab}	26.61±0.63^{b}
Short Rainy	17.63±0.42^{a}	21.78±0.60^{ab}	79.45±3.79^{a}	27.71±0.71^{ab}

[a]SMWT=Six Month weight, NMWT=Nine month weight, YWT=Yearling weight and PoADG= Post weaning average daily gain

[b]Values with different letters are significantly different (at least at $P < 0.05$)

The overall mean 17.11±0.22kg, 20.79±0.36kg 26.55±0.28kg, respectively for six month (SMWT), nine month (NMWT) and yearling weight (YWT) obtained in this study was lower than the research result 20.43±0.30kg, 24.53±0.34kg and 31.37±0.38kg respectively, revealed for Dorper × local cross-bred sheep (Lakew *et al.,* 2014). However, weightier than 13.18±0.97kg, 24.96±3.34kg reported for Dorper X 50% Afar (Abebe *et al.,* 2015). More importantly, the current result obtained for YWT is 1.55kg heavier than previous research result 25kg (Galal, 1983), 24kg (Abegaz, 2002) and 23kg (Mukasa-Mugerwa *at al.,* 1994), respectively revealed for black head, Horro and Menz sheep in different parts of Ethiopia. The factors Sex, Season and Year were found to be significant source of variation for all Post-weaning traits

and this result is in line with previous research findings of Tibbo (2006) and Taye *et al.* (2009) who confirmed the effects of the mentioned factors on post weaning growth.

On the other hand the overall post weaning average daily gain (73.12±1.36g day^{-1}) for 25%Dorper 75%Black head cross-bred sheep observed in the current study under pastoral production system is encouraging one. It is greater than the result 49.2g day^{-1} (Ayele *et al*., 2017) and within the range of 60.4g day^{-1} to 95.6g day^{-1} (Wogene, 2007) reported for pure breed black head sheep that consumed basal diets and supplemented with different types of feed stuffs. Sex had significant effect ($P<0.05$) on growing rate. This phenomenon is in agreement with previous studies where significant sex effect on growth rate of sheep was confirmed (Bathaei & Leroy, 1997; Fernandes, 2001). Sex difference is attributed by the influence of sexual hormones associated with animal development affecting body dimensions, fat deposits, and muscle and bone tissues (Selaive-Villarroel *et al*., 2008).

Conclusion and Recommendation

Generally growth performance evaluation studies as demonstrated in the results of current on-farm research revealed tremendous potential of crossing indigenous Black head sheep with Dorper breed for improved productivity at on-farm level. However, comparative research in related to reproductive potential, survival rate, mutton quality and profits or cost-benefit analysis need to be performed considering the pure and cross-breds of black head sheep.

Lamb sex, season and year of birth were all significant for growth of lambs and except the first (Lamb sex) the other factors are associated with availability of feeds. Therefore, intervention in related to feeds need to be arranged for efficient exploitation of the genotypes and even for up grading the Dorper breed blood level to at least 50% at on-farm level. But, survival data which is missed in this research need to be incorporated using objectively developed flock structure recording forms for detail understand of the crosses regarding adaptation.

Good farm routines that would increase growth performance, reduce climatic stress, limit malnutrition and starvation during dry season in particular need to be introduced. In addition, frequent training about the management of terminal sires/ram breeding system need to be given to pastoralists until they internalized it.

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Fisheries Research Results

In-vivo and in-vitro evaluation on the efficacy of chemotherapeutic agents against important and pathogenic bacteria of fishes under constant condition

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Abstract:

An experiment was conducted to compare the efficacies of some selected antibiotics against common bacterial fish pathogens viz., Aeromonas hydrophila, Edwardsiella tarda, E.coli, Staphylococcus aureus and Salmonella. The test was conducted by infecting fish with selected bacterial pathogen which were then subjected to treatment. Four different antibiotics viz., CFCIN (ciprofloxacin), Renamycin (oxytetracycline), AMYN (amoxicillin) and Sulfatrim (sulphadiazine + trimethoprim) were exposed in different doses against common fish bacteria. After ten days of observation blood sample were taken and bacterial analysis were made. Colony forming unit were then enumerated. After 3 days of exposure to ciprofloxacin and oxytetracycline Colony forming unit count was reduced significantly than amoxicillin. Ciprofloxacin showed the best result with 100% recoveries of challenged fish in prolonged treatment. Comparing with the amoxicillin, the CFU count of the oxytetracycline was significant ($p<0.05$). In conclusion, Ciprofloxacin, and oxytetracycline show better antimicrobial activity than amoxicillin and Sulfatrim in removing test bacteria from the blood.

Key words: Fish, Treatment, Antimicrobial efficacy, Bacterial pathogen, CFU

Introduction

Fish are the most diverse group of vertebrate occupying a variety of marine and fresh water habitat. They are cold-blooded or poikilothermic animals. Their body temperature varies passively in accordance with the temperature of the surrounding water. Although fish as a group are tolerant of a wide range of temperatures, from just below 0^0C up to 45^0C individual species generally have a preferred optimum, as well as a more restricted temperature range. Each species of fish has preferred ranges for the various parameters of water quality, such as temperature, dissolved oxygen and salinity and ideally the fish farm should operate at the optimum levels of each parameter to achieve fast growth and efficient performance 1

One of the problems of the fishery sector in the capture fisheries and wild population is parasite and disease condition of fish parasite which reduces fish production by affecting the normal physiology of fish and if left uncontrolled, it can results in mass mortalities or in some cases, can be serve as source of infection for human and other vertebrates that consumed fish 2. A common mistake of fish culturists is misdiagnosing disease problems and treating their sick fish with the wrong medication or chemical. When the chemical doesn't work, they will try another, then another. Selecting the wrong treatment because of misdiagnosis is a waste of time and money and may be more detrimental to the fish than no treatment at all. In addition it enhances development of drug resistance to already available limited number of antimicrobial and other chemical agent that used to treat fish 3.

Understanding the etiology of the disease is of crucial importance as it determines the choice of potential treatment. Hence, the knowledge of fish bacteria and their relationship with the host as well as their effective treatments will help to select fish species for importation or for introduction from one locality to another and for introduction to different pond 3.

One of the main emphases in Ethiopia is to develop aquaculture to its full potential making a big contribution to national food availability, food security, economic growth, and trade and improved living standards. However, along with the growing interest in the development of fish industries in the different sites of the area, there will be an increasing awareness of importance of fish disease as one of the major detrimental factors in culturing fish in the coming future.

Objectives of the study

***General Objective*:** The main objective of this study was to identify the most important treatments of fish Pathogenic bacteria under constant condition without causing danger to the host.

Specific objectives

- To identify appropriate dose of Chemotherapeutic Agents in Constant water parameter.
- To compare the efficacy of different drug of the same property.

Materials and Methods

Study Area: The study was conducted on fish collected from Lake koka, lake langanno, and Ziway lake.

Fish Selection:
Fishes samples were collected using different centimeter mesh sizes of gillnets which were set at certain study sites of the lake during day time and throughout the night. Immediately after capture, total length (TL) and total weight (TW) of each specimen was measured to the nearest 0.1 cm and 0.1g, respectively. Then after, fish was adapted to the environment.

Fish examination:
The codes of each fish, species, TL, TW, name of the site, date of sampling, types of parasites observed and different health related notes were recorded for each fish on separate field protocol. Any abnormalities on the fish were record. A hand lens was used for quick identification of any lesion on the skin and fins of the fish sample. Skin will also checked if there were capsules with metacercariae of trematodes in black dots and yellowish cysts which were sliced off the skin for further investigation and bacterial examination.

Fish husbandry:
After examination, the relatively free fish was kept in separated plastic tank and was fed with different locally available fish meal at the rate of 5% of body weight of fish per day. Fish was randomly divided into 5 groups, four for fish to be treated with antibiotic and remain as a control for treatment. Fish was held indoors in circular tanks (150 1it) and oxygen was supplied with aerator.

Diet preparation:
Both medicated and control diets were prepared. To prepare the control diet, locally available fish meal was pelleted to 4.5 mm diameter. Whereas medicated diets was prepared from locally available fish meal which was powdered and four drug of ant-biotic property (Ciprofloxacin, Renamycin, amoxicillin and Sulfatrim) in powder form was directly added to wet weight food with different doses. After thorough mixing, medicated diets were pelleted to a size similar to that of the control diet.

Selection of Pathogens:
The common fish pathogenic bacteria were taken from the Ethiopian Health and Nutrition Research Institute, Microbiology Laboratory. All the bacterial cultures were maintained in nutrient broth. Serial dilutions of all the bacterial cultures were prepared in nutrient medium and used for further studies. Bacterial isolation, their characterization and pathogenicity test were completed according to the method described by Barrow and Feltham (1993) and Chowdhury and Muniruzzaman (2002). Finally, high virulent species *viz., Aeromonas hydrophila*, *E.coli*, *staphylococcus aureus, salmonella spp* and *Edwardsiella tarda* were used for the experiment.

Selection of antibiotics:
Locally available veterinary grade antibiotics used for the prophylaxis and treatment of livestock disease problems were used for this experiment. Based on preliminary investigation and availability in markets four available antibiotics *viz.,* CFCIN (Ciprofloxacin 10%; FnF) Renamycin (Oxytetracyclin, USP 200 mg; Renata Ltd.), Amoxicillin and Sulfatrim (Sulphadiazine BP 40% + Trimethoprim BP 8%; Techno Drugs) were selected for this study.

In-vitro Efficacy Test

Disc preparation:
Suspensions of cultured bacterial isolates were prepared and 0.1 ml of each bacterial suspension was spread over Tryptone Soya Agar (TSA, Oxoid) plates using a sterilized glass rod. Fifty µl of testing agents were inoculated separately at pre-fixed doses on the sterile disc of blotting paper (3 mm diameter), dispensed earlier on the culture plates.

Antibiotic sensitivity test:
Effects of selected antibiotics were determined by antibiotic sensitivity test using drug disc (paper disc) method against the most virulent bacterial isolates. Due to unavailability of different antibiotic discs, selected antibiotics were diluted in four different concentrations *viz.*, 25, 50, 75, 100 ppm and 50 µl was dropped on each blotting paper (3 mm in diameter) disc and incubated for 5 days at 20^{o}C. Sensitivity was recognized with clear zone surrounding the disc. The diameters of the restricted halos around the paper disc were measured time to time for determining the minimum inhibitory dose (MID).

Bacterial cultures were spread on nutrient agar plates and these plates incubated at 32 ± 1^{0}C for 24 hrs. Three to four colonies were selected and transferred into 5ml nutrient broth medium and further incubated at 32 ± 1^{0}C for 6-8hr. Sterile cotton swab was dipped into the bacterial suspension and pressed along the walls of tubes to remove excess of culture The entire agar surfaces were streaked with the swab. The

inoculum was allowed to dry for 10-15 min with closed lid. The discs were placed inside culture plates under aseptic conditions and incubated at 32±1^{0}C for 24hr. After incubation the plates were observed and the diameter of inhibition zone was measured. The diameter of zone was calculated by using the following formula.
π (R1- R2) (R1+R2) where R1 = Radius of zone of inhibition + Radius of test bacteria zone. R2 = Radius of test bacteria zone (Well)

In-vivo Efficacy Test:
After preparation of bacterial suspension, injections of selected bacterial isolates were performed on free *Oreochromis niloticus.*

Healthy young *Oreochromis niloticus* weighing 60 to 70gm were injected smoothly and carefully with 1.0 ml disposable syringes at a dose of 0.1 ml/fish comprising the suspensions of pre-selected pathogenic bacterial isolates. The experimental infection of the injected fish was expressed as lesion on fins, skin, head or body surface.

Treatment and sampling:
After experimental infection with virulent isolates, diets medicated with different four ant-microbial properties were administered for each of four separated trial groups, and each group was feed for 10 days twice per day to observe their effects. Temperature was maintained at room temperature and dissolved oxygen was ensured by regular aeration. The date that the test diet first administered was labeled as study day 0. On Days 1 and 10 after the last exposure to the antimicrobial diet, randomly selected 5 fish of each group was sampled for bacteriological investigation. The treatments selected for this purpose were T1 with CFCIN, T2 with Renamycin, T3 with Amoxacilin, T4 with Sulfatrim and T5 as control. Sampling was performed at midmorning to avoid diurnal variation. The fifth group was served as a control which was received the same diet with the same rate of feeding without the medication being added.

Bacteriological Examination:
Blood can be serves as the ideal non-lethal tissues for detection of systemic infection. Blood was collected only from large enough fish that withstand the procedure. No more than 1ml of blood was collected from a 100g fish not to cause lethal result. Vacutainer tube with anti-coagulant was used for collection of blood sample.

Culturing and examination of the sample:
After blood collection, the media was prepared for enumeration of bacterial by dissolving the required amount of media in distilled water and autoclaved together with petri dish to have sterile required media. One milliliter (1 ml) of homogenized blood sample was serially diluted in 9 ml of peptone water (ratio of 1:10) up to six dilutions. Sterile duplicate glass Petri dishes were labeled according to the dilution index. One ml of the dilutions will be aseptically withdrawn using a sterile 1 ml Pasteur pipette and was delivered into an open and sterile petri dish and then closed. The same was done for a duplicate petri dish. This was repeated till all the dilutions were pipetted into their corresponding plates. This was followed by pouring about 15 ml of standard plate count agar. The sample and the agar were then gently mixed by alternate clock and anti-clockwise rotations and left to solidify on the bench for about 30 min. The plates were inverted and incubated at 37°C for 48hr. After incubation, plates inoculated with sample dilution

yielding between 30 and 300 colonies were counted. Colony count was made by using colony counter and expressed as CFU/ml of blood.

Data management and Statistical Analysis:

Statistically data was analyzed using descriptive statistics and mean comparison procedure of the Statistical Package for Social Science Software (SPSS 20.0).

Results and discussion

The antibiotics giving zone in range 0-1.4cm were resistant, 1.4-2.0cm were intermediate and 2.1cm or above were sensitive. Effective inhibition was observed in ciprofloxacin and Renamycin against fish bacterial pathogens and the zone of inhibition ranges from 3.0-3.8cm and 2.6-3.6cm respectively. Ciprofloxacin and Renamycin has given the maximum zone of inhibition 3.8 cm and 3.6 cm against *S. aureus* and *A. hydrophila*, respectively. Few bacterial species were resistant to this antibiotic. All the pathogenic species were resistant to amoxicillin at low concentration.

Table 1. Selected antibiotics and their varied doses applied on bacterial isolates and inhibition zone

No.	Name of antibiotics		Doses	Inhibition zone(cm)
	Trade name	Type of antibiotics		
1	CFCIN	Ciprofloxacin	25 ppm	3
			50 ppm	3.3
			75 ppm	3.5
			100 ppm	3.8
2	Renamycin	Oxytetracyclin	25 ppm	2.6
			50 ppm	3.2
			75 ppm	3.4
			100 ppm	3.6
3	AMYN	Amoxicillin	25 ppm	0.9
			50 ppm	1.1
			75 ppm	1.4
			100 ppm	2.2
4	Sulfatrim	Sulphadiazine + Trimethoprim	25 ppm	1.4
			50 ppm	1.9
			75 ppm	2.3
			100 ppm	2.5

Effect of different antibiotics on the fish pathogenic bacteria under laboratory condition provided useful information for treatment of bacterial fish diseases. Antibiotic sensitivity test of each pathogenic species was performed under *in-vitro* condition to determine minimum inhibitory dose (MID). All tested isolates (100%) were sensitive to CFCIN followed by Renamycin (84%) at 75 ppm. salfatrim was not so effective in lower concentration but sensitive for 80% isolates at 100 ppm. Moreover, only 53.33% pathogens were sensitive in case of Amoxacilin at 100 ppm. After investigation on 106 (out of 132) mesophilic aeromonads 4 found that all strains (*A. hydrophila, A. veroni bv. sobria, A. caviae*) were susceptible to ciprofloxacin. 5 also reported that 99% of *Pseudomonas aeruginosa* strains were susceptible to ciprofloxacin. 6 performed drug sensitivity test and found that 50% of the *Aeromonas sobria* isolates

were highly sensitive to oxytetracycline, oxolinic acid and chloramphonical and resistant to erythromycin and sulphamethoxazole.

Therapeutic effects of the antibiotics tested were examined through experimental infection. Best result was obtained with 100% recovery (Table 2) of infected fish when the antibiotic, CFCIN was used for prolonged fed treatment in laboratory condition. Renamycin was also found to be effective in healing bacterial infection (90.00 ± 2.89%) followed by Sulfatrim (80.00 ± 5.78%). Amoxacilin was detected as less effective with 60.00 ± 4.62% recoveries of challenged fish. 7 and 8 used oxytetracycline in aquaculture as bactericide. 9 found positive effect of oxytetracycline in controlling *Pseudomonas* sp. in Tilapia fry. According to 10 (about 20 ppm) oxytetracycline in a dip or bath solution is used against bacterial disease in Malaysia and Singapore. According to 11 positive effect of Renamycin (oxytetracycline) against bacterial infection was observed.

Table 2. The effect of antibiotics on experimentally infected fish with bacterial pathogens

Treatment	Dose (g/kg diet)	Recovery (%)
CFCIN	5	100.00 ± 0.00 a
Renamycin	5	90.00 ± 2.89 b
Amoxacilin	10	60.00 ± 4.62 c
Sulfatrim	10	80.00 ± 5.78 c
Control	No dose	0 d

Note: The same letter in the same column is not significantly different at CI of 95%.

Antibiotics and chemotherapy have been used to prevent disease outbreaks and control proliferation of pathogens for a long time, causing the emergence of drug-resistant bacteria. Presently, although a good number of antibiotics such as norfloxacin, ciprofloxacin, oxytetracycline, gentamicin, chloramphenicol 12, cefazolin 13 and aztreonam 14, tetracycline-resistant strains have been proven to be successful in controlling the infection.

In this study, the sensitivity of five pathogens was checked against different antibiotics. Ciprofloxacin and Renamycin possessed effective inhibition against bacterial growth. The zone of inhibition in range of 3.0-3.8 cm was observed for *Aeromonas hydrophila*, *E.coli*, *staphylococcus aureus, salmonella spp* and *Edwardsiella tarda* and these were sensitive to ciprofloxacin whereas *A. hydrophila, and Salmonella* sp. were sensitive to Sulfatrim whereas Most of the bacterial species were resistant to amoxycillin, 14 also observed zone of inhibition in range less than 1.4cm for these antibiotics. But there has been risk of using antibiotics as control agents in fish farming due to spread of antibiotic resistance to fish pathogens 15, 16. Therefore, different researchers suggested the alternative to the non-pathogenic strains of bacteria in the form of probiotics can be applied in fish disease prevention and control.

Conclusion and recommendations

The antibiotic compounds although potent against various pathogenic organisms in medicine but in aquaculture, different studies indicated the chances of development of antibiotic resistance among the fish pathogens. Keeping this in view, the probiotics (with single and multiple strains of non-pathogenic bacteria and / fungi), plant extracts, different oils, and more potent the bacteriophage therapy can be used to control fish pathogens. In this study, we have used different antibiotic to check their effectiveness and antimicrobial potency against the five fish pathogens and results validated through statistical analysis. However, further *in vitro* as well as *in vivo* studies need to be conducted to know more specifically about the effect and doses of probiotics and plant based extracts compounds that prove to be used in fish farming and management.

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Fish – maize based recipe formulation and optimization

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Abstract

Functional properties, chemical composition and anti-nutrient contents of flour blends containing various levels of fish (100-0%) and maize (0-100%) were studied. The packed bulk density, loose bulk density, water and oil absorption capacities of the blends were fairly high ranging from 0.526 to 0.666 g/ml, 0.434 to 0.487 g/ml, 2.0 to 2.5 g of g water/ g sample and 1.638 to 2.457 g oil / g sample respectively. On the other hand, increasing the level of maize flour in the blends considerably reduced the oil absorption capacities of the blends. Porridge prepared from maize and fish contained proteins ranging from 12.42±0.17 to 75.95±0.32. Gross energy scores (385.85±0.85 Kcal/100 g) for porridge showed that the best (optimum) level of combination was 50 % maize flour and 50 % Barbus gananensis flour.

Keywords: *Fish, maize, functional property, blend, porridge, proximate, anti-nutrient*

Introduction

Fish contains high concentrations of two essential amino acids called lysine and methionine, in contrast to cereal proteins. Thus, fish and cereal protein can supplement each other in the diet (FAO, 1970).Maize is the staple food of people in the Central Rift Valley of Ethiopia and provides immense contribution of their total caloric intake and protein intake. It is foods with low nutritional value as they are not adequate sources of micro and macro nutrients (Brown, 1991). Efforts to improve the nutritional value of maize have been based on fortification with fish to boost the deficient amino acids (Bressani & Elias, 1983; Salami, 1988). The essential amino acids limiting in cereals, roots and tuber crops are present in fish; a mix containing fish and these foodstuffs are therefore complementary. Soft porridge from cereals especially maize is a very popular weaning food for infants as well as breakfast cereal gruel for adults in Africa. It has a low nutritional value; the energy as well as nutrient density is further lowered with the introduction of large volume of water required during production. These resulted in products of variable organoleptic properties and poor digestibility; which is attributed to the low solubility of plant protein (Okeiyi and Futrell, 1983). There is however a need to make use of the underutilized *Barbus gananensis* fish for the development of highly digestible and proteinous porridge thereby reducing the post-harvest losses of fish especially in the riverine areas in Genale River, where the harvest is enormous. There is limited information on the physicochemical properties of blends of cereals and proteins especially animal protein (fish). This study is aimed at investigating the functional, chemical and anti-nutrient properties of fish- maize porridge in order to enhance utilization of discarded fish.

Materials and Methods

Sample collection and preparation

Genale river is known for the group of diadromous fishes in Ethiopian fauna, eel, *Anguilla bengalensis labiata* (Peters) and goby *Glossogobius giuris* (Hamilton (Golubtsov *et al*., 2012). *Barbus gananensis* was harvested from Genale River, Guji Zone using gill net of 16 cm mesh size during fish species identification and participatory evaluation of fishing gears at Genale river from July 2014 to June 2015. Fish specimen was cleaned, descaled, eviscerated and filleted manually using stainless steel knife. Immediately after filleting, it was semidried under shade. The semi-dried sample was oven dried, finally ground with laboratory miller into fine powder and stored in polythene bag for analysis. 20 kg of 124-b (113) maize variety was brought from Bako Agricultural Research Institute. The maize was cleaned with water, then dried and ground into flour.

Fig. 1 Sieving of ground fish flour

Recipe formulation

Five different blends were formulated based on fish and maize flours in the ratios of 100:0, 75:25, 50:50 and 25:75 and 0:100 respectively. The formulation was designed to obtain the most acceptable product which has the highest energy content.

Functional properties

Water absorption capacity (WAC)

The procedure of Sathe *et al*. (1982a) was used. Accordingly, 10 ml of water was added to 1.0 g of each blend samples, the suspension was transferred into centrifuge tubes and centrifuged at 3,500 rpm for 5 min. The volume of decanted supernatant fluid was measured using a 10 ml measuring cylinder. The volume of free water absorbed (total minus free) was multiplied by its density for conversion to grams. Absorption capacity was expressed as the grams water absorbed (or retained) per gram of sample (as is basis). Density of water was assumed to be1 g/ml. All experiments were conducted at room temperature.

Oil Absorption Capacity (OAC)

The procedure of Sathe *et al*. (1982a) was used as described above. Instead of water , cooking oil with density of 0.91 g/ml was used. The oil and the flour blends (1g from blends in 10 ml oil) were mixed and then centrifuged at 3,500 rpm for 5 minutes, the amount of oil separated as supernatant was measured

using 10 ml cylinder. The difference in volume was taken as the oil absorbed by the samples. The volume of free oil absorbed (total minus free) was multiplied by its density for conversion to grams. Absorption capacity was expressed as the grams oil absorbed (or retained) per gram of sample (as is basis). Density of oil was determined as 0.91 g/ml. All experiments were conducted at room temperature. The oil absorbed was expressed as % g/g of oil absorbed.

Bulk Density (Packed Bulk Density and Loose Bulk Density)

Bulk density of floor was determined according to the method of Okaka and Potter (1979). Bulk densities were determined by weighing 10g into a 25 ml graduated measuring cylinder. The bottom of the cylinder was gently tapped several times on the palm of hand until no further diminution of the sample level was observed. The results for bulk density were reported as g/ml for packed bulk density. For loose bulk density space was not eliminated by tapping.

Porridge preparation

The porridge was prepared at Batu Fishery and Other Aquatic Life Research Center Laboratory. Accordingly, 200 g of flour was added to water with similar proportion of water to flour ratio of 3:1. Before adding blended flour to boiled water, the flour was sieved and mixed properly until it became uniform. The mixture was stirred continuously during cooking to avoid formation of a product with a lumpy texture. The blended flour was cooked for 10 minutes. It was then removed from the stove and allowed to cool at room temperature. The fresh porridge was dried at 60 ^{0}C for 72 hours in oven and milled in laboratory mill into flour, sample was sieved using local sieve. The resulting flours were packed in airtight polythene sachets and stored in a cool 4^{0}C till they were analyzed for proximate and anti-nutritional factors.

Figure 2 Floor of fish, maize and porridge

Determination of proximate composition

The proximate composition (moisture content, crude protein, crude fat and ash) of *B.gananensis*, maize and mixture of fish-maize porridge was analyzed according (AOAC, 1998) procedure at Center of Food and Nutrition Science of Addis Ababa University.

Moisture content

Immediately after porridge was prepared, moisture content was determined using oven drying methods. For the purpose 5 g of porridge was placed in oven and dried at 105^{0}c for 3 hours until constant weight is obtained.

Determination of crude protein

Crude Protein of porridge was determined by Kjeldahl methods. 0.5 g of dried porridge was weighed into Kjeldahl flask and digested by heating at 370 ^{0}c for four hours in the presence of 6 ml sulfuric acid (H_2SO_4), 3.5 ml Hydrogen peroxide (H_2O_2) and 3 g of catalyst Copper Sulfate ($CuSO_4$) and Potassium Sulfate (K_2SO_4). After digestion was completed, formed clear solution was cooled for 30 minutes and neutralized by addition of 25 ml of NaOH (40 %) and diluted using 25 ml distilled water. Then 25 ml of distilled water, 25 ml of boric acid and 3 drops of methyl blue was added into receiving flask of 250 ml capacity connected to the distiller by tube. The distillation process was terminated when the volume of receiving flask reached between 200 to 250 ml. Eventually the nitrogen content was estimated by titration of the borate anion with 0.1 N HCl using the following formula.

Note: All chemical reagents were added except the sample blank.

Determination of crude fat

Crude fat was determined by semi-continuous solvent extraction methods (Soxhlet method). Accordingly 2 g of fine powder was placed in porous cellulose extraction thimble and covered with fat free cotton. The thimble was placed in extraction chamber which is suspended above a flask containing 50 ml diethyl ether. The flask was heated at 55 ^{0} c and the solvent evaporates and moves up into the condenser where it converted into a liquid that trickles into the extraction containing the sample. At the end of extraction process, which typically lasts for 3 hours, the flask containing the solvent and lipid was removed, the solvent was evaporated at 70 ^{0}c and the weight of lipid remaining was quantified gravimetrically.

Determination of total ash

Total ash content was determined using dry ashing method. For the purpose, 2 gram of powdered fish fillet was weighed into ashing crucibles, placed on a hot plate under a fume hood and the temperature was slowly increased and awaited until smoking ceases and the samples become thoroughly charred. The crucibles was placed inside muffle furnace set at 550^{o}c for 4 hours, and removed from the muffle furnace and then placed in desiccators for 1 hour to cool. The amount of ash in the sample was measured from difference in weights .Carbohydrate was determined by difference

Calculation of gross energy

Gross energy value (Kcal/ 100g) was calculated according to Atwater's conversion factors; by overall addition of the protein content multiplied by 4 and total fat content by 9.

Determination of phytic acid

Phytic acid content was determined by the methods reported by Davies and Reid (1979). A 2 g sample was soaked in 50 ml of 0.5 mol/ l nitric acid in stoppered 150 ml conical flask to extract its phytic acid content. The mixture was agitated at 30 ^{0}C in a water bath. Phytic acid values were read colorimetrically and reported as means of duplicate determinations.

Determination of tannin

The method described by Pearson (1976) was used for the determination of tannin content of samples. Extraction of tannin in the sample was achieved by dissolving 5 g sample in 50 ml distilled water in a conical flask, allowing the mixture to stand for 30 min with shaking of the flask at 10 min interval and

then centrifuging at 5000g to obtain a supernatant (tannin extract). The extract was diluted to 100 ml in a standard flask using distilled water. Five milliliters of the diluted extract and 5 ml of standard tannic acid (0.01 g/l tannic acid) were measured into different 50 ml volumetric flasks. 1 ml of Folin–Denis reagent was added to each flask followed by 2.5 ml of saturated sodium carbonate solution. The solutions were made up to 50 ml mark with distilled water and incubated at room temperature (20–30 1C) for 90 min. The absorption of these solutions were measured against that of the reagent blank (containing 5 ml distilled water in place of extract or standard tannic acid solution) in a spectrophotometer at 760 nm wavelength. Tannin content (mg/100 ml in cell) was calculated in duplicate as Sample reading blank Standard reading blank

Data analysis

All data of proximate composition (moisture, protein, fat and ash) was expressed in g/100g dry matter (DM). Mean of different blends was compared using one way analysis of variance (ANOVA) of Statistical package for Social Sciences (SPSS). All data was presented as means ± standard error. Difference was considered statistically significant at $p < 0.05$. Data was subjected to Duncan Multiple Range Tests where differences detected.

Results and discussion

Functional property (Bulk density, water and oil absorption capacities)

Functional property is defined as any properties of a food or food ingredient, besides the nutritional ones, that affects its utilization. Functional properties determine the application and use of food materials for various food products.

Bulk density is defined as the weight of the sample per unit volume of the sample (g/mL). Bulk density, water and oil absorption capacities values are shown (Table 1). Loose bulk density value ranged from 0. 434 g/ml for fish flour to 0.487 g/ml for maize flour while packed bulk density value ranged from 0.526 g/ml for maize flour to 0.666 g/ml for fish flour. Fasasi et al., 2005 indicated that, the loose bulk densities (LBD) of maize-tilapia flour blends ranged from 0.355-0.384 g/ml while the packed bulk densities (PBD) ranged from 0.513 – 0.610 g/ml. When the amount of fish flour was increased to 100 % packed bulk density was increased and loose bulk density was decreased. Packed bulk density seemed to be affected by addition of fish flour to maize flour

Bulk density is influenced by particle size and the density of the flour. It is important in determining the packaging requirement and material handling (Plaami, 1997). It has been shown that high bulk density is desirable for greater ease of dispersibility and reduction of paste thickness. Low bulk density has been found to be an advantage in formulating complementary foods as it enhances nutrient and calorie density per feed of child (Akpata and Akubor, 1999). 100 % fish flour with low loose bulk density apart from improved protein quality and vitamins have been reported to cause reduced viscosity on the thickening of fish based gruels there by making it suitable for the formulation of high nutrient density weaning foods (Fagbemi et al., 2005).

Table 1 Bulk density, water and oil absorption of blended floor

Recipe	Water absorption capacity (g water/ g sample)	Oil absorption capacity (g oil / g sample)	Bulk density	
			Packed	Loose
100 % fish 0 % maize	2.0	2.457	0.666	0.434
75 % fish 25 % maize	2.2	2.275	0.625	0.444
50 % fish 50 % maize	2.3	2.184	0.625	0.465
25 % fish 75 % maize	2.4	2.002	0.588	0.476
0 % fish 100 % maize	2.5	1.638	0.526	0.487

The water and oil absorption capacities of the flours and their blends range from 2.0 to 2.5 g water/g sample and 1.638 to 2.457 g oil/g sample, respectively (Table 1). Water absorption characteristics represent the ability of a product to associate with water under conditions where water is limiting (eg dough and pastes). The results obtained suggest that maize flour would be useful in food systems such as bakery products which require hydration to improve handling characteristics. Increasing the amount of maize flour in the blend increased water absorption capacities but decreased oil absorption capacity. Water absorption capacity is important for certain product characteristics, such as the moistness of the product, starch retrogradation, and the subsequent product staling (Saddiq et al., 2010). Protein content appears to be primarily responsible only for water absorption; other food components may also have an influence. Water absorption variations among the blends may be related to the nature and type of proteins differing between fish and maize. Water absorption capacity is also differed on a crude protein basis. Polar amino acids residues of proteins have an affinity for water molecules (Narayana and Ransinga Rao, 1982). Hydrophilic properties of proteins are related to such polar groups as carbonyl, hydroxyl, amino, carboxyl, and sulfhydryl. Water binding capacity varies with the number and type of polar groups (Kuntz, 1971). The difference in water absorption capacities among the blend may reflect this fact. The higher water absorption capacities of flours investigated may be important to properties such as swelling, solubility, viscosity and gelation (Deshpande et al., 1982). The high water absorption capacity in maize flour suggests that the maize flour can be used as a thickener in food system. The higher water absorption as compared to oil absorption in maize flour is suggested the presence of high amount of hydrophilic carbohydrates in the flours (Shanmugasundaram and Venkataraman, 1989).

The oil absorption capacity of blended flours ranged from 1.638 g/g for maize flour to 2.457 g/g for fish flour (Table 1). The oil absorption capacity of flours is important for the development of new food products as well as their storage stability particularly for flavor binding and in the development of oxidative rancidity. Oil absorption capacity is important since oil acts as flour retainer and increases the palatability of foods (Kinsella, 1976). The mechanism of oil absorption is mainly attributed to the physical entrapment of oil and is related to the number of non-polar side chains on proteins that bind hydrocarbon chains of fats (Kinsella 1979; Lin et al., 1974). Both the protein content and the type contribute to the oil-retaining properties of food materials (Ravi and Sushelamma, 2005). The higher oil absorption as compared to water absorption in fish flour is suggested the presence of high amount of non-polar amino acid in the flour (Shanmugasundaram and Venkataraman, 1989).

The oil absorption capacity of the protein is useful applications in ground meat formulations such as sausage, meat replacers and extenders, doughnuts, pancake, baked goods and soups (Abbey and Ibeh, 1988).

Chemical composition

The chemical composition of fish, maize and their blends are presented in (Table 2). The result showed that fish contained higher amounts of protein (75.95±0.32), fat (6.52±0.01) and ash (6.4±0.00) as compared to protein (12.42±0.17), fat (2.5±0.00) and ash (1.2±0.00) in maize flour.

Fish contains significant amounts of all essential amino acids, particularly lysine in which cereals are relatively poor. Combinations of the two flours at various levels significantly increased the nutrient contents of the blends when compared to maize flour. Maize is low in lysine; hence the proteins of the fish may compliment the maize protein and improve the nutritional quality of the blends. Fish protein can be used therefore to complement the amino acid pattern and improve the overall protein quality of recipe (blend). A fish supplement can significantly raise the biological value of a cereal-based diet.

Both fish and maize and their blend flours contained adequate amounts of energy 362.5±1.39 in fish and 385.85±0.85 in blend with a mean caloric value of 375.45± 6.86 kcal/100 g. Blend containing 50% fish and 50 % maize had the highest gross energy (385.85±0.85) value.

Table 2 Proximate composition and ant-nutritional factor in porridge

Recipe	Moisture (g/ 100 g)	Protein (g/ 100 g)	Fat (g/ 100 g)	Ash (g/ 100 g)	Carbohydrate (g/100 g)	Gross energy (Kcal/100 g)	Phytic acid Con. (mg/g)	Tannin con. (µg/g)
100 % fish 0 % maize	10.50±0.10^{a}	75.95±0.32^{a}	6.52±0.01^{a}	6.4±0.00^{a}	ND	362.5±1.39^{a}	ND	ND
75 % fish 25 % maize	5.59±1.68^{a}	59.98±0.51^{b}	5.32±1.05^{a}	5.00±0.25^{b}	24.10±0.63^{c}	384.24±11.09^{a}	0.304 ± 0.006^{d}	2.09±0.11^{c}
50 % fish 50 % maize	6.90±0.10^{a}	44.71±0.08^{c}	5.25±0.25^{a}	3.20±0.00^{c}	39.93±0.26^{b}	385.85±0.85^{a}	0.406 ±0.002^{c}	2.30±0.12^{c}
25 % fish 75 % maize	6.18±1.89^{a}	36.66±4.09^{c}	2.62±0.23^{b}	2.10±1.91^{d}	52.42±6.37^{b}	379.98±7.2^{a}	0.602 ±0.000^{b}	3.79±0.16^{b}
0 % fish 100 % maize	10.08±0.08^{a}	12.42±0.17^{d}	2.5±0.00^{b}	1.2±0.00^{e}	73.79±0.25^{a}	367.38±0.32^{a}	1.034 ±0.018^{a}	16.93±0.22^{a}

Anti-nutritional properties of porridge

Phytate ranged from 0.304 ± 0.006 to 1.034 ±0.018 mg/g. These anti-nutrients chelate divalent cations, such as calcium, magnesium and iron, reduce their bioavailability. Toxicity of phytates for humans was set at 2-5 g/day and the consumption of diet rich in these anti-nutrients may result in kidney disease. The phytate level of the porridge in this work is safe for human consumption.

Conclusion

The functional properties of maize flour could be enhanced through the addition of fish flour. The WAC of the blends therefore gave it an advantage of being used as a thickener in liquid and semi-liquids foods

since the flours were able to absorb water and swell for improved consistency in food. The bulk density of the blends offer it a packaging advantage and suitable in the preparation of high nutrient density weaning food. Maize-tilapia flour blends may serve as good binder or provide consistency in food preparations. Maize and fish flours can be combined to produce acceptable porridge with a greatly improved nutritional quality. This is an advantage in a *Barbus gananensis* discarding area. It is also of interest in child feeding programs and food for the low income groups. The study showed that the porridge prepared from blend of fish and maize was nutritionally rich, low in anti-nutrients and suitable for local consumption and industrial utilization. The results shown in this study demonstrate that there is a potential for using underutilized *Barbus gananensis* fish to make nutritionally adequate foods for both infants and adults in riverine areas of Guji Zone, Genale where they are often discarded there by reducing post-harvest losses.

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Study on the Prevalence and Temporal Abundance of Parasites of Fishes in Ganale River, Oromia Region, Ethiopia

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Abstract:

The Study on Prevalence and Temporal Abundance of Parasites of Fishes in Ganale River was carried out from November 2014 to June 2015 by collecting different fish species by using gillnets of various mesh sizes and hooks to assess the baseline information on common fish parasites affecting fish species. Thus, a total of 319 of which *Bagrus docmac* (77), *Varicorhinus beso* (81), *Anguilla labiata (5), Mormyrus caschive (59) and Labeobarbus gananensis* (97) were examined. From totally examined fish, 37(11.6%) of them were found to be infected with different parasite. The major parasites identified during the investigation include adult *Contracaecum* (Nematoda), Eustrongylides (Nematoda) and metacercariae of *Clinostomum spp*. (Digenea). All parasites recorded in the present study, could be medically important from public health point of view since the parasites can be transmitted to humans by eating raw fish. Therefore, further studies should be made for identification of other zoonotically important common fish parasites which might cause production loss in the fishery sector.

Keywords: *Fish, Ganale River, Parasite, Prevalence*

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Introduction

The fishery sector makes a vital contribution to the food and nutritional security of 200 million Africans and it provides income for over 10 million people engaged in fish production, processing and trade. Moreover, fish has become a leading export commodity for Africa, with an annual export value of US$ 2.7 billion (FAO, 2003). Africa hosts a great diversity of freshwater fish of which more than 3,000 species have been identified (Skelton, 2001).

More than 200 species of fish are known to occur in lakes, rivers and reservoirs in Ethiopia. Ethiopian water bodies have an estimated surface area of 7334 km^2 of major lakes & reservoirs and 275 km^2 of small water bodies with 7185 km of rivers within the country (FAO, 2003). The annual fish production potential of Ethiopia based on empirical methods on individual lake surface area and mean depth of major water bodies was estimated to be 30,000 to 51,000 tones (Breuil, 1995; FAO, 2003 and ADF, 2004).

Despite the availability of huge potential for fish production, the country has annual consumption of 240g per person, which is the lowest in Africa. However, 10kg per person per year achieved in areas where there is regular and sufficient supply of fish**.** To improve the productivity of the fishery sector, important constraints remain to be addressed (EARO, 2002). One of the problems of the fishery sector in the capture fisheries and the wild population is parasite and disease condition of fish parasite that reduces fish production by affecting the normal physiology of fish and if left uncontrolled, it can results in mass mortalities or in some cases, can be serve as source of infection for human and other vertebrates that consumed fish (Paperna, 1996).

Freshwater fish can serve as definitive, intermediate or paratenic (transport) hosts in the life cycles of many species of protozoan, helminthes and crustacean parasites. The parasites usually exist in equilibrium with their hosts as a survival strategy (Bush *et. al.,* 2001). However, in instances where the hosts are overcrowded, such as in fish farms, parasitic diseases can spread very rapidly and cause gross mortalities (Paperna, 1996), losses in productivity in different water bodies and also human diseases in many areas of the world (Paperna, 1980; Roberts, 1989 both cited in EshetuYimer and MulualemEneyew, 2003). They can also spoil the appearance of fish and usually affect the marketability of commercially produced fish, thus raising public health concerns especially in areas where raw or smoked fish is eaten (Paperna, 1996). In natural systems, they may threaten the abundance and diversity of indigenous fish species.

Understanding the etiology of parasitic disease is of crucial importance as it determines the choice of a potential treatment. Hence, identification of parasite to the genus level is generally sufficient to implement an effective therapeutic or prophylactic strategy (Paperna, 1980). However, the presence of a massive number of parasites on each fish might constitute a real threat to the fish population and should require immediate action.

Fish parasites include parasitic protozoans, acanthocephalans, nematodes, digeneans, cestodes, and crustaceans. Those fish ectoparasites reported to be problematic in African capture fishery and aquaculture include protozoans, monogeneans, leeches, crustaceans and larval bivalve mollusks. The endoparasites recorded include digeneans, cestodes, acanthocephalans, nematodes and several protozoans (Akoll Peter, 2005). The impact exerted by parasites on host could be mechanical, chemical or physical. Effects of parasitic infection on fish are of notable importance, for instance respiratory function of the skin and gills of fish are disturbed by genera *Gyrodactylus, Dactylogyrus* and argulosis and infected fish become dull, feeble, frequently swimming to water surface with erratic movement and may die of exhaustion.Feeding on superficial skin or gill layers causing irritation and cloudiness or focal reddening due to excess mucus production, epithelial hyperplasia or hemorrhage. Heavy infestation may lead to death and probably transmit bacteria and other agents. Metacercaria of the trematode *Clinostomum marginatum* are known to cause considerable damage to the viscera and musculature of many fish species both wild and cultivated (Hoffman & Bauer, 1971).

It is estimated that there are more than hundred edible species of fish found in the inland waters of Ethiopia. Only few studies were done on fish parasites of natural water bodies in Ethiopia. Furthermore; our knowledge of fish disease and their impact on the fish production in the inland waters of the country is far from adequate. This is due to the fact that there had not been systematic studies undertaken in the past years.

The habit of raw fish eating is common among fishermen and people in Ethiopia, especially people near to water bodies. Ganale River is the contributor of fish source for the country. But potential fish parasites that can easily be disseminated to these water bodies are not sufficiently known.

Since researches are the base to undertake intervention measures many studies have to be implemented in this area for the future. The intention of making a study on the parasite of fish in Ganale River, therefore, arose for the following reason. Primarily parasites of fish are known to cause economic losses in fishes of inland water bodies. Therefore, there were need to identify the most common economically important parasite of fish. Secondly, the knowledge of fish parasites and their relationship with the host were also help to select fish species for introduction from one locality to another. Lastly, there were no attempts to study the parasitic fauna affecting fish in the Ganale river in the past and it is hoped that this study contribute to fish parasite information and complement the works in other water bodies of Ethiopia. The main objective of this study was to study the prevalence and temporal abundance of fish parasite and to investigate the epidemiology of the most common ecto and endoparasites of fish in Ganale River.

Materials and Methods

Fish Examination, Parasite Collection and Identification

Samples of fishes was collected monthly for a year (November, 2014 to June, 2015) using different mesh size of gill nets from the selected sites. The gears were set in the afternoon and lifted in the following morning. In addition, fish caught by fishermen were included to provide a wide range of fish and to supplement the data on certain aspects of parasite infestation/infection of the fish. Immediately after capture, total length (TL) and total weight (TW) of each specimen was measured to the nearest 0.1 cm and 0.1g, respectively. Each specimen was then dissected and its sex determined by inspecting the gonads.

External examination

The codes of each fish, species, sex, TL, TW, name of the site, date of sampling, organ of fish to be sampled, types of parasites observed, number of parasite per organ and different health related notes was recorded for each fish on separate field protocol.

Any abnormalities on the fish were recorded. A hand lens was used for quick identification of ecto-parasites on the skin and fins of the fish sample. Skin was also checked if there were capsules with metacercariae of trematodes in black dots and yellowish cysts which were sliced off the skin for further investigation.

To examine ecto-parasites on gills, after opercula were removed using scissors; the gills was removed and then placed in Petri dish containing normal lake water. Gill rakers was detached apart by forceps and examined under stereomicroscope for some worms.

Internal Examination

- First the coelom was opened by making a ventral surface cut from the anus forward to an imaginary line at the posterior portion of the operculum. Then cut out the entire side of the coelom by cutting a rectangle of skin from behind the operculum, anterior to the anus, and ventral to the backbone.
- Secondly, by following the digestive system from the esophagus to the anus and listing the number of parasite found on different organ.
- Thirdly, small and large intestines were cut out and a wash bottle was used to flush out the inside so that parasite like, tapeworms will come out the back end.
- The eye balls were taken out using scissors and forceps, then crushed; examined under the stereo microscope and dissecting microscope

Each parasite that gets each fish was kept in a plastic bag containing 4% formaldehyde solution. Samples were then transported to Addis Ababa University College of Veterinary Medicine and Agriculture, parasitology laboratory for further laboratory studies.

Fixation, preservation and identification of parasites

With regard to the technique and method used in fixing, preserving and identification of each parasite specimens, the appearance and procedures of Paperna (1980), Yamagutti (1971) and Bykhovskaya-Pavlovskaya (1964) was used as a guideline. Larva nematodes were fixed in 4 % formalin and later stored in the saline solution. Encapsulated larvae were carefully dissected before the tissue was fixed. Preserved larvae was cleared in rectophenol and then observed under low power magnification. Adult nematodes were fixed in hot formalin to insure their relaxation and preserved in 4 % formalin mixed in 1 % glycerine to avoid accidental drying.

Parasite Trematodes were fixed in AFA (Alcohol Formalin Acetic acid).Crustacean parasites were fixed in 70% alcohol or 4% formaldehyde. Each parasite was collected in labeled flat bottom tubes containing the specific preservative or fixative agent. Length of Nematodes, Crustacean and Trematode parasites was determined. For microscopic study, Nematodes were cleared in rectophenol for 24 hours and examined under lower magnification microscopy. In the case of Trematodes and Cestodes, diagnosis was made after being carmine stained and cleared in absolute alcohol followed by 70% alcohol. Crustacean parasites was examined alive or fixed in either 70% alcohol or 4% formaldehyde, stained in cotton blue and cleared in lactic acid. Live specimens of Crustaceans were recovered by collecting these parasites in normal saline.

Data management and Statistical Analysis

Mean intensity of infection, abundance and prevalence was calculated for all the recovered parasites following the indications of Bush *et al*. (1997). Numerical results were analyzed by Microsoft Excel 2013. Then statistically data was analyzed using descriptive statistics and mean comparison procedure of the Statistical Package for Social Science Software (SPSS 20.0).

Results

Occurrence of parasites in sampled fishes

Out of 319 individuals of fishes examined during the study period, 37(11.6%) were infected with parasites. The prevalence of the parasite was found in different rate. The identified parasites were recorded as, *Contracaecum*, *Clinostomum* and *Eustrongylides*. and *Argulus.*

Parasite prevalence in relation to sex

Sexes were assessed to observe their influence on the parasite infection results. when analyzing the infection rate of all examined parasites larvae by host sex shown one hundred ninety eight males examined of which 16(8.08%) infected, on the other hand, out of one hundred twenty one females examined, 21(17.35) were infected by different parasite species.

Table 1: Prevalence of parasites on sex base of the host (n:431)

Sex	number of examined	number of infected	Percentage of (infected)
Male	198 (62.07%)	16	8.08
Female	121 (37.93%)	21	17.35

Over all prevalence in relation to temporal variation

Figure 1 shows that the prevalence of parasites in sampled fishes in relation to time variation. Relatively high prevalence (27%) was recorded at June followed by April and the lower parasites prevalence (6%) was observed on November.

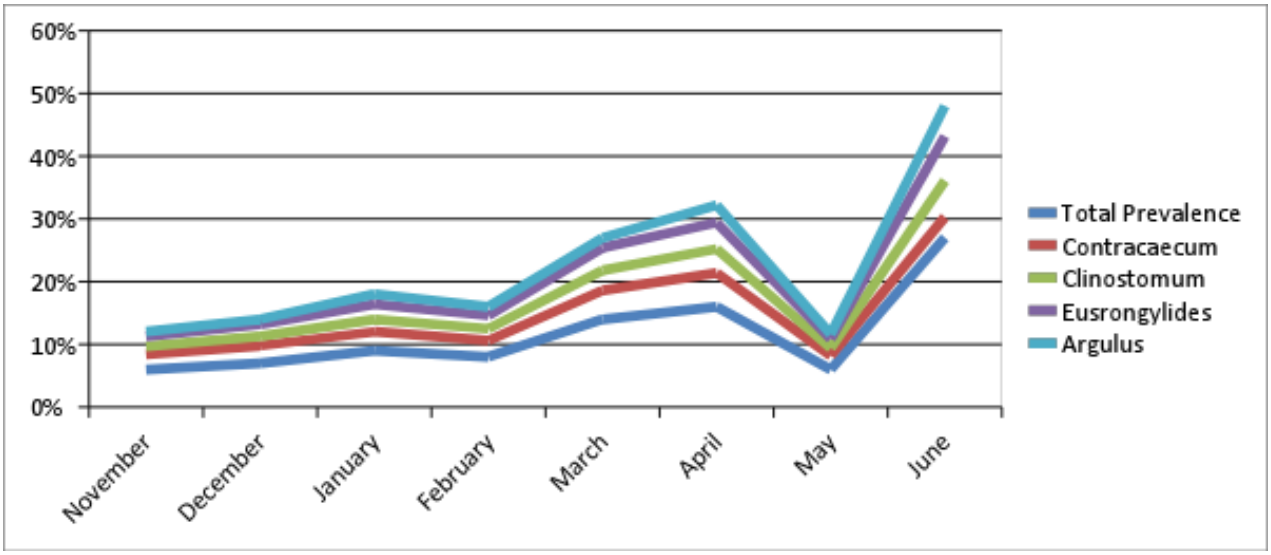

Figure 1: Temporal variation of each parasite prevalence from sampled fish

Prevalence of each parasite species identified during study period

Among the types of fishes examined of which thirty seven were positive, twenty five of them were infected by *Contracaecum* larvae 25(67.56%) while 11(29.73%), and 19(51.35%) were *Clinostomum* sp

and *Eustrongylides* respectivily. This indicates higher prevalence of *Contracaecum* parasite during study period in Ganale River.

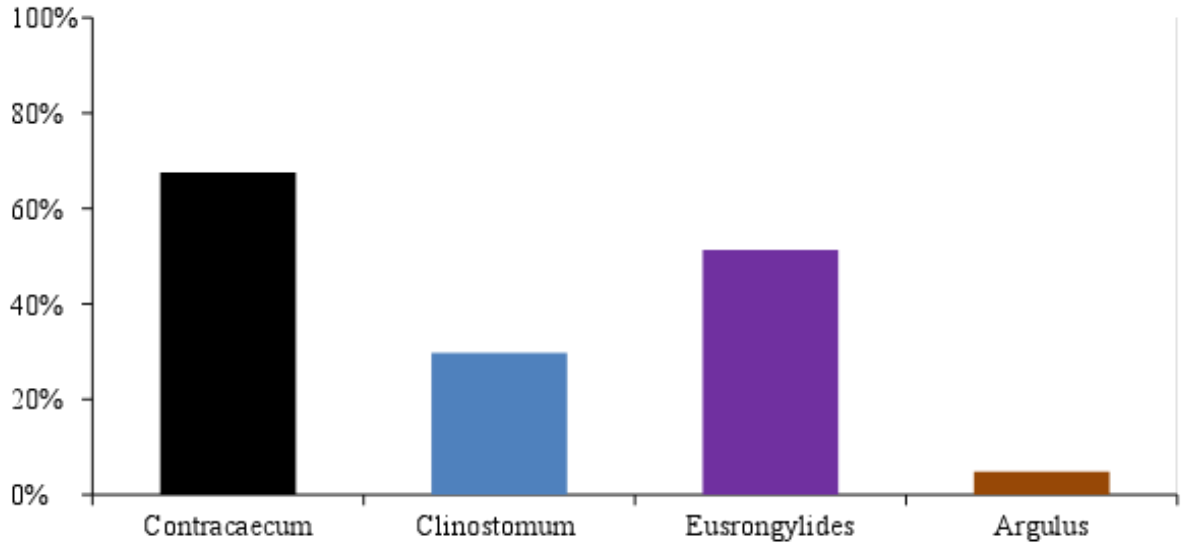

Figure 2: Prevalence of parasites from sampled fish

Discussions

The results of the present study showed that the prevalence of 11.6% which is far lower than the previous reports of 75.67% (Temesgen,2003) at Lake Hawassa, 73.24% (Teferra, 1990) at Lake Tana, 48.12% (Shibru and Tadesse, 1997) and 58% (Amare, 1986) at Lake Hawassa. The variation of prevalence rate might be the dynamic nature of parasitism and the variation between these water bodies are probably due to geographical difference offering suitable ecological niches for the parasites and/or affecting the susceptibility of the hosts and the availability of intermediate hosts. Since, the definitive hosts of *Clinostomum* species are birds like herons, darters, cormorants and pelicans. Trematodes are established in the mouth and pharynx of these piscivorous birds (Paperna, 1991). It is likely that a large population of piscivorous birds around the lake harbor the adult parasites. *Contracaecum* species that infect freshwater fish are usually found as adults in fish-eating birds, such as cormorants and pelicans. Larval stages are seen in cyprinids (carp and related species), ictalurids (channel catfish), centrarchids (sunfish and bass), tilapia and other cichlids, and percids (perch).

Among helminthes identified during the study period from sampled fish species, Clinostomatid digeneans and nematodes of the genus *Contracaecum* could represent human health risk factors by eating raw or smoked meat of parasitized fish. *Clinostomum complanatum* is known to cause laryngopharyngitis infections in humans as was reported in Japan (Kakizoe et al., 2004) and Near East (Paperna, 1980) resulting apparently from ingesting inadequately cooked fish. The works of Dias et al. (2003) and Paperna (1996) also reveal that egret and cormorant birds are definitive hosts for *C. complanatum* though it failed to become established in pelicans (Finkelman, 1988).

The most prevalent larval nematodes were *Contracaecum spp.* recovered range of prevalence in Ganale River comparatively coincides with the works of Eshetu Yimer (2003) in Lake Tana (59.8%). Eshetu Yimer et al. (1999) also reported a prevalence of 2.09% of this genus from Lake Chamo. Eshetu Yimer

(2000) also reported prevalence of 15.35% from Lake Ziway which is also in the Ethiopian Rift valley system. Identification of these larval nematodes to species level is difficult unless it is supported by DNA sequencing technique linked with their adult identification from the definitive bird hosts. Encapsulated larval nematodes are known to cause fibrous capsule (Paperna, 1980) and the non-encapsulated larvae cause extensive tissue damage by migration. Apart from this, the larval stages of *Contracaecum multipapillatum* were reported as potentially zoonotic parasite in Mexico (Vidal-Martinez *et al.*, 1994). Another parasite species, the nematode *Eustrongylides ignotus* was also reported to be infectious to humans (Guerin et al., 1982; Eberhard et al., 1989 and Wittner et al., 1989 all cited in Barros et al., 2004) and the presence of the genus Eustrongylides in mesentery of African catfish from Lake Chamo was indicated by the work of Eshetu Yimer et al. (1999).

Conclusions and recommendation

Apart from economic and public health importance, parasites impair fisheries activity. At the lakes and Rivers the harvested fish, fishing equipment and fishermen are loaded on the too narrow boat. Therefore, parasites that detach from the fish host bite the bare foot of fishermen causing pain, bleeding and breakage of skin that might allow the entrance of other organisms which may cause anxiety and fear among young fishermen employed in the job. The present study shows that the proportion of parasites differ in prevalence. It may be difficult to draw a definite conclusion that particular parasites is definitely absent from a particular water body. Thus further investigation in all water bodies are urgently needed to determine the effect of parasite infestation and their seasonal dynamics. *Clinostomum,* Eustrongylides and *Contracaecum* species could therefore represent potential health risks of eating uncooked or slightly cooked fish.

Based on the above findings and conclusion the following recommendations are forwarded:-

- Identification of the genera Clinostomum and Contracaecum to species level is important to check for the occurrence of zoonotic parasites
- Parasite status should be taken into consideration in the study of stocking density of fish
- Capacity building in fish parasitology and pathology by establishing network with international institutes experienced in the field
- Consumers should not eat uncooked or slightly cooked fish and health education should be given for them on the risk of eating raw and partly cooked fish.

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Changes in fish diversity and fisheries in Ziway-Shala basin: the case of Lake Ziway, Ethiopia

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Abstract

Lake Ziway is an economically important lake in the country. However, the physico-chemical parameters of the lake seem to be threatened by anthropogenic and climatic factors, which in turn affect biotic factors as reflected in fish catch. A study was made to assess the status and trends of fish diversity and fishery during October 2012 to September 2014 in Lake Ziway. Ten fish species were identified with low species diversity for the lake (H′ value of 1.67). The composition of the fishes has undergone some changes as compared to the last few decades. For instance, *Carassius auratus and Labeobarbus microterolepis* were not caught in this study. In addition, *Cyprinus carpio*, which was never reported in earlier catch has attained the highest relative frequency (25.19 %) in this study, next to *Oreochromis niloticus* (27.88 %). The third and fourth higher relative frequencies are *Carassius carassius* (20.71%) and *Clarias gariepinus* (20.51%) respectively. Canonical correspondence analysis showed that the average abundance of *C. carpio*, *C. carassius* and *C. gariepinus* were positively correlated with nutrients, whereas the abundance of *Labeobarbus ethiopicus* and *Labeobarbus intermedius* had negative correlation with most of the physico-chemical variables. The fish catch of Lake Ziway currently declined from 3180 tons in 1997 to 1157.14 tons in 2014. Most of the threats resulted from the anthropogenic impacts on the lake including pressure of fishing. Currently, plenty of pumps are abstracting fresh water from the lake by state and private commercial farms throughout the year that are critically impacting the water level of Lake Ziway. As a result, the lake ecosystem is being affected by catchment degradation and siltation. The study suggested that if nutrient levels continue to increase and water levels continue to decline, further changes in fish composition can be expected in the lake, especially with a shift towards fish that are mainly turbidity-tolerant species such as *C. carpio*. Hence, appropriate management is an urgent requirement that could assist in sustainable exploitation of the resources, so that the resource could contribute to food security in the study area in particular and in the country in general.

Key words*:* Abundance, *catch, fish composition, physico-chemical factors, Lake Ziway*

Introduction

Ethiopia has a number of lakes and rivers with substantial quantity of fish stocks. Many artificial water bodies have also been stocked with fish for fishery. Most of the lakes are located in the Ethiopian Rift Valley, which is part of the Great East African Rift Valley system. Lake Ziway is one of the lakes in the rift valley used for multiple purposes like irrigation, fishing, domestic water supply, transportation, recreation, supply of fresh water to Lake Abijata through the out flowing Bulbula River.

There are seven indigenous fish species in Lake Ziway comprising *Barbus paludinosus, Garra dembecha, Garra makiensis, Labeobarbus ethiopicus, Labeobarbus intermedius, Labeobarbus microterolepis* and *Oreochromis niloticus* (Golubtsov *et al.,* 2002; Abebe Getahun, 2010). Of these, *L. ethiopicus, G.*

makiensis and *L. microterolepis* were reported as endemic to the lake (Golubtsov *et al*., 2002 and Abebe Getahun, 2010). The lake also harbors five exotic fish species (*Tilapia zillii, Cyprinus carpio, Carassius carassius* and *Carassius auratus)* which were introduced to enhance its production, and *Clarias gariepinus* that slipped into the lake accidentally (Abebe Getahun and Stiassny, 1998; Golubtsov *et al*., 2002). Therefore, the lake has several important fish species for fisheries. The fish yield potential of the lake estimated from 3000 to 6680 tons per year (FAO, 1982) and the fisheries production has been the second largest from the Rift Valley lakes, which accounted for 3180 tons next to Lake Chamo that produced 4500 tons per year (LFDP, 1998). However, according to Yared Tigabu (2003), there was a continuous decline in the annual catch of some fish species like *O. niloticus* from the lake since 1997, but an increase of *C. gariepinus* was observed in the fishermen catches since 2010 (Mathewos Hailu, 2011). In the same way, very recently increase in the catches of *C. carpio* was recorded (Lemma Abera *et al*., 2014). For all these, there are several evidences in the lake, such as decline in phytoplankton biomass (Getachew Beneberu and Seyoum Mengistou, 2009), increase in dominance of toxin-producing blue-green algae (Girma Tilahun, 2006), imbalance between water inflow and outflow (Tenalem Ayenew and Dagnachew Legesse, 2007) and decreased in lake water volume (Girum Tamire and Seyoum Mengistou, 2012).

Although several studies were conducted on Lake Ziway on various aspects, the changes on the lake are fast and hence the information on the lake gets obsolete quickly. Therefore, regular updating, monitoring and control are essential and this study becomes important and relevant for better management and sustainable use of the resources. Therefore, this paper attempts to assess the variations in some physico-chemical factors that influence the fish community structure; to update the species composition, distribution and relative abundance of the fishes; and finally to assess the trends of the commercial catch in relation to some environmental factors that were recorded earlier.

Materials and Methods

Location of the study area

Lake Ziway belongs to the Central Ethiopian Rift. On the average, the lake is located at an elevation of 1650 meter above sea *level*, $7^0$89'- $8^0$05' N latitude and $38^0$72' - $38^0$92' E longitude located at about 163 km south of Addis Ababa. The lake is shallow and has an open water area of 434 km^2, shoreline length of 137 km and an average depth of 2.5 m (Von Damm and Edmond, 1984). The maximum length and width of the lake is 32 km and 20 km, respectively (LFDP, 1997).

The study area is arid and even during the rainy seasons dry periods of several weeks are common. According to the data obtained from National Meteorological Agency, during the study period the mean monthly minimum air temperature ranged from 11.9 to 16.4 ^{0}C, while the maximum mean monthly air temperature varied from 24.6 to 29.8 ^{0}C (Fig.1). Monthly total rainfall also varied from 1.9 mm (November 2013) and 249 mm (July 2014) (Fig.1).

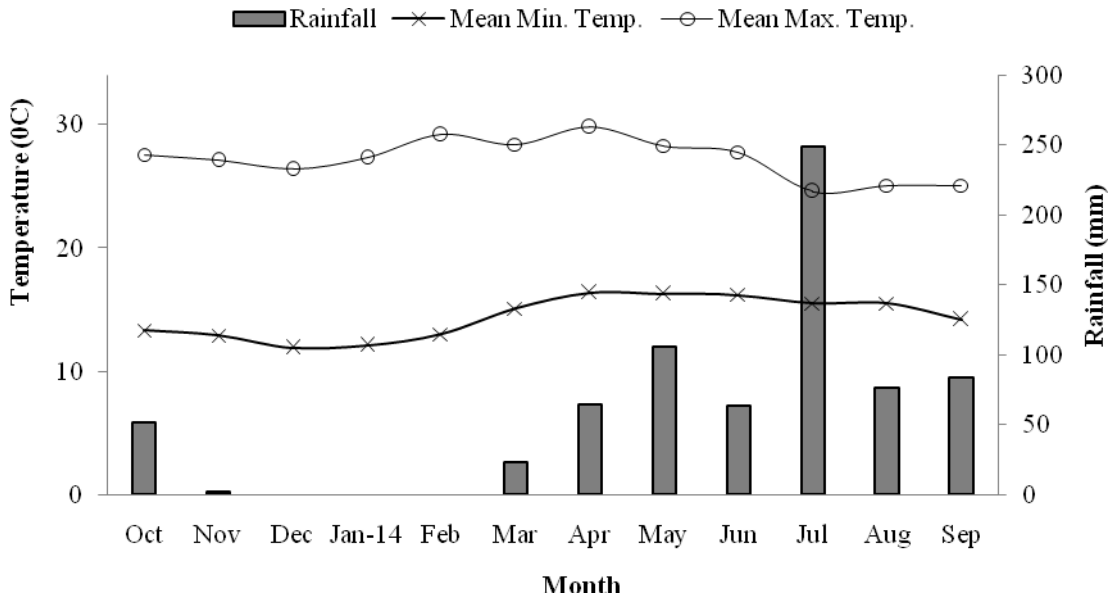

Fig.1. Monthly total rainfall; mean minimum and maximum air temperature of the lake region (From October 2013 to September 2014) (Source: National Meteorological Agency).

Site selection

To assess the variation in Physico-chemical factors that influences the fish community structure of the lake, six sampling sites were selected based on geographical proximity and/or habitat similarity, their distance from human settlements and anthropogenic effects. Based on these, the detailed characteristics of each site are described as follows:

Site 1: The site is located in the western part of the lake and the shoreline is characterized by intensive cultivation with horticulture and field crops including flower farm. The depth was between 1.5 to 2.9 meter and on average the vegetation cover around the shoreline is degraded. *Site 2*: The site is located around the river mouth of Bulbula in the area between intensively and moderately cultivated shorelines. The depth was between 1.5 to 2.3 meters. *Site 3*: It is located on eastern part of the lake in Ziway Dugda district in between Yerera landing site and Tulu Gudo Island. The sampling site depth was between 1.5 to 3.10 meter and the vegetation cover around the shoreline is almost conserved woodland. *Site 4*: It is located around the river mouth of Ketar. As is the case with the other sites, the area is also characterized as moderately cultivated. The depth was between 1.5 to 3.20 meters. *Site 5*: The site is located at the northern part of the lake and characterized by high human interference with horticulture and field crop activities next to site one. The water depth of the sampling site was 1.5 to 2.9 meter. Finally, *Site 6*: It is located almost at the center of the lake at a depth of 3.2 to 4.8 meters. The site was characterized by the activities of some fishermen using gillnets and long-lines.

Field sampling and measurements

Physico-chemical parameters

Physico-chemical parameters of the water were measured monthly from each site for two consecutive years (October 2012 to September 2014). Temperature, pH and conductivity of the lake were measured *in situ* during sampling periods at each sampling site. Transparency was measured with a Secchi disc of 20 cm diameter. Depth was also recorded at each sampling station. Water samples were collected from each site in dark plastic bottles, washed with acid and rinsed with distilled water several times in duplicates for nutrient analysis.

Fish parameters

Parallel to the Physico-chemical sampling, every month the fishes were collected at all sites using variety of fishing gears, which included gill nets of various mesh sizes (6, 8, 10 and 12 cm stretched mesh size), monofilament nets with various stretched mesh sizes (5 mm to 55 mm stretched mesh size) and multiple long-lines with hooks of different size (9, 10, 11 and 12). The gears were set in the afternoon (4:00 pm) and were collected in the following day (7:00 am). Immediately after capture, some morphometric measurements were measured and the fish samples were put in plastic jars containing 10 % formalin and labeled with all necessary information. Then the preserved specimens were soaked in tap water for many days to wash the formalin away. Then, they were transferred to 75 % ethanol before species identification was conducted. The specimens were identified to species level using taxonomic keys of Shibru Tedla (1973), Golubtsov *et al*. (1995); Witte and Wim (1995); Stiassny and Abebe Getahun (2007); Redeat Habteselassie (2012) and figures from Fish base.

Catch and effort

Catch and effort data were recorded from the landing sites of the lake between October 2012 and September 2014. Data collection was done by the staff members of Ziway Fishery Resource Research Center as well as the selected cooperative in each district (Adami Tullu Jiddo Kombolcha, Dugda and Ziway Dugda). Total landing by species in kg, the number and type of gears used for fishing and the number of settings for each gear were recorded. The number of gears in a community was monitored by the data collector responsible for it. Total effort per gear type was estimated based on the number of gears (gill net and hooks), settings (beach seine) and time (the number of days the gear was deployed in the month). The number of gears and settings in relation to fish catch in each gear were obtained through interviews with the fishermen. These data were also used as raising factor in the estimation of annual yield. A review was also made on the long-term trend of fish production from various published results and unpublished data collected by Ziway Fisheries Resource Research Center.

Some previous physico-chemical variables were reviewed to assess the effects on the fish production. Monthly and yearly rainfall and temperature for the study area was obtained from National Meteorological Agency. Surface water level was also measured by a standard calibrated vertical scale to refer surface level gauge.

Data analysis

Species abundance at each sampling station was presented as a numerical contribution by each species. This was determined by calculating the percentage of each species represented in the total catch for each station. Redundancy analysis was performed to observe the relation of species abundance data to environmental factors using CANOCO for windows 4.5 version software. Fish species diversity in the lake was computed using Shannon and Wiener Diversity Index following Shannon and Wiener (1963). Descriptive statistics were also used to analyze the remaining collected data using SPSS software (SPSS V.19.0).

Results and discussion

Distributionanddiversityoffishes

Ten species of fishes in the Families Cyprinidae, Clariidae and Cichilidae were identified from the different sites in the lake (Table 1). The species were *B. paludinosus, C. carassius, C. carpio, G. dembecha, G. makiensis, L. ethiopicus* and *L. intermedius* from the Family Cyprinidae, *C. gariepinus* from the Family Clariidae and *O. niloticus* and *T. zillii* from the Family Cichilidae. The status (presence/absence) of the species from the sampling sites is provided in Table 1.

Table 1. Fish species identified from the study sites of Lake Ziway (Present (+), Absent (-))

Family	**Fish species**	**Sampling Sites**					
		S1	**S2**	**S3**	**S4**	**S5**	**S6**
Cyprinidae	*Barbus paludinosus*	+	+	+	+	+	+
	Carassius carassius	+	+	+	+	+	+
	Cyprinus carpio	+	+	+	+	+	+
	Garra dembecha	+	+	+	-	-	-
	Garra makiensis	+	+	+	+	-	-
	Labeobarbus ethiopicus	-	+	-	+	-	+
	Labeobarbus intermedius	+	+	+	+	+	+
Clariidae	*Clarias gariepinus*	+	+	+	+	+	+
Cichilidae	*Oreochromis niloticus*	+	+	+	+	+	+
	Tilapia zillii	+	+	+	+	+	-

A total of 7741fishspecimens were recorded from the three families during the study period. The species were *B. paludinosus, C. carassius, C. carpio, G. dembecha, G. makiensis, L. ethiopicus* and *L. intermedius* from the family Cyprinidae (50.73 %); *O. niloticus* and *T. zillii* from the family Cichilidae (28.76 %); and only *C. gariepinus* from the family Clariidae which accounts 20.51% (Fig. 2). Among the species that have been currently captured *C. carpio, C. carassius, C. gariepinus* and *O. niloticus* are commercially important fishes. *Oreochromis niloticus* was the major species of the sample accounting for 94 % in previous studies (Schroder, 1984). However, the contribution of the fish has gradually declined to 89.3 % of total catch in 1994, 50.9 % in 2010 and 42 % in 2010 (Mathewos Hailu, 2013); and 31 % in 2012 (Lemma Abera *et al*., 2014) and 27.88 % in this study (Fig.3). On the contrary, the catch composition of *C. gariepinus* was 8.1 % in 1994 and increased to 41.8 % in 2010 (Mathewos Hailu, 2013) and currently decreased to 20.51 % (Fig. 3).

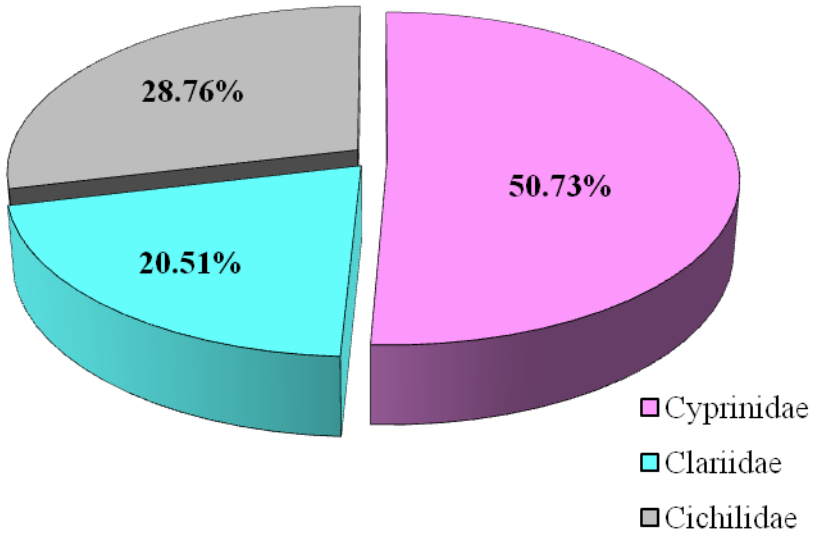

Fig. 2. Composition of fish at family level in the lake (%)

The fish species diversity of Lake Ziway was low (H′ value in between 1.51 to 1.67 on different sites) (Table 2) compared with some published data of similar works on lake (H' value in between 1.9 to 2.4) (Sylvester and John, 2010). Sylvester and John (2010) also reported that homogeneity of habitats favored lower diversity of fishes in water courses of Uganda. The lower fish diversity around the two inlets of the rivers was due to lower fish abundance at both sites. On the other hand, relatively higher fish diversity was observed at the southern part of the lake (S2) around the outlet of Bulbula River, and this may be due to the relatively high densities of fishes.

Table 2. Shannon Weiner diversity index, H', value and number of fish species, N, in the lake

	Sites					
	S 1	**S 2**	**S 3**	**S 4**	**S 5**	**S 6**
N	9	10	9	9	7	7
H'	1.5472	1.6681	1.5473	1.5213	1.5142	1.5127

Abundance of fish species in relation to environmental variables

The numerical abundance from the three families that exist in the lake, *O. niloticus*, *C. carpio*, *C. carassius* and *C. gariepinus* each as a group contributed to the bulk of the fishes (Fig. 3) The details of the remaining species were also described in Figure 3.

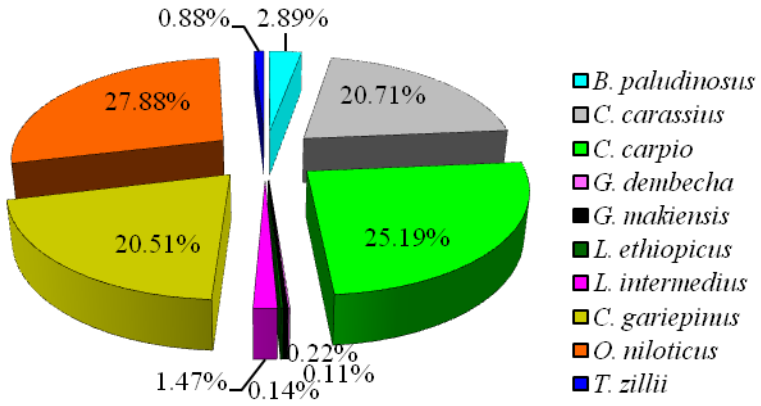

Fig.3. Fish species composition by number (%)

The RDA ordination of the species-environmental association indicated that nitrate, conductivity, nitrite, SRP, Chl-*a*, temperature and pH were negatively correlated with the first axis. Secchi depth was positively correlated to *L. ethiopicus* and *L. intermedius* with the axis, which contributed 88.4% of this variance (Table 3 and Fig. 4). The remaining environment factors and fish species were negatively correlated with this axis (Table 3 and Fig.4).

Table 3. Result of redundancy analysis of abundance of the fishes and physico-chemical associations including eigenvalues and percentage variance explained by the first two axes, as well as the correlations between environmental variables and the axes (strong correlations are marked bold)

Variables	**Canonical coefficients**	
	Axis 1	**Axis 2**
Eigenvalues	0.884	0.093
Cumulative percentage variance of species-environment relation	0.884	0.977
Temperature	-0.0289.	-0.4912
Secchi depth	0.0263	**-0.7482**
Nitrate	**-0.5869**	0.3866
Nitrite	**-0.6302**	0.5450
SRP	**-0.9191**	-0.335
Chlorophyll-*a*	-0.4406	-0.4658
pH	-0.0853	-0.4518
Conductivity	-0.4804	0.3651

The second axis was positively correlated with the environmental variables nitrite, nitrate and conductivity that were associated with relatively high abundance of the two carp species (*C. carpio* and *C. carassius*) (Table 3; Fig. 4). The remaining fish species (*O. niloticus*, *T. zillii*, *C. gariepinus* and the two *Garra* species) were negatively correlated with the two axes of the environment variables such as Chl-*a*,

SRP, pH and temperature.

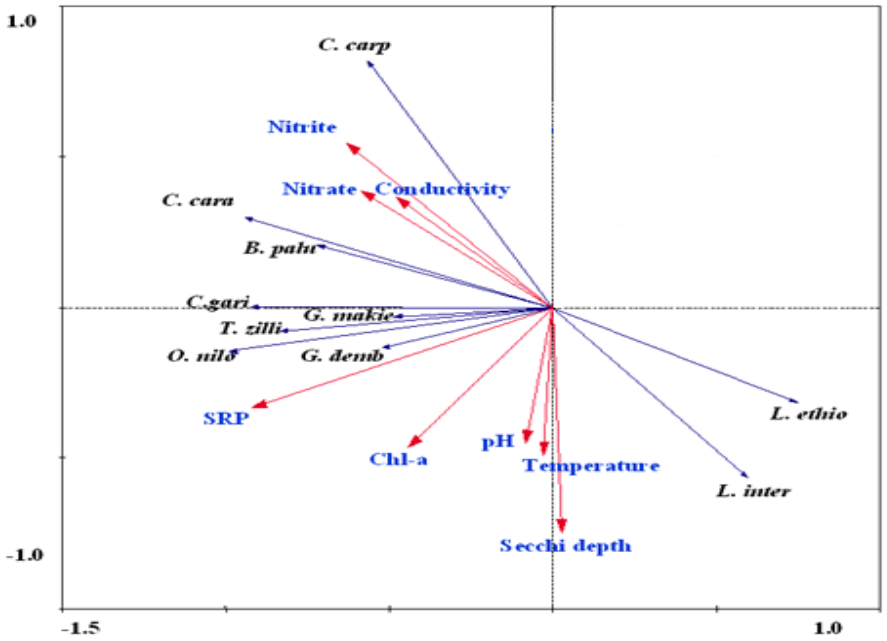

Fig.4. Biplots of the first two axes of correspondence analysis showing the association of fish species numerical abundance and environmental variables (Abbreviation: *L.ethio.* - *Labeobarbus ethiopicus, L.inter.- Labeobarbus intermedius, B.palu.- Barbus paludinosus, G.makie.-Garra makiensis, G.demb.- Garra dembecha, O.nilo.- Oreochromis niloticus, C.carp.-Cyprinus carpio, C.cara.- Carassius carassius* and *C.gari.- Clarias gariepinus* and SRP - Soluble Reactive Phosphate).

Hence, abundance of fish species in the lake was probably affected by changes in physico-chemical properties of the lake. Some parameters were correlated significantly with the abundance of fish species (Table 3 and Fig.4). Similar trend was highlighted by other authors (Schoener, 1988; Whitefield, 1990) who suggested that physico-chemical parameters influence the aquatic system.

Species composition of the commercial catch

Very recently, the catch composition of the most commercially important fishes is estimated to be about 42.5 % *O. niloticus*, 27.1 % *C. carpio*, 16.4 % *C. carassius* and 14.1 % *C. gariepinus* (Table 4). The long-term trends of the species composition of the catch are described in Figure 5.

Table 4. Catch percentage of fishes by species and gears in 2013/2014.

	Total catch (metric tons)					
Gear	***O. niloticus***	***C. gariepinus***	***C. carassius***	***C. carpio***	**Total**	**Catch size with gears (%)**
Gill net	80.06	14.91	28.42	46.73	170.12	14.7
Beach Seine	411.48	94.97	161.2	266.37	934.02	80.72
Long line	0	53	0	0	53	4.58
Total	491.54	162.88	189.62	313.1	1157.14	100
Species composition (%)	42.48	14.08	16.39	27.06		

Currently, the commercial catch composition has changed with a decline in *O. niloticus*, but a progressive increase in the proportion of *C. carpio* and *C. carassius* and became significant part of the landings (Fig. 5). The catch composition of *C. gariepinus* was 176 tons in 1994 and increased to 1046 tons in 1999 then decreased to 163 tons in 2014 (Fig. 5). In general, currently the contribution of the fishes to the catch has decreased (Table 4 and Fig 5). The decrease in catch trend since 2011 (Fig 6) is due to an excessive increase in effort with gill nets, beach seines and number of hooks in long line (Table 5). The catch of *O. niloticus* and *C. gariepinus* decreased from 575.82 to 491.54 tons and 487.09 to 162.88 tons during 2011/12 to 2013/14, respectively. That of carps was increasing from 93.8 to 502.72 tons (Fig. 5). This could be due to overfishing of selected fish species with inappropriate gears and degradation of the catchment area that breeding of some fish species that take place. All these leads to decline in species like Nile tilapia.

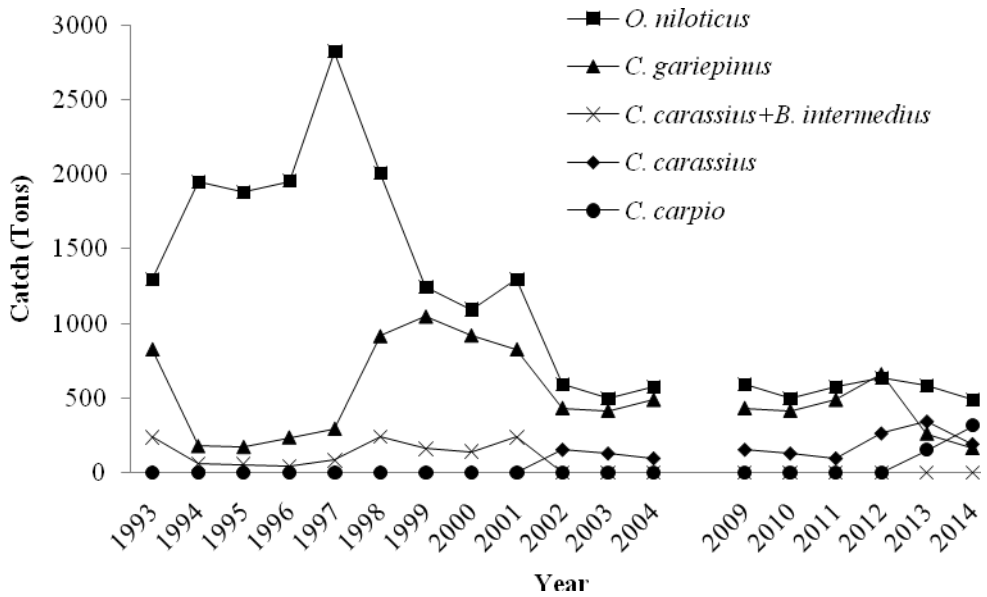

Fig. 5. Trends in species composition of catch from Lake Ziway (Source: LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2011; Brook Lemma, 2012, and the current study).

Annual fish catch

The annual fish catch of the lake shows different trends with time (Fig. 6). The first fishing phase was before 1994, which was a period of fisheries where the catch has been stable with a mean annual catch of 780 tons. The second phase was the growth period between 1994 and 2000, which was a period when yield increased dramatically to 2500 tons which has exceeded the recommended annual catch of 2163 tons. The third phase was the period in which fish catch declined with an average of 1200 tons in 2010, and currently, in this study years the catch again decreased to 1157.1 tons (Table 4 and Fig. 6).

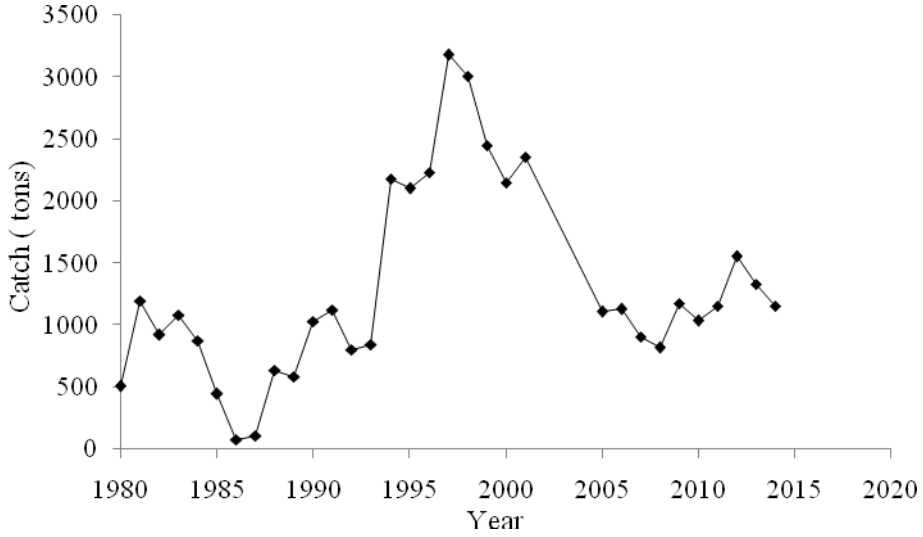

Fig. 6. Change in total anual fish catch from Lake Ziway between 1980 and the present (Source: LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2011, Brook Lemma, 2012, and the present study).

Factors that affect the fish production

Fishing gears

The fishing activity of Lake Ziway was operated by three types of gears: beach seines, gillnets and long-lines (Table 5). Beach seine was the most common fishing gear used, whose presence increased from about 116 in 1993-1995 to 5596 in 2001/02 (Table 5) that most of the catch were recorded (Fig.6). During this study, the assessment done has indicated that the number of beach seines have decreased to 127 only (Table 5). The decline in the number of beach seines was associated with decrease in catch, which led some fishermen to move Lakes Langano, Koka and Fincha (Personal observation). The recommended minimum beach seine mesh size in the cod end was 6 cm, minimum mesh size in the wings was 8 cm, and maximum allowed length 150 meters for Lake Ziway (LFDP, 1997). However, Megersa Endebu *et al*. (2013) reported that the beach seines operating currently are twice as long as the recommended length. About 56.3 % of the fishermen use beach seine whose wing mesh size is less than 8

cm and 42% of the fishermen use beach seine whose cod end mesh size is less than 6 cm. that directly affect the production of the fish.

Table 5. Summary of fishing gears trend involved in Lake Ziway in different years (in number)

Years	Gill nets	Beach seines	Long-line(Hooks)	Reference
1993-1995	1,810	116	1,056	LFDP, 1996
1996-1998	2,470	124	1,413	Felegeselam Yohannes, 2003
2000-2001	1,098	5,596	399,995	Yared Tigabu, 2003
2009-2010	104	68	56,070	Mathewos Hailu, 2013
2012-2013	1,445	127	400,461	Current study

The number of gill nets has also decreased drastically from 2470 in 1996 -1998 to 104 (2009/10) and then increased during this study period to 1445 (Table 5). The decrease in gillnet could be due to the decrease in tilapia catch in the lake's fishery. In the management plan of Lake Ziway set during LFDP 1997, the minimum stretched mesh size of gillnet was 8 cm in the first year, 9 cm in second year and 10 cm thereafter, with maximum length of 60 m. (Megersa Endebu *et al*. ,2013). Also Megersa Endebu *et al*. (2013) reported that 41.9 % of gill net users were confirmed to use gill nets whose mesh size is less than 8 cm very recently that influence the production.

In contrast to beach seines and gill nets, the number of hooks utilized in long-lines have increased from 1,056 in 1993/95 to 399,995 in 2000/01(Table 5) and also catch were more during this period (Fig.5). Again the number of the hooks decreased in 2009/2010 to 56,070 and currently the number increased and reached 400,461 (Table 5). The appearance of the long-line and its expansion was after the increase in *C. gariepinus* population, which was exotic to the lake. The increase in long-line fishery is associated with low labor and capital investment requiring only one person and just a raft, while using a beach seine requires three or more persons to operate with a wooden boat.

Lake water level

Currently, plenty of pumps are abstracting freshwater from the lake by the state, investors and private commercial farms throughout the year (Personal observation). Even during the rainy seasons water for horticultural crops is collected from the lake. Hence, the current irrigation practices in the upstream areas have considerably reduced the volume of the inflowing water from Meki and Ketar River and the lake itself, critically impacting the water level of Lake Ziway. As a result, the lake ecosystem is being affected by catchment degradation, siltation, imbalance between water inflow and outflow. Even if there were high anthropogenic pressures in Lake Ziway, abundant fish species were collected when the water level of the lake increased (Fig. 7).

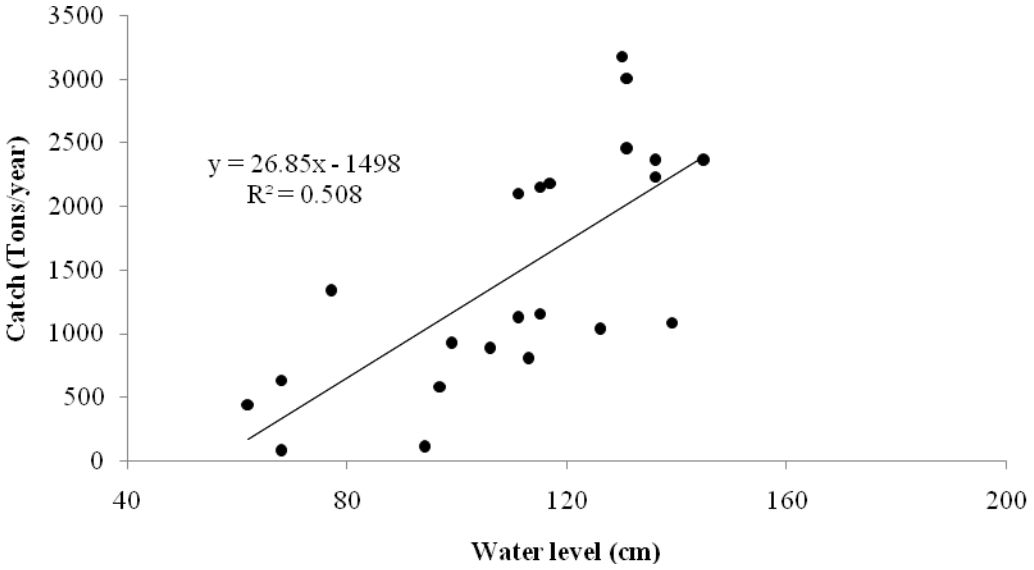

Fig.7. Relationship between water level and fish catch in Lake Ziway (1982-2014) (Source: LFDP, 1998; Felegeselam Yohannes, 2003; Mathewos Hailu, 2011; Brook Lemma, 2012 and the current study).

Water quality

Aside from problems related to decreasing water level of the lake, water abstraction started to induce salinity, due to loses of freshwater from the lake. Simultaneously, the application of agrochemicals (Personal observation) and fertilizers due to intensification of irrigation practices around the lake has increased and affected the water chemistry of the lake (Table 6).

Table 6. Trends in some physico-chemical factors of Lake Ziway

Parameters	Unit	Amount Previous	Present study	General trend
Secchi depth	cm	40 -106 (Girma Tilahun, 1988)	17.8-22.1	Decreasing
pH	-	8.5 (Elizabeth Kebede *et al*., 1994)	8 - 8.4	Decreasing
D. Oxygen	mg/L	7.1 (Adamneh Dagne, 2010)	3.4 - 6	Decreasing
Chl-*a*	µg/L	150 - 212 (Girma Tilahun, 1988)	37 - 54.5	Decreasing
Nitrate	µg/L	28 (Girma Tilahun, 1988)	30.1 - 61.7	Increasing
SRP	µg/L	5.5-16.2 (Girma Tilahun, 1988)	38.2 - 64.7	Increasing
Ammonium	µg/L	36.4 (Elizabeth Kebede *et al*., 1994)	64.17- 258.92	Increasing
Conductivity	S/cm	347- 400 (Girma Tilahun, 1988)	361.5 - 484.5	Increasing

Hence, currently, the high concentration of SPR, Ammonium and nitrate were recorded in the lake (Table 6). The farm lands located near the shore use fertilizers which are rich in nutrients, especially phosphates and nitrates, and hence can increase the concentration of SRP (Table 6). On the other hand the increment in turbidity was measured by the low Secchi depth measured during the study period as compared to

previous records (Table 6). The lower Secchi depth can be partly caused by the rising levels of siltation as conductivity increased. Hence, on this line some of the physico-chemical features of the lake water were changed and some of them may affect the aquatic organisms, such as fish kills occurring at the outlets of the flower farm effluents (Personal observation). Also evidence from other lakes in Ethiopia show that the longer term impact of human induced changes like deforestation increases the risk of flooding such as Hawassa Lake or even complete degradation of the lake like in the case of Haramaya (Brook Lemma, 2011).

Conclusion and recommendation

Lake Ziway has shown some undesirable changes in terms of some physico-chemical factors and shift in catch composition of fish species. The fish fauna of Lake Ziway is dominated by Cyprinids. Of the total 12 species recorded in the lake only 10 species were sampled with the three families. Seven species from Cyprinidae and the rest are included in the Families Clariidae and Cichlidae. Clariidae is represented by only one species (*C. gariepinus*) and Cichlidae by two species (*O. niloticus* and *T. zillii*). *C. auratus* and *L. microterolepis* were not encountered during the study. *Oreochromis niloticus*, *C. carpio, C. carassius* and *C. gariepinus* were the most abundant in number, and commercially the most important fishes of the lake. Based on percentage composition, *O.niloticus* is relatively the most dominant fish in L. Ziway, which contributed to 27.88 % of the total catch. Among the Cyprinids, *C. carpio* and *C. carassius* contributed 25.19 % and 20.71 %, respectively, of the total fishes. *Clarias gariepinus* contributed 20.51 % of the samples from the lake.

Abundance of fish species in the lake was related to water quality of the lake. For instance, *C. gariepinus*, *C. carassius*, and *C. carpio* were found in relatively nutrient-rich sites. The major cause for the accelerated water quality changes in the lake was identified as human impact in the catchment of the lake. This includes land use changes, particularly removal of vegetation cover, irrigation, diversion of inflows and industrial use of the water were taken as the cause for the decline in water quality and quantity that directly have an effect on the current change in fish catch composition and abundance.

Therefore, sustainable utilization and conservation measures should be taken. Like, in Lake Ziway, large numbers of small sized fish of all species are being exploited and proper management actions are required to protect the immature fish. Particularly, capture size of the stock should be determined taking into consideration the size at first maturity of fishes. Therefore, the fishery management plan such as prohibiting fishing on spawning ground during the breeding season is needed for the lake before the fishery resource is overexploited. Thus, management tools like closed seasons, catch quota restriction, mesh size regulations, gear restrictions and limits on the number of fishers has to be for sustainable exploitation of the stocks. The development of aquaculture and other related alternative fisheries (Integrated-fish-horticulture-poultry farming and Aquaponics technology) to reduce the pressure on the natural system should be encouraged.

Acknowledgments

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Assessment of fish post-harvest losses in selected water bodies of Oromia

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Abstract

An assessment of fish post-harvest losses involving two types of fish losses along the chain; harvesting, handling, processing and marketing from ten selected water bodies in Oromia region was carried out between July 2011 and June 2015 for four years. Format was developed to collect fish catch and loss data at every segment of the chain. Four fish species were commercially important and mostly harvested by the fishermen in the surveyed areas namely; *Oreochromis niloticus* (571.28 tons), *Cyprinus carpio* (348.92 tons), *Clarias gariepinus* (201.54 tons) and *Lebeobarbus intermidus* (4.4 tons) were the most harvested fish species while Nile Tilapia was the most processed and stored fish species. Most processing activities (filleting and gutting) were carried out manually by small scale fishermen, but private processors for Nile Tilapia were emerging. From the total harvested 1126.14 tons of different fish species, about 166.26 tons was lost owing to physical loss and 0.99 tons was lost owning to quality loss. It was recommended that improving conventional handling, processing preservation and marketing practices in the region must be improved in order to make the desired impact on fish availability.

Keywords: *Fish post-harvest losses, Tilapia, Catfish, Carp, Lebeobarbus, selected water bodies*

Introduction

The term post-harvest refers to the period of time from when a fish is separated from its growth medium (Morrissey, 1988). This includes the time a fish enters a net, caught on a hook or in a trap. There are four types of fish post-harvest losses namely; Physical loss, Quality loss, market force losses and Nutritional loss (Ward and Jeffries, 2000). Physical loss is when fish or product is discarded, for example, thrown away or consumed by insects or animals and not sold for whatever reason. Causes of physical are loss due to spoilage, eaten by animals (Crocodile, cormorant, dogs, cats and stork) and discarded by-catch (trash fish). Quality loss is when fish or its product is downgraded and sold for a lower price than it could have been sold for if the quality was better. Quality loss is the difference between the potential value of fish or fish product if no deterioration had taken place (best quality) and the actual value of the fish after it had undergone change due to spoilage (lower quality) and was sold for a low price. Market force loss is loss due to a drop in price below an optimum price, or a loss because marketing and production costs outweigh revenue earned. Because of changes in demand and supply, but not quality, the price of fish can also change.

Post-harvest losses in fisheries include material losses of fish due to spoilage, insect infestation and breakage, losses in value when quality decreases, and nutritional losses as a result of spoilage and over processing (Ames, 1992). Post-harvest losses occur at various points from capture to marketing. There is no any holistic study on estimation of quality loss of wet fish post-mortem, though it is thought to be a loss encountering up to 40% in some developing countries (FAO, 2000) and fish post-harvest losses in

Genale river was 34% (Alemu, 2017). Every fishery and fish distribution system in the world probably has some post-harvest fish losses associated with it and published estimates of annual global fish losses include 3 million tons (Johnson and Esser, 2000).

The fisheries sector has acquired a unique status in Oromia's region economy contributing to the socio-cultural setting, rural employment and food and nutritional security. Because of its vast span, conducive ecological conditions and immense potential for development, the sector continues to provide direct and indirect livelihood opportunities to over 50 thousand people. Considerable information exists on the Fishery Biology and Limnology of the natural lakes and reservoirs of Oromia but little is known about the fish post-harvest losses. Assessments of fish post-harvest losses in some Ethiopian water bodies are generated. Some of which are from Tekeze dam (Solomon and Mekonnen, 2017), Lake Hashange (Yared Tigabu, 2012; Solomon and Mekonnen, 2017), Lake Zeway (Yared Tigabu et al., 2006), Koka reservoir (Yared Tigabu, 2010). Fish post-harvest losses in the rest of water bodies have not been studied. The aim of this project was to identify the kind and quantify the magnitude of fish postharvest losses in selected water bodies of Oromia.

Materials and Methods

Description of study areas

Assessment of fish post-harvest loss was conducted in three selected zone of Oromia. The three zones were HoroGuduruWollega, Jimma and East Shoa. The location of water bodies are indicated as below (Fig.1).

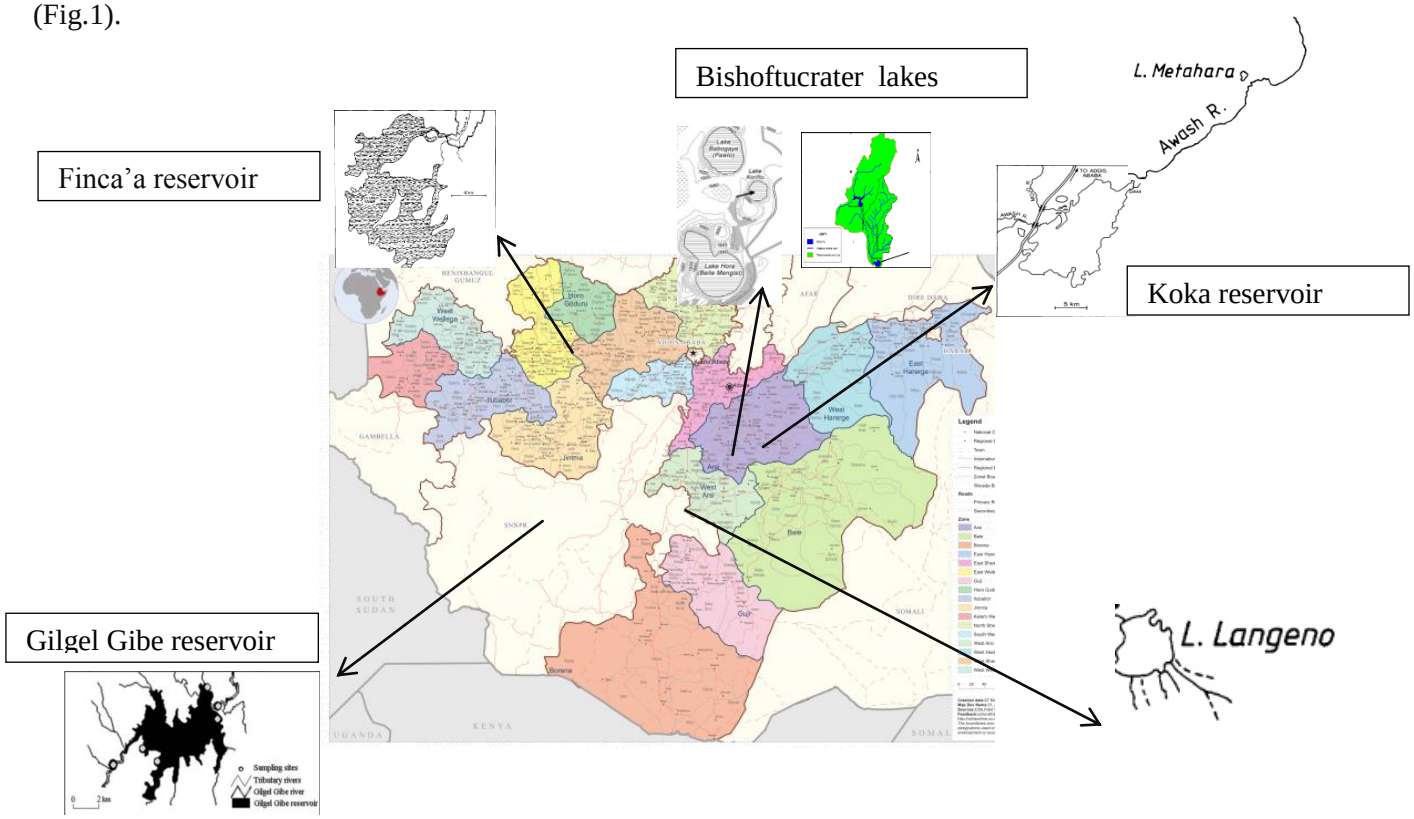

Fig. 1 Maps of selected water bodies of Oromia (MelakuMesfin et al., 1988, Elizabeth Kebede et al., 1994; SeifuKebede et al., 2001; ArgawAmbelu et al., 2014)

Table 1 Location and fishery potential of studied water bodies

Name of water bodies	Distance from Addis Ababa (Km)	Altitude (masl)	Area (Km^2)	Mean depth (M)	Fishery potential (ton per year)	Authors studied
Finca'a-Amerti reservoir	314	2218	350	5	1330	Melaku Mesfin et. al., 1988
Gilgel Gibe reservoir	260	1650	51	20	84	EELPA, 1997; Daba Tugie, 2006; Mathewos Hailu 2017
Koka reservoir	90	1584	255	9	1500	LFDP 1997
Belbela reservoir	55	2300	1.5	4	53	OLFRDB annual report; Daba Tugie, 2006
L. Langano	200	1585	230	17	1900	LFDP, 1997
L. Beseka	190	955	54	6	160	OLFRDB, 2016
L. Kuriftu	47	1860	0.4	2		Brook Lemma *et al*., 2001
L. Kilole	65	1980	0.77	2.6		Prosser et al., 1968, Green, 1986
L. Harsedi	50	1860	1.03	17.5		(Prosser et al., 1968; Wood and Talling, 1988; Brook Lemma, 2009)
L. Babogaya	50	1870	0.58	38		(Prosser et al., 1968; Wood and Talling, 1988; Green, 1986)

Finca'a-Amerti reservoir

Finca'a reservoir (09^0 33'.782'' N, 37^o 21'.298''E) constructed in the course of Chomen swamp in 1973's which has water storage capacity of approximately 650 million cubic meters and a maximum and mean depth of 25 m and 5m, respectively, and catchment area of 1,318 km^2 (Buzayhu and Graaff, 2006). Finca'a reservoir has an area of 350 km^2 (Daba T. 2006). The area is characterized by dry weather November through March. The average annual rainfall is 1709.2mm. Amerti reservoir (9°.63' N, 37°.23' E) is located at an altitude of 2243 m above sea level. The reservoir was built to supply water to the adjacent Finca'a reservoir through a tunnel for hydroelectric power generation. The water temperature of the reservoir ranges between 18.9 and 23.1°C. The area has annual rainfall of 1823 mm with long rains occurring from May to August and the short rains from November to February.

Gilgel Gibe reservoir

Gilgel gibe reservoir (7°42'50"- 07°53'50"N; 37°11'22"E - 37°20'36"E) was formed by the construction of a concrete dam on the Gilgel Gibe river located at 260 km South West of Addis Ababa, Ethiopia. The Gilgel Gibe 1 hydroelectric project was commissioned in 2004 and is currently generating 183MW at its full capacity. The Project is characterized by a large 40m high dam with a storage capacity of 839 Mm^3 covering more than 54 km^2 of land at its full supply level. The reservoir is characterized by a rock fill dam with asphalt concrete, situated on a plateau approximately 1650 m.a.s.l..

Bishoftu crater lakes

Lake Babogaya

Lake Babogaya is one of the volcanic Crater Lake found in the vicinity of Bishoftu town in East Showa. The Lake is a small, roughly circular and fairly deep lake found at an altitude of 1870 m and at about 9^0N latitude and 39^0E longitude (Prosser, *et al.*, 1968; Wood, *et al*., 1984). Like the other volcanic crater lakes of the area, it is a closed system surrounded by very steep and rocky hills. The vertical distance from the lake's surface to the crater rim is 20 m, and this affords moderate protection from wind.

Lake Hora-Kilole

Lake Hora-Kilole is located 18 Km East of the town of Bishoftu in a locality known as Hidi at $8^0$48` N and $39^o$5` E and at an altitude of 1980 m.a.s.l. Lake Hora-Kilole occupies a small area and in the East and South it has ill-defined crater and consequently the exposure to wind is high. Diameter of Lake Hora-Kilole alone has a greatly exceeding the maximum of 1.6 Km. The lake is small, shallow, roughly circular, not totally enclosed by crater wall and well mixed (turbulent).

Lake Kuriftu

Lake Kuriftu is one of the lakes found in and around the town of Bishoftu. It is found at an altitude of 1860 m, some 47 Km Southeast of Addis Ababa. The lake is located at 8^0 47' N and 39^0 00'E. It is a shallow (~ 6 m) (Brook Lemma *et al*., 2001) lake formed by diverting and damming the tributary of the perennial Mojo River.

Belbela reservoir

Belbela Reservior is microdam, established in Ada'a-Liben district in East Showa zone of the Oromia region by damming Belbela river. It is a cascade reservoir created by damming along the course of Belbela river. It is located some 15 km East of Bishoftu and about 55 Km Southeast of Addis Ababa along the road to Chafe Donsa. It is found between 38^0 01'- 40◦ 04' E longitude and 08◦ 47'- 09◦ 00' N latitude. The reservoir is situated on a highland with an average elevation of 2,300 m a.s.l.

Koka reservoir

Koka reservoir is located in the Ethiopian Rift Valley (08°23'22" N - 39°05'15"E) at an altitude of 1 590 m.a.s.l., about 90 km Southeast of Addis Ababa. It has a surface area of about 255 km^2 with a maximum and mean depth of 14 m and 9 m, respectively (LFDP, 1997).Water in- and outflow is mainly provided by the Awash River. In addition, the Mojo River may also generate inflow during the rainy season (Melaku Mesfin *et al*., 1988).

Lake Langano

It is located 200 Km South of Addis Ababa lying between 7°36′ N; 38°45′ E. It is 18 km long and 16 km wide with an open water area of 230 Km^2, 7.5 km shoreline and 1,600 km^2 catchments area. The main fish species in the lake include *Oreochromis niloticus, Cyprinus carpio and Clarias gariepinus* species and with the total annual catch of 1,000 tones.

Lake Beseka

Lake Beseka is located about 190 Km from Addis Ababa to the East. The lake is found in the rift valley system at 955m.a.s.l. It is known by its alkaline water chemistry, high pH (pH = 9.5), saline with electrical conductivity of 6300 µs/cm). The time series of satellite data documented that Lake Beseka's surface area was about 3 km^2 in 1957 but reached 54 km^2 in 2006. The lake is known for its two commercially important fish species (Cat fish and Nile tilapia).

Data collection

Primary data were collected from the fishermen cooperatives of six different lakes and four reservoirs. The reservoir includes Finca'a-Amerti reservoir, Gilgel Gibe reservoir, Koka reservoir and Belbela reservoir. The lake includes Langano, Beseka, Hora Kilole, Hora Harsedi, Babogaya and Kuriftu. The data was collected monthly for twelve months for each water bodies. The study was carried out by adopting Informal Fish Loss Assessment Method (IFLAM) and Load Tracking (LT) methods. On the first step Informal Fish Loss Assessment Method (IFLAM) which was an informal method based on Participatory Rural Appraisal principles was used to generate qualitative and indicative quantitative postharvest fish losses data. Data collection for the selected water bodies has followed the procedure of Ward and Jefferies (2000). Accordingly, information help to identify key locations for IFLAM was collected, checklist for semi-structured interviews for different groups (fishers, fish processors and fish traders), checklist to guide during IFLAM observation was conducted. Landing sites were selected based on volume of fish landings, canoe and fishing gears owners, distance from main/feeder road to the site, fish transporters. Then after, the Load Tracking (LT) was used to quantify losses at different stages along the distribution chain or losses related to specific activities such as fishing, transport, processing and marketing. The methods are designed to generate data primarily on physical losses, quality losses and to a lesser extent market force losses. Any of these types of loss can occur at any point in a fish marketing or distribution chain, from capture to consumer. The total catch of the fish by species, the total amount of fish discarded (due to spoilage, size, lack of market, etc) was measured. The total fish catch and losses at the landing sites were determined by using the following calculations:-

Results and discussion

Based on the Informal Fish Loss Assessment Method (IFLAM), the factors (variables) which contribute to post-harvest fish losses were; Spoilage, Size discrimination, Species preferences, Operational loss (fishing gears), Animal predation (dogs, stork, cormorant and crocodile). Physical loss and quality loss were the two pertinent kinds of losses. There is no clearly implicated market force loss

Finca'a-Amerti reservoir

Different fish species were introduced to Finca'a reservoir for different purposes in the past time, along which Nile Tilapia (*Oreochromis niloticus*), Common carp (*Cyprinus carpio*) and grass carp (*Ctenoparyngodon idella*) were introduced into the reservoir in 1980's. Except grass carp which did not observed during sampling, the former two species and *Tilapia zillii* were reported to be well adapted and established in the reservoir (Daba Tugie, 2006; Fasil Degafu et al., 2012).

Postharvest fish losses assessment result indicates that from the total annual 98, 784 Kg Tilapia (*Oreochromis niloticus and Tilapia zillii*) catch within twelve months, the total post-harvest fish loss was 6,816Kg (6.9 %) of which 2,076 Kg of tilapia due to size discrimination, 1,323 Kg due to operational loss, 648 Kg due to less market access and 2,497 Kg due to spoilage were lost. The total carp species catch were 31,317 Kg. From the total Carp species harvested, the post-harvest fish loss constitutes 3,539 Kg (11.3%), of which 560 Kg of carp species due to size discrimination, 2,143Kg due to species preference and 447 Kg due to spoilage were discarded Fig. 1 The current fish post-harvest loss with regard to Nile Tilapia is very low in Finca'a reservoir as compared to Koka reservoir. Yared Tigabu 2010 reported that 11.19% Tilapia was lost from the total catch and 5% carp species was lost from the total catch at Koka reservoir in 2007/2008. The difference in fish post-harvest losses between water bodies is due to differences in fish species preference among the society as carp species is preferred by the society around Koka reservoir and discriminated by the society around Finca'a, and Amerti reservoirs as well as the central market. It may also due to the differences between the fishing material as beach seines used at Koka reservoir regularly while very little number of beach seines are engaged at Finca'a and Amerti reservoirs. Even though it is difficult to quantity loss due to market force losses (unexpected market demand and supply forces), there are some disputes between legally cooperated fishermen and fish trader on fish price determination. Some illegal fishermen and cooperatives sold their products at lower prices, which was challenging for the legal operators. These cause fishermen to sell their product at a price below expectations.

Gilgel Gibe reservoir

The fish catch of the Gilgel Gibe I reservoir is composed of *O. niloticus*, *L. intermidus* and *Labeo cylindricus* (Mathewos Hailu, 2017). However Eskedar *et al*., 2009 reported L. *intermedius,* O. *niloticus*) and one Gara species. From estimated 40.6 tons total Nile Tilapia (*O niloticus*) catch within 12 months, 4.2 tons (10.34 %) of Tilapia was discarded due to size discrimination and spoilage. From estimated 4.4 tons of *L. intermidus* catch, 0.54 tons (12.27 %) were discarded due to size discrimination and spoilage. The most prevalent fish loss is physical loss owning to size discrimination and spoilage. All the fishermen uses recommended gillnet of mesh size 10 cm and above. The most prevalent fish loss (10.34 %) in Nile Tilapia and 12.27 % in *L.intermidus* is physical loss owning to size discrimination and spoilage because, all the fishermen uses gillnet of mesh size 10 cm and keep the nets for more than 24 hours in the water.

Koka reservoir

The commercially important fish species in Koka reservoir are *O.niloticus*, *C.carpio* and *C.gariepinus*. The common fishing gears used in the reservoir includes beach seines with 6 cm mesh size cod end, gillnets having 10 cm mesh size and Long lines with hook sizes ranging from 4/0-6/0 but beach seine catches contribute about 60 % to the annual landings (Gashaw Tesfaye and Zenebe Tedesse,2008).

From estimated 293 tons of Nile tilapia (*O. niloticus*) catch within 12 months, the total post-harvest loss constitutes 47.8 tons (16.31 %) due to size discrimination and spoilage. From estimated 315 tons of *C.carpio* catch, the post-harvest losses were 66.2 tons (21.01 %) due to size discrimination and spoilage. From estimated 192 tons of *C.gariepinus* catch, the post-harvest losses were 34.6 tons (18.02 %), due to size discrimination and spoilage. There is no proper fish handling and preserving facilities both on boat and landing sites. Long fishing hours, as well as, extended period between capture and arrival at landing sites causes spoilage of fish in Koka reservoir. Fishers usually got to fishing grounds in the morning to set

their gears and return the following morning to collect their catch (24 up to 48 hours fishing time). The reason of highest fish loss is due to inaccessible landing sites from nearest town (Dera and Adama), size discrimination, fish species preferences and spoilage.

Bishoftu crater lakes and Belbela reservoir

Previous work on the four Bishoftu crater lakes has described bathymetry and major ionic composition (Prosser *et al*., 1968), photosynthetic productivity (Tailing et al., 1973), as well as the seasonal pattern of thermal stratification and mixing (Wood *et al.,*. 1976). The lakes have also been studied for their important feature on stratification (Baxter *et al.,* 1965; Tailing, 1969). These crater lakes are important for their ecotourism as they are the hub of social and cultural dignity of the region. These crater lakes are ecologically important, however from fish production point they contribute insignificant to fish catch and loss in the region

Table 2. Amount of fish harvested and lost at different water bodies in tons

Year of data collection	Name of water bodies	Fish species	Catch in tons	Loss in tons	Percentage (%) of loss	Financial loss (ETB)
2011/2012	Finca'a-Amerti reservoirs	Tilapia	98.8	6.8	6.88	34,000
		Common carp	31.3	3.5	11.18	3,500
2012/2013	Gilgel Gibe reservoir	Tilapia	40.6	4.2	10.34	38,000
		Labeobarbus	4.4	0.54	12.27	540
2013/2014	Koka reservoir	Tilapia	293	47.8	16.31	239,000
		Common carp	315	66.2	21.01	66,200
		African catfish	192	34.6	18.02	86,500
2013/2014	Belbela reservoir	Tilapia	2.1	0.3	14.28	1,500
		Carp species	1.1	0.17	15.45	170
2013/2014	Hora Kilole	Tilapia	3.21	0.42	13.08	2,100
		Carp species	1.52	0.25	16.44	250
2013/2014	Hora Aresede	Tilapia	0.6	0.09	15.00	450
2013/2014	Babogaya	Tilapia	0.2	0.03	15.00	150
2013/2014	Kuriftu	Tilapia	0.9	0.07	7.77	350
2014/2015	Beseka	African Catfish	9.549	0.29	3.03	14,023
2014/2015	Langano	Tilapia	131.87	1.9977	1.51	9,988.75
Grand total						496,721.75

Lake Langano

The major fish species caught was Nile Tilapia, African catfish and Common carp. Majority of the fishermen uses beach seine fishing gear and occasionally Gill net. The main reason for discarding fish is due to size s beach seine is non-selective. It takes up to 1.5 hr. to set and haul depending on the length of beach seine. The average fish harvested per day ranges from 0 to 33 kg. The harvested fish is stored without ice. Regularly the fishermen set beach seine near to offshore so it took less than an hour to sail back with fish, land and sell their fish. From the harvested fish, 20-30 fish is fingerlings (Shaiti) which discarded and contributes to major physical losses in Lake Langano. Shaiti is an an Afan Oromo word which mean small fish. The other major physical loss contributor is wading dogs (Fig 2.) and cats. The major fish processing method is filleting and major fish product is fillet. The root cause for the post-

harvest quality loss is due to the long distances involved in the transportation of fresh fish using open truck, high ambient temperature in combination with the poor quality packing materials.

Fig. 2 Picture taken during fish postharvest losses assessment at Lake Langano

Lake Beseka

Lake Beseka harbor two commercially important fish species (Cat fish and Nile tilapia), Crocodiles, alligators, different birds and hot springs. The fish resource of the lake was estimated to be about 205 tons per year whereas current production does not exceed 17 tons per year. For its high salinity, the lake water is not used for drinking purpose both for human and domestic animals although it is in area where water scarcity is much prominent. From estimated 9.549 tons of African cat fish harvested within 12 months, 0.29 (3.03 %) tons was lost due to spoilage (high ambient temperature) and crocodile predation. High ambient temperature at Metahara triggers fish spoilage. The fishermen cooperative has one deep freezer with a capacity of holding 150 kg. After filleting, the fishers immediately load their product in the freezer which resulted in low fish post-harvest losses. The reason for fish post-harvest loss at Beseka lake is fishing materials (long line), high temperature which causes spoilage and animal predation (crocodile).

Fish harvesting, handling, processing, preservation and marketing in Oromia region is primitive and backward, hence exacerbated fish post-harvest losses. From different fish species Carp species is the most discarded fish species in the region (Table 2).

Table 2. Fish postharvest losses of different fish species in the selected water bodies of the region

Fish species	Amount harvested in tons	Amount lost in tons	Percentage of loss (%)
Nile Tilapia	571.28	61.7	10.80
Carp species	348.92	70.12	20.09
African catfish	201.54	34.89	17.31
L. intermidus	4.4	0.54	12.27

Fish post-harvest loss characteristics in Oromia

Following the model of Bourne (1977) and proposal of Obeng-Ofori (2011) the leaky food pipeline with the post-harvest practices in the study area, loss agents and the most affected fish species at each stage of the supply chain are shown in Fig. 3. Using the current price of 5 birr per kg whole Nile Tilapia, 2.5 birr

per kg for African Catfish, 1 birr per kg for Common carp and *L. intermidus* monetary or economic loss was estimated to be 496,721.75 Ethiopian birr. The types, extent and seasons of fish post-harvest losses in the study areas revealed a serious problem that needs urgent intervention to reduce them.

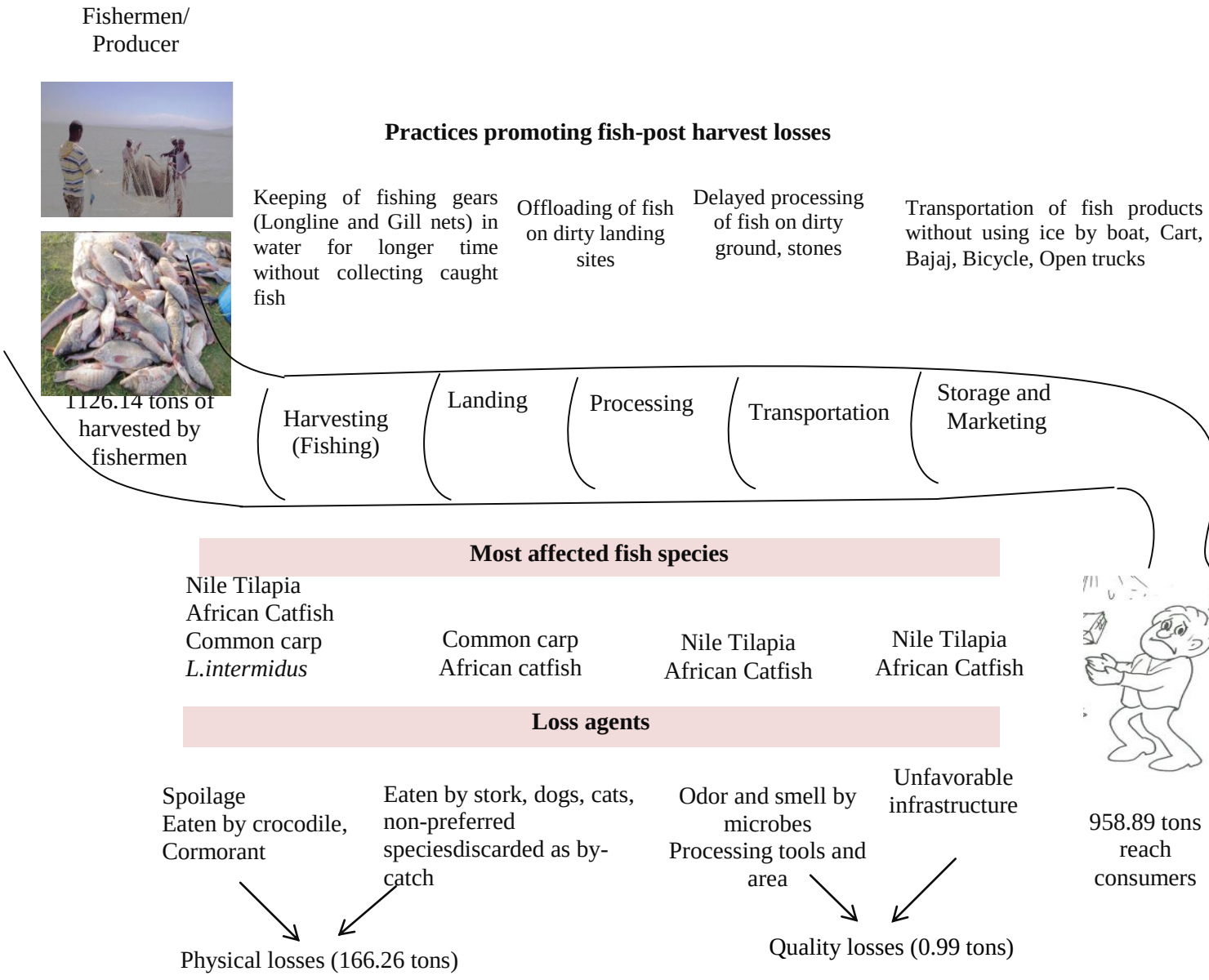

Fig. 3 The leaky food pipeline with the post-harvest practices in the study area, loss agents and the most affected fish species at each stage of the supply chain

Conclusion and Recommendation

Although the extent of fish post-harvest loss varied from lake to lake, species to species, the region as a whole is losing huge amount of fish (167.25 tons) annually through post-harvest losses. This is a massive economic and nutritional loss, for a country like Ethiopia which suffers from protein malnutrition. The main causes for post-harvest losses include inadequate handling, processing and storing facilities, delay

between catch, collection and distribution, lack of proper fish market channel, absence of regulations governing quality and standards of fish to be sold for human consumption, poor extension services and lack of knowledge on proper fish preserving techniques. There are a number of general factors or variable that can increase the likelihood of post-harvest losses. These include unreliable transportation, inadequate preservation techniques, adverse weather conditions, preference of fish species and fishing gear. The factors (variables) which contribute to post-harvest fish losses were; spoilage, size discrimination, species preferences, operational loss (fishing gears) and Animal predation (dogs, stork, cormorant and crocodile). Physical loss and quality loss were the two pertinent kinds of losses.

Fish, being an extremely perishable foodstuff, requires careful handling and processing. Hence, coping strategies during harvesting, processing, storage and distribution should be taken to reduce fish postharvest loss. Fishermen who use gill nets in Finca'a and Gilgel Gibe should not keep for more than 8 hours in the water. Multi hauling techniques of gill nets ought to be followed to avoid spoilage. Fishermen who use Beach Seine in Koka reservoir and Lake Langano need to increase mesh size to greater than 8 cm. Fishermen around Lake Beseka should use ice during transportation of fish from landing site to storage or freezing units. Value added fish product should be developed to improve the utilization of Common carp (non-preferred fish species in the region).

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Preservation of Nile Tilapia fillet using polyphenols extract from moringa and green tea leaves

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Abstract

The ethanolic extract of the leaves of moringa (Moringa stenopetala) and green tea (Camellia sinenses) was examined on preservative potency of Nile Tilapia (Oreochromis niloticus) fillet at room temperature. Fresh fillet was preserved in 2% aqueous solutions of moringa and green tea extract (GTE) separately and then preserved for 84 hours. Fresh fish fillet contain 6.3 x 10^4 CFU/g S.aureus, 3.5 x 10^6 CFU/g of Enterobacteriaceae, 2.1 x 10^6 CFU/g of fecal coliform and 1.4 x 10^5 Yeast and Molds. After preservation for 84 hours in both green tea extract (GTE) and moringa, the growth of S.aureus was completely halted by polyphenols. Catechin gallates such as ECg intercalate into phopsholipid bilayers of S.aureus and it is likely that they affect both virulence and antibiotic resistance by perturbing the function of key processes associated with the bacterial cytoplasmic membrane. The growth of enterobacteriaceae, fecal coliform and Yeast and Molds were beyond the acceptable limits after preservation for 84 hours in polyphenols extracted from moringa and green tea. Ethanolic extract of leaf of Moringa stenopetala and Camellia sinenses can halt the growth of pathogenic S,aureus. However, the extracts have no any inhibition effects on the growth of Enterobacteriaceae, fecal coliform and Yeast and molds after preservation for 84 hours.

Keywords: Polyphenol, Nile tilapia, Fillet, Moringa, Green tea

Introduction

Fish being highly perishable after harvest requires proper preservation and storage to increase the shelf life (Clucas and Ward, 1996). Freshly caught fish spoil easily and need to be properly preserved. Fish begin to deteriorate as soon as they leave the water. Of all flesh foods, fish is the most susceptible to tissue decomposition, development of rancidity, and microbial spoilage. Utmost care should be exercised during handling and processing to avoid compromising its quality and safety. The main cause of deterioration is the activity of spoilage seafood microorganisms that provoke loss of essential fatty acids, fat-soluble vitamins and protein functionality, production of biogenic amines, and formation of off-odors (Gram and Huss,1996).

The Spoilage of fish begins as soon as fish dies. In tropical conditions, fish spoils quite rapidly, within a few hours of landing, if not properly cooled. The spoilage rate of fish may be reduced by good handling practices and effective temperature control from very beginning. In raw fish, spoilage takes place mainly due to three reason viz., Enzymatic, Microbial and Chemical action. Enzymes and bacteria do not cause any deteriorative changes in the living cell because of the natural defensive mechanism. In dead fish, enzyme become involved in the autolytic changes and bacteria can invade the fish muscle and proliferate there. In order to reduce the bacterial processes, immediately on death fish should be de headed, gutted, washed and chilled in order to inhibit unfavorable enzymatic and microbiological processes. If fish is not

sold fresh, preservations methods should be applied in order to extend shelf life. Fish preservation is a very important aspect of the fisheries. Plants produce primary and secondary metabolites which encompass a wide array of functions. Some of these have been subsequently exploited by humans for their beneficial role in a diverse array of applications. Polyphenols are the natural antioxidants prevalent in fruits, vegetables, beverages (tea, wine, juices), plants, seaweeds, and some herbs and show anti-oxidative and anti-microbial activities in different fish and fish products. Thus, plant polyphenolic compounds can serve as potential additives for preventing quality deterioration or to retain the quality of fish and fish products. Previous investigations have shown tea polyphenols also possess antioxidants, natural enzyme inhibitions, and antibacterial properties (Taylor *et.al*., 2005). So, preservation of fish fillet with natural compounds is effective preservation methods for fish products. The objective of the study was to evaluate the effect of Moringa and green tea leaves polyphenol extracts on some pathogenic microorganism associated with Nile Tilapia fillet.

Materials and Methods

Collection of green tea leaves and moringa

20kg of green tea leaves was collected from wush wush tea plantation (Ethio Agri Ceft plc) Southern Nations and Nationality people, Bonga. Green tea leave was dried under shade, pulverized by miller. 100g of moringa powder was purchased from supermarket.

Extraction of Polyphenols from moringa leaves

100 g of powdered green tea was added to 400 mL ethanol, then macerated for 3 three hours, then filtered through whatman no.1. The filtrate was evaporated using rotavapor at 40 ^{0}C at reduced pressure. Finally two gram of Green tea extract (GTE) was recovered from bottom round bottle. The same procedure was followed for moringa powder (Bharadwaz A and Bhattacharjee C., 2012). 2g of extracted polyphenols from each green tea and moringa was diluted with 500 mL distilled water. 100 g of fillet was immersed in the solution for 84 hours.

Preparation of fish homogenate

Five grams of raw fish fillet was homogenized with 45 ml of sterile buffered peptone water solution. 5 ml of this homogenate was added to an Erlenmeyer flask containing 45 ml buffered peptone water solution to get a dilution of 10^{-1}. Similarly, serial dilutions up to 10^{-7} were prepared. From each serial dilution, one ml was taken and spread plated on petridish and incubated for 24 hours. Then, number of colony forming unit (CFU/g) of pathogenic microorganism was recorded using the formula;

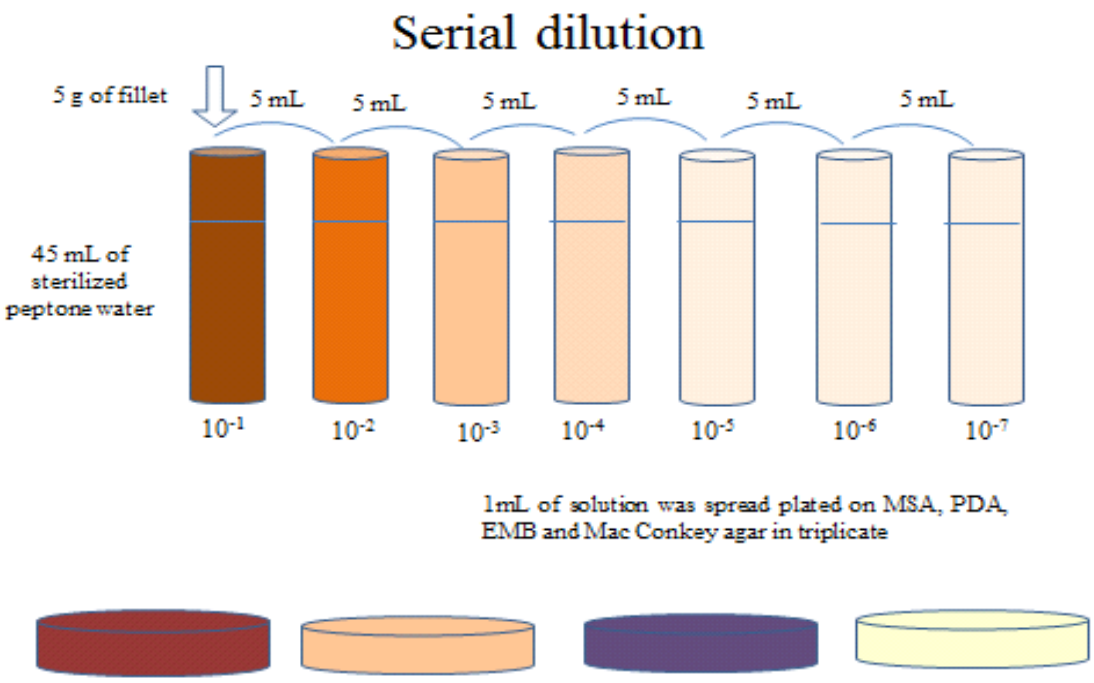

Fig 1. Serial dilution

Enumeration of S. aureus

The enumeration of *S. aureus* was carried out using standard method. Selective medium used for the isolation of *S. aureus* was Manitol Salt Agar. One ml from each dilution (10^{-3} to 10^{-5}) for fresh fillet and (10^{-5} to 10^{-7}) for preserved fillet was spread over a dry surface of Manitol Salt agar plate in duplicate. Inoculated plates were incubated at 37°C for 24 hours.

Enumeration of Enterobacteriaceae

The number of enterobacteriaceae was enumerated using mac conkey agar. Lactose fermenters appear as pick and non-lactose fermenters (salmonella and Shigella) develop into transparent colorless colonies.

Enumeration of coliforms

Eosin Methylene Blue Agar is a both selective and differential culture medium. Colored colonies in Eosin Methylene Blue (EMB) Agar: Lactose fermenter, Colorless colonies in Eosin Methylene Blue (EMB) Agar: Non lactose fermenter.

Enumeration of yeast and molds

Potato Dextrose Agar (PDA) medium was used for yeasts and molds count. 5 gram of fish fillet was homogenized with 45 mL sterilized peptone water. Seven times dilution was undertaken. 1 mL of solution was spread plated on PDA from 10^{-3} to 10^{-5} for fresh fillet and 10^{-5} to 10^{-7} from preserved fillet. The petridish was incubated at 37 ^{0}c for 24 hours.

Results and discussion

Extracts of leaves from the tea plant *Camellia sinensis* contain polyphenolic components with activity against a wide spectrum of microbes. Studies conducted over the last 20 years have shown that the green tea polyphenolic catechins, in particular epigallocatechin gallate (EGCg) and epicatechin gallate (ECg), can inhibit the growth of a wide range of Gram-positive and Gram negative bacterial species with moderate potency.

Table 1. The amount of CFU/ g in fresh fillet and fillet preserved in polyphenol

	S.aureus	**Enterobacteriaceae**	**Fecal coliform**	**Yeas and mold**
Fresh fillet	6.3×10^4	3.5×10^6	2.1×10^6	1.4×10^5
Fillet preserved in green tea (84hr)	No growth	4.1×10^7	$>3 \times 10^9$	$>3 \times 10^9$
Fillet preserved in moringa (84hr)	No growth	3.3×10^8	$>3 \times 10^9$	1.3×10^8

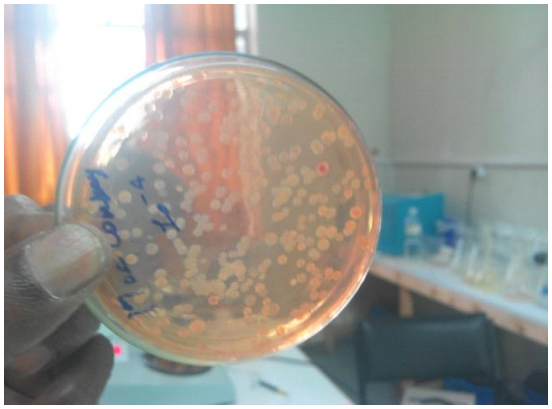

Fig.2 Colony forming units of enterobacteriaceae on Mac Conkey agar

In this study, fresh fish fillet contain 6.3×10^4 CFU/g *S.aureus*, 3.5×10^6 CFU/g of enterobacteriaceae, 2.1×10^6 CFU/g of fecal coliform and 1.4×10^5 Yeast and Molds. After preservation for 84 hours in both green tea extract (GTE) and moringa, the growth of *S.aureus* was completely halted by polyphenols. It is revealed that the ethanolic extract shows antimicrobial properties on *S. aureus.* The antimicrobial activity shown by the extract might be due to some antimicrobial substances present in M. oleifera (Pal *et al*., 1995).

Catechin gallates such as ECg intercalate into phopsholipid bilayers and it is likely that they affect both virulence and antibiotic resistance by perturbing the function of key processes associated with the bacterial cytoplasmic membrane (Taylor et al., 2005). Kalpana et al., 2013 has revealed that, Ethanolic extract of leaf of *Moringa oleifera* showed maximum diameter of zone of inhibition against *Staphylococcus aureus* i.e (15mm).

The growth of Enterobacteriaceae, Fecal coliform, Yeast and molds were beyond the acceptable limits after preservation for 84 hours in polyphenols extracted from moringa and green tea. The count of enterobacteriaceae was higher for fish fillet preserved in moringa, however the count of yeast and molds was highest for fish fillet preserved in green tea extract. Indeed fish and other free-swimming marine animals do not usually carry those organisms generally considered to be typical of the mammalian

microflora, including *Escherichia coli,* the 'faecal coliforms', and enterococci. The presence of human enteric organisms on marine food products is clear evidence of contamination from a terrigenous source (ICMSF, 1986).

Conclusion and recommendation

Ethanolic extract of leaf of *Moringa stenopetala* and *Camellia sinenses* can halt the growth of pathogenic *S,aureus*. However, the extracts have no any inhibition effects on the growth of Enterobacteriaceae, fecal coliform and Yeast and molds after preservation for 84 hours. However, further investigation is needed to determine the bioavailability of the active compounds and to determine the dose and toxicity before it can be used as preservative agents.

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Evaluation of small barbus silage through inclusion into commercially formulated poultry feed

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Abstract

The aim of the present study was to produce fish silage by formic acid fermentation and evaluate its use in feeding of Lohman brown. A total of twenty five 120 day old Lohman brown were used for the experiment. A 24 weeks experiment was conducted to investigate the utilization of a diet based on commercial poultry feed and silage. Five diets containing various levels of fish silage (0, 2, 4, 6 and 8%) were evaluated. The birds were weighed and allotted to five pens containing five birds each. Daily feed intake, number and weight of egg laid were daily measured. Body weight was measured monthly. The highest average feed intake was recorded in treatment four (135.89±7.82) g/ poultry in which 6 % of silage was included into commercial diet. The highest body weight obtained was (1968.00±119.39) during 33rd week in which 6 % of silage was included into commercial diet. The highest average weight of egg (68.59 ± 4.96) was observed in T4 (6% silage included). It was concluded that addition of 6% fish silage into commercial poultry diet increased early egg laying, feed intake, body weight gain, egg production and average weight of eggs. Laying hen fed on 6% silage gained average weight of 649 gram, average egg number (117) and egg weight (60 gram) for feeding period of 24 weeks.

Keywords: Silage, small barbus, poultry, feed intake, weight gain and egg production

Introduction

Fish silage is a semi-liquid product resulting from the preservation of whole fish or parts by the addition of acids (inorganic or organic) or by bacterial fermentation, adding latter a carbohydrates source along with lactobacilli species to convert sugars into lactic acid (Borghesi et al., 2008; Ramírez-Ramírez et al., 2008). Acid silage was developed in 1920 by A. I. Virtanen, using hydrochloric and sulphuric acid for the conservation of forages. Experiments with fish began in Sweden in 1936, using hydrochloric, sulphuric, and formic acids and sugars (Tatterson and Windsor, 1974). The presence of mineral or organic acids or the lactic fermentation decreases the pH, which inhibits the growth of bacteria, and hence enables long-term storage of the raw material. Fish silage made with organic or mineral acids is commonly referred to as acid fish silage, while that which requires the addition of a source of carbohydrates and anaerobic storage conditions is known as fermented or biological fish silage (Clucas, 1982). Liquefaction is caused by enzymes present in the fish, and is accelerated by the acid which in addition to creating the right conditions for the enzymes to work, helps to break down bone and limits the growth of spoilage bacteria (Tatterson, I.N., 1982).When fish is ensiled with formic acid, the pH is kept under 3.5 (Tatterson and Windsor, 1974). This preserves the amino acids, but during storage autolysis takes place so that the protein is broken down to shorter peptides and free amino acids (Espe *et al.*,1989).

Fish silage is used in Norway in feeds for fur animals and farmed fish and recently it has become permitted for use at a 30 g/kg dry weight basis in feed mixtures for poultry and pigs. Since then, several scholars have successfully utilized acid-preserved silage obtained from different raw materials in diets for different animal species. Fish silage can substitute fish meal or soybean for quality protein at low cost. Feeding experiments which substituted fish silage with fish meal/soybean meal in diets of different animals has been conducted. Some of the animals used were White leghorn chickens (Espe et al., 1992); broiler chickens (Al-Marzooqi et al., 2010, Vizcarra Magana et al., 1999, Ramirez Ramirez et al., 2016, Hammoumi et al., 1998, Kjos et al., 2000); laying hens (Kjos et al., 2001); *Labeo rohita* fingerlings (Haider et al., 2016); Juvenile *Litopenaeus vannamei* (Gallardo et al., 2012); Tilapia (Fagbenro and Jauncey, 1998) laying Japanese quails (Ramírez Ramírez et al., 2013, Zynudheen et al., 2008), Common Carp (*Cyprinus carpio*) fingerlings (Ramasubburayan *et al*, 2013) and Young rats (Espe et al., 1989). The incorporation of fermented fish silage in dietary feed formulation in poultry may be used as an effective, suitable and cheaper protein source (Zynudheen et al, 2008). Viscarra-Magaña et al., (1999) reported that 15% of a mixture of fish silage-sorghum (70%-30%) might be included in the diet without adverse effect on feed intake, weight gain and feed conversion ratio of broilers. Other research conducted by Kjos et al., (2000) reported that chicks (36.3±0.6 g) fed with fish silage diets (by-products of farmed salmon) at levels of 5 and 10% had a significant greater weight gain and feed intake. Recently, AlMarzooqi et al., (2010) reported that fish silage could replace up to 20% of soybean meal in broiler diets without affecting growth performance and sensory quality of meat.

Fish silage offers an opportunity to make use of by-catch, viscera and by-products from the fishing vessels and fish processing sites. By-catch is often thrown overboard because of its low price. Preserving and storing as silage is a convenient way of utilizing such resources. In Lake Ziway, unexploited strait fin barb, *Barbus paludinosus*was identified and its MSY (Maximum Sustainable Yield) is estimated between 0.60-0.83 tons per km^2. Considering the total area of the lake (434 km^2) it is estimated that an annual production of 260.4 to 360.2 with mean of 312 tons per annum of *B. paludinosus* can be harvested from Lake Ziway. With the observed substantial biomass, high productivity, high growth rate and short generation of *B. paludinosus* fishery can be started at pelagic habitats (Mathewos Hailu, 2017). It is based on this recommendation that, the by-catch, unexploited strait fin barb (*Barbus paludinosus*) was selected as a raw material for silage preparation. The objective of this study was to determine the chemical composition (Moisture content, Crude protein, Fat and Ash content) of fish silage and evaluate small barbus silage through inclusion into commercially formulated poultry diet.

Materials and Methods

Experimental site

This trial was conducted at Batu fishery and Other Aquatic life researcher center. Five houses having an area of $4m^2$ were constructed from mud brick; roof was covered with twisted bamboo, the polyurethane finally thatched by typha. The front side of the houses was built by 90 cm x 100 cm mesh wire to let the light enter.

Fig.1 poultry house

Preparation of silage

A total of 50 kg specimen of Small barbus (*Barbus paludinosus)* was harvested from Lake Zeway using a monofilament. The total length of the specimen ranged from 7.4 to 12.5 cm with mean length of 8.89 cm, and the weight ranged from 3.9 to 15.1 g with a mean weight 7.68g. The fish was minced using electric meat mincer (220 kg/hr) then mixed with 3% by weight solution of 98% formic acid in the ratio of 30L for 1 tone (Tatterson and Windsor, 2001) to lower the pH up to 3.5, then continuously stirred twice a day for ten days. Initially, the mixture was in semi-solid form but it started to liquefy on the fourth day. Eventually the silage was placed in acid-resistant container plastic bucket and sealed until fermentation was completed. The mixture was stored at room temperature for a period of 120 days.

Fig.2 Small barbus harvested using monofilament

Determination of chemical composition of fish silage and prepared feed

Proximate composition and anti-nutritional factors of prepared fish acid silage was determined by standard methods of Association of Official Analytical Chemists (2005) for moisture, protein, fat and ash contents.

Moisture determination

Wet silage sample was weighed, placed in crucible and then dried in oven at 105°C for overnight. Crucible was taken out the next day and weighed again. The loss in weight represented the moisture contents and was determined. The percentage is determined by the following formula:

$$Moisture = \left(\frac{W1 - W2}{W1}\right) \times 100$$

Where W1 = initial weight of the sample W2 = final weight of the sample

Protein determination

Five grams of dried fish silage sample was taken in a flask and mixed with mixture of (Potassium Sulphate + Copper Supphate) and transferred to a flask containing 200 mL of concentrated H_2SO_4. This flask was placed on a heating block, the heaters were turned on and the flask was kept there until white fumes stopped appearing and the solution became clear, indicating completion of the digestion process. The solution was removed away from the heater and then cooled. The solution was diluted with the addition of 60 mL of distilled water and its pH was raised to 6.5–7 by adding 45% NaOH solution. Then five to six drops of indicator solution was added and the flask was connected with a condenser with the tip immersed in standard acid and heated until NH_3 was evaporated. The final solution mixture was then titrated using 0.2N HCl against NaOH. Protein contents were then determined applying the following mathematical formula:

$$Protein = \frac{(A - B) \times N \times 14 \times 6.25}{W}$$

A = volume of 0.2 N HCl used for sample titration
B = volume of 0.2 N HCl used in blank titration
N = normality of HCl
W = weight of sample
14 = atomic weight of nitrogen
6.25 = constant for nitrogen calculation

Ash determination

Ten grams of sample was taken in a crucible and weighed. Crucible with sample was placed in muffle furnace at a temperature of 550°C for 5 hours. When the sample turned white, it was taken out and weighed again. White-colored contents remaining at the bottom of the crucible represented ash, which was carefully weighed and its percentage present in the feed was calculated by the following formula.

$$\text{Ash content} = \frac{W2 - W1}{W3} \text{ X } 100$$

Where: W_1 = Mass of empty porcelain dish
W_2 = Mass of dish with ash
W_3 = Mass of original product sample

Lipid determination

The soxhelt apparatus was set and 5 g of sample was placed in the extraction thimble and transferred to the condenser. Petroleum ether was filled in a flask and the apparatus was switched on. This process was continued for 16 hours. Then turned the heaters were switched off, and the flask was removed and gently dried on the same heater. When the contents of the flask smelled oily, they were removed and weighed and the fat content in the test sample was calculated using the following formula.

$$\text{Fat content} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \text{ X } 100$$

Feed preparation

Feed was prepared by adding fish silage into commercially formulated poultry feed purchased from Alama koudijs plc.

T1= 0% fish silage + 100% commercially formulated poultry feed
T2= 2% fish silage + 98 % commercially formulated poultry feed
T3= 4% fish silage + 96 % commercially formulated poultry feed
T4= 6 % fish silage + 94 % commercially formulated poultry feed and
T5= 8% fish silage + 92 % commercially formulated poultry feed

Poultry management

A total of twenty five 120 day old Lohman brown were used for the experiment. Twenty five poultry was assigned to five different silage inclusion rates. Each of five poultry house was equipped with round feeder and waterer. The birds were weighed and allotted to five pens containing five birds each. The birds were maintained under the standard management practices with ad libitum feeding and clean drinking water throughout the period of the experiment (24 weeks). The eggs were weighed daily using an electronic balance to an accuracy of 0.1 g. Every month, the weight of poultry was recorded using sensitive balance.

Data collected

Body weight, feed intake, Egg production, chemical composition (Moisture content, crude protein, ash and fat content) of commercial poultry feed and prepared feed was measured. Initial body weight and final body weight of each treatment was compared using ANOVA. Feed offered and refused was recorded daily to determinate the feed intake. Feed intake was monitored by feeding weighed quantities of feed daily and subtracting the left over from the quantity fed the previous day. The birds were weighed monthly and body weight between two consecutive weighing was recorded.

Results and discussion

Chemical composition of silage and prepared feed

The total chemical composition of silage, commercial feed and the different formulated feed was reported in Table 1. Silage which was hygienically prepared from small barbus had contain 79.8±0.63 % moisture content, 16± 0.47 % crude protein, 0.5±0.02 % crude fat and 3.5±0.32 % ash. After the chemical composition of silage was determined, it was added to commercial poultry feed purchased from Alema Koudijs plc.

Table 1 Chemical composition of fish silage, commercial control feed and formulated diets (%)

Variables	Fish silage (%)	T1 (Mean ± Std.error)	T2(Mean ± Std.error)	T3(Mean ± Std.error)	T4(Mean ± Std.error)	T5(Mean ± Std.error)
Moisture content	79.8±0.63	6.72± 0.46	6.9±0.52	7.44±0.59	7.51±0.64	8.33±0.72
Crude protein	15.9± 0.47	16.0± 0.2	15.98±0.2	15.89±0.1	15.85±0.3	15.80±0.4
Ether extract	0.5±0.02	5.14±0.09	4.23±0.08	6.18±0.07	5.65±0.08	5.25±0.06
Total ash	3.5±0.32	6.62±0.7	7.41±0.5	5.1±0.6	6.26±0.7	8.99±1.2
Carbohydrate	-	65.52±3.2	65.48±2.9	65.39±2.3	64.73±1.9	61.63±0.9
Phytate mg/100g	-	151.82±5.6	145.68±4.5	143.46±4.3	95.99±3.8	56.6±2.9
Tannin mg/100g	-	53.13±2.3	51.92±2.4	46.78±2.1	44.72±1.9	43.88±1.8

Feed intake

Feed intake of egg laying hen was variable, resulting in the lowest value at first 4 weeks in treatment three (62.80±1.72) gram per bird in which 4 % of silage was included. The highest average feed intake was recorded between 25 and 28 weeks in treatment four (135.89±7.82) gram per bird in which 6 % of silage was included into commercial diet.

Table 2 Feed intake (g/hen) of laying hens fed on diets containing different levels of fish silage

Age of poultry in weeks	T1 (Mean ± Std.error)	T2(Mean ± Std.error)	T3(Mean ± Std.error)	T4(Mean ± Std.error)	T5(Mean ± Std.error)	p-value
17-20	67.57±2.72 ^{a}	68.91±1.72 ^{a}	62.80±1.72 ^{a}	70.82±3.69 ^{a}	68.32±2.39 ^{a}	0.251
21-24	103.79±4.10^{ab}	103.62±5.91^{ab}	93.16±6.29^{b}	119.41±6.31^{a}	110.06±5.61^{ab}	0.031
25-28	120.53±5.11^{a}	115.44±5.83^{a}	116.70±7.26^{a}	135.89±7.82^{a}	118.60±6.39^{a}	0.264
29-32	106.36±1.77^{ab}	105.60±1.96^{ab}	98.89±4.46^{b}	110.36±5.71^{a}	113.86±1.99^{a}	0.019
33-36	107.41±1.29^{c}	113.86±1.33^{a}	112.95±1.61^{ab}	109.21±1.18^{bc}	111.52±1.10^{ab}	0.003
37-40	104.49±1.37^{a}	106.62±1.19^{a}	104.60±5.13^{a}	102.05±4.86^{a}	105.96±1.28^{a}	0.853

Means followed by the same letter with in the column are not statistically significant

Various factors may modulate feed intake in birds such as environmental temperature, energetic content of the diet, texture and palatability of the feed (Abdullah *et al*., 2010; Siegel, 2014). Feed intake may be increased due to increased frequency of feeding, feeding at cooler times of the day and use of longer periods of light (NRC, 1994).

Body weight

Table 3 Body weight (g) of poultry during experimental period

Age of poultry in week	T1 (Mean ± Std.error)	T2(Mean ± Std.error)	T3(Mean ± Std.error)	T4(Mean ± Std.error)	T5(Mean ± Std.error)
17th week body weight	1191.9 ± 34.26^{a}	1190.8 ± 19.39^{a}	1285.2 ± 65.10^{a}	1337.6 ± 53.11^{a}	1158.6 ± 59.03^{a}
21st week body weight	1619.51±48.90 ^{a}	1482.12±51.54 ^{a}	1443.98±44.88 ^{a}	1627.14±67.70 ^{a}	1472.38±74.18 ^{a}
25th week body weight	1728.36±16.06^{a}	1633.20±42.61 ^{a}	1631.40±18.89 ^{a}	1725.80±58.95 ^{a}	1615.20±55.51 ^{a}
29th week body weight	1838.60±40.30 ^{a}	1818.80±72.90 ^{a}	1802.00±66.66 ^{a}	1883.80±87.80 ^{a}	1719.20±77.10 ^{a}
33rd week body weight	1863.80±35.92 ^{a}	1933.20±68.11 ^{a}	1923.80±86.62 ^{a}	1968.00±119.39 ^{a}	1794.40±57.94 ^{a}
37th week body weight	1862.80±36.52 ^{a}	1906.60±98.71 ^{a}	1896.26±87.80 ^{a}	1950.40±113.76 ^{a}	1746.40±64.42 ^{a}

Means followed by the same letters are not statistically significant

Supplementation of fish silage in the diet had no significant (P> 0.05) effect on body weight. However, chickens showed great feed intake, which was implicated in a rapid increase in weight from the beginning

of the experiment (Table 2). Body weight of chickens monthly did not show significant difference between treatments (P>0.05), although the chicks in treatment with 6 % fish silage included exhibited a slightly higher body weight (1968.00±119.39 gram) than other treatments. Different scholars supplemented this finding that the inclusion of fish silage in the diet showed no effect on weight gain in broilers s(Espe *et al*., 1992; Vizcarra-Magaña et al., 1999; Santana-Delgado et al., 2008; Al-Marzooqy *et al*., 2010). However, Kjos *et al*. (2000) found better weight gain in broilers by including 5% fish silage and 0.8 % fish oil in the diet. Skrede and Kjos (1996) reported that fish silage is a source of highly available amino acids. The results of this study suggested that layers fed containing 6% biological silage had an acceptable production and egg quality performance.

Egg production

Table 4 Egg number per bird (No.) and Hen-day egg production (%) at 4 weeks interval starting from 21 weeks of age

Age of poultry in weeks	T1 (Mean ± Std.error)	T2(Mean ± Std.error)	T3(Mean ± Std.error)	T4(Mean ± Std.error)	T5(Mean ± Std.error)
21-24	11 (36.7)	8.4(28)	3.6(12)	12.2(40.7)	9.6(32)
25-28	24.6 (82)	16.6(55.3)	16.8(56)	25.4(84.7)	22.6(75.3)
29-32	24.4(81.7)	20.2(67.3)	21.8(72.7)	26.6(88.7)	25.4(84.7)
33-36	25.6(85.3)	22(73.3)	22(73.7)	26.2(87.3)	24.4(81.3)
37-40	26.8(89.3)	23.2(77.9)	22.8(76)	26.4(88)	25(83.3)
Total number of egg per bird	112.4	89.6	87	116.8	107
Over all hen day egg production (%)	74.9	59.7	58	77.8	71.3
Age at start of laying egg (day)	157	154	152	149	152

The age at first egg ranged between 149 days to 157 days. Age at first egg was lowest (149 days) in hens feeding on 6% fish silage and highest (157 dads) in hens fed no fish silage included diets, which is lower than the Gramapriya and Vanaraja as reported by Haunshi et al. (2009) and higher than that reported in a two-way cross variety by Niranjan *et al*. (2008). There exists difference for the egg production between different four weeks intervals. Egg production at different weeks of age (Table 4) indicates that the birds are laying good number of eggs at different weeks of age and the egg production was better than the report of Niranjan *et al*. (2008) in various two way crosses except in Gramapriya, which was produced 237.35 eggs up to 72 weeks of age. Egg production at 4 weeks of interval starting from 21 to 40 weeks of age indicated that the peak production was observed between 37 and 40 weeks of age (Table 4). There were differences between treatments in egg production; which was highest for the 6 % silage treatment (116.8 eggs/hen/ five months), followed by 0% silage (112.4 eggs/hen/ five months), 8 % silage (117 eggs/hen/ five months), 2 % silage (89.6 eggs/hen/ five months) and 4% silage (87 eggs/hen/ five months), which corresponded to % hen-day egg production rates for the four groups of 77.8 %, 74.9 %, 71.3%, 59.7 % and 58 % for the 6%, 0%, 8%, 2% and 4% treatments, respectively.

Egg weight

Egg weights recorded at different weeks of age starting from 21 weeks of age are presented in Table 5, including the first egg weight. Significant (P < .05) difference between egg weights at different weeks of age was observed and is in agreement with the reports of Padhi *et al*. (2014b) and Padhi *et al*. (2013a).

Table 5 Egg weight (g) and egg number per treatment at 4 weeks interval starting from 21 weeks of age

Age of poultry in weeks	T1 (Mean ± Std.error)	T2(Mean ± Std.error)	T3(Mean ± Std.error)	T4(Mean ± Std.error)	T5(Mean ± Std.error)
21-24	48.81 ± 0.51^{a} (55)	49.06 ± 0.94^{a} (42)	52.58 ± 0.87^{a} (18)	49.85 ± 0.97^{a} (61)	50.78 ± 0.80^{a} (48)
25-28	53.76± 0.44^{c} (123)	53.45±0.38^{c}(83)	56.73±0.47^{ab} (84)	56.96±0.62^{a} (127)	55.42±0.34 ^{b}(113)
29-32	57.69±0.41^{c} (122)	56.77±0.40^{bc} (101)	58.79±0.35^{ab} (109)	59.72±0.59^{a}(133)	59.75±0.44^{a}(127)
33-36	59.32±0.31^{c}(128)	58.31±0.34^{c}(110)	61.82±0.37^{b}(110)	64.79±0.46^{a}(131)	61.32±0.44^{b}(122)
37-40	60.70±0.21^{d}(134)	62.20±0.39^{c}(116)	63.93±0.45^{b}(114)	68.59±0.43^{a}(132)	64.59±0.58^{b}(125)
Total number of eggs	562	448	435	584	535

The effect of treatment on mean egg weight for the whole period was significant (P<0.05). Egg weight increased with an increase in the age of birds and between 37-41 weeks age, mean egg weight was 60.70±0.21, 62.20±0.39, 63.93±0.45, 68.59±0.43 and 64.59±0.58 for treatments 0%, 2%, 4%, 6% and 8%, respectively. This finding is in agreement with the reports of Padhi et al. (2014b) and Padhi et al. (2013a). The egg weight at 40 weeks of age (68.59±0.43 g) was better than Vanaraja and Gramapriya as reported by Haunshi et al. (2009). Egg weight is correlated with body weight of laying hens. The relative egg weight during a laying cycle parallels the relative body weight. Within a flock, heavier birds lay heavier eggs (NRC, 1994).

Conclusion and recommendation

Fish silage is a versatile animal feed and if correctly made can be safely stored, even for a year. Inclusion of fish silage into commercial poultry diet has enormous advantage. It was observed that, age at first egg laying was 149 days in hens fed on 6% fish silage while it was 157 days in hens fed on diet which do not contain fish silage. The average hen day egg production was best for the 6 % silage diet included (116.8 eggs/hen/ five months) as compared to diet containing no silage (112.4 eggs/hen/ five months). A Laying hen fed on 6% silage laid 68.59 gram average weight as compared to 60.7 gram average weight during feeding period of five months. Addition of 6% fish silage into commercial poultry diet increased early egg laying, feed intake, weight gain, egg production and average weight of eggs. Generally, including 6% fish silage into commercial poultry diet has increased 2.9 % hen days egg production, decreased 8% age at first egg laying days and increased 7.89 % in egg weight. Further research needs to be done on growth performance and meat quality of broilers

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A Study of Immune Response in Nile Tilapia (*Oreochromis niloticus*) Fed Levamisole Incorporated Diet

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Abstract

This study was undertaken to evaluate the influence of levamisole on the immune enhancement of Nile tilapia (*Oreochromis niloticus)* against potential bacterial pathogens, Fish with weight of 98±5 g were randomly distributed into seven groups each at a rate of 20 fish per 300-L aquarium and fed on a diet containing 0.0, 250, 500, 750, 1000, 1250 or 1500 mg levamisole/kg diet for eight weeks. After the feeding trial, fish were challenged by pathogenic *Aeromonas hydrophila, E.coli, Staphylococcus aureus* and *Salmonella*, which was given by intraperitoneal (IP) injection and they were kept under observation for 10 days to record any abnormal clinical signs and the daily mortality rate. Levamisole fed fish groups showed significant activation of non-specific immunological measures together with a relative enhancement of resistance against challenged bacteria. Interestingly, the indices study indicated that the fed group showed significant ($p<0.05$) increment in all immune parameters like phagocytic activity, serum bactericidal activity and leukocrit. The challenge studies (RPS) also clearly indicated that fish supplemented diet containing 1500 mg levamisole/kg diet showed high protection (85%) over the control group. The lowest fish mortality and bacterial counts were obtained when fish fed diet containing 1.25-1.5g levamisole. These results indicate that levamisole supplementation is promising for disease prevention in tilapia culture.

Key Words: Levamisole, *O. niloticus, Immune system, Fish, Pathogenic Bacteria*

Introduction

Aquaculture represents one of the fast growing food producing sectors and in the aim to increase productivity per unit space, fishes are usually cultured in narrow space such as pond or net cages under high densities, thus overcrowding tends to adversely affect the health of cultured fish making them a feasible target to infectious disease. As a consequence, several studies have looked into modulation of fish immune system in order to prevent the outbreak as reviewed recently by Sakai (1999). Disease outbreaks are increasingly being recognized as a potential constraint on aquaculture production and trade and cause massive financial loss either through mortality or reduced meat quality, resulting in reduced profit margins (Smith *et.al*., 2003).

One of the major issues in intensive finfish aquaculture is loss associated with disease. A number of approaches have been applied in an attempt to address this problem including sanitary prophylaxis, disinfection, chemotherapy with a particular emphasis on the use of antibiotics, and in recent time's vaccination against specific diseases (Chevassus and Dorson, 1990). However there are practical difficulties and undesirable consequences associated with some, if not all of these approaches. For instance, prophylaxis, based on sanitary isolation is difficult to achieve due to the presence of other fish

species, invertebrates or the water itself (Chevassus and Dorson, 1990). Antibiotic therapy is undesirable, as there is the potential for enhanced microbial resistance and the accumulation of residues in the tissues of the fish (Siwicki, 1989). Vaccination, although highly effective in some instances, is time consuming, labor intensive and costly and protection is often pathogen specific (Robertsen *et al.,* 1994). An alternative approach has been the application of various compounds to boost or stimulate the innate immune system of cultured fish (Castro *et al.,* 1999).

The use of chemicals to control bacterial and other parasitic infections in fish population resulted in bioaccumulation, human carryover and pollution. Similarly, the widespread use of antibiotics leads to development of antibiotic resistant bacteria, immunosuppression and destabilization of helpful bacterial population. The application of antibiotics and other chemicals to pond culture is also quite expensive and undesirable, as it risks contamination of the environment and the final product as well as impaired growth. The use of antimicrobial drugs in Norway, a major fish producer, has dropped from approximately 50 metric tons per year in 1987 to 746.5 kg in 1997, measured as active components, and this is mainly due to mass vaccination and selection programs for important diseases (Verschuere. *et.al,* 2000).

Considering the recent successes of these alternative approaches, the Food and Agriculture organization of the United Nations (FAO) defined the development of affordable yet efficient vaccines, the use of immunostimulants and non-specific immune enhancers, and the use of probiotics and bio-augmentation for the improvement of aquatic environmental quality as major areas for further research in disease control in Aquaculture (Subasinghe, 1997).

One of the main emphases in Ethiopia is to develop aquaculture to its full potential making a big contribution to national food availability, food security, economic growth, and trade and improved living standards. However, along with the growing interest in the development of fish industries in the different sites of the area, there will be an increasing awareness of importance of fish disease as one of the major detrimental factors in culturing fish in the coming future.

Objectives

- To assess the concentration response and time course effects of levamisole treatment through oral route on selected components of the immune system of Nile tilapia (*Oreochromisniloticus*) and to evaluate the responses of levamisole treated Nile tilapia (*Oreochromisniloticus*) to the experimental bacterial challenge.

Materials and Methods

Fish and husbandry conditions

Fishes samples were collected using different centimeter mesh sizes of gillnets from selected water bodies. Gillnets will be set at certain study sites of the lake during day time and throughout the night. Immediately after capture, total length (TL) and total weight (TW) of each specimen will be measured to the nearest 0.1 cm and 0.1g, respectively. The fish was immediately disinfected with 3% sodium chloride for 5 min and they were kept for 2 weeks under observation for acclimatization in water tank. Fish was randomly distributed into each of 7 PVC tanks (300 liter capacity) filled with 150 liters of water. Each

tank was supplied with aerated de-chlorinated fresh water every four days; water temperature was maintained at 25 ± 1°C with dissolved oxygen of 8.5 ppm.

Diet preparation

A fish feed was prepared by first mixing dry ingredients fish meal together for 15 minute to ensure homogeneity and then adding in hot water. This mixture was steamed for 15 min, allowed to cool and levamisole at 0.0, 250, 500, 750, 100, 1250 and 1500mg/kg of diet was added to steamed and cooled feed mixture and then palletized. All pellets was separately air dried and stored in tightly sealed plastic bags at 8-10°C until they used in the feeding experiments.

Levamisole treatment

Fish was randomly distributed into each of 7 PVC tanks (300 liter capacity) filled with 150 liters aged tap water with continuous aeration. Fish in each tank were fed with 0.0, 250, 500, 750, 100, 1250 and 1500mg levamisole/kg diet, on the first day and every 3rdday for 16 days (7 doses, two divided doses per day) and fed with the control diet for the remaining days. Half of the water in each of the tanks was exchanged with fresh aged tap water every four days.

Blood sampling:

Collection of blood samples was taken place from five fish from each tank at 14 and 21 days after the last application of levamisole for immunological assay. Blood samples were taken from the fish by bleeding from caudal vein by using 21 G needles. Fish was anaesthetized in neutralized benzocaine (200 mg L^{-1}) prior to blood sampling (Treves-Brown, 2000).

Haematocrit and leucocyte counts

At the end of the feeding trial, fish were fasted for 24 hours immediately prior to blood sampling and five fish per aquaria were randomly chosen and anesthetized with benzocaine (200 mg L^{-1}). The blood was extracted from the caudal vein in Eppendorf tubes with sodium heparinate (500 U/L), used as anticoagulant, for the counting of white blood cell (WBC) at 14 and 21 days after the last application of levamisole. For detection of the haematocrit levels, blood samples was taken into heparinized capillary tubes and centrifuged in the haematocrit centrifuge at 2000 rpm for 20 min. Heamatocrit (PCV) value of each sample was measured using the haematocrit gauge. Total leucocyte count was determined using Shaw's solutions as dilution fluids following the method of Hesser (1960). A Blood smear of the fish was prepared, fixed in 100% methanol and stained with Wright-Giemsa stain. Different types of leucocytes were identified as described by Hibiya (1982) and Brown (1988).

Phagocytosis assays:

Phagocytic cells were detected using identified bacterial pathogen of fish as described by Anderson and Siwicki (1995). A sample (0.1 mL) of blood was placed in a micro titer plate well, 0.1 mL of *Aeromonas hydrophila, E.coli, Staphylococcus aureus and Salmonella* cells suspended in phosphate buffered saline was added and then mixed well. The bacteria–blood solution was incubated for 20 minutes at room temperature. 5µL of this solution was taken on to a clean glass slide and a smear was prepared. The smear was air dried, then fixed with ethanol (95%) for 5 min and air dried. Then the smear was stained with Giemsa stain for 10 min. The two smears were made from each fish. The total of 100 neutrophils and monocytes from each smear was observed under the light microscope and the number of phagocytizing

cells and the number of bacteria engulfed by the phagocyte were counted. Phagocytic rate (PR) was calculated as follows: Phagocytic activity equals the number of phagocytizing cells divided by the total number of phagocytes counted.

PR= (Number of phagocytes with engulfed bacteria/Number of phagocytes) X 100

Relative percentage of survival:
Bacterial pathogen (*Aeromonas hydrophila, E.coli, Staphylococcus aureus and Salmonella)* was taken from Ethiopia Institute of Health and Nutrition Research and was inoculated in a tryptone soy broth and was incubated at 30°C. These species of bacteria were selected because they play a great role in causing disease in open water of the country. After centrifugation at 800g for 15 min, the packed cells were washed and prepared in PBS. At the end of the study, fish in each aquarium were divided into two groups. The first group was challenged with 0.1 ml dose from virulent bacterial pathogen. The second group was IP injected by 0.1 ml of saline solution as a control. All groups were kept under observation for 10 days to record any abnormal clinical signs and the daily mortality rate. The cause of death was ascertained by re-isolating the bacteria from the kidney and liver of dead fish (Misra *et al*., 2006). Relative percentage survival (RPS) was calculated as follows: Mortality (%) of untreated minus Mortality (%) of treated divided for Mortality (%) of untreated controls multiply by 100

Bacteriocidal activity
Bacteriocidal activity in fish samples was analyzed according to the Miles–Misra technique (Okada *et al.,* 1999). *Bacteria* used in this assay was stocked at −80°C in glycerol solution. These strains were inoculated with tryptone soy broth (TSB). Bacteria culture was grown for 24 h at 30^{o}C on TSB medium, and the culture broth was centrifuged, washed with saline solution and suspended in gelatin veronal buffer (GVB). Viable counting was conducted by inoculating with serial dilution in GVB on tryptone soy agar (TSA). The serum sample was mixed with GVB (1:1 v/v) and stored at 4^{o}C. Serum samples were mixed with an equal volume of bacterial suspension and incubated at 30^{o}C. The number of viable bacteria was then calculated by counting the resultant colonies from the incubated mixture on TSA (tryptic soy agar) plates after incubation for 24 h in duplicate

Data Management and Analysis
Statistically data was analyzed using descriptive statistics and mean comparison procedure of the Statistical Package for Social Science Software (SPSS 20.0).

Results and discussions

Fish fed on diets containing 750-1500mg levamisole /kg diet exhibited similar RBC and WBCs counts and their ranges were 2.22 – 2.64 x 10^{6}/L and 3.39 – 4.34x10^{5}/L, respectively. The low counts of RBCs and WBCs were obtained at the control diet 1.66 x 10^{6}/L and 2.94x10^{5}/L, respectively (Table 1). No significant changes in lymphocytes were observed at 750 – 1500 mg/kg diet, whereas the lowest one was observed at the control diet (81.4%). Contrarily, the control diet produced the highest monocytes and granulocytes, which decreased with the increase of Levamisole levels in fish diet ($P < 0.05$; Table 1).

The bacterial count after incubation with fish sera decreased with increase of levamisole level in fish diets. The lowest bacterial count was obtained in fish fed 750-1500mg levamisole/kg of diet, whereas the highest one was obtained when fish fed control diet (Table 2).

Fishes fed with higher concentration (750-1500mg levamisole/kg of diet) showed significant survival rate when challenged with *Aeromonas hydrophila, E.coli, Staphylococcus aureus and Salmonella*. High mortality rate was observed in control group. The experimental groups that received low doses of levamisole showed mortality at a lower rate when compared to that of control group. The total fish mortality 10 days after IP with pathogenic bacteria decreased significantly ($P < 0.05$) with the increase of levamisole supplementation (Fig. 1).

No significant leukocyte concentration ($x10^3$cells/mm^3) was observed in throughout the study period. The group fed 1500mg/kg levamisole supplemented diet showed elevated leukocrit value, but not statistically significant one ($p>0.05$). Phagocytosis rate (PR) on bacterial cells was not much influenced by *levamisole* supplementation but in high dosages PR was significant ($p<0.05$) than control and other group. The groups fed with lower concentration of *levamisole* did not showed significant bactericidal activity ($p>0.05$) but higher concentration (1500mg/Kg) showed significant bactericidal activity ($p<0.05$).

Table 1. Red blood cell count (RBC), white blood cell count (WBC), lymphocytes, monocytes and granulocytes of Nile tilapia fed practical diets containing different levels of levamisole for 8 weeks.

Items	**Levamisole levels (mg/kg diet)**						
	0.0	**250**	**500**	**750**	**1000**	**1250**	**1500**
RBC ($x10^6$/µL)	1.66±0.087b	1.92±0.079b	2.07±0.127 ab	2.22±0.153 a	2.48±0.158 a	2.54±0.127 a	2.64±0.138 a
WBC ($x10^5$/µL)	2.94±0.124b	3.21±0.133b	3.29±0.176 ab	3.39±0.098 a	3.97±0.127 a	4.02±0.133 a	4.34±0.136 a
Lymphocytes(%)	81.4±0.19 c	86.1±1.59 bc	92.2±2.52 bc	94.1±2.71 ab	94.1±2.71 ab	96.3±2.62 ab	97.8±0.233 ab
Monocytes (%)	11.2±0.18 a	9.1±0.16 a	5.5±0.19 b	4.6±0.15 b	4.6±0.15 b	2.8±0.06 c	1.9±0.08c
Granulocytes(%)	7.4±0.13 a	4.8±0.03 b	2.3±0.06 c	1.3±0.06 c	1.3±.0.06 c	0.9±0.06 d	0.3±0.05d

Note: The same letter in the same row is not significantly different at CI of 95%.

Table 2. The total counts of *bacteria* 24 hr-after incubation with serum of Nile tilapia fed different levels of levamisole for 8 weeks.

Item	**Levamisole levels (mg/kg diet)**						
	0.0	**250**	**500**	**750**	**1000**	**1250**	**1500**
Bacterial count ($x10^4$ cell)	82.7±3.28 a	68.0±1.73 b	61.2±1.73 c	46.7±2.96 d	42.3±2.03 d	43.3±2.03 d	33.2±2.03 d

Note:The same letter in the same row is not significantly different at CI of 95%.

Table 3. The immune parameters of Nile tilapia fed with different levels of *levamisole* in water tank for 8 weeks

Items	**Levamisole levels (mg/kg diet)**						
	0.0	**250**	**500**	**750**	**1000**	**1250**	**1500**
Phagocytic Rate	36.66±2.7 b	37.7±2.9 b	38.34±2.7 b	37.5±1.53 b	39.48±1.58 b	42.54±1.27 b	51.4±1.38 c
Bactericidal Activity	0.02 a	0.06 a	0.07 a	0.07 a	0.06 a	0.07 a	0.11 b
Leukocrit ($x10^3$cells/mm^3	22.4±1.9 c	24.2±2.1 c	22.23±1.5 c	23.12±1.3 c	21.1±1.7 c	22.26±1.6 c	26.7±1.3 c
PRP (%)	0 a	20 a	40 a	75 c	80 c	80 c	85 c

Note: The same letter in the same row is not significantly different at CI of 95%.

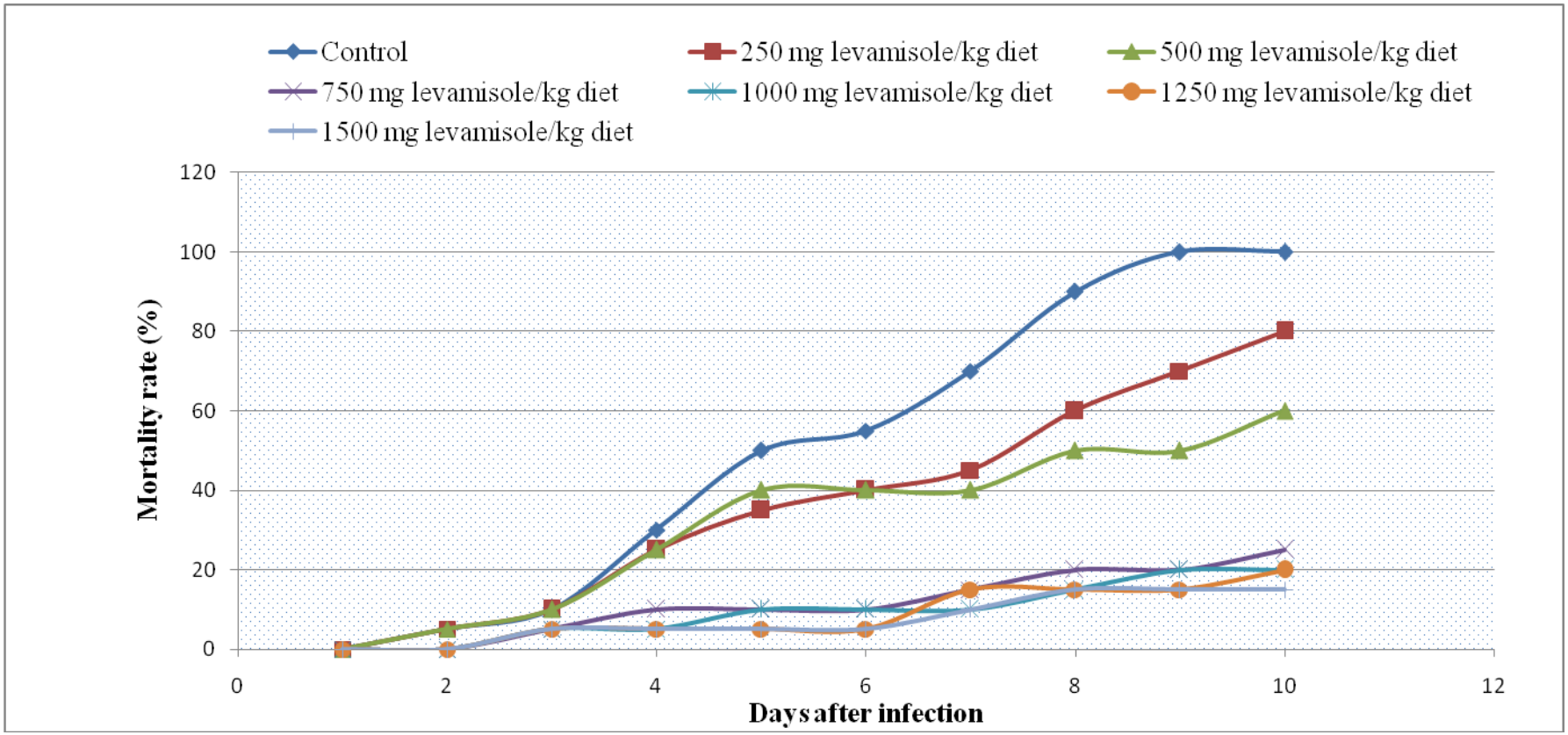

Figure 1. Mortality rate of Nile tilapia fed with different levels of levamisolein water tank for 8 weeks and challenged by bacteria for 10 days

Application of immunostimulators in the aquaculture industry can be considered a remarkable advantage because of their safety and the fact that they are considered environmentally friendly (Dügenci *et al*., 2003; Jian and Wu, 2004). Levamisole has been found to stimulate the immune responses significantly in both *in vitro* and *in vivo* in mammals. In the present study, oral administration of Levamisole increased serum lysozyme activity in all groups which receive Levamisole than normal control groups. It has been observed that immunostimulants, vaccines and probiotics can enhance the plasma lysozyme activity (Swain *et al*., 2006; Yuan *et al*., 2007). Lysozymal activity is an important defense mechanism in fish, which causes lysis of bacteria and activation of the complement system and phagocytes by acting as an opsonin.

In the present study, fish fed on diets containing 750–1500mg levamisole /kg diet exhibited higher RBCs and WBCs counts, as compared with fish fed the control diet. Since levamisole has the ability to initiate and boost the immune system of different organism, it will resulted in increased number of WBCs. These results proved the improvement of fish health when fed levamisole-supplemented diets. No significant changes in lymphocytes were observed at 750–1500mg/kg diet, whereas the lowest one was observed at the control diet (81.4%). Contrarily, the control diet produced the highest monocytes and granulocytes, which decreased with the increase of Levamisole levels in fish diet.

In the present study, the results of bacteria challenge and bacteriocidal activity suggest the increase in phagocytosis in blood at higher levamisole level, which have an important role for prevention of infectious disease. Phagocytosis by these cells is a process of internalization, killing and digestion of invading microorganisms. In phagocytosis, phagocytes produce oxygen free radicals during the respiratory burst, which is toxic to bacteria. Several authors reported that phagocytosis is stimulated by oral administration of probiotics (Rengpipat *et al*., 2000; Li and Gatlin, 2004; Panigrahi *et al*., 2005; Taoka *et al*., 2006).

It is very important to estimate the useful impacts on fish treated with immuno-stimulants. In this study, the obtained results showed that tilapia fed 750–1500mg levamisole/kg diet increased the fish resistance against bacterial challenge. In this regard, Watanuki *et al*. (2006) estimated the fluctuation in the number of bacterial cells in Spirulina-treated fish organs after an artificial challenge with *A. hydrophila*. They found that the bacteria numbers were lower in the liver and kidney of carp treated with Spirulina than the control group suggesting the increased resistance *A. hydrophila* infection.

The present study concluded that levamisole positively improved resistance to bacterial infection of Nile tilapia. In addition, this study found that the optimum rate of levamisole in the fish practical diet is 750–1500mg levamisole /kg diet.

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Feeds Resource and Rangeland Management Research Results

Determination of Optimum Planting Date and Seed Rate of *Brachiaria Decumbens* at Bako Condition

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Abstract:

The experiment was conducted at Bako Agricultural Research Center (BARC) for three years (2013, 2014 and 2015) to compare the effect of sowing dates and seeding rates on productivity of Brachiaria decumbens. The treatments consisted of four sowing dates (1 week, 3 weeks, 5 weeks and 7 weeks) after onset of main rain and four levels of seeding rates (6, 8, 10 and 12) kg ha^{-1}. Accordingly, sowing dates started on May 28, 2013 and thereafter at 14-days intervals: June 11, 2013; June 25, 2013 and July 09, 2013. An experimental design of a randomized complete block in factorial arrangement with three replications was used. The analysis of variance indicated that seeding rate by planting time interaction effect was highly significant ($p<0.01$) for herbage DM yield and seed yield. However, none significant differences were observed for plant height, plot cover and vigorousity. The highest herbage dry matter yield and seed yield (18.67 ton ha^{-1}) and (6.37 Qt ha^{-1}), respectively were obtained from seeding rate of 6 kg ha^{-1} that planted at three weeks after the commencement of main rainy season. Year have also significant ($p<0.01$) effect on both herbage dry matter and seed yields. Maximum herbage dry matter yield (22 ton ha^{-1}) and seed yield (9.76 qt ha^{-1}) were obtained during the first year (2013) than in the second sowing time (June 11, 2013) at 6 kg ha^{-1} seeding rate. Therefore, it can be recommended that the lower seed rate (6kg ha^{-1}) sown at 3 weeks after commencement of the main rain was produced better herbage DM (18.7 ton ha^{-1}) and seed yields (6.37 qt ha^{-1}) and was favorable for Bako area and similar agro ecologies.

Keywords: *Brachiaria decumbens*, herbage yield, sowing time, seed rate

Introduction

The low production and productivity of Ethiopian livestock is a result of several limiting factors among which feed is the major one. For the country as a whole the existing feed does not meet the amount required by livestock. In most parts of the country natural grasslands are confined to degraded shallow upland/highland, fallow crop lands and soils that cannot be successfully cropped due to physical constraints such as flooding and water logging. They are low yielding and their production is insufficient and grazing conditions are only favorable for four to five months per year (Alemayehu *et al*., 2016). Residues from cereals are the main source of animal feed but these are low in protein and have poor digestibility. Fodders are the most valuable and cheapest source of feed for livestock having rich source of metabolizable energy, nutrient elements, carbohydrates and protein. The production of adequate quantities of good quality dry season forages to supplement crop residues and pasture roughages is the

only way to economically overcome the dry season constraints affecting livestock production. Generally, good quality forage is high in protein and digestible nutrients, and low in fiber and lignin. Also, animal performance is a better indicator of forage quality (Ahmed A. Bakhashwain, 2010).

Brachiaria decumbens (Signal grass) is a highly productive tropical grass that is widespread in different agro-ecologies due to its adaptation to a wide range of soil types and environments including infertile acid soils with low pH (<3.5) and climates ranging from tropical to sub-tropical (Keller-Grein, *et al.*, 1996, Bogdan, A., 2012). It is able to withstand short-term drought conditions by re-allocation of biomass and adjustment of growth rates' resulting in no significant differences in biomass yield but is highly susceptible to water logging and can only tolerate flooding for a few days(Loch, D.S, 1977 and Guenni, O., *et al*., 2002). In the past three decades, extensive research has been done at BARC to evaluate the adaptability and performance of different forage species under different agro-ecological zones particularly in the western region with the special focus on the mandate areas of the center. Among these forage species *Brachiaria decumbens* is one of the potential grass that was adopted at BARC and was expected to solve the severe feed deficit that the region is presently facing. However, information on the production packages (agronomic practices); like sowing date and seed rate are not yet determined and lagging behind.

Germination is a natural process that occurred during growth period of seeds in which they meet the minimum condition for growth and development (Sangronis et al., 2006). Germination of tropical grasses and legumes is typically low mostly due to dormancy restriction (Antonio sotomay & pitman, 2001), which might be improved through planning at proper planting time. Date of planting has a significant role in harvesting maximum yield from a plot of land. Besides other agronomic management recommendations, seeding rate and planting date play a great role in harvesting maximum yield from a plot of land (Tessema Zewudu.1996). Therefore, the objective of the current study was to determine the suitable seeding rate and a specific planting time to optimize *Bracharia decambus* yield.

Materials and Methods

Description of the Study Area

The experiment was conducted at BARC which is found at 1650 m.a.s.l, 7°17'12.5"N; 38°25'47.5"E and 250 km west of Finfine. During the growing seasons of 2013, 2014 and 2015, the annual rain fall were 1431, 1067 and 944mm, respectively with the average mean value of 1147 mm. Mean value of the temperature recorded was 21^{o}C with a range of 13 to 29^{o}C (BARC meteorological station 2013-2015). Dominant soil types are Nitosols with fertile alluvial soils in valley bottoms. The area is known for its mixed crop livestock farming system in which cultivation of maize , teff (*Eragrostis tef*), noug (*Guizotia abyssinica*), sorghum, finger millet are the major crops in their order of importance (BARC, 2003). Major animal feed resources are natural pasture, crop residues and improved forage species. Cattle and sheep are important livestock species abundantly found in the areas.

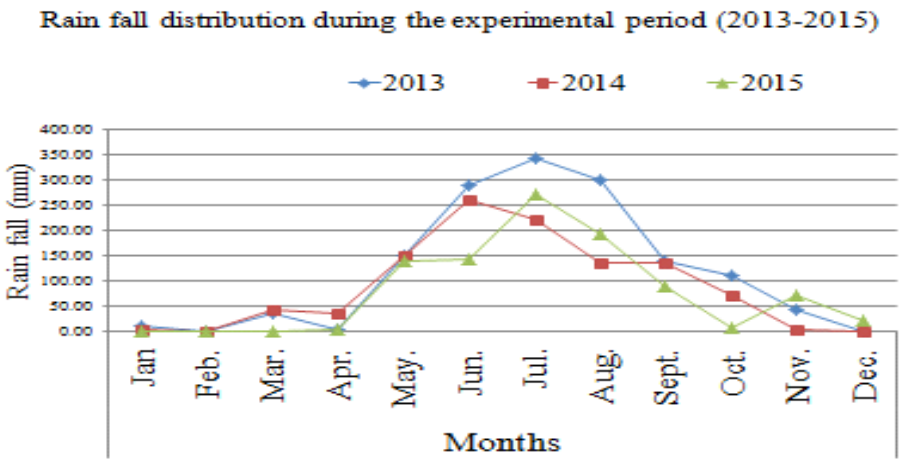

Figure 1: Rain fall distribution of the tested environment during the experimental period (2013-2015):

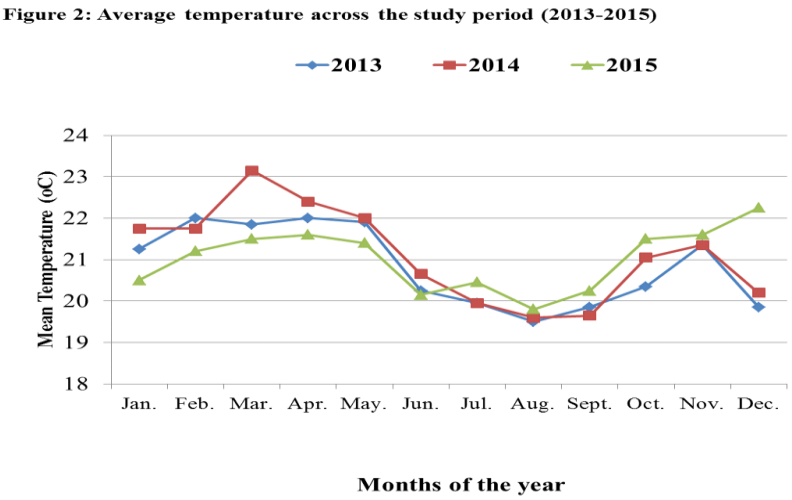

Figure 2: Average temperature across the study (2013-2015):

Treatment Description and Experimental Design

The treatments consists of four sowing dates (1 week, 3 weeks, 5 weeks and 7 weeks) after onset of main rain and four seed rates (6, 8, 10 and 12) kg ha^{-1} of *Brachiaria decumbens* species**.** Randomized complete block design in factorial arrangement with three replications was used. The seed was planted on $12m^2$ plots (3m* 4m) having six rows with intra-row spacing of 30cm and 1m distance between rows. Crop management practices (hoeing, weeding etc.) were practiced as required. Both DAP and Urea at the rate of 100kg/ha with split application was used followed during the first season. Data from herbage yield, seed yield and other important agronomic parameters were measured as dependent variables. For

sampling 200gm fresh biomass were taken and partial DM contents were determined by oven drying at 65oC for 72 hours to a constant weight. All agronomic parameters were subjected to ANOVA using SAS (SAS, 2008) software.

Results and Discussion

The results of the analysis indicated a significant effects of B*racharia decumbas* sowing date and seeding rate on most of the tested variables (Table 1). Seeding rate by planting time interaction effect was highly significant ($p \leq 0.01$) for herbage DM yield and seed yield. However, no significant differences were observed for plant height, plot cover and vigorousity. The planting time mean square was significant for all parameters considered. Similarly, highly significant ($p \leq 0.01$) variations between the years for almost all parameters except vigorousity which was showed non-significant results. This might be due to the variations of rainfall distribution during the experimental period. The mean square of seeding rate also showed a significant effect on DM yield, seed yield and plot cover, however, non-significant differences were observed for plant height and vigorousity..

Table 1: Mean squares of ANOVA for seeding rate and planting date of *Bracharia Decumbas* at BARC.

Source of variation	DF	Mean squares				
		DMY	SY	PH	PC	Vig
Block	2	4.569	6.93	10.82	21.88	3.5625
Planting_date	3	41.466**	4.2431*	108.14*	6.465*	3.7292*
Seeding_rate	3	13.772*	2.6755*	41.92	4.187*	1.0625
Year	2	441.419**	415.64**	10364.34**	26.271**	0.00
Planting_date *seedingrate	9	25.426**	5.5306**	27.98	0.763	0.8403
Planting_date *.year	6	4.341	0.6537	29.39	1.215	0.00
Seeding_rate.*year	6	1.478	0.3241	18.35	0.354	0.00
Plantingdate *seedingrate*year	18	1.069	1.379	37.49	1.249	0.00
Error	94	3.391	0.9687	33.95	1.499	0.754

Where, *, **: Significant at 5% and 1%, respectively. DF: Degree of freedom, DMY: herbage yield in Dry mater bases, SY: Seed yield, PH: Plant height, PC: Plot cover, Vig: Vigourisity.

Effects of planting date

Planting date was affected virtually all of the yield and agronomic parameters (DM yield, seed yield, plant height, plot cover and plant vigor). Similarly, experimental periods were shown significant ($p \leq 0.01$) effect on herbage DM yield, seed yield, plant height and plot cover, but non-significant results was observed for plant vigor (Table 1). This might be related to climatic conditions mainly temperature and rain fall of the study area during planting season.

Effects of seeding rate

Seeding rate significantly ($p \leq 0.05$) influenced herbage DM yield, seed yield and above ground cover. On the other hand, seeding rate was not significantly affected plant height and plant vigor in this study (Table 1).

Seeding rate and planting date interaction

Interestingly, there was a significant interaction between seeding rate and planting time on herbage dry matter yield and seed yield concurrently. The highest herbage dry matter yields and seed yield (18.67 ton ha^{-1}) and (6.37 Qt ha^{-1}), respectively were obtained from seeding rate of 6 kg ha^{-1} that planted at three weeks after the commencement of main rainy season (Table 2). This indicated that lower seed rate can provide optimum yields when sufficient moisture and moderate temperature obtained. This is probably due to climatic condition of the study area i.e. under perceived optimal conditions for plant emergence (e.g. ample soil moisture and appropriate soil temperature). Such scenario is suitable for the crops to get the chance to germinate quickly. As germination getting faster, optimum production would be expected.

Surprisingly in this study, lower seeding rate (6 $kgha^{-1}$) has been produced optimum herbage dry matter yield and seed yield comparing with the other seeding rate. On the other hands, there was no significant interaction were observed on plant height, plot cover and plant vigor. Planting Bracharia seed at one week after main rain commencement at higher rate (12 kg ha^{-1}) was produced relatively better herbage dry matter yield (13.86 ton ha^{-1}). This was probably increasing the seeding rate at first rain drop could resulted moderate herbage yield and seed yield production than lower seed rate in this study.

Table 2. Interaction effects of seeding rate and planting date of Bracharia Decumbas at BARC

Planting date	**Seeding rate (Kg ha^{-1})**				**Mean**
Herbage DM yield (ton/ha)	**6**	**8**	**10**	**12**	
1 week after main rain fall	10.9^{e}	13.58^{bcd}	12.04^{de}	13.86^{bc}	12.60
3 week after main rain fall	18.67^{a}	14.61^{b}	12.72^{cd}	13.39^{bcd}	14.85
5 week after main rain fall	14.6^{b}	12.38^{cde}	13.31^{bcd}	13.76^{bcd}	13.51
7 week after main rain fall	12.32^{cde}	13.06^{bcd}	12.36^{cde}	12.52^{cde}	12.57
LSD(0.05)	1.72				
CV %	13.8				
Grain yield (Qt ha^{-1})					
1 week after main rain fall	4.545^{bcd}	3.9^{cde}	3.827^{cde}	3.911^{cde}	4.05
3 week after main rain fall	6.374^{a}	4.431^{bcd}	3.461^{e}	5.1^{b}	4.84
5 week after main rain fall	3.756^{cde}	5.093^{b}	4.281^{bcde}	4.118^{cde}	4.31
7 week after main rain fall	3.972^{cde}	4.537^{bcd}	$4.664b^{c}$	3.691^{de}	4.22
LSD(0.05)	0.9212				
CV %	22.6				

Variation in seeding rate had less pronounced effect on herbage dry matter yield and seed yields than did variation in planting time (Table 2). The responses to seeding rate x planting date were different in each year. The highest average herbage yields (16.18 ton ha^{-1}**)** were obtained during the first year (2013) while 13.81 and 10.16 ton ha^{-1}) obtained during the 2nd and 3rd year respectively. Similarly, seed yields followed the same trend observed on herbage dry matter yields. In view of that, an average seed yield of (6.96, 4.95 and 1.16)qt ha^{-1} were produced during the 2013, 2014 and 2015 cropping season respectively (Table 3). Generally, at first year of growing stage, optimum production was obtained and as the crop getting older the herbage dry matter yields and seed yield was radically decreased.

Impact of experimental duration/years

Interaction effects of seeding rate by planting date on herbage dry matter yields and seed yields were significantly ($p \leq 0.01$) impacted by experimental year. As a result, during the first year (2013) maximum herbage dry matter yield (22 ton ha^{-1}) in the second planting time (*June 11, 2013)* at 6 kg ha^{-1} of seeding rate (i.e. 3*6 planting time by seeding rate interaction) and lower performing (15 ton ha^{-1}) at the same junction during the 3rd year of the experimental period (fig.3). The same trends were followed for seed yield in this study (figure 4). This result is probably due to less competition with weeds, which destroyed the germinated weeds after the initial preparation of the area for the first sowing time, as well as due to climatic conditions encountered in that period.

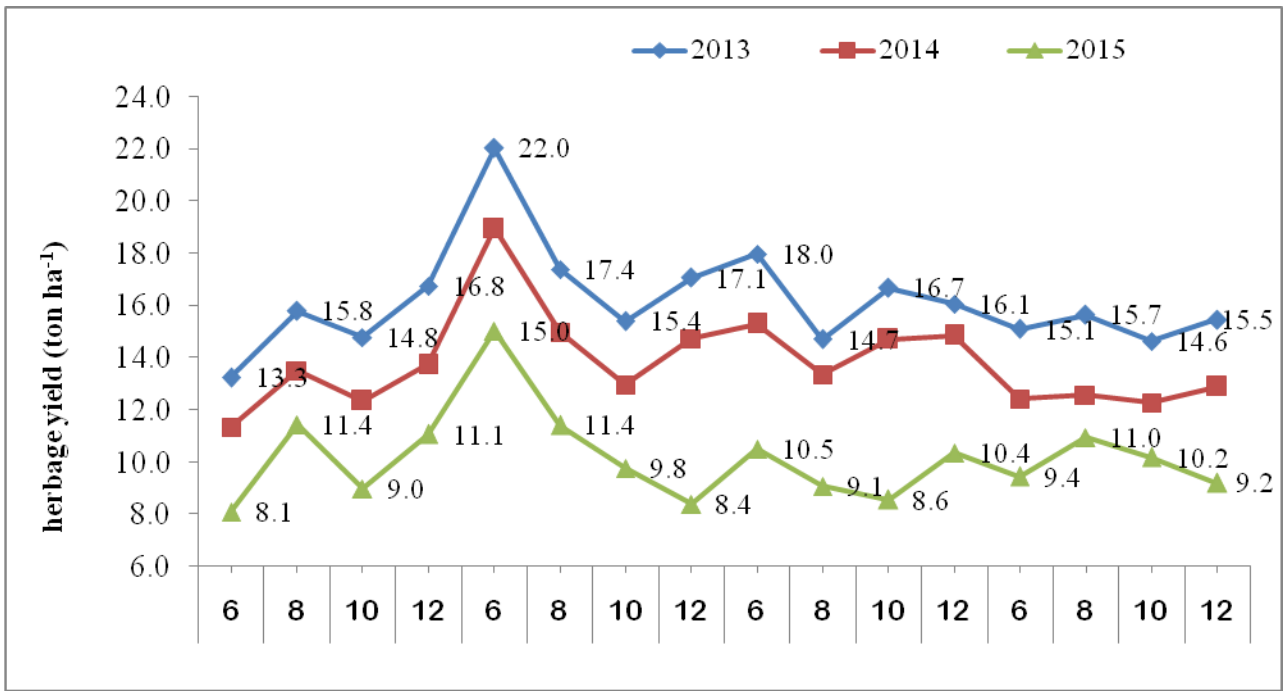

Figure 3: Interaction effects of seeding rate and planting time on DM yield (ton ha^{-1}) of *B.decumbas* across years (2013-2015)

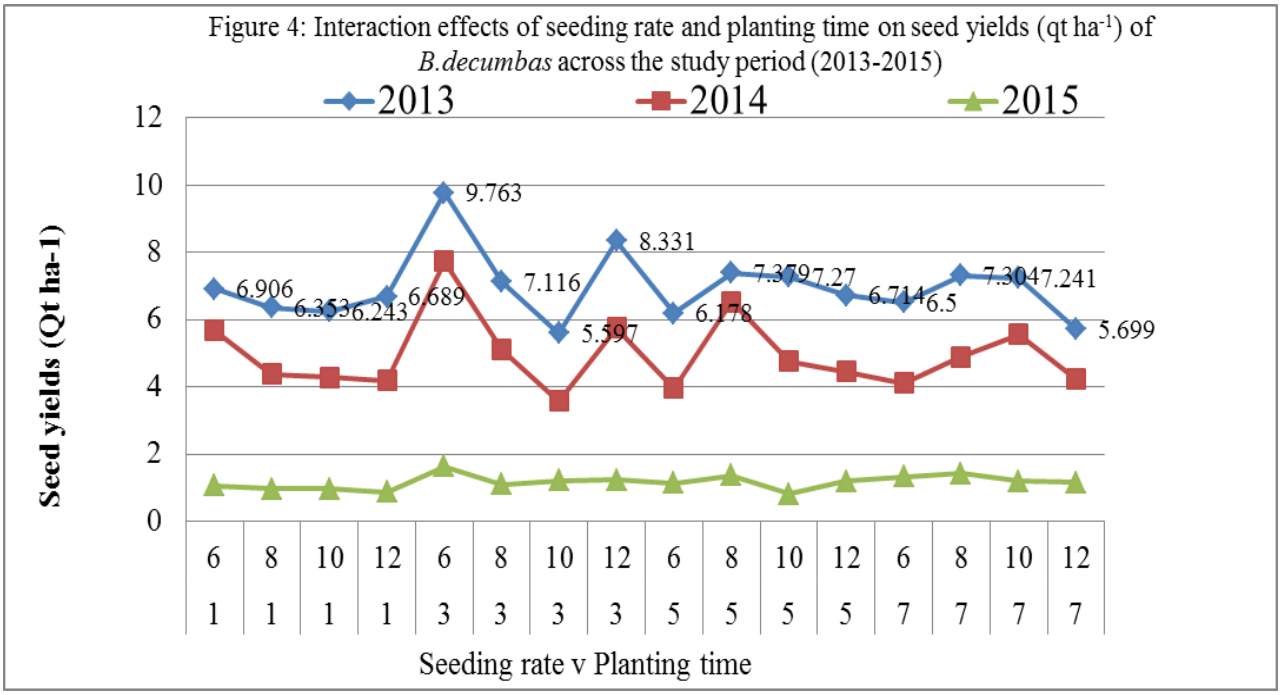

Figure 4: Interaction effects of seeding rate and planting time on seed yield (qt ha^{-1}) of *B.decumbas* across the study period (2013-2015)

Conclusions and Recommendation

The current study showed the interaction effect of planting date and seeding rate was significantly affected both herbage DM and SY, with better harvests taken 6kg ha^{-1} planted at 3 weeks after onset of main rain fall. This might be due to the existence of ample soil moisture and appropriate soil temperature, which may be created optimal condition for plant emergence. It also concluded that the highest seed rate treatment groups, 8, 10 and 12 kg ha^{-1} during the 3-7 weeks onset of rain fall produced lower yields. This could be due to a higher population of plants on a single plot of land resulting in higher competition for soil resources.

In this study experimental year was highly affected ($p \leq 0.01$) production of both herbage dry matter and seed yields, in which the first year (2013) exhibiting superior herbage DM yields (22 ton ha^{-1}) and seed yield (9.76 qt ha^{-1}) in the second sowing time (*June 11, 2013)* at 6 kg ha^{-1} seeding rate. Hence, as the age of the perennial grasses getting older resulted in significant yield reduction and needs remarkable improvements. Therefore, it can be recommended that the lower seed rate (6kg ha^{-1}) sown at 3 weeks after commencement of the main rain was produce better herbage DM (18.7 ton ha^{-1}) and seed yields (6.37 qt ha^{-1}) and was favorable for Bako area and similar agro ecologies.

Acknowledgments

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Registration of "*Gebis-17* and *Beresa-55*" Dolichose lablab *(Lablab purpureus)* varieties

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Abstract

Ten Dolichose lablab (Lablab purpureus) genotypes including the local check were tested across two environments (Bako and Billo) in western Oromia, Ethiopia during 2012, 2013 and 2014 main cropping season to evaluate the performance of Dolichose lablab genotypes for both herbage yield, nutritional quality and their stability across environments. The genotypes were collected from International Livestock Research Institute (ILRI) and arranged in randomized complete block design (RCBD) with three replications. All agronomic managements that were recommended for herbaceous legumes were applied uniformly. Two varieties ' Gebis-17 (ILRI Acc.# 14417)and Beresa-55(ILRI Acc.# 14455) were shown to have superior yielding ability both in herbage yield and other desirable traits over the corresponding check 'ILRI Acc.# 11703)'. The two genotypes had significantly ($p<0.01$) higher herbage yields of 8.43 and 8.37 ton ha^{-1} with 15.01% and 14.19% yield advantage, respectively over the check (4.07 ton ha^{-1}). Besides, Gebis-17 and Beresa-55 varieties had higher ($P<0.05$) crude protein (CP) content with mean value of 26.46 % and 24.86% respectively over the check (21.37 %). . Genotype and genotype by environment interaction biplot analysis (GGE) also confirmed Degagsa and Belebas varieties showed better stability and thus ideal varieties recommended for production in the tested environments and other areas with similar agro-ecologies.

Keywords: *Lablab purpureus, Degagsa, Belebas herbage yield,*

Introduction

Feed shortage and poor quality are indicated as factors responsible for lower production, reproduction and growth performance of animals especially during the dry season (Legesse *et al*, 2008). Crop residues are the dominant livestock feed resources in Ethiopia mainly under crop-livestock mixed production systems. But they are characterized by high fiber (>55%) and low CP (<7%) contents (Dereje *et al*., 2010; Osuji *et al*, 1995). Consequently, their intake level is limited and they scarcely satisfy even the maintenance requirements of animals. So supplementation and treatment of such feeds need to be a focus of attention for ensuring sustainable utilization as animal feed resources for maintainable livestock production in the country. Thus, supplementation of crop residues with plant protein sources such as leguminous forage crops possibly will improve protein deficiency as these contain medium to high levels (12 – 25%) of CP (Solomon et al.,, 2005). The introduction of forage legumes in cereal-based cropping systems is therefore, a promising strategy for improving animal feeds that leads to increase in crop and livestock productivity. As the western Oromia is also characterized by such farming system (cereal-based), the introduction of forage legumes into the cropping system is a means through which livestock productivity could be

increased. Hence, selecting and integrating potential leguminous forages varieties that would enhance the nutritive value of the dominantly used low quality feeds is very crucial.

Thus far, forage legumes genotype selection activities have been conducted at Bako agricultural research center (BARC) and similar agro-ecologies of western Oromia. One of such potential legume species for integration into the existing livestock feeding system is Dolichose lablab (*Lablab purpureus).*

Dolichos lablab (Lablab purpureus) is an herbaceous, climbing, warm-season annual or short-lived perennial fodder legume with a vigorous taproot sown for grazing and conservation. It has a thick, herbaceous stem that can grow up to 0.95m , and the climbing vines stretching up to 7.65 m from the plant (Maass *et al*., 2010). *Lablab purpureus* can grow in a variety of soils, from sand to clay, in a pH range of 4.5–7.5. It has low salinity tolerance with symptoms being chlorotic leaves, reduced growth and plant death (Cook *et al*., 2005), but it grows better than most legumes under acidic conditions. It can continue to grow in drought or shady conditions, and will grow in areas with an average annual rainfall regime of 650-3,000 mm and altitude up to 2000 m.a.s.l. (Maass *et al*., 2010). It grows best where average daily temperature ranges between 64 to 86°F. It better adapted to cold compared to other warm-season forages such as velvet bean (*Mucuna pruriens)* or cowpea (Cook *et al*., 2005).

Lablab purpureus is used as commercial crop, animal feed and as cover crop/green manure. Maass *et al*. (2010) observed that *Lablab purpureus* used as green vegetable (green bean, pod, leaf) and protein isolate from the bean can be used as a food additive for improving cake quality. As forage, it produces significantly more forage DM both as a pure crop and as a simultaneously planted intercrop (Abubeker *et al*., 2003). The leaf has crude protein of about 21 to 38% and seed contains about 20 to 28% (Cook *et al*., 2005). *Lablab purpureus* is used as a nitrogen-fixing green manure to improve soil quality. Lablab's prolific root system remains in the soil after harvest and enriches the soil with organic carbon (Pasternak, 2013). It not only produces nitrogen through fixation, but returns nitrogen through leaf decay (FAO, 2012). Therefore, the objective of the project was to select the top performing varieties for variety release.

Materials and Methods

Ten Dolichose Lablab genotypes including local check 'ILRI #11703' were evaluated across locations (Bako and Billo) in altitude ranging from 1300 to 1800 m.a.s.l for three years (2012-2014) with the objective to evaluate the performance of Dolichose Lablab genotypes for herbage yield and other agronomic parameters and their stability across environment. The tested accessions were *ILRI*-Acc#11614; Acc. 14417, Acc. 14429, Acc. 14455, Acc. 14461, *Acc.* 14487, Acc. 14493, Acc. 14550 and *Acc.* 7379 and local check (ILRI #11703). Accessions were arranged inRCBD with three replications in which each plot comprises of six rows having 3m length. The spacing between rows and plants were 50cm and 40cm, respectively. A 100kg ha^{-1} DAP fertilizer was applied at planting. Agronomic Management practices were uniformly applied according to their recommendations. ***Data from herbage yield, seed yield and other important agronomic parameters and forage quality parameters were measured as dependent variables. For sampling 200gm fresh biomass*** were taken and dried in an oven at 65^{o}C for 72 hours to a constant weight. Partially dried feed samples were ground to pass through a 1mm sieve screen using Wiley mill and stored in airtight plastic bags for chemical analysis.

Results and discussions

Varietal Origin/Pedigree and Evaluation

Gebis-17 and *Beresa-55* are the name given by the breeder to a released Dolichose Lablab (*Lablab purpureus*) varieties with the pedigree of *ILRI-Acc#14417* and *ILRI-Acc#14455*), respectively. These and the other Dolichose Lablab genotypes were collected from ILRI and evaluated against the locally adopted genotype *(ILRI #11703) which was used as local* check, across two environments (Bako and Billo) in 2012, 2013 and 2014 main cropping seasons.

Herbage yield performances

The released varieties named '*Gebis-17 and Beresa-55'* were evaluated along with local check (*ILRI #11703*) and other genotypes cross years and locations. Significant differences ($P<0.01$) were observed among genotypes in the mean herbage yields except at Billo Boshe during the first year, 2012. *Gebis-17 and Beresa-55* varieties produced mean herbage yields of 8.43 and 8.37 ton ha^{-1} respectively (Table 1). This means that the herbage yields of *Gebis-17 and Beresa-55* were found to be 15.01% and 14.19%, respectively higher than the check (7.33 ton ha^{-1}).

Table 1: Mean herbage DM yield (ton ha^{-1}) of different accessions of Dolichose Lablab (*Lablab purpureus*) genotypes across locations (Bako and Bilo Boshe) from the year 2012 - 2014 G.C.

Trts (Acc.)	Mean herbage yield in DM bases (ton ha^{-1})						Mean	Yield Adv.%
	2012		2013		2014			
	Bako	Billo	Bako	Billo	Bako	Billo		
ILRI.No.11614	6.30	3.43	3.56	4.34	6.53	4.68	4.81	-52.39
ILRI.No.14417	**8.63**	**3.95**	**9.39**	**9.71**	**10.72**	**8.18**	**8.43**	**15.01**
ILRI.No.14429	3.36	1.30	2.34	2.85	1.74	2.52	2.35	-67.94
ILRI.No.14455	**8.62**	**3.92**	**11.07**	**9.73**	**7.72**	**9.14**	**8.37**	**14.19**
ILRI.No.14461	3.82	2.11	3.30	4.86	2.99	1.37	3.08	-57.98
ILRI.No.14487	6.79	3.69	6.25	6.22	4.89	3.84	5.28	-27.97
ILRI.No.14493	3.56	3.69	5.73	7.03	4.73	4.33	4.85	-33.83
ILRI.No.14550	5.91	4.51	3.56	7.78	8.43	3.56	5.63	-23.19
ILRI.No.7379	4.59	3.97	2.42	2.86	4.35	2.16	3.39	-53.75
ILRI #11703(check)	6.69	3.47	9.30	7.75	8.86	7.90	7.33	0
Mean	5.83	5.69	6.31	4.77	5.83	5.69		
CV	22.56	47.57	22.01	22.6	24.71	23.89		
LSD	2.26	2.78	2.15	2.45	2.58	1.96		
SL	**	Ns	**	**	**	**		

Key: **= highly significant, SL=significance level,

Seed yield performances

Significant differences ($p<0.05$) were observed for seed yield among the genotypes except for Billo site in which none significant results ($p>0.05$) were perceived during 2012 and 2013 cropping season (Table 2). The mean seed yield over six environments ranged from 15.44qt ha^{-1} to 25.44qt ha^{-1} with a grand mean of 19.48qt ha^{-1}.*Gebis-17 and Beresa-55* varieties produced mean seed yields of 18.50 and 19.13qt ha^{-1} respectively. This indicating that Gebis -17 and Beresa-55 were showed 19.79 % and 23.87% yield advantages over the local check in that order (Table 2).

Table 2: Mean seed yield (qt ha^{-1}) of different accessions of Dolichose Lablab (*Lablab purpureus*) across locations (Bako and BiloBoshe) from the year 2012 - 2014 G.C.

Trts (Acc.)	Mean Seedyield (Qt ha^{-1})						Mean	Yield Adv.%
	2012		2013		2014			
	Bako	Billo	Bako	Billo	Bako	Billo		
ILRI.No.11614	9.28	30.00	26.11	13.34	24.76	28.34	21.97	42.30
Gebis-17	13.94	26.70	13.89	12.87	20.13	23.44	18.50	19.79
ILRI.No.14429	16.65	17.00	20.56	11.13	26.43	14.07	17.64	14.25
Beresa-55	14.51	29.97	11.11	14.44	20.22	24.50	19.13	23.87
ILRI.No.14461	14.47	23.89	18.33	16.21	20.47	21.72	19.18	24.23
ILRI.No.14487	14.93	31.44	25.56	20.58	30.39	29.73	25.44	64.76
ILRI.No.14493	11.52	20.00	24.44	5.84	30.95	14.26	17.84	15.51
ILRI.No.14550	8.04	23.66	23.33	12.58	15.58	19.62	16.30	5.58
ILRI.No.7379	13.72	33.75	23.33	14.07	25.13	29.95	23.33	51.07
ILRI #11703(check)	11.63	23.78	10.78	10.28	16.64	19.53	15.44	0
Mean	12.45	27.32	20.74	13.13	23.07	22.52		
CV	29.23	31.62	27.45	28.31	23.12	27.54		
LSD (0.05)	7.51	15.03	9.86	11.19	9.23	10.54		
SL	*	ns	*	ns	*	*		

Stability of Performance/Adaptation

Yield stability parameters for ten Dolichose lablab genotypes tested for three years at two locations were studied based on the methods of Eberhart and Russel (1966). Analysis using the GGE biplot confirmed that *Gebis-17 and Beresa-55 varieties* had unity regression coefficient associated with the highest mean herbage DM yield implying that it has good general adaptability compared to the remaining tested genotypes in the test environments and similar agro-ecologies (figure 1). Besides, the *Gebis-17 and Beresa-55* varieties showed herbage yield advantage of about 15.01% and 14.19%, respectively over the corresponding check. Figure 1. Showed that stability and adaptability of pigeon pea genotypes across years and locations.

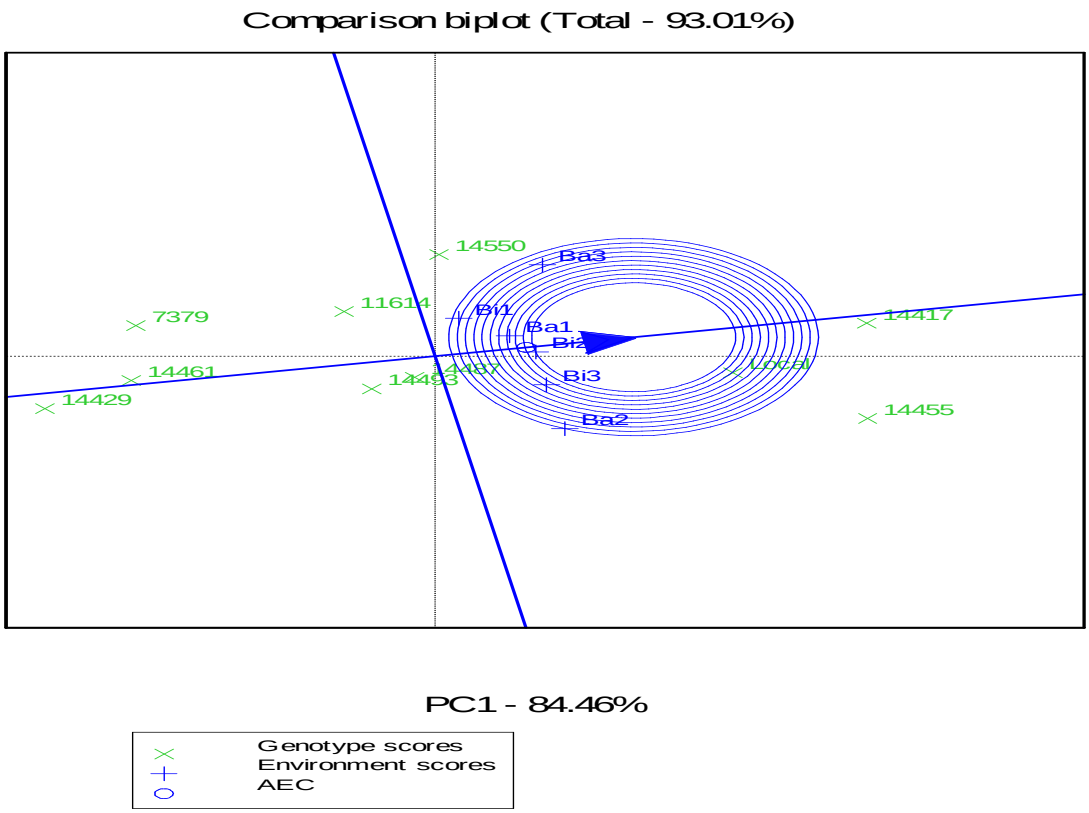

Figure 1: GGE biplot analysis showing the stability of genotypes and test environments.

Key: Ba=Bako, Bi= Billo

Nutritional Quality Analysis

The mean value of nutritional composition of Dolichose lablab genotypes tested were presented in table.2 - The CP content was significantly ($P<0.05$) differ among the genotypes, while the other quality parameters had shown non-significant results. The highest CP value was recorded for genotype ILRI-Acc#14417 followed by genotype ILRI-Acc#14455 while the least value was recorded for genotype ILRI-Acc#14461.

Table 3: Mean nutritive value of Dolichose Lablab (*Lablab purpureus)* genotypes across locations (Bako and Billo Boshe)

Accession	% DM							
	DM%	Ash	CP	NDF	ADF	Lignin	IVOMD	OM
LRI-Acc#11614	58.26	7.62	16.79	41.2	31.89	2.79	47.28	50.64
ILRI-Acc#14417	**62.93**	**5.32**	**26.46**	**25.61**	**21.20**	**2.30**	**48.33**	**57.61**
ILRI-Acc#14429	57.24	7.29	18.99	32.96	27.95	3.01	41.26	49.96
ILRI-Acc#14455	**61.94**	**5.42**	**24.86**	**25.31**	**22.00**	**2.17**	**50.48**	**56.52**
ILRI-Acc#14461	58.96	7.76	13.7	33.05	27.52	4.90	42.22	51.14
ILRI-Acc#14487	57.85	6.44	17.84	40.48	27.80	4.01	45.87	51.42
ILRI-Acc#14493	56.66	7.30	15.54	31.19	24.87	3.95	45.37	49.36
ILRI-Acc#14550	59.49	5.92	15.31	29.15	25.48	3.95	40.67	53.57
ILRI-Acc#7379	56.26	7.56	16.92	33.43	28.51	4.19	39.7	48.71
ILRI #11703(check)	58.96	6.45	21.37	30.44	24.51	3.22	46.95	52.51
CV	8.7	20.3	16.9	19.4	22.7	24.1	20.5	9.1
LSD (0.05)	11.452	3.034	7.072	13.765	13.24	1. 825	20.52	10.583
SL	NS	NS	*	NS	NS	NS	NS	NS
p-value	0.933	0.544	0.032	0.285	0.784	0.11	0.953	0.639

Note: *NS, non-significant; *, significant at p<0.05; SL=significance level; DM, dry matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; IVOMD, in vitro organic matter digestibility; OM, organic matter; CV, coefficient of variation.*

Reaction to Major Diseases

Bacterial blight, ALSpot and Ascochyt B are economically importance disease for herbaceous legumes like Dolichos lablab production. Fortunately, the released varieties and other tested genotypes including the local check revealed resistance to these diseases throughout the study periods (Table 3).

Agronomic and Morphological Characteristics

Gebis-17 (ILRIAcc.# 14417) and *Beresa-55* (*ILRIAcc.#14455*) both have white flower color, Dark brown and brown seed color respectively. They are herbaceous legumes. Both are yields high biomass yields. The released varieties; *Gebis-17* and *Beresa-55* had 1000 seed weights of 253 and 250g, respectively. The detailed agronomic characters of the newly released variety are indicated in (Table 3).

Table 4. Agronomic/morphological characteristics of *Gebis-17, Beresa-55* varieties and *local check.*

Characteristics	**Gabis- 17**	**Beresa-55**	**Local check**
Attributes	Description		
Adaptation area:	Bako, Biloboshe, Gute, Chewaka and similar agro ecologies		
Altitude (masl)	1300 – 2000		
Rainfall (mm)	800 – 1200		
Seeding rate (kg/ha):	25-30 kg		
Spacing (m)	Between row 50 and between plant 40		
Planting time:	At late June-early July		
Fertilizer rate: (kg/ha):	P_2O_5: 46; N: 18		
Days to 50% flowering:	98	92	90
Days to seed maturity:	Indeterminate (it goes up to three pecks, first harvest will be started after 5 months of planting and subsequent harvesting can be made after 2 weeks of the first harvest).		
Height at biomass harvest (cm):	138.07	146.13	139.57
Life span	Annual	Annual	Annual
Flowering color	White	White	Yellow
Seed color:	Dark brown	brown	Brown
Seed size:	Oval	Oval	Oval
Thousand seed weight (g):	253	250	252
Yield			
Grain yield(qt ha^{-1})	17.33	17.96	16.94
Biomass yield (DM/t ha^{-1}:	8.43	**8.37**	7.33
Leaf-to-stem ratio	1.25	1.22	1.04
Crop pest reaction (1-9 scale)			
B blight	1	2	2
ALSpot	2	2	3
Ascochyt B	1.5	1	2
Fodder quality:			
DM (%):	62.93	61.94	58.96
CP (%):	26.46	24.86	21.37
OM (%):	57.61	56.52	52.51
IVDMD (%):	48.33	50.48	46.95
Ash (%):	5.32	5.42	6.45
NDF (%):	25.61	25.31	30.44
ADF (%):	21.20	22.00	24.51
ADL (%)	2.30	2.17	3.22
Special merits:	High biomass yield	Climbing	
Year of release:	2016	2016	
Breeder/maintainer:	(OARI/ BARC)		

Note: *IVOMD = In Vitro Organic Matter Digestibility*

Conclusion and Recommendation

The released varieties, '***Gebis-17*** and ***Beresa-55***' had better herbage dry matter yield performance, good general adaptability, moderately resistant to Bacteral blight, ALSpot, and Ascochyt B than the local check. The released varieties had better nutritional quality, especially Crude Protein, organic matter and invtro digestibility, good general adaptability.

Therefore, smallholder farmers and other stockholders who have engaged in animal production residing in western Oromia (Bako, Billo, Gute) and areas with similar agro-ecologies can utilize the forage varieties as protein supplements for low quality feed resources.

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Compatibility Study of *Chloris Guana* Intercropped with Different Accessions of *Cajanus cajan* under Bako Condition

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Abstract

The experiment was carried out at Bako Agricultural Research Center during 2014-2016 cropping season with the objective to identify compatible and productive mixtures of pigeon pea accessions with Rhodes grass on herbage dry matter (DM) yield and other yield components. Rhodes grass (massaba) and four pigeon pea genotypes (ILRI 16524, ILRI 16520, ILRI 16526, ILRI 16555), and two improved pigeon pea varieties; Belebas and Degagsa were used for grass-legumes intercropping. The experimental plots were laid out in a Randomized Complete Block Design(RCBD) with 3 replications. Significant ($p<0.01$) effect was observed among the pigeon pea genotypes on whole DM yield, leaf DM yield, steam DM yield, leafiness and plant vigor except plant height ($P>0.05$). The highest mean value of herbage DM yield was recorded for Degagsa (ILRI 11575) variety in sole stand (3.8 ton ha^{-1}) and in mixture with rhodes (2.4 ton ha^{-1}). From the sole stand plots of pigeon pea, the lower herbage DM yield (3 ton ha^{-1}) was obtained from Belebas variety and ILRI 16524 genotype. While, from the mixture treatments, the least DM yield value (1.5 ton ha^{-1}) was obtained from genotype ILRI 16526 with rhodes grass. . Sole legumes gave better herbage DM yields (3.0-3.8 ton ha^{-1}) than when intercropped with Rhodes grass (1.4-2.4 ton ha^{-1}). Rhodes grass gave higher herbage DM yield (4.86 ton ha^{-1}) in a sole crop and (3.54 ton ha^{-1}) when intercropped with Degagsa variety. The overall mean value of pigeon pea land equivalent ratio (LER), Rhodes grass LER and Total LER were 0.54, 0.79 and 1.34, respectively. LER for both crops was below a unity which indicates the DM yield of crops in the mixture is below a pure stands of the respective crops. Generally, higher cumulative total herbage DM yield was obtained from the mixture than both of the sole crops, resulted in total LER values greater than one and ranged 1.42-1.49. Even though, all the tested pigeon pea genotypes and varieties have the potential to be used for intercropping with Rhodes grass, Degagsa variety was found to be more compatible and high yielder so that it produce high total LER (1.49). Therefore, it can be concluded that Degagsa variety perform a better association with Rhodes grass than the other genotypes, so that, it is recommended as the most compatible combination to improve the forage quantity and quality.

Keywords: Herbage dry matter, Intercropping, Pigeon pea, Land equivalent ratio, Rhodes grass

Introduction

The mainstay of livestock in western part of the country is natural pasture and crop residues which is of poor quality and insufficient quantity for sustaining animal production (Lemma and Diriba. 1998). The farming system; however, still remains far behind to make an adequate supply of feed and shortages prevail year round. With endeavors to overcome the existing feed shortages, high yielding forage grasses

and legumes with minimum package have been introduced to different agro-ecologies (Alemayehu, 2000). Now a days, it is rare to get grass and legumes in a balanced stand on uncultivated fields. Hence, it is very important to establish grass-legume mixture of good quality on the scarce plots of lands we have and utilize efficiently to improve the production and productivity of our livestock.

In western part of Oromia livestock depend on natural pasture and crop residues. These feedstuffs are grossly low in quantity and quality to sustain production. A constant supply of good quality forage in sufficient quantities is a basic necessity in livestock farming. The feed quality of crop residue is generally lower than the required to meet production goals for many livestock classes, whereas legume-cereal mixtures are important protein and carbohydrate sources for livestock (Karadau, 2003). Mixed cropping especially with legumes can improve both forage quality and yield because legumes are good source of protein (Khandaker 1994). Osman and Osman, (1982) reported that mixture of grass-legume have advantages including reducing the infestation levels of diseases and pests and creation of a suitable micro-climatical soil improvement. Similarly, Ibrahim, (2005) testified that forage intercropping between grasses and legumes increase yield, improve growth, improve palatability, supply the soil with nitrogen , make a better soil coverage and keep it from erosion, compete weeds, attained a balanced and highly nutritive feeding to animals and decrease animals bloats.

Pigeon pea (*Cajanus cajan*) is well adapted to the climate and uniquely combines such optimal nutritional profiles, high tolerance to environmental stresses, high biomass productivity and most nutrient and moisture contributions to the soil. Its foliage is an excellent fodder with high nutritional value comprising 20-22% CP, 1.2% fat, 65% carbohydrate and 3.8% ash and used for all classes of animals (Khandelwal *et al*., 2010). Pigeon pea can be grown as forage intercropped with sorghum and/or millet. The deep taproot of pigeon pea draws water from deeper soil depths than most legumes. As a perennial plant it has been successfully used in alley cropping systems with cereals and legumes (Cook 2005).

Rhodes grass (*Chloris gayana*) is an important tropical grass widespread in tropical and subtropical countries. It is useful forage for pasture and hay, drought-resistant and very productive, of high quality when young. Due to its deep roots, Rhodes grass can withstand long dry periods (over 6 months) and up to 15 days of flooding (FAO, 2014; Cook *et al*., 2005). The nutritive value of Rhodes grass can be improved through fertilizer, manure applications and intercropping with forage legumes. In order to optimize the harvested biomass, Rhodes grass hay is generally harvested at advanced maturity stages. However, hay alone can hardly meet the nutritional requirements of productive ruminants and must therefore be supplemented (Osuga *et al*., 2012). It is therefore, important to ensure that compatible legumes are planted as part of the combination of Rhodes grass so that they may utilize fixed nitrogen that improves the feeding value of the sward. Therefore; the objective of the study was to identify compatible and productive mixtures of pigeon pea accessions/varieties with Rhodes grass on herbage DM yield and other yield components.

Materials and Methods

Description of the study area

The experiment was conducted at Bako Agricultural Research Center (BARC) during 2014, 2015 and 2016 cropping season. The centre is located at a distance of 260 km to the west of Addis Ababa on the main road to Nekemte and represents mid-altitude sub-humid agro-ecology of the region. The area lies at latitude and longitude of 9°06'N; 37°09'E, respectively, at an altitude of 1650 m above sea level. The area receives an annual rainfall of about 1200 mm, 90% of which falls between June and September. Average temperature of the study area is about 27°C ranging from 22°C to 31°C (BARC, 2003). About 60% of the soil of BARC is reddish brown in colour, and clay-loam in texture. Dominant soil type is Nitosols with fertile alluvial soils in valley bottom. The area is known for its mixed crop livestock farming system in which cultivation of maize is the dominant crop and cattle and sheep are important livestock species found in the areas. Major animal feed resources are natural pasture, crops residues**,** improved forage grasses, herbaceous legumes and multipurpose trees.

Treatment Description and Experimental Design

The treatment consists of four pigeon pea genotypes (ILRI 16524, ILRI 16555, ILRI 16520, ILRI 16526, and two recently released pigeon pea varieties; Belebas (16527) and Degagsa (11575) and a variety of Rhodes grass (Massaba). The experimental plots were laid out in RCBD with 3 replications. Spacing for Pigeon pea is 1m between rows and 50cm between plants. Half (50%) of the recommended seed rate for sole Rhodes grass was uniformly drilled between pigeon pea rows in $6m^2$ (2m*3m) plot area. The distance between the plots within replication and between replications were was 1.5 m and 2m respectively. Chemical fertilizer at the rate of 100kg ha^{-1} DAP was used.

Table 1: Description of the experimental treatments

Treatments	Description	Treatments	Description
T1	Sole Rhodes grass	T8	Rhodes grass + ILRI 16524
T2	Sole ILRI 16524	T9	Rhodes grass + Belebas (16527)
T3	Sole Belebas (16527)	T10	Rhodes grass + ILRI 16520
T4	Sole ILRI 16520	T11	Rhodes grass + ILRI 16526
T5	Sole ILRI 16526	T12	Rhodes grass + ILRI 16555
T6	Sole ILRI 16555	T13	Rhodes grass + Degagsa (11575)
T7	Sole Degagsa (11575)		

Forage samples were harvested at 50% flowering stage. For sampling 200gm fresh biomass were taken and partial DM contents were determined by oven drying at 65oC for 72 hours to a constant weight.

Land equivalent ratios (LER)

The LER were calculated as: LER = (Yip/Ysp) + (Yir/Ysr), Where Yip and Ysp are the yields of intercropped and sole PP, Yir and Ysr are the yield intercropped and sole Rhodes grass, respectively. Where LER is more than 1.0, this indicates a positive intercropping advantage which shows that interspecific facilitation is higher than interspecific competition (Vandermeer, 1989).

Statistical Analysis

Data obtained was subjected to ANOVA following the GLM procedure of SAS (SAS, 2008). Differences among treatment means were tested using Least Significant Difference (LSD).

Results and Discussion

Legume Herbage Dry Matter Yield

The compiled analysis results revealed that the whole DM yield, leaf DM yield, steam DM yield, leafiness, vigour and plant height of pigeon pea genotypes in sole and mixed plots was given in (Table 2). The treatments (genotypes) have significant ($p<0.01$) on mean of whole DM yield, leaf DM yield, steam DM yield, leafiness and plant vigour while no significant effect was observed for plant height ($P>0.05$). The highest mean value of herbage DM yield was recorded for Degagsa (ILRI 11575) variety in sole (2.4 ton ha^{-1}) and in mixed plots (3.8 ton ha^{-1}) than the other tested genotypes. On the contrary, accession number ILRI 16526 gave lower herbage DM yield (1.5 ton ha^{-1}) in the mixture and Belebas (ILRI 16527) variety in pure stand (3 ton ha^{-1}). Plant leafiness was significantly affected by the fodder crop mixtures. The highest 7.8 for Degagsa in intercrop and 8.8 for Belebas variety in mono-cropping were scored. As far as the legume shrubs issue is concerned, leaf DM yield is the most valuable component of feedstuff for livestock and better mean value of DM yield were recorded for Degagsa variety in sole (2.1 ton ha^{-1}) and intercropped (1.9 ton ha^{-1}) with Rhodes grass..

Table 2: Pigeon pea dry matter yield (t/ha) and other parameters in sole and intercrop with Rhodes grass

Cropping System	PP genotypes	WDMY	LDMY	SDMY	PH	leafiness	Vigor
Pigeon pea-Rhodes mixture	ILRI 16524	2.0	1.5	1.0	151.1	7.3	7.3
	Belebas (16527)	1.8	1.0	0.7	152.0	7.3	7.7
	ILRI 16520	1.6	1.4	2.2	138.3	7.0	7.1
	ILRI 16526	1.5	1.0	1.2	130.3	6.4	6.6
	ILRI 16555	1.9	1.1	0.8	140.1	7.4	7.3
	Degagsa (11575)	2.4	1.9	1.2	160.8	7.8	7.4
Sole Pigeon pea	ILRI 16524	3.0	1.9	1.5	151.3	8.4	8.4
	Belebas (16527)	3.0	1.7	1.1	149.8	8.8	8.7
	ILRI 16520	3.4	1.8	1.3	145.2	8.3	8.0
	ILRI 16526	3.3	1.7	1.3	129.2	7.1	7.7
	ILRI 16555	3.6	1.9	1.7	159.2	8.0	8.1
	Degagsa (11575)	3.8	2.1	1.3	158.3	7.9	8.1
Mean		2.59	1.55	1.22	147.1	7.66	7.70
LSD (0.05)		0.28	0.24	0.22	13.79	0.75	0.75
CV (%)		11.6	16.6	19.7	10	10.4	10.5
LS		**	**	**	ns	**	**

Key: **=highly significant, ns; non-significant, LSD; Least significant different, CV; coefficient of variation, LS; level of significance, WDMY: whole dry matter yield, LDMY; Leaf dry matter yield, SDMY; Steam dry matter yield, PH; plant height.

Generally, sole legumes gave better herbage DM yield values ranged from 3.0-3.8 ton ha^{-1} comparing when intercropped with Rhodes grass (1.4-2.4 ton ha^{-1}). Similar results were also obtained by Amole, T. (2015) in the grass-legume mixture experiment which sole *Lablab purpureus* gave the highest legume dry matter yield (7.78t/ha). This might be due to soil resource competition from the grass component. However, the total herbage DM yield obtained from the mixed pasture was higher than the pure stand of the respective species in the present study. This was indicated that intercropping any of the fodder legumes with Rhodes grass will produce reasonable herbage DM yields from the mixed sward.

Grass herbage DM yield and seed yield

The mean value of herbage DM and seed yields (Table 3) were showed high significant ($p<0.01$) differences among the treatments sown in the two cropping system. The highest mean value of herbage DM yields were recorded for Rhodes grass sown in pure stand (4.86 ton ha^{-1}) and in intercropped(4.5 ton ha^{-1}) with Degagsa variety, respectively. While the lowest herbage DM yield (3.54 ton ha^{-1}) was recorded from Rhodes grass intercrop with pigeon pea genotype (accession number ILRI 16524). The result from the present study also indicated that the mean value of seed yield was significantly affected ($p<0.01$) by treatment. The highest mean value of seed yield (3.75 qt ha^{-1}) was recorded from sole planted of Rhodes grass whereas the . lower mean value of seed yield were obtained from the grass-legume mixed plot which was ranged from 1.91-2.6Qt/ha.

Table 3: Rhodes grass herbage dry matter yield (ton ha^{-1}) and seed yield under sole and intercrop with pigeon pea

Cropping system		Herbage DMY (ton ha^{-1})	Seed yield (Qtha^{-1})
Sole Rhodes grass		4.86	3.75
Rhodes grass -Pigeon pea mixture	ILRI 16524	3.54	1.91
	Belebas (16527)	3.65	2.21
	ILRI 16250	3.82	2.11
	ILRI 16526	4.38	2.42
	ILRI 16555	3.88	1.92
	Degagsa (11575)	4.50	2.6
Mean		3.79	2.062
LSD($p<0.05$)		0.56	0.34
CV (%)		15.3	17.1
LS		**	**

The total biomass yield recorded from Rhodes grass intercropped with any of the pigeon pea genotypes ranging from 5.42-6.9 ton ha^{-1} than Rhodes grass mono cropping yields (4.86 ton ha^{-1}). It seems that the total DM yield increased in mixture was one of the advantages obtained due to intercropping of the component species. This might be in agreement with Mergia (2014), who reported that higher total biomass yield from maize-forage legumes intercropped fields (10.20-10.84 ton ha^{-1}) than maize pure cropping fields (8.74 ton ha^{-1}). Diriba, 2000, also reported that in the grass-legume mixtures grasses showed higher herbage DM yield, which is agree with the result of the current study. Similarly, NJOKA-NJIRU E.N. *et al.,* (2006) reported increased yield of Napier grass when planted adjacent to leucaena

hedgerows than sole Napier grass or Napier grass growing away from leucaena. However, the result of the study is contradicts with the results of Mwangi (2002) who found out that intercropping Desmodium depressed DM yield of Napier grass.

Table 4: Summary of herbage dry matter yield (t/ha) of sole pigeon pea, sole Rhodes and Pigeon pea-Rhodes mixture

Treatments	Pigeon pea	Rhodes	Pigeon pea-Rhodes mixture (Total)
ILRI 16524	2.0	3.54	5.54
Belebas (16527)	1.8	3.65	5.45
ILRI 16520	1.6	3.82	5.42
ILRI 16526	1.5	4.38	5.88
ILRI 16555	1.9	3.88	5.78
Degagsa (11575)	2.4	4.50	6.9
Sole (16524)	3.0	-	3.0
Sole (16527)	3.0	-	3.0
Sole (16520)	3.4	-	3.4
Sole (16526)	3.3	-	3.3
Sole (16555)	3.6	-	3.6
Sole (11575)	3.8	-	3.8
Sole R/Grass	-	4.86	4.86
LSD (0.05)	0.28	0.56	
CV %	11.6	15.3	
LS	**	**	

Land Equivalent Ratio (LER)

Land equivalent ratio of pigeon pea, Rhodes grass and mixture (total land equivalent ratio) are presented in table 4. The overall mean value of land equivalent ratio of pigeon pea, Rhodes grass and mixture were 0.54, 0.79 and 1.34, respectively. Land equivalent ratio less than one means that the yields obtained in mixed stand is less than those obtained in pure stands. The total land equivalent ratio which compare yield of the component variety in the mixtures with the respective to pure stand varieties; when TLER=1, indicates the situation where there is no yield advantage in mixed cropping; TLER>1, the two species are, at least, partly complementary in resource use and there is a biological yield advantage in intercropping and TLER<1, the intercropping negatively affects the yields of plants grown in mixture (Dhima et al., 2007). The LER for both Rhodes grass and pigeon pea genotypes was below a unity which indicates the DM yields of species in a mixture is below a pure stands of the respective species; however, all exceeded 0.5 (Table 4).

The intercropping system resulted in higher cumulative total herbage DM yield than either of the sole crops, resulted in total LER values greater than one and ranged between 1.42 and 1.49, indicating a yield advantage of 42-49% over that from an average of pure stands of the different species (grass and legumes). This implies that 42-49% more area would be required for a sole cropping system to achieve the yield obtained from an intercropping system.

Table 5: Land equivalent ratio (LER) for dry matter yield of Rhodes grass intercropped with Pigeon pea at BARC.

Intercropping	Pigeon pea	Rhodes	Total (Mixture)
Rhodes grass + ILRI 16524	0.66	0.76	1.42
Rhodes grass + Belebas (16527)	0. 60	0.75	1.35
Rhodes grass + ILRI 16520	0.42	0.74	1.16
Rhodes grass + ILRI 16526	0.46	0.85	1.30
Rhodes grass + ILRI 16555	0.54	0.77	1.31
Rhodes grass + Degagsa (11575)	0.63	0.86	1.49
Mean	**0.54**	**0.79**	**1.34**

Similar results were also obtained by Amole, T. *et al., (*2015*),* that mean LER of all grass-legume mixtures herbage DM yield recorded for Lablab intercropped with *A.gayanus* greater than 1 and which ranged between 1.21 and 1.78. The total LER value above 1 suggests partial or no competition among species in the mixtures, most likely due to the contribution of the legumes to the environment of the grass via nitrogen fixation (Tessema & Baar, 2006) or simply the mixtures avoided competition due to a different rooting pattern, which may have prevented the uptake. This LER does not only give a better indication of the relative competitive ability of the component species, but also it showed the actual advantage due to intercropping Erol *et al*. (2009) also reported that intercropping maize with faba bean gave higher TLER than unity.Temesgen *et al*., (2014) also pointed out TLER greater than unity (1.24-1.70) from the intercropping of maize with different Dolichos lablab accessions. Diriba (2000) also reported a similar result from intercrops of *Panicum coloratum* and *Stylosanthes giuanensis*.

Conclusions and Recommendation

The study revealed a significant effect among the pigeon pea genotypes on DM yield and other parameters. The highest mean value of herbage DM yield was recorded for Degagsa (ILRI 11575) variety in sole and mixed plots whereas the lower yield was obtained for ILRI 16526 in the mixture and Belebas variety in pure stand. Generally, sole legumes gave better herbage dry matter yield as compared to intercropping with *Rhodes grass.* However, the total herbage DM yield obtained from the mixed pasture was higher than the pure stand of the respective species. Similarly, Rhodes grass also gave higher herbage DM yields in a sole crop and when intercropped with Degagsa variety.

The LER for both Rhodes grass and pigeon pea genotypes was below a unity which indicates the DM yields of species in a mixture is lower than a pure stands of the respective species. Generally, higher cumulative total herbage DM yield was obtained from the mixture than both of the sole crops, resulted in total LER values greater than one indicating a yield advantage of 42-49% over that from an average of pure stands of the forage components. Even though, those tested pigeon pea genotypes have potential to be used for intercropping with Rhodes grass, Degagsa variety was more compatible and high yielder so that produce high TLER. Therefore, it was concluded that Degagsa variety formed a better association

with Rhodes grass than the other genotypes, so that, it is recommended as the most compatible combination to improve the forage quantity and quality.

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Adaptation Trial of *Sesbania sesban (L.) Merril* Tree legume accessions at Haro Sabu, Kelem Wollega

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Abstract

The experiment was conducted at Haro Sabu ARC (on station), Kelem Wollega zone of Western Oromia for two consecutive years (2015-2016) with the objective to identify, high herbage dry matter (DM, seed yield(SY) and disease/pest resistance accessions. Seven accessions were used as experimental treatments in a randomized complete block design (RCBD) with three replications. Percentages of survival rate were differ among accessions at different ages. Maximum percentage of survival rate (100%) were obtained from DZ-96 and DZ-123 at the age of one year and 59.7% of survival rate was recorded from DZ-96 at two years age. The minimum survival rate of71.5% and 75% were recorded for 0092 and 0347, respectively at one year age while at two years age these accessions were completely died.- The mean value of days to 50% flowering showed statistically significant ($p<0.05$) variation among the treatments. Mean value of plant height at different ages and seed yield were significantly differ at ($p<0.05$) among the tested accessions . Mean plant height were 308.95, 373.29 and 445.02 cm at age of 6 month, 1 year and 2 year respectively. Mean DM yield s was not significantly ($p>0.05$) differ between treatments even though numerically higher accessions DM yield (84.43 t ha^{-1}) was recorded from DZ- 96 accessions . The best seed yielders among the tested accessions of Sesbania were DZ-96 with 47.25 q ha^{-1} followed by DZ-89 with 46.84 q ha^{-1}. Hence, it is concluded that DZ-96 and DZ- 89 accessions were better performing accessions which are suitable for use as animal feeds.

Key words*: Sesbania sesban; dry matter yield; seed yield; fodder tree*

Introduction

Livestock are an important part of the farming system of Kelem and West Wollega zone. The major feed resources in the area are mainly crop residues and grazing lands. However, these feed resources are very scarce and poor quality to boost better production and productivity. Hence, development of improved forages to improve livestock production and productivity is crucial.

Leguminous fodder trees and shrubs offer considerable potential for use in mixed crop-livestock production systems to alleviate and complement the low feeding value of crop residues and natural pastures that constrain livestock production (Gutteridge and Shelton, 1994; Mekoya, 2008). They are among the feed resources with important high-quality protein supplement for the crop residues and natural grassland which form the bulk of animal feed. They have the added advantage of fixing nitrogen through their symbiotic relationship with Rhizobium, which can have considerable impact on soil fertility for the production of subsequent crops. Animals with access to fodder trees performed better than those kept on natural pasture in milk yield, weight gain, reproductive performances and survival rates (Elbasha

et al., 1999; Mohamed-Saleem and de Leeuw, 1994; Norton, 1994). The effect of fodder trees can often be attributed to the supplementation of Nitrogen (N) to the diet. Among the multi-purpose tree species which have been the subject of research for use as animal feeds. It grows all over the subtropics in a wide accession of soils, and is one of the few nitrogen fixing forage trees that can grow in cooler highland regions in the tropics. Sesbania [*Sesbania sesban* (L.) Merril.] Belongs to family Fabaceae (Manjusha *et al*., 2012) and is a multipurpose small stature tree (Nigussie & Alemayehu, 2013). It is grown as a short duration perennial green manure (Mahmood *et al*., 2008), deep rooting shrub with high-quality foliage, and it serves as a protein supplement (Nigussie & Alemayehu, 2013). *S.sesban* can tolerate soil alkalinity and salinity to a considerable degree. Sesbania grows at altitude of between 100-2300m where the average annual temperature is between 18-23°C, and does not go below 10°C or above 45°C where the average annual rainfall is between 500-2000mm. *Sesbania sesban* has been found to provide a high-quality leaf material, which is of an equal quality to vetch hay when fed to small ruminants (ILCA, 1988).

Different exotic multipurpose fodder trees like *Sesbania sesban ha*ve been promoted by different organizations in Ethiopia to alleviate feed shortages (Mekoya et al., 2009b), maintain soil fertility and prevent land degradation. Sesbania is relatively well suited for highland areas when compared to other multipurpose forage trees such as *Gliricidia*, *Calliandra* and Leucaena (Mekoya et al., 2008). Despite the importance of this tree legumes, there is very little or no attention is given for the identification of best performing *Sesbania sesban* accessions under the condition of Haro Sabu areas. Therefore, the study was undertaken with the objective to identify higher herbage DM and seed yield of *Sesbania sesban* accessions for the study area.

Materials and Methods

Description of the study area

The study was conducted for two consecutive years (2015-2016)at Haro Sabu agricultural research center on station site. The area is at latitude of 8^{o} 52'51" N and longitude 35^{o}13'18'' E and altitude of 1515 m above sea level. The center is located in western Ethiopia of Oromia region at 550 km from Finfine (Addis ababa). The average rain fall of the area is about 1000 mm and its distribution is uni-modal. Their maximum and minimum temperatures were 30 ^{0}c and 14 ^{0}c respectively with average mean of 22 ^{0}c. The area is characterized by coffee based farming system and crop-livestock mixed farming system (HSARC, 2012). The soil type of the experimental site is reddish brown with sandy loam in texture.

Experimental treatments and design

Seven *sesbania sesban* accessions ; Dz-80, 0347, Dz-104, Dz-123, 0092, Dz-96 and Dz-89were used as experimental treatments to evaluate their performances in RCBD with three replications. Planting materials of *sesbania sesban* were obtained from Debrezeit agricultural Research center They were planted on plot with 4m*3m at spacing 1m between rows and 50cm between plants. The plants were weeded by hand to control the weed. Recommended fertilizer rate of 100 kg/ha DAP were used during experimental period. The survival and growth of *sesbania sesban* accessions were attended for two years. Important data including survival rate, re-generation percentage after pruning, disease/pest, days of 50% flowering, plant height, seed yield and biomass yield were recorded.The data were subjected to statistical

analysis of descriptive statistics and using SAS 9.1 computer software. Treatment means were compared using Least Significant Difference (LSD) test at 5% level of probability.

Results and discussions

Germination Percentage and Survival rates

accessions Mean value of germination percentage and plant survival rate at different age were presented in table 1.All the tested *Sesbania sesban* accessions were germinated.. At the ages of six months, all germinated plants were survived and their trends were similar to those shown for germination. The survival rates were decline when the ages of plant was increased. However, there were differences among accessions in survival rate at age 1 and 2 years. At the age of one year old, the accession DZ-89 and DZ-104 had maximum percentage of survival rate (100%) followed by DZ-96 and DZ- 123 had 95.8%, while minimum percentage survival rate of 71.5% and 75% were recorded from 0092 and 0347 respectively.

Table1. Germination percentage and survival rate at different ages

Accessions	Germination %	Survival rate %		
		at 6 month	at 1 year	at 2 year
DZ-80	100	100	91.6	47.2
DZ-89	100	100	100	50
DZ-96	100	100	95.8	59.7
DZ-104	100	100	100	48.6
DZ-123	100	100	95.8	52.7
0092	100	100	71.5	0
0347	100	100	75	0

At the age of two years, accession DZ- 96 had maximum percentage of survival rate (59.7%) and had better performance than other accessions followed by DZ- 123 (52.7%). However, accessions 0092 and 0347 were completely destroyed because of having annual life span. Based on this result, the percentage of plant survive was declined when the life span of the plant increased.

Days to 50% flowering and plant height

Days at 50% flowering of different *sesbania sesban* accessions tested at HSARC during adaptation periods was highly significance ($p<0.05$) difference between the treatments. Some tested accessions flowered early at 3.8 months after planting while others took 5.9 to 6.8 months to flower. The result shows that from seven different adapted accessions , 0347 and 0092 accessions took 116 and 119 days respectively to reach 50% of flowering where as the longer days (206.3) for 50% flowering was recorded for DZ-123 accession .

Table 2. Mean value of days to flowering and plant height of *Sesbania sesban* accessions tested at on-station for two years

Accessions	DoF	PH 6mth (cm)	PH 1 yr (cm)	PH 2 yr (cm)
DZ-80	202.6[a]	282.92[c]	328.17[b]	374.87[c]
DZ-89	179.6[b]	288.67[c]	380[a]	458.47[ab]
DZ-96	204[a]	277[c]	371.42[a]	477.8[ab]
DZ-104	204[a]	312.5 [a-c]	363.67[ab]	425.67[bc]
DZ-123	206.3[a]	307.5[bc]	401[a]	488.3[a]
0092	119[c]	348.67[a]	392.42[a]	-
0347	116[c]	345.42[ab]	376.42[a]	-
CV	4.3	7.14	5.93	6.7
Mean	175.95	308.95	373.29	445.02
LSD	13.48	39.28	39.38	56.21

In each column, Means followed by different letters are significantly different (P<0.05); DoF= days of flowering, PH= plant height

Plant height is a good indicator of growth rate and adaptation of a accession to the environment. The mean performance of plant height of different *Sesbania sesban* accessions at different ages (6 month, 1year, and 2year) were investigated during 2015 and 2016. The results indicated there is a significant ($p<0.05$) differences among the means of the accessions for the plant height were observed (table 2).

At the age of 6 month, the plant heights were ranged from 277cm to 348.67cm . The accessions highest plant height (348.67cm) was obtained from 0092 accession followed by 345.42cm and 312.5cm from 0347 and DZ-104 respectively where as the shortest plant height (277cm) was recorded from DZ-96.

At the age of 1 year, the tallest plant height (401 cm) was recorded from accession DZ-123 while accession DZ-80 had the smallest plants (328.1 cm). Similarly, the highest plant height was recorded from DZ-123 accession at the age of 2 years.

Plant re-growth ability (%)

The tested sesbania varieties were pruned at age of 1 year on 75 cm height above the ground to see the re-growth ability of the plant. From the tested accessions two accessions of them were died because they are annual fodder tree type. On the other hand accession DZ-96 had maximum percentage (83.3%) of plant re-growth or re-generated followed by DZ-80 and DZ-123.

Table 3. Plant re-growth ability (%)

Accessions	NPP	NPR	% of PR
DZ-96	12	10	83.3
DZ-89	12	9	75
DZ-80	12	9.3	77.5
DZ-104	12	8	66.67
DZ-123	12	9.3	77.5
0092	12	0	0
0347	12	0	0

NPP=No. of plant pruned, NPR= No. of plant regrowth, PR= plant regrowth

Forage dry matter and seed yield

The analysis result of on dry matter and seed yield of tested *Sesbania sesban* varieties were presented in table.4. The mean dry matter yield of the tested accessions were significantly($p<0.05$) different between the treatments.

The highest DM yield (27.64 tha^{-1},) was produced by DZ- 96 accession while the minimum DM yield (9.88 tha^{-1}) was recorded from DZ-104 accession . Previous work also reported the dry matter yield of 20 ton/ha of S*esbania sesban* in Kenya (Wambugu et al., 2006) was in the range of the DM yield result obtained in the present study. accession According to the studies Dutt et al., 1983; Gore SB &Joshi RN, 1976; Galang et al., 1990, the DM yield of *S. sesban* ranged from 4 to 12 tonnes/ha/year depending upon locations. Hence, from the tested *Susbania susban* accessions at Haro sabu agro ecologies, DZ-96 performs best in DM yield followed by DZ-89 and DZ-123 respectively.

Seed yield was significantly ($p<0.05$) different between the tested treatments with mean yield of 30.54 ton/ ha. The best seed yielders among the tested *Sesbania susban* accession was from DZ-96 with 47.25 q ha^{-1} followed by DZ-89 and DZ-104 with 46.84 and 35.96 qha^{-1} respectively while the yield of DZ-80 was lower than all accessions with 15.77 q ha^{-1}.

Table 4. Mean value of dry matter yield (ton/ha) and seed yield (q/ha) of *sesbania sesban* accessions tested at Haro sabu agricultural research center (on station) for two years

Accessions		DMY (ton/ha)	SY (q/ha)
DZ-80		11.54^{b}	15.77^{d}
DZ-89		18.91^{ab}	46.84^{a}
DZ-96		27.64^{a}	47.25^{a}
DZ-104		9.88^{b}	35.96^{ab}
DZ-123		18.36^{ab}	28.86^{bc}
0092		-	19.26^{cd}
0347		-	19.83^{cd}
CV		39.59	21.65
Mean		17.27	30.54
LSD		12.87	11.76

DMY= dry matter yield, SY= seed yield

Conclusion and Recommendation

It can be concluded that among the tested *Sesbania sesban* accessions DZ-96 and DZ-89 have greater performances in terms of their high forage herbage dry matter yield, seed yield and other agronomic parameters. They are suitable for use as animal feeds under the study area. Hence, these accessions are the best suitable once in the study area and should be accessions demonstrated and popularize for the smallholder farmers so that to utilize its benefit especially in enhancing the nutritional value of poor quality feed resources such as crop residues.

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Adaptation Trail of Oat *(Avena sativa)* Varieties at Haro Sabu, Kelem Wollega zone, Oromia, Ethiopia

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Abstract

The experiment was conducted at Haro Sabu and Hawa Galan sites of Haro Sabu Agricultural Research Centre (HSARC) to identify the adaptable and high yielding oat variety (s) for the study agro-ecologies. Accordingly, seven (7) oat varieties (Jasary, CI-8251, CI-8235, CI-8237, Bonsa, Bonabas and lampton) were tested in Randomized Complete Block Design (RCBD) with three replications. Data on dry matter yield, seed yield and other agronomic parameters including plant numbers and plot coverage were taken and analyzed using SAS software. Treatment means were compared using Least Significant Difference (LSD) test at 5% level of probability. The analysis of the result showed a significance difference ($p<0.05$) among the tested varieties in dry matter yield, seed yield and other agronomic parameters. Higher mean dry matter yield was obtained from Bonabas (11.96 t/ha) followed by Bonsa (9.3 t/ha), Jasary (9.25 t/ha), and CI-8237 (9.2 t/ha). The seed yield of Bonsa (95.16 q/ha) was significantly higher ($p<0.05$) than all the varieties followed by Jasary (68.98 q/ha), CI-8237 (57 q/ha) and Bonabas (53.95q/ha). Hence, it can be concluded that oat varieties of Bonabas, Bonsa Jasary and CI-8237 should be recommended to farmers of Haro Sabu and Hawa Galan sites and of similar climatic conditions in order to enhance livestock feed production.

Key words: dry matter yield, seed yield, oat varieties

Introduction

Providing quality forage for animals mainly in the dry season is one of the biggest problems in animal production in Ethiopia. During the dry season, livestock feed is normally in short supply and is also of poor quality. Residues from cereals and pasture roughages are the main source of forage but these are low in crude protein and have poor digestibility. As a result, animals hardly meet their nutritional requirements and livestock productivity, in terms of meat and milk, is very low, draft power from oxen is minimal which thereby affects food crop production under smallholder crop/livestock farming systems. Hence, production of adequate quantities of good quality dry season forages to supplement crop residues and pasture roughages is the way to overcome the dry season constraints affecting livestock production (Alemayehu 2002).

Therefore, to overcome the feed shortage problem, some grass and legume forage species have been tested under rain fed condition. Among the forage grasses, oat (*Avena sativa*) is the best adapted and productive forage grown under rain fed conditions with minimum input usage. It can be used for making

hay and for grazing (Wheeler 1981). High yielding and good quality of oat varieties have been developed for different agro-ecologies. Hence, it is very crucial to evaluate oat varieties for dry matter, seed yield and other agronomic parameters so that to recommend best performing varieties to the study areas and similar ago-ecologies.

Material and Method

Description of the study area

The study was conducted at Haro Sabu and Hawa Galan sites of HSARC during the main cropping season. The centre is located at 550 km from Addis Ababa. It lies at latitude of 8^{o} 52'51" N and longitude 35^{o}13'18'' E and altitude of 1515 m above sea level. It has a warm humid climate with average minimum and maximum temperature of 14 and 30^{o}C, respectively. The area receives average annual rainfall of 1000 mm and its distribution pattern is uni-modal. The rain season covers from April to October. The soil type of the experimental site is reddish brown with sandy loam in texture. The area is characterized by coffee based farming system and crop-livestock mixed farming system (HSARC, 2012).

Experimental treatments and design

Seven (7) oat varieties (Jasary, CI-8251, CI-8235, CI-8237, Bonsa, Bonabas and lampton) were used as treatments using RCBD with three replications. Experimental plots were 2m x 3m with ten rows of 2 meters length with row to row distance of 30 cm and distance of 2m between replication. Diammonium phosphate (DAP) and Urea fertilizer was applied at sowing at a rate of 100 kg/ha for each as recommended by Bogdan (1977). Weeding was done as early as possible to eliminate re-growth of undesirable plants and in order to promote fodder re-growth by increasing soil aeration will also be done.

Data collection and analysis

Detailed observations regarding agronomic characteristics (plot cover, vigour, and yield parameters) were recorded at different physiological stages of the plant. During the first four and eight weeks after establishment data was recorded on number of plant, plot cover and disease incidence. Oats harvested at blooming stage post establishment using (1x1) m^2 quadrant. The 100gm sample was weighed and oven dried at 65ºC to constant weight (72 hrs). The dry weight of the whole plant was obtained and used to calculate dry matter (DM) yield. For yield determination, the entire herbage from the net plot area (1m x 1m) was cut close to the ground. The harvested green forage was weighed plot wise using hanging scale of 50 kg capacity and the total sample fresh yield (TSFW) in q ha-1 was estimated. Sub samples of about 100 gm was taken from each plot and dried in oven at 60 °C to constant weight from which DM yield was determined by dividing the oven-dried weight to its fresh weight expressed as percentage. The DM yield in qha-1 was estimated by multiplying the green forage yield (qha^{-1}) with that of the sample dry matter content divided by 100. All the data obtained in both years from seven oat varieties were analyzed using SAS 9.1 computer software. Treatment means were compared using Least Significant Difference (LSD) test at 5% level of probability.

Results and Discussions

Agronomic performance of the oat varieties

The tested oat varieties were significantly ($p<0.05$) differ for four and eight weeks plant number and 50% flowering for both experimental sites. The evaluated varieties also significantly ($p<0.05$) differ for four weeks plot coverage under Hawa Galan site. Number of plants at four and eight weeks of age were significantly higher for variety CI-8235 (87) than all other varieties except CI-8237. At four week plot coverage, Bonabas variety had greater percentage than all varieties at both locations. But, with regard to eight weeks plot cover, there was no difference ($p>0.05$) differences among oat varieties at Hawa Galan site (table.1).

Days to 50 % flowering ranged from 94 days for CI-8251 to 82 days for CI-8235 under Haro Sabu and 94 days for CI-8251 to 81.333days for Bonsa under H/Galan sub-site. This shows that CI-8251 is late flowering variety as compared to the other varieties.

Table 1: Agronomic performance of Oat varieties at Haro Sabu and Hawa Galan sites

Varieties	Haro Sabu					Hawa Galan				
	PNFW	PNEW	PCFW	PCEW	DF	PNFW	PNEW	PCFW	PCEW	DF
Jasary	79.33^{bc}	78b^{cd}	29.33^{ab}	82.66^{d}	85.66^{ab}	114.33^{e}	114.33^{e}	23.00^{b}	91.00^{b}	86.00^{b}
CI-8251	73.66^{d}	73.33^{d}	26^{ab}	90.33^{bc}	94^{a}	140.33^{d}	140.33^{d}	28.00^{b}	93.67^{ab}	94.33^{a}
CI-8235	87^{a}	87^{a}	32.33^{a}	92.66^{b}	81.66^{b}	148.67^{bc}	148.00^{b}	23.33^{b}	91.67^{ab}	92.00^{a}
CI-8237	82.33^{ab}	82^{ab}	23.33^{b}	88^{c}	88^{ab}	159^{b}	159.00^{b}	28.67^{ab}	96.67^{ab}	92.33^{a}
Bonsa	75.67^{cd}	75.33^{cd}	27.33^{ab}	93.66^{ab}	85^{ab}	115.67^{e}	115.67^{e}	24.00^{b}	96.33^{ab}	81.33^{c}
Bonabas	80^{bc}	83.33^{ab}	30.66^{a}	98^{a}	82^{b}	230.33^{a}	230.33^{a}	35.33^{a}	98.67^{a}	84.33^{cb}
Lampton	81^{b}	81a^{bc}	28.66^{ab}	92^{bc}	83.66^{b}	130.67^{d}	130.67^{d}	24.67^{d}	92.00^{ab}	92.33^{a}
LSD (5%)	4.95	6.54	6.72	4.59	9.8516	13.52	13.1	6.82	7.41	3.58
SE(M)	7.74	13.54	14.27	6.66	30.66	7.60	7.36	3.83	4.16	2.01
CV (%)	3.48	4.6	13.38	2.83	6.46	5.12	4.96	14.36	4.42	2.26

Means with the same letter in a column are not significantly different ($p>0.05$). PNFW = Plant number at 4 weeks age, PNEW =Plant number at 8 weeks age, PCFW= Plot coverage at 4 weeks age PCEW= Plot coverage at 8 weeks age, DF = days to 50% flower

The two locations combined analysis result indicated a significant ($p<0.05$) differences in plant number, plot covers, and 50% flowering (table 2). A significantly higher value of number of plants counted from Bonabas with a value of 155.17 and 156.83 respectively at four and eight weeks. Similarly, Banabas variety had maximum percent of plot coverage at four (33 %) and eight (98.33 %) weeks than all tested varieties. Days to 50 % flowering were 83.167 for Bonsa and Bonabas and 94 days for CI-8251variety. This shows that CI-8251 variety is a late flower whereas Bonsa and Bonabas varieties are early flowering varieties at the study area.

Table 2: Mean value of number of plants , plot cover and days to 50% flowering of oat varieties from combined locations (Haro Sabu and Hawa Galan)

Varieties	Combined location (Haro Sabu and Hawa Galan)				
	PNFW	PNEW	PCFW	PCEW	DF
Jasary	96.83^{b}	96.17^{c}	26.167^{b}	86.83^{c}	85.833^{bc}
CI-8251	107.00^{b}	106.83^{bc}	27^{b}	92^{b}	94.167^{a}
CI-8235	117.83^{b}	117.50^{bc}	27.83^{ab}	92.17^{b}	86.833^{bc}
CI-8237	120.67^{b}	120.50^{b}	26^{b}	92.33^{b}	90.167^{ab}
Bonsa	95.67^{b}	95.50^{c}	25.66^{b}	95^{b}	83.167^{c}
Bonabas	155.17^{a}	156.83^{a}	33.00^{a}	98.33^{a}	83.167^{c}
Lampton	105.8^{b}	105.83^{bc}	26.66^{b}	92b	88^{bc}
Mean	114.14	114.16	27.47	96.66	87.33
LSD (5%)	13.36	12.95	3.03	2.31	2.81
SE(M)	21.26	20.6	4.8	3.6	4.47
CV (%)	18.63	18.05	17.5	3.9	5.12

Means with the same letter in a column are not significantly different (p>0.05). PNFW = Plant number at 4 weeks age, PNEW =Plant number at 8 weeks age, PCFW= Plot coverage at 4 weeks age PCEW= Plot coverage at 8 weeks age, DF = days to 50% flower

Dry matter and seed yield

Dry matter and seed yield result of oat varieties tested at the two locations are indicated in table 3. Dry matter yield was significantly differ ($p<0.05$) among the varieties at Haro Sabu site. In this site, Bonabas variety produced the higher (9.86 t/ha) was dry matter yield than the other all varieties followed by Jasary (7.65 t ha^{-1}), CI-8237(6.28 t ha^{-1}), and Bonsa (6.28 t ha^{-1}) while CI-8251 variety was produced the lowest dry matter yield (4.84 t ha^{-1}). At Hawa Galan, the mean DM yield of the oat varieties was 10.96 t/ha. Although there was no significant difference in the dry matter yield at this site, Bonabas was higher than Jasary, CI-8251, CI-8235, CI-8237, Bonsa and lampton. The mean DM yield of the varieties were 10.91t/ha.

Similarly the DM yield of combined locations were significance difference at ($p<0.05$) among the tested Oat varieties. Higher mean of dry matter yield was obtained from Bonabas (11.96 t/ha) followed by Bonsa (9.3 t/ha), Jasary (9.25 t/ha), and CI-8237 (9.2 t/ha) respectively. The mean dry matter yield of combined studied areas of the varieties were higher than the figure reported by Arelovich *et al.*, (1994) (1.17 t/ha), Tewdros Alemu and B.Amare (2016) (5.89 t/ha) of dry matter yield. But, similar with the report of Yehalem (2012) indicated (8.58 t/ha) dry matter yield in irrigation areas at Ribb River.

Significant ($P<0.05$) difference was observed among the tested oat varieties in seed yield at the two sites. Among oat varieties Bonsa produced the highest seed yield 93.62 q/ha and 96.71 q/ha respectively at Haro Sabu and Hawa Galan sites. Mean seed yield of the oat varieties at Haro Sabu and Hawa Galan sites were 41.88 and 55.53 q/ha respectively.

The combined analysis result indicated that seed yield was significantly ($P<0.05$) highest for Bonsa (95.16 q/ha) followed by Jasary (68.98 q/ha), CI-8237 (57 q/ha) and Bonabas (53.95 q/ha). The mean

seed yield (55.53 q/ha) recorded for the combined sites were higher than the range mean grain yield reported (15 to 30 q/ha) by AARC (2002) progress report and it is higher than (22.43 q/ha) the report of Arelovich *et al.* (1994). It is also higher than the report of Yehalem (2012) (0.291 kg/ m^2 or 29.1 q/ha) in irrigation areas at Ribb River.

Table 3. Combined analysis result of dry matter and seed yield of oat varieties tested at Haro Sabu and Hawa Galan sites

Varieties	Haro Sabu		Hawa Galan		Combined	
	DMY t/ha	SY qt/ha	DMY t/ha	SY q/*h*a	DMY t/ha	SY q/ha
Jasary	7.65^{b}	49.62^{b}	10.84 ^{a}	88.33^{ab}	9.25^{ab}	68.98^{b}
CI-8251	4.8^{c}	13.22^{c}	10.36 ^{a}	57.7^{bcd}	7.60^{b}	35.46^{de}
CI-8235	6.67^{bc}	43.71^{b}	8.80 ^{a}	54.35^{cd}	7.73^{b}	49.03c^{de}
CI-8237	6.28^{bc}	30.74^{bc}	12.14 ^{a}	83.26^{abc}	9.20^{ab}	57.0^{bc}
Bonsa	6.28^{bc}	93.62^{a}	12.33 ^{a}	96.71^{a}	9.30^{ab}	95.16a
Bonabas	9.86^{a}	47.25^{b}	14.05 ^{a}	60.65^{bcd}	11.96^{a}	53.95^{bcd}
Lampton	5.98^{bc}	15.01^{c}	7.86 ^{a}	43.25^{d}	6.92^{b}	29.13^{e}
Mean	6.79	41.88	10.91	69.17	8.85	55.53
LSD (5%)	1.90	21.02	6.4	33.68	1.57	10.64
SE(M)	11.43	8.37	3.6	18.93	2512.6	16.93
CV (%)	15.72	28.21	330	27.36	28.3	30.4

Means with the same letter in a column are not significantly different (p>0.05). DM t/ha=dry matter yield in tone per hectare, SY= grain yield in quintal per hectare

Conclusions and Recommendations

Based on the result, it can be concluded that oat variety of Bonabas is the best performing variety followed by Bonsa, jasary and CI-8237 in dry matter yield. While the highest seed yielder was Bonsa followed by Jasary, CI-8237 and Bonabas. Hence, it can be concluded that Bonabas, Bonsa and Jasary varieties should be recommended to farmers of Haro Sabu and Hawa Galan areas and of similar climatic conditions in order to enhance the production and productivity of animals.

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Apiculture Research Results

On station adaptation and evaluation of buckwheat (*Fagopyrum esculentum*) at Bako Agricultural Research Center

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Abstract

The flexibility and wide adaptation of buckwheat recently led it to be grown on different agro ecology, even though it is not native to our country. A field experiment was conducted to study the adaptation of buckwheat (Fagopyrum esculentum) at Bako Agriculture Research Center. There were 5 treatments having 10 days different between each treatments with three replications laid out in Randomized Complete Block Design (RCBD). The experimental result showed that there was significant difference between White seeded Variety (V2) of buckwheat having 37 days stay with flowering which is planted in the Mid July and early August with the mean value of about 31 days with extended flowering period and proceeds prolifically for about a month before gradually tapering off as the plant matures. The result showed that buckwheat reach mature in 11 weeks. The later buckwheat is planted, the faster it matures. Therefore, speed of maturity depends on the planting date. Grain yield of buckwheat under different sowing date showed significant differences ($p \leq 0.05$) in grain yield the higher yield recorded for both Varieties planted in mid July and late July compared to those planted in the late August with the mean value of 14.40ku/ha.

Key words: Buck Wheat, Sowing Date, Yield.

Introduction

The flexibility and wide adaptation of buckwheat (*Fagopyrum esculentum*) recently led it to be grown on different agro ecology, even though it is not native to our country. The seeds germinate and emerge rapidly when planted in warm soil, typically in three to four days. Flowering begins about three weeks after planting, and proceeds prolifically for a few weeks, before gradually tapering off as the plant matures. The prolific flowers on buckwheat have made the crop a good nectar source for honeybee keepers. Buckwheat flowers are very fragrant and are attractive to bees that use them to produce a special, strongly flavored, dark memorable honey. Plant height and speed of maturity depend on planting date. If planted early in the summer, and given good fertility, plants usually may take 11 to 12 weeks to mature. If planted in the latter part of July, buckwheat will mature in about 9 to 10 weeks. The later buckwheat is planted, the faster it will mature. The reason to plant buckwheat relatively late is to push flowering into a period when nights are starting to cool down, which will normally be the case in late August or early September. In buckwheat, seed set is globally very low, around 15-30% ,which is the major constraint to buckwheat production worldwide.

Buckwheat is primarily a human food crop, used in similar fashion to cereal grains such as wheat or oats. Even though buckwheat is not a true cereal, it is sometimes called a "pseudo cereal." It has also been used widely as a cover crop to smother weeds and improve the soil. The crop seems to improve soil tilt, and is reported to make phosphorous more available as a soil nutrient, possible through root-associated

mycorrhizae. Common buckwheat is one of the best source of high quality, easily digestible protein, having a balanced amino acid composition (Eggum *et al.*, 1981) and a good source of minerals. It is cholesterol free and perfectly fits our modern low calorie, high nutrition diets (Francischi *et al.*, 1994). In alternative medicine, it is used for balancing the sugar and cholesterol level in the blood (Jiang *et al.*, 1995).

Buckwheat is cross pollinated and an entomophilic plant; honeybees are the major pollinators. The cultivation of buckwheat along with beekeeping may produce 50 to100 kg of honey per hectare, due to its extended flowering period for more than 30 days (Rajbhandari, 2010). Many factors, such as the floral physiology and morphology, pollinator characteristics, as well as effects of weather influence the success of pollination. Buckwheat pollen is not windblown; therefore, insects are necessary for the transfer of pollen. Buckwheat flowers in the first sunshine and during which time it is highly attractive to bees (Phillips and Demuth, 1922) and most of the pollination activities occur. It is said that a single visit of buckwheat flowers by a bee increases plant productivity by 25-30% (Grigorenko, 1979); three to four insect visits are enough to pollinate one blossom of buckwheat while bee visiting more than 5 times the productivity of plant decreases (Bjorkman, 2002). In buckwheat, seed set is globally very low,around 15-30% which is the major constraint to buckwheat production worldwide. The farmers' knowledge and perception regarding the effect of pollination on vegetative characters and yield attributes of buckwheat has not well understood.

An acre of buckwheat will yield about 45 to 67.kg of dark honey recognized for its ability to extract and accumulate phosphates from soils. Apparently, organic acids released from their roots solubilize phosphate precipitates in the soil profile and subsoil. Practically speaking, this means buckwheat will thrive on low phosphorus soils**,** and that it can function as a phosphorus cycling cover crop. Its dark color and taste are reminiscent of molasses, and it's a favorite in Europe. Darker honey like this is said to contain more antioxidants. Darker honeys are rich in antioxidants. Also rich in iron and minerals, this honey is renowned for its restorative properties and toning more effective than dextromethorphan (DM) as a cough suppressant for children. Antioxidants provide a defense against free radicals, and are said to help fight heart disease, cancer, and other maladies. Buckwheat honey is also a **great source of iron**. Other benefits include: Higher in mineral content, No fat or cholesterol, Provides quick energy, Can be stored without refrigeration.

Materials and Methods

The on station adaptation and evaluation of Buckwheat was conducted at Bako Agricultural Research Center. The experiment was laid out to fit the experiment into Randomized Complete Block Design (RCBD) with 5 treatments and 3 replications (blocks). Land preparation was done by conventional tillage and harrowing. First treatments of buckwheat seeds were sown in mid July, the second were sown 10 days after the first treatment and continuous up to the fifth treatments which were sown 10 days after fourth treatment with plot size of 3m×3m. 1m between reps and plots, 30cm between rows and seed rate of 50 kg/ha and 46kg/ha Fertilizer rate were used. Plants were harvested manually with the help of sickle when it is expected to be matured and allowed to dry for easy threshing. Threshing was done by beating with sticks.

The data obtained from experimental plots were recorded and analyzed by using the ANOVA procedure described by Gomez and Gomez (1984). When the F-test indicated statistical significance at the (P = 0.05) level, the Duncan's Multiple Range Test was used to compare the difference of the means.

Results and Discussion

No significance difference has been observed on the days of emergency for both buckwheat varieties planted at different dates. Nevertheless, there were significance difference on the days of heading, longer heading days for both buckwheat varieties planted in the late July (24 Days) and shorter heading days Black seeded (V1) buckwheat varieties planted in mid- August (17 Days), with the mean heading date of about three weeks after planting.

Both buckwheat varieties planted in the late July shows significantly longer days (28 days) of flowering with the shorter days white seeded (V2) buckwheat planted in mid August (25 days) after planting. There was significance difference on stay with flowering for long period of time having longer (37 days) of buckwheat white seeded (V2) planted in the Mid July and early August, with the mean value of 31 days having extended flowering period and proceeds prolifically for about a month before gradually tapering off as the plant matures.

Buckwheat flowers are very fragrant and are attractive to bees that use them to produce a special, strongly flavored, dark memorable honey. From the result displayed in Table 1, buckwheat matures in 11 weeks. This is similar with the other publications which states that if planted early in the summer, and given good fertility, plants usually may take 11 to 12 weeks to mature. If planted in the latter part of July, buckwheat will mature in about 9 to 10 weeks. The later buckwheat is planted, the faster it will mature. Therefore, speed of maturity depends on the planting date.

Grain yield of buck wheat under different sowing date were highly significant ($p \leq 0.05$) highest grain yield for both Varieties planted in mid July and late July with the lowest grain yield observed for both Varieties planted in the late August with the mean value of 14.40ku/ha. This result has been found in the range of world grain yield which states that, the grain yield of common buck wheat may reach 137.25 g/m^2 if it is pollinated by honey bees.

Table1. Adaptation and evaluation of buckwheat varieties sown at different dates

Sowing Date	Variety	Days of Emergency	Days to Heading	Days to Flowering	DF-to DEF	Days to end flowering	Days to Maturity	Yield in Ku/ha
July, 15	1	4.17^{a}	20.67^{bc}	27.17^{abcd}	30^{cd}	57.17^{bc}	79.0^{bc}	19.54^{a}
	2	4.67^{a}	21.17^{ab}	27.83^{abc}	37.67^{a}	65.50^{a}	88.0^{a}	21.61^{a}
July, 25	1	4.83^{a}	24.00^{a}	28.83^{a}	26.5^{d}	55.33^{bc}	77.0^{bc}	19.35^{a}
	2	5.17^{a}	24.00^{a}	28.33^{ab}	35.50^{ab}	63.83^{a}	86.33^{a}	21.72^{a}
August, 05	1	4.33^{a}	21.83^{ab}	26.83^{bcd}	28.83^{d}	55.67^{bc}	73.0^{cde}	11.92^{bc}
	2	4.83^{a}	22.33^{ab}	26.83^{bcd}	37.17^{a}	64.00^{a}	81.0^{ab}	17.79^{ab}
August, 15	1	5.67^{a}	17.33^{d}	26.17^{cd}	26.83^{d}	53.00^{c}	69.67^{de}	8.38^{cd}

	2	5.33 [a]	18.00[cd]	25.33[d]	34.17[abc]	59.50[b]	75.33[bcd]	10.44[cd]
August, 25	1	4.67[a]	20.33[bc]	26.00[cd]	26.83[d]	52.83[c]	65.8[e]	4.78[d]
	2	5.17 [a]	20.83[bc]	26.17[cd]	31.50[bcd]	57.67[b]	69.17[ed]	19.06[d]
Mean		4.88	21.05	26.95	31.50	58.45	76.4	14.40
Std. Dev		1.03	2.83	1.66	4.94	5.15	9.9	8.68
CV		19.56	8.34	3.92	9.23	4.43	5.7	35.19

Conclusion and recommendation

Buck wheat is one of the important honey bee forage. The seeds of buckwheat germinate and emerged rapidly 4-5 Days after planting. Flowering begins about 27 Days after planting and proceeds prolifically for about one month (31 Days) before gradually tapering off as the plant matures 10-11 Weeks after planting. The obtained average grain yield was about 14.4kg/ha, Even though the seed set is the major constraint to buckwheat production worldwide. Therefore, planting buck wheat in the mid July to Late July is appropriate time for buckwheat adaptation and grain yield, with the seeding rate of 50kg/ha and fertilizer rate of about 46kg/ha for Bako and similar agro ecologies.

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Assessment and identification of causes of massive honeybee colony deaths in selected Zones of Oromia Region

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Abstract

Assessment and diagnostic survey was conducted in selected zones of Oromia National Region Sate based on case report for honeybee massive deaths. Accordingly, case reports were received from five districts namely, Wolmera (Oromia special Zone around Finfinne), Woliso South West Shoa zone), Alaltu (North Shoa zone), Chora (Ilu Ababora zone) and Gera (Jimma zone) during the five study period. Based on the report, thorough field assessment were undertaken and adult and brood bee samples were collected from 18 Peasant Associations (PAs) from these districts based on the case reports. A total of 46 representative samples (33 adult bees and 13 broods) were collected and diagnosed in Holeta Bee Research Center laboratory for the major causes of honeybee massive death in studied areas. The result indicates that, about 91.7 % and 68% of massive honeybee deaths in Wolmera and Woliso districts, respectively were caused by pesticide exposure. High varroa mite infestation rate (79%) with associated pathogens was detected in the bee massive deaths at Gera districts. However, chilly weather and colony starvation was identified for the time of bee deaths in case of Alaltu district. The case from Chora was identified as seasonal drone bee deaths and this indicates that there is lack of knowledge about the natural cycle honeybee colonies both by Development actors and beekeepers of the area. It is concluded from the this study that multifaceted factors including application of pesticides, high infestation level by parasites and pathogens (like Varroa mite) and food shortage causing the abnormal deaths of honeybees and colony decline in areas. Of these factors, the major cause for massive honeybee colony deaths is identified as exposure to heavy pesticide application in most studied areas.

Key words: *Massive death, diagnosis, pesticide, pathogens*

Introduction

The honeybee, Apis mellifera, has long been managed by humans for its crucial economical and ecological importance. They provide tremendous significances for human beings through high value products and critical component of modern agriculture industry, in the course of their leading pollination role of the world's crops (Aizen and Harder 2009; Johnson, 2011). Moreover, bees provide commercial products playing increasing roles in income generation, healthy food and alternative medicinal values for small-holder farmers and rural families. As a result, beekeeping significantly contributes to sustainable livelihoods of small-scale farmers and play great role in the global food security and environmental stability (FAO, 2012). To this fact, the essential and valuable contributions of honeybees depend upon the healthy population of honeybees (FAO, 2012).

Unfortunately, in recent decades, serious losses of managed and wild honey bees and decline in bee populations have been reported from different parts of the world (Van der Zee *et al*., 2012; Potts *et al*., 2010). This dramatic honeybee colony losses in many parts of the world (Van Engelsdorp *et al*., 2009; Genersch, 2010) has been raised substantial concerns from different directions, but their underlying causes are yet remain unclear (Aston, 2010; Charrière and Neumann, 2010; Currie *et al*., 2010). As a result, the vulnerability of honeybees to biotic and abiotic factors can have harmful effects on honeybee health and the services they offer, which in turn can lead to severe economic losses (Genersch, 2010; Bradbear, 2009). Widely reported evidences indicate that the losses and decline of honeybees is due different factors are involved in this problem, including honey bee diseases and pathogens (Traynor *et al*., 2016; Neumann and Carreck, 2010; Higes *et al*., 2010), honey bee management practices (Giacobino *et al*., 2015), shortage of food (Odoux *et al*., 2012), and climatic change (Le Conte and Navajas, 2008). But many recent publications suspect the profound impact of agricultural practices and the varied and massive use of chemicals (Lee *et al*., 2015; vanEngelsdorp *et al*., 2009). Honeybees may frequently become exposed to chemical pesticides as a consequence of their foraging activities (VanEngelsdorp and Meixner, 2010).

Recently, there is also growing reports both from beekeepers and agricultural experts in Ethiopia for the massive deaths of honeybees and colony decline due to unknown reasons. Only few reports indicated the significant effect of indiscriminate use of pesticides on honeybees in the country (Amssalu *et al*, 2012; Dessalegn, 2015). Apart from this, no clear evidences indicating the diverse and substantial causes for the honeybee massive deaths and colony decline in the country. This has been increased national concern for assessment and identification for the factors causing the mortality of honeybees based on case report in different regions of the country. Therefore, the aim of this study is to assess and identify the underlying factors and mechanisms responsible for colony losses in Ethiopia and recommend emergency measures and sustainable management strategies at the national level in the country.

Material and Method

Study sites

The study was conducted in 18 PAs found in 5 districts (Wolmera Choke, Woliso, Alaltu, Chora and Gera) Oromia National Reginal State, Ethiopiabased on the case reported to Holeta Bee Research Centre directly from beekeepers and zonal or District Livestock and Fishery Resouce offices. Field trips were made to the specific Apiary sites (PAs), and preliminary information was collected from beekeepers. At this occasion, information on colony holding size of the beekeepers by hive types and the external symptoms they observed to report the case as "abnormal death" were collected. Subsequently, visual inspections were done externally to bee colonies for any abnormally dead bees and pictures were taken.

Inspection and sample collection

Victimized bee colonies were examined through internal inspection and visual assessments in the hive to observe clinical symptoms for major bee pathogens, pests, pesticides and lack of nutrition. Furthermore, samples of adult honeybees and broods were collected purposively for further laboratory diagnoses. The samples were diagnosis for varroa mite, nosema, amoeba and other bacterial diseases. Moreover, dead bees were examined for the toxicity expositor through major and specific clinical symptoms such as

massive dead bees near or under their hive and in hives with protruded tongue, massively crawling and jerking bees around their hives.

Laboratory Examination

Both diseased and dead samples were diagnosised in the laboratory for major bee diseases and pests according to the standard epidemiological methods. Clinical symptoms for bee deaths due to pesticide exposure were also observed both during the study period.

Finally, the mean colony infection/prevalence rate was calculated as the mean number of dead colonies per beekeeper, divided by the mean number of colonies sampled following the protocols:

$$\textit{Prevalence} = \frac{\textit{Number of positive Cases}}{\textit{Total number of sampled population}} \times 100$$

$$\textit{Infection/infestation level} = \frac{\textit{Number of positive bee}}{\textit{Total number of sample bees}} \times 100$$

Result and discussion

The results of the study showed that there were multifaceted factors causing ubnormal deaths of honeybees in reported districts. Chemical poisonings, disease and pests and food shortage during dearth period are the major factors causing massive deaths in the studied areas. Assessment and diagnosis for clinical symptoms of honeybee massive deaths in Wolmera Choke PA of Wolmera district showed that 91.7% of bee deaths were caused due to unwise and indiscriminate uses of chemical pesticides, particularly for floriculture and open farm PLCs. This can be attested through typical clinical symptoms such as: heap of dead bees near or under their hive and in hives, too much number of dead bees with protruded tongue, massively crawling and jerking bees around their hives (Fig. 1).

Fig.1 Massive dead honeybees both inside and under the bee hive in wolmera district

Fig.2. Typical clinical symptoms for deaths of honeybees due to pesticide exposure

Pesticides are among many identified factors known to affect bee health, including pests and diseases, diet and nutrition, genetics, habitat loss and other environmental stressors, and beekeeping management issues, as well as the possibility that bees are being negatively affected by cumulative, multiple exposures and/or the interactive effects of several of these factors.

Table 1. Assessment and test of factors for causes of honeybee deaths in selected districts of Oromia region

Zone	**District**	**No. PAs**	**No. of colonies**	**Percentage of +Ve test (%)**					
				Varroa	***Nosema***	***Amoeba***	***CBD***	***Poisoning***	***Drone death***
E/zone of Finfine	Wolmera	4	**36**	**5.5**	**2.8**	**0**	**0**	**91.7**	**0**
South West Shoa	Woliso	2	**13**	**23.7**	**7.6**	**7.7**	**0**	**61.5**	**0**
North Shoa	Alaltu	1	**4**	**0**	**41**	**16**	**0**	**0**	**43**
Jimma	Gera	3	**7**	**79**	**0**	**21**	**0**	**0**	**0**
Illu- ababora	Chora	1	**4**	**12**	**0**	**0**	**0**	**0**	**56**
Total mean in %		**11**	**64**	**41.44**	**13.6**	**13.17**	**0**	**76.6**	**33.7**

Honey bees are endangered not only by the acute toxicity of pesticides but also by their sub-lethal, chronic and delayed lethal effects (Rondeau *et al*., 2014), depending on the specific mode of action of the active ingredient. A growing number of publications indicate that combined exposure to individually non-lethal stressors can have a harmful effect on honey bees.

Severe varroa mite infestation rate (79 %) with associated pathogens like *Nosema Apis* and *Amoeba* were detected in the bee massive deaths at Gera (Jimma zone) district (Table.1). The symptoms described by the beekeepers were bees unable to fly, all fallen down and commonly march in one direction, broken out wing, wingless, newly born more affected, dragged away by the worker bees etc) has lead the team to suspect the case to be varroa mite effects. The collected and diagnosised samples from three locations of Gera district, almost all are positive test for varroa mite. The percentage of varro mite infestation in these districts during the study period revealed higher percentage than the economic threshold value (29 %) for winter honeybee losses. This lead to the cause for bee deaths in these areas might be due to high infestation of varroa mite as indicated above. In USA and Europe, varroa mite infestation is accounted for

the majority of honeybee colony losses and disruption of agricultural pollination services (Muli *et al*., 2014).

However,chilly weather and colony starvation associated with infestation of *Nosema apis* (41%) (Table 1) was speculated for the bee deaths in case of Alaltu district (North Shoa zone). In the diagnosis sample from this district, neither bee pathogen infestation, nor clinical symptoms for pesticide effect were detected. This most likely agree with shortage of nutrition and climate change which can cause abnormal deaths of bee colonies as indicated in several literatures (Odoux *et al*., 2012; Le Conte and Navajas, 2008). The rest abnormal colony deaths in Chora district of Illu Ababora zone was identified as seasonal drone bee deaths reported by beekeepers unknowingly. Worker honeybees kill drone bees during the food shortage to sustain their generation across the dearth period.

Conclusions and recommendations

Honey bees provide critical pollination services to agriculture and natural landscapes, and the honey and wax produced by honey bees represent a potential source of income for families in East Africa and across the world. Our study suggests that multifaceted factors include application of pesticides, high infestation by new parasites and pathogens (like Varroa mite) and food shortage causing the abnormal deaths of honeybees and colony decline in Ethiopia. The study revealed that pesticide exposure has been identified as the main causes for widespread honeybee colonies collapse in most studied areas.
Therefore, strong management of honeybee colonies against newly emerging pest and parasite is recommended. Moreover; proper utilization and influencing policy is required against the application of pesticides in the country to minimize the impact of chemicals on honeybees and bee products.

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Physico-chemical Property Analysis of Stingless bee (*Meliponula beccari)* honey from West Showa zone of Oromia region, Ethiopia

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Abstract

Physiochemical properties study were conducted on stingless bee honey in view to analyzing moisture content, electrical conductivity, pH, Ash, Free acidity, HMF, insoluble materials and proline. Twenty honey samples (0.35-1.5 lit volumes) from underground nests were obtained from four potential districts (Wolmera, Jeldu, Tokke Kutaye and Chalia) of West Shoa zone of Oromia region, Ethiopia. Then, stingless honey samples for each district were pulled in one and analyzed in Holeta Bee Research Centar (HBRC) Lab following the standard procedures. The result of the study showed that there is no significant difference (P > 0.05) between mean values of parameters: MC (29±1.45), EC(0.22±0.03), PH(3.73±0.13), Ash(0.41±1.1), TA(7.3±0.36), HMF (18±3.45) and IM (0.70±0.3), except for proline value for honey samples collected from different locations. The values compared against the standard Apis mellifera *honey quality parameters and significantly vary for some of them. From these investigations, it is concluded that most of the analyzed parameters like electrical conductivity, PH, hydroxymethylfurfural, Proline and insoluble matter in the honey samples of stingless bees' best comply with the requirements of the standard national honey quality of Ethiopia. The results however, indicate that parameters like moisture content and free acidity do not comply with the limits. From this conclusion, it is recommended that other parameters like sugar and mineral contents and stingless bee honeys of different agro-ecological zones across the country should be conducted to come with more concrete and excusive findings. It also recommended that analyzing and characterizing stingless bee honey based on botanical origin is paramount important to utilize both for medicinal and nutritional roles.*

Key words: Stingless bee, Physico-chemical, parameters, standard, honey

Introduction

Honey is a natural sweet substance produced by different bee species from plants nectar, plant secretions, or excretions of plant-sucking insects on the living parts of plants (Codex Alimentarius, 2001). With its composition and constituents, honey is known globally to have a wide variety of uses and applications, and in various countries, it is used as sweetener in food and for medicinal purposes (Alvarez-Suarez *et al.,* 2010). Honey is composed of sugars, mainly monosaccharide, with carbohydrates constituting about 95 to 97% of the dry weight of honey (Bruno et al., 2006). Fructose (38%) and glucose (31%) are the most predominant sugars present and responsible for nutritional characteristics of honey (Alvarez-Saurez *et al*., 2010; Sato and Miyata, 2000). The volatile compound found in honey includes alcohols, ketones, aldehydes, acids and esters that determine its flavour and aroma (Cotte et al., 2003). However, the

chemical composition in honey is rather variable and is primarily dependent on floral source, geographical origin, seasonal and environment factors and processing methods (Alvarez-Suarez *et al.*, 2010; Silva et al., 2013). Moreover, honey-making processes are highly related to enzymes added by the bees, so that the types of bee species (Siok et al., 2016) also affect composition of honey.

Apinae (*Apis mellifera*) honey and Apidae (*Stingless bee*) honey are the two commonly known honey types found in the world (Temaru *et al*., 2007). In Ethiopia, both honey types are produced all over the country and exclusively the stingless bee (*Meliponula beccarii)* honey commonly known as "Damma Damuu" or "Tazma Mar" honey is a valuable bee product with long consumption tradition, to which several medical uses are attributed. The unique stingless bees (*M. beccarii)* in Ethiopia live harboring underground and store their honey in honey pots constructed from ceriman of various plant species. Its honey harvesting process from feral colonies is absolutely traditional and destructive that endangered the existing species and reduces the quality of honey (Fig.1).

Certainly with its specific delicate taste and medicinal property, the value of stingless bee "Tazma Mar" honey in Ethiopia is higher than the value of *Apis mellifera* honey (Andualem, 2013; Lemma *et al*., 2013; Pimentel *et al*., 2013). To this fact, stingless bee honey has high local market demand, achieving higher prices than the A*pis* honey and commercialized in different regions of the country. Despite its high demand and medicinal value stingless bee honey is not yet included in the international standards for honey and the food control authorities due to the scant knowledge about the product composition do not control it. In contrast, several studies have been conducted for the characterization of Apis honey with botanical and geographical origins so that its quality parameters are standardized both at national and internationally level (QSAE, 2005; Codex, 2001). Although the use of "Tazma" honey has been of great importance traditionally in the country, the information on composition of stingless bee honey from Ethiopia is still scarce to set its quality standard fit both for nutritional and medicinal value. The objective of this study was therefore, to evaluate the chemical profiles of proximate composition of stingless bee honey of Ethiopia to determine its quality standard in comparison with *Apis mellifera* honey in the Ethiopian Quality Standard Authority. This is the first study investigated on composition of stingless bee honey in Ethiopia.

Material and Methods

Study area Description

The study was conducted in West Shoa Zone of Oromia National Regional State, which is located in western part of Ethiopia. The study focused on purposively selected districts for having high potential for stingless bee honey "Tazma Mar" and diverse floral composition like: *Wolmera,* (09^{o}03'.51 N and 038^{o}30'.37 E latitude and longitude with altitude 2398 masl s) *Jeldu,* (09 ^{o}04'.01 N and 039 ^{o}06'.45 E latitude and longitude with altitude 2400 masl), *Toke Kutaye* (08 ^{o}58'.12N and 037 ^{o}46'.03 E of latitude and longitude with altitude 2304 masl) *and Chalia (*09 ^{o}02'.11N and 037^{o}25'.35 E) of latitude and longitude with altitude 2329 masl) .

Honey harvesting and sample collection

All the honey samples were collected from stingless bee species (*M. beccari*) (Gribodo, 1879), which is commonly called in the country as "Kanniisa Damuu" or "Tazima Nib" , which lives by harboring underground in the soil. Following the honey flow season, the stingless bee honey samples were collected

from four districts (*Wolmera, Jeldu, Tokke Kutaye and Chalia) o*f West Shoa zone of Oromia National Regional State. Honey samples were collected by carefully excavating in to the underground nest until reach at the nest chamber containing both honey and pollen stores. When the honey pots are sealed, the honey is already ripe and ready to harvest. Accordingly, 20 honey samples (350 ml-1.5 lit) (Table1.) were harvested directly from sealed honey pots with disposable syringes and collected in to air tighten glass jars for each respective areas (districts). The collected samples were further strained for impurities and stored in refrigerator (-4 ^{o}C) until laboratory analysis conducted (Fig.1).

Fig. 1. Stingless bee honey harvesting and sample collection process

Physicochemical properties Analysis

Physicochemical properties for parameters of moisture content, electrical conductivity, PH, Free acidity, HMF, Insoluble materials and Proline were analyzed in HBRC Lab following standard procedure, the harmonized methods of the international honey commission (Bogdanov, 2002) in Holeta Bee Research Centar (HBRC) Lab.

Moisture Content

The moisture content of stingless bee honey was determined using a portable digital, professional hand held refractometer (Bellingham RFM 330, SER. No.016468, made of UK) with the range expressed in percentage (%) and with the refractive index for water (n_D) at 20°C after waiting for 6 minutes for equilibration. The method was based on the principle that refractive index of the honey increases with solids content. Moisture contents of sample were measured twice, and the average value was recorded and it was done following the procedure of Codex Alimentarius Commission Standards (2001).

PH and Free Acidity

The pH and acidity in stingless bee honey samples were determined in accordance with the methodology adopted by Moraes and Teixeira (1998). The pH value was determined using a solution containing 10 g of honey dissolved in 75 mL of distilled water, homogenized and subjected to reading in a pH meter (3100 Janeway, England), calibrated at pH 4.0 and 7.0. The solution was further titrated with 0.1M sodium hydroxide (NaOH) solution to pH 8.30 (a steady reading was obtained within 2 minutes of starting the titration). For precision, the reading to the nearest 0.2ml using a 10 ml burette was recorded. Free acidity, expressed as milli equivalents or milli moles of acid/kg honey was equal to ml of 0.1M NaOH x 10, and the result expressed to one place of decimals and done following the procedure of the harmonized methods of the international honey commission (Bogdanov, 2002).

$$\textbf{Acidity} = 10V,$$

Where: ***V = the volume of 0.1N NaOH in 10 g of honey.***

Determination of Ash Content

The ash content of stingless bee honey samples was determined according to the standard procedure of Marchini *et al*, (2004) and A.O.A.C.) (1990). First, the crucibles were identified and heated in a furnace for approximately 25 min at 300 ^{o}C. Then, they were transferred to the desiccators for 20 min to cool down and were weighed separately to 0.001g (M_1). Then, 10 gram of stingless bee honey sample was weighed accurately into an ignited and pre-weighed crucible. In each sample two droplets of olive oil was added to prevent frothing and the samples gently heated on an electric hot plate until the samples were completely carbonized. The samples were then incinerated in an electric muffle furnace (CFS 11/B, England) (600 ^{o}C) for about 5 hours until complete incineration (white to light gray color) to reach the constant weight. The crucibles were then cooled in the desiccators and weighted for constant weight (M_2). Percent ash in g/100g honey was calculated using the following formula, following the procedure of Codex Alimentarius Commission Standards (2001).

$$\textit{Ash, \% by mass} = \frac{M_2 - W_1}{M} X100$$

Where: M_1 =weight of empty crucible

M_2 = weight of the ash and crucible

M = mass of the sample taken for the test

Hydroxymethylfurfural (HMF)

The determination of HMF was based on the readings in different UV absorbance scales (284 and 336 nm wavelengths) in a spectrophotometer according to the procedure of the harmonized methods of the international honey commission (2009). The HMF is expressed in mg kg-1 in the equation:

$$HMF = (A_{284} - A_{336}) \times 149.7 \times 5 \times D/W,$$

where: A_{284} = absorbance at 284 nm
A_{336} = absorbance at 336 nm
D = dilution factor, if necessary
W = weight of honey sample (g)

Electrical Conductivity

Twenty grams of honey (on dry matter basis) were dissolved in distilled water and transferred to a 100 ml volumetric flask, and made up to volume with distilled water. 40 ml of this solution was poured into a beaker and placed in thermo stated water bath at 20 °C. Electrical conductivity measurements were obtained with a low range conductivity meter (4310 Wagtech, England) with a cell constant of 1.03. The conductivity cell was there after immersed in the sample solution and the conductance in MS read after temperature equilibrium had been reached. Electrical conductivity was calculated using the formula based on the harmonized methods of the international honey commission (2009).

$$SH = K. G,$$

Where: SH = electrical conductivity of the honey solution in mS.cm-1
K = cell constant in cm-1
G = conductance in mS

Determination of Proline

For the determination of proline content, 5g of homogenized stingless bee honey was weighed and dissolved in water, then quantitatively transferred to a 100 ml volumetric flask and diluted with water. The absorbance was determined using a Lambda 25 double-beam spectrophotometer UV/Vis, Perkin Elmer, Waltham, Massachusetts, USA. A spectrum of proline from 440 to 560 was performed to evaluate the wavelength at a maximum absorbance, which was 510 nm.
Proline in mg/kg honey at one decimal place is calculated following equation developed by International Honey Commission (2009):

$$\text{Proline (mg/kg)} = \frac{Es}{Ea} \times \frac{E1}{E2} \times 80$$

Where: Es = Absorbance of the sample solution
Ea = Absorbance of the proline standard solution (average of two readings),
E1 = mg proline taken for the standard solution
E2 = Weight of honey in grams.
80 = Dilution factor

Insoluble matter

Approximately 20 grams of honey samples were accurately weighed and dissolved in 200ml of water at about 80^0 C by mixing well. After drying a crucible in the oven, it was weighed for total dry mass. Then, the sample solution was filtered through the crucible and washed extensively with warm water until free from sugars. A few drops of concentrated sulphuric acid was mixed and run down the sides of the tubes. Finally, the crucible was dried at 135^OC for an hour, in the oven and cooled in the desiccator then again returned to the oven for 30 minute intervals until constant weight is obtained. The % of insoluble matter then calculated according to the following formula based on the harmonized methods of the international honey commission (Bogdanov, 2002).

$$\% \text{ Insoluble matter in g/100g} = \frac{M}{M_1} \; X\ 100$$

Where; M = mass of dried insoluble matter and
M1 = mass of honey taken

Statistical analysis

One-way ANOVA was computed to compare means for each physicochemical property of honey samples data in triplicate and the data was expressed as mean and standard errors (±). For all the computations, SPSS version-20 statistical software was employed and tests were made at 95% level of significance.

Result and discussion

The result of the study indicates that average honey amount collected from each nest ranged from 350 ml -1.5 lit which was varied among every district (Table 1.). The highest honey amount (2.3 lit) was harvested from Chalia district (Sekondo site), while the lowest honey amount (250 ml) was recorded from *Toke Kutaye* district (Gorosole site). This variation among stingless bee honey yield from nest to nest was determined based on several factors such as the nest size, colony population size, vegetation type and longevity of established colony harbored in the specific nest (traditionally estimated by counting the number of guard bees on their nest entrance, equivalent to year of colony established).

Table 1. Area description and stingless bee honey volumes collected from underground nest

No.	Zone	District	Specific area/PA	Bee species	Nest nature	Agro ecology	Average honey volume
1	West shoa	Chalia	Gedo /Sokondo	M. beccari	Underground	High land	1.5 lit
2	West Shoa	Jaldu	Gafaree/ Meja	M. beccari	Underground	High land	500 ml
3	West shoa	Wolmera	Holeta / around	M. beccari	Underground	Mid high land	680 ml
4	West Shoa	Toke Kutaye	Goro Sole	M.beccari	Underground	Mid high land	350 ml

The results of physicochemical analysis of 20 (twenty) stingless bee honey samples revealed that no significant differences ($P > 0.05$) for values of all parameters (m*oisture content, electrical conductivity,*

pH, Ash, free acidity, HMF, insoluble materials) for honey samples collected among different locations except for proline value. Proline is higher in Jeldu district (293±14) and lower in Wolmera district (171±13). The value of moisture content, electrical conductivity and HMF were compared against Venezuela and Australian stingless bee honeys and not significantly different ($P > 0.05$). Moisture is one of the most relevant characteristics of honey, because it influences viscosity, specific weight, maturation, crystallization, taste and enhance the shelf life of the product (Nascimento *et al*., 2015). In this study, the moisture contents of all honey samples ranged from 25.1-35.0% with mean value 29.6±1.4% (Table 2). There was no significance difference ($P > 0.05$) in moisture content of honey samples collected from all districts. However, the mean moisture (29.6±1.4%) content of honey produced by stingless bees demonstrated significantly higher when compared to the Ethiopian standard *Apis mellifera* honey moisture (20.5%) content (QSAE,2005). This might be due to high hygroscopicity characteristic of Meliponinae honey which is mostly harvested from high humidity (Alves *et al*, 2005). This fact, according to the author, shows that the moisture content in honey is an intrinsic characteristic of bee species with no significant influence of vegetation type and the producing honey source.

The higher moisture content characteristic of honey from stingless bees largely influenced by the air relative humidity and, possibly, by the process of harvesting and storage. This may facilitates the proliferation of yeasts, causing a fermentation process, which makes the product unfit for human consumption and hinders its marketing (Ribeiro *et al*., 2009). The high moisture in stingless bee honey is therefore; reinforce the need to store this product in refrigerated chambers to avoid its degradation or fermentation, thereby ensuring a product with quality to the consumer. The pH and free acidity parameters showed statistically no significant differences among stingless bee honey produced from all districts. The overall pH value ranged between 3.4-3.9 with mean value of 3.7±0.15. This value is lower than commonly known standard pH value of honey from Apis mellifera, which ranges from value 4.3-4.85 (Bekele *et al*., 2016). This indicates that stingless bee honey is more acidic than Apis honey. The pH is a physical-chemical parameter associated with the microbial development in any food. Therefore, in the current result the low pH of stingless bee honey confirms that it prevent the development of microorganisms that require neutral or basic pH values, significantly limiting the spectrum of potentially contaminating microorganisms.

The ash content expresses the richness of honey in mineral content, which is mainly influenced by the botanical origin of the nectar, region, bee species and type of manipulation. In this study, the honey samples assessed for ash content showed no statistical difference among the locations ranged between 0.21 to 0.57 % which is consistent with allowable range (Table 2). However, the ash content of stingless bee is relatively higher (0.41±1.1%) than the *Apis* honey (0.21±007%). This might be related to the origin of stingless bee honey that is harvested uniquely from the ground in the soil where the mineral content is expected richer than in the beehives. This is result indicates that the ash content in honey denotes the amount of minerals in the product, while the mineral content is related to the soil type. Therefore, the result of current study revealed that honey produced from stingless bee honey in Ethiopia is richer in mineral content and good if standardized for both medicinal and nutritional consumption.

The free acidity of honey is the content of all free acids in particular amount, expressed in milliequivalents/kg honey. The recommended acidity of honey is usually less than 40 meq acid/kg of honey Codex Alimentarius (2001). In this study, it was observed that there was no significant variation

(P>0.05) in free acidity among the honey samples from the four districts (Wolmera, Jeldu, Chalia and Toke Kutaye) but it was ranged from 16.7 - 21 meq kg−1 and with mean value of 17.3 ± 0.7 meq kg−1 value. The electrical conductivity of honey can be used to identify the botanical origin of honey and the result is expressed in milli Siemens per centimeter ($mS.cm^{-1}$) (Richter *et al*, 2011). This is closely related to the concentration of minerals, organic acids and proteins, and it is a parameter that shows great variability depending on the floral source of honey. The electrical conductivity values in the investigated honey samples from the four locations varied in the range 0.16-0.34 $mS.cm^{-1}$ with overall average value of 0.21±0.16 $mS.cm^{-1}$, while values for Apis honey ranges 0.22-1.52 $mS.cm^{-1}$ (Table 2). The non-significance differences in electric conductivity of honey samples between the four locations indicated the similarity of flora composition in similar ecological condition of West Shoa zone.

Table 2: Mean comparison of physic-chemical properties of stingless bee honey samples collected from four districts of West shoa zone, oromia and compared to National honeybee honey standards (N=20)

		Parameters (Mean ± SE)							
Districts	**N=20**	**M.C (%)**	**E.C (mScm-1)**	**PH**	**Ash (%)**	**F A (meq kg^{-1})**	**HMF ($mgkg^{-1}$)**	**IM (%)**	**Proline ($mgkg^{-1}$)**
Wolmera	5	28.2±1.5[a]	0.21±0.1[a]	3.8±0.3[a]	0.41±3.2[a]	16.9±0.5[a]	18.6±4.3[a]	0.71±0.06[a]	171±13[a]
Jeldu	5	32.5±2.5[a]	0.20±.01[a]	3.7±0.1[a]	0.38±2.5[a]	17.1±0.1[a]	15.9±2.6[a]	0.68±0.0[a]	293±14[b]
T/ Kutaye	5	29.0±1.0[a]	0.22±.01[a]	3.8±0.1[a]	0.56±4.[a]	16.8±0.5[a]	22.4±0.0[a]	0.66±00[a]	213±21[a]
Chelia	5	28.7±0.8[a]	0.24±0.6[a]	3.6±0.1[a]	0.23±02[a]	18.4±1.3[a]	15.1±0.0[a]	0.73±0.7[a]	181±14[a]
Overall mean		29.6±1.4	0.21±0.16	3.7±0.15	0.41±1.1	17.3±.7	18±1.7	0.69±.06	214±15
Overall range		**25-35**	**0.16-0.34**	**3.4-3.9**	**0.21-.57**	**16.7-21**	**11.2-22.4**	**0.56-0.87**	**124-307**
Standards Apis Honey		**18-23**	**0.22-1.52**	**3.2-4.5**	**0.14-.30**	**< 40**	**< 40**	**…**	**….**

ab*=means with different superscripts within column are significantly different (P<0.05), N=Number of sample SE= Standard Error*

Notice: *MC =moisture content, EC = Electric conductivity, PH =PH value, FA = Free acidity, HMF = hydroxyl methyl furfural, IM = insoluble matter, P=Proline *Source: Quality and Standards Authority of Ethiopia (2005)*

The hydroxymethylfurfural (HMF) is a chemical compound formed by the reaction of certain sugars with acids and used as an indicator of honey freshness and good quality (Marchini *et al*., 2004) regarding product adulteration or improper storage conditions. The greatest HMF was recorded at *Toke Kutaye* district (22.4 $mgkg^{-1}$) and the lowest was observed at *Chelia* district (15.1 $mgkg^{-1}$) with the overall mean of 18±1.7 $mgkg^{-1}$(Table 1). This parameter shows values within the range of established national honey standard (Codex, 2001) that allows a maximum of 40mg kg^{-1} and in agreement with Ethiopian honey HMF value studied by different authors (Bekele Tesfaye *et al*., 2016; Belie, 2009; Nuru Adgaba, 1999)

Insoluble matter is estimation for the presence of impurities in the product (in %) and therefore for indicate its cleanliness as stated by international Honey Commission (2009). The Current study showed that the insoluble matter in stingless bee honey ranged 0.56% - 0.87% with mean value 0.69±.06%. Good manufacturing practices in production and processing, plants are generally effective to assure the observance of law limits.

Proline is the predominant free amino acid of honey and it is a measure of the level of total amino acids (Iglesias *et al*, 2004). The proline content of honey is measured as a criterion for estimating the quality (Bogdanov, 2002) and the antioxidant activity of the honey (Meda *et al*., 2005; Saxena *et al*, 2010) and it may be used also for characterization on the basis of botanical origin. The value of proline in the present study significantly different between the localities, where the highest mean value is record in honey from Jeldu district (293 $\pm$14 $mgkg^{-1}$) and the lowest mean proline recorded in honey from Wolmera district (171$\pm$13 $mgkg^{-1}$). This difference might be related to the degree of nectar processing by the bees themselves and which makes the honey proline content is a criterion of honey ripeness (Together with other factors related to bees, such as saccharide and glucose oxidase activities) (Cristina *et al*., 2013).

Conclusions and recommendations

Honey is a naturally sweet and viscous fluid produced by different bee species from the nectar of flowers. Apinae (*Apis mellifera*) honey and Apidae (stingless bee) honey are the two commonly known honey types found in the Ethiopia. Despite its high medicinal and market price value, little is known about the composition of stingless bee honey when compared to *Apis mellifera* honey. Due to this fact, there is no quality standard established both at national and international level. The result of this study revealed that most of the analyzed parameters like electrical conductivity, PH, hydroxymethylfurfural, Proline and insoluble matter in the honey samples of stingless bees' best comply with the requirements of the standard national honey quality of Ethiopia. The parameters of the moisture content and free acidity however, do not comply with the limits. More study is recommended for other parameters like sugar and mineral contents of stingless bee species across different agro-ecological zones of the country. Moreover, this first study points out to the necessity of analyzing a specific composition for stingless bee honey, given the specific bee species exist in the country and the different characteristics of the honey that they produce based on botanical origins.

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Harvesting royal jelly using splitting and grafting queen rearing methods

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Abstract

An experiment conducted at Gedo, Muger and Holeta sub site using grafting and splitting queen rearing methods in 2015 and 2016, to assess the suitability of the methods for royal jelly harvesting from local bees without affecting the honey yield. For these 24 well-established uniform honeybee colonies in box hives were randomly assigned for the two treatment groups each with four replications. The result of the experiment showed that there was no significant difference between the two royal jelly harvesting methods on the royal jelly yield obtained from all the sub-sites with mean production of 15.48 gm/colony from splitting and 14.3 gm/colony from grafting methods. From this study, it is concluded that both methods of bee queen rearing are found suitable methods for royal jelly harvesting among the other methods. It was also recommended that another well designed research should be conducted by involving all possible queen rearing techniques to identify the best technique that can lead to more quantity royal jelly production and applicable for any areas and agro ecologies.

Key words: grafting, honeybees, queen rearing, royal jelly, splitting

Introduction

Royal jelly is a proteinaceous secretion of the hypopharyngeal and mandibular glands of 6-12 days old worker bees, called nurse honeybees (Haydak, 1970). The royal jelly has three uses: feeding worker honeybee larvae, up to 90 hour of larval life; feeding of the queen during all its larval phase and adult life; and feeding of drone larvae during all its larval phase (Wang and Moeller, 1969).

Royal jelly performs numerous functions and hence has an important commercial appeal and nowadays it is used in many industries like health foods, pharmaceuticals and cosmetics in many countries around the world (Sabatini *et al.*, 2009; Ramadana and Al-Ghamdi, 2012). The commercial production of royal jelly today generally relies on large-scale queen rearing operations, during which it is accumulated and harvested. Royal jelly production can be affected by honeybee genes and external or internal environment of the colony (Jianke et al., 2003), involving intrinsic biological and behavioral factors (Weneger et al., 2009).

In many parts of the world, studies have identified the potential of the local honeybee colonies and different hybrids for royal jelly production and various factors associated with yield of the product (Crane, 1990; Toledo, 1997; Azevedo-Benitez et al., 1998; Mohanny, 1999; Saleh, 1999; Ibrahim, 2002; Zeedan, 2002; Jianke et al., 2003; Cao et al., 2016). However, in Ethiopia, no such high value honeybee products have been given attention to evaluate the potential of the existing honeybees for royal jelly production. Therefore, the aim of this study was to investigate the production potential of local honeybees through splitting and grafting queen-rearing methods in the central highland parts of the country.

Material and Methods

The study was conducted in apiary sites of Holeta Bee Research Center and at Gedo, Muger and Holeta sub sites during active seasons of 2015 and 2016. A total of 24 well established honeybee colonies in box hives with similar strength were used for both the splitting and grafting queen rearing. For splitting queen rearing, four colonies were used at each site, while 16 honeybee colonies were used for grafting technique. Four colonies at each site were used as larvae donating, while 4 others were used as starter-finisher colonies. The experimental colonies were set up in CRD with four replications.

Harvesting royal jelly from grafted and accepted larvae

Forty worker bee larvae younger than 48 hrs of age from the larvae donating colonies were grafted in to 40 plastic cell cups mounted on cell bars. The bars were placed gently into strong starter-finisher bee colonies, dequeened twenty-four hours before the introduction of frames (following the Harry and Laidlaw, 1981 cited in Zewdu Ararso *et al*., 2013). Then, the bars were removed from the starter-finisher colony 3 days (72 hrs) after grafting the larvae; and larvae were removed from the queen cups using forceps. The royal jelly was collected from queen cups with a plastic spatula and quantified using sensitive balance.

Harvesting royal jelly from splitting colonies

Four honeybee colonies at each apiary site were split following the procedures cited by Nuru Adgaba and Dereje Wolteji (1999). Three days after splitting, royal jelly was collected from each individual queen cell with plastic spatula after removing the larvae from the queen cups using forceps.

Statistical analysis

Data obtained from the experiment were analyzed using the analysis of variance (ANOVA) and mean separation about the amount of royal jelly harvested was conducted by using Least Significant Difference test (L.S.D).

Results and discussion

The results of this study showed that royal jelly can be harvested from queenless honeybee colonies of *Apis mellifera bandasi* through application of splitting and grafting queen rearing techniques with no significant difference between the two methods. The study indicated that comparable volume of royal jelly can be harvested by employing splitting queen rearing to induce strong honeybee colonies to be queenless and start rearing new queens and hence, royal jelly production (Table 1). This result has never been reported so far as all the available literatures demonstrated royal jelly production using grafting and *jenter* queen rearing techniques, and not using splitting queen rearing method (Mouro and Toledo, 2004; Muli *et al*., 2005; Jianke *et al.*, 2003; Wu *et al*.., 2015; Cao *et al*., 2016). The average royal jelly production from split colonies (*ca* 15gm/colony/harvest season) is significantly higher compared to the production from Carniolian honeybees (*ca* 4gm/colony/harvest season) and Africanized honeybees (*ca* 2gm/colony/harvest season) in Brazil (Mouro and Toledo, 2004); and (*ca* 2gm/colony/harvest season) for *A.m. monticolla* and *A.m. scutellata* in Kenya as reported by Muli *et al* (2005).

The analysis of the data of the royal jelly yield from the grafted and accepted larvae showed that about 14gm of royal jelly can be harvested per colony, in single harvest season (Table 1). The amount of royal jelly harvested doesn't show significant difference among the study sites. Again, when compared to the results reported by various authors that undertook larvae grafting and royal jelly harvesting for queen right colonies, the yield is satisfactory (Mouro and Toledo, 2004; Muli *et al*., 2005; Abbasi *et al*., 2016).

In a conclusion of this study, Carniolian colonies were the favorable hybrid for royal jelly production where it gave an average of 1.141 gm royal jelly/colony as compared with Italian and Egyptian hybrids that gave 0.966 and 0.519 gm royal jelly/colony through the same period.

Table 1. Mean ± SD royal jelly yield per colony in single harvesting season

Study site	**Grafting**	**Splitting**
Gedo	11.95 ± 0.23gm	11.75 ± 0.64gm
Holeta	15.23± 2.54gm	20.25 ±9.54 gm
Mugger	15.70 ± 3.11gm	14.44 ±2.83 gm
Over all mean	14.292.73 gm	15.486.39 gm

In average 15.486.39 gm/colony and 14.292.73gm /colony, Royal Jelly was produced from the four treatments of the splitting and grafting method respectively in the two active seasons of the year from the apiary sites. This shows that statistically both splitting and grafting methods of queen rearing have no significant difference in value at $P<0.05$ on royal jelly production yields.

Different factors may interfere in royal jelly production that include genetics; colonies internal population conditions; food flow; queen's egg-laying; and external environment related to weather conditions and food availability (Sahinler and Kaftanoglu, 1997; Mouro and Toledo, 2004; Jianke *et al.*, 2003; Sharaf El-Din *et al*., 2010). For instance, Mouro and Toledo (2004) evaluated royal jelly production in Africanized honeybees, in which the colonies with the best production remained in the experiment and their queens replaced by the respective daughters. They obtained an increase of 109% in royal jelly production per colony, confirming the feasibility of selection for this trait. The tremendous change of royal jelly productivity from about 0.2kg to 8kg per colony in Chinese beekeeping is actually the result of development and establishment of high royal jelly- producing lineage of honeybees (HRJB), which was derived from an Italian honeybee subspecies, *A. m. ligustica* (Cao *et al*., 2016).

During grafting, the age of the larvae affects the acceptance of the larvae by workers and hence the royal jelly production intended to feed the growing queens. 24 hr old age larvae are more accepted and the royal jelly produced to feed these larvae is more than that produced to feed older larvae (36hrs, 48hrs or more) (Muli *et al*.,2005; Sharaf El-Din *et al*., 2010). In this regard, the larvae grafted in this experiment were about 48 hrs old. Hence, it is expected that if younger larvae were grafted the production obtained in this trial could be greater. The other important factor affecting royal jelly production is the time interval between grafting and harvesting. In this regard, most of the authors recommend 72 hrs after grafting is

best to optimize royal jelly production (Mouro and Toledo, 2004; Abbasi *et al*., 2016) compared to 48 hrs harvesting and at or later than 72 hrs.

Mostly, grafted larvae are provided to queen right colonies separated to bottom and upper boxes of the hive using queen excluder so that the growing colonies have continuous supply of nurse bees to feed the growing queens. This gives the opportunity to increase the frequency of providing new batches of grafted larvae up to fifteen times in a single active season (Mouro and Toledo, 2004; Muli *et al*., 2005). However, in this study the growing colonies were given only two batches of grafted larvae in a single active season because of use of queenless colonies. Considering the yield from single batches of graft, this result is close to what have been reported for honeybees in East Africa (Muli *et al*., 2005) and higher than production in Egypt and Brazil (Mouro and Toledo, 2004; Sharaf El-Din *et al*., 2010; Abbasi *et al*., 2016)

Conclusion and recommendation

Royal jelly has been considered as one of the high value bee products and its harvesting was started with use of frame box hives and application of queen rearing using grafting technique. However, in this study it was demonstrated that splitting can be used to harvest equivalent amount of royal jelly as grafting from *A. m. bandasi* colonies. Therefore, royal jelly harvesting can be conducted in transitional beehives which is suitable for simple splitting. The production of royal jelly recorded in this study is comparable to what have been reported in East Africa for *A. m. monticolla* and *A. m. scutellata* under similar production technique. However, the yield is far lower than the production of royal jelly from bees that have been genetically improved in different parts of the world.

Generally, royal jelly production is a function of lot of intrinsic and external factors. Therefore, it is advisable to design and investigate by involving all possible queen-rearing methods that are applicable for any areas and agro ecologies and the other important factors to optimize the production of royal jelly including exploitation of genetic potential.

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Poultry Research Results

Introduction and Evaluation of Dual Purpose Chicken (*Potchefstroom KoeKoek*) Breed at BARC

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Abstract

To increase the production and productivity of chicken in the area, it is important to introduce and evaluate the exotic chicken breeds with higher productivity. To this effect introduction and evaluation of dual-purpose chicken breed was undertaken at Bako Agricultural Research center. The dual-purpose chicken (Potchefstroom Koekoek breed) was a day old when the test was started. The experiment was undertaken for forty eight (48) weeks of period 2015/ 2016. The management and the data on the performance of chickens were divided into three parts (0 to 8, 12 to 20, 27 to 48 weeks of age). The result of the experiment showed that average feed intake of this dual-purpose breed (Potchefstroom Koekoek) during starter phase in (g/bird/day) and (g/bird/week) for both sexes are 33.04 and 231.32 respectively. And their average weekly total body weight (g/bird/week), weight gain (g/bird/week) and mortality (%) of dual purpose breed for bothsexes are 150.92, 42.75 and 3.26 respectively. Average daily and weekly feed intake of this dual-purpose breed during later stage for female is 118.88g and 848.42g, respectively. The average weight gain (g/bird/week) is 0.44 and 0.38 for male and female with no recorded mortality during layer stage (27 to 48 weeks). The average egg production per week at minimum and maximum in percentages are from 56.97% and 63.73% during the later stage of 27 to 48 weeks. Majority of egg shape are oval and shell color are brown and the average egg weight and shell thickness 50.8 and 0.34gm respectively. The average albumen weight, yolk weight, yolk color, and yolk/albumen ratio of dual purpose breed are 26.13gm, 13.62gm, 3 and 56.86 respectively. The dual-purpose breeds are good in fertility (90%) and they start to lay eggs at 22th weeks of age that is comparable to the standard breed of layers.

Introduction

With regard to breed, 96.83 percent, 2.37 percent and 0.8 percent of the total poultry were reported to be indigenous, hybrid and exotic, respectively (CSA 2015/16).Census is 52million, excluding pastoral and agro pastoral areas. However, the majority of the population is composed of low producing scavenging chickens.

The expansion of commercial chicken is almost walking on its knee. Poultry can be managed udder different feeding systems, depending on the husbandry systems and available feed (Pousga *et al*., 2005). However, majority of the chicken population is composed of low producing scavenging chickens. The sector shows a clear distinction between traditional, low input systems on the one hand and improved production systems using relatively advanced technology on the other hand(Alemu,1995). The system is characterized by its low input and corresponding low output(Tadele *et al*., 2000). With this back ground , the objective of the study was to evaluate and recommend the promising dual purpose breed technologies on station

Methodology

One dual-purpose breed was brought from DZARC. Originally this breed was from or known in Lesotho University and South African Poultry industry. The first 72 hours in the life of chicken was very critical. Therefore necessary precautions were taken in order to guarantee their future performance. The breeders'manual was therefore strictly followed in this regard.

The management of the chickens was divided into three parts (0 to 8, 12 to 20, 27 to 45 weeks of age). The chickens were kept in open house with concrete floor and saw dust bedding at thickness of 5 to 7cm. The chickens were housed at a recommended stocking density ($4m^2$). The standard lighting program by the breeders' was also applied. The feed for the chicks were purchased from kalit feed processing company. Feeders and drinkers were placed in the house according to the recommendation of the breeders. The necessary vaccines were purchased from NVI, Debrzeyit and also hygienic procedures were employed. When the growers were about to start laying (Usually at the age of 18 weeks), individual nest which were made from local carton was provided to them in the ratio of 1 nest to 8 layers. Data on averages feed intake (g/bird/day) and (g/bird/week), growth rate (group) (g/bird/day) and (g/bird/week), FCR, mortality in %week, average egg production (bird/week in %) were collected. The external (egg shape, egg shell color, shell thickness, average egg weight) and internal (Albumen weight, yolk weight, yolk color, yolk/albumen ratio) egg quality measurements, age at first egg laying, fertility and hatchability were recorded.

Result and Discussion

The performance of dual purpose breed (*Potchefstroom Koekoek*) under Bako Agricultural research center through the experimental period were expressed as average feed intake, average total body weight, body weight gain, mortality, average egg production, the external and internal egg quality measurements, age at 1^{st} egg laying, fertility, hatchability were expressed as follow.

Average Feed intake during the starter phase (0 to 8 weeks)

The average feed intake for this dual purpose breed (Koekoek) during starter phase in (g/bird/day) and (g/bird/week) for both sex are 33.04 and 231.32respectively (Table 1).

Table 1: Average feed intake (g/bird/day) of female and male dual purpose breed (Koekoek) during starter phase (0 to 8 weeks)

Weeks	No of birds(F&M)	Feed intake(g/b/day)	Feed intake(g/b/week)
Week1	508	8.65	60.55
Week2	458	14.42	100.94
Week3	440	22.76	159.32
Week4	438	27.24	190.68
Week5	438	37.61	263.27
Week6	437	40.52	283.64
Week7	437	54.82	383.74
Week8	429	58.34	408.38
Mean		33.04	231.32

Key :(g=gram b=bird)

Average Body weight during starter Phase (0 to 8 weeks)

The average weekly total body weight(g/bird/week), weight gain (g/bird/week) and mortality in % week of dual purpose breed (Koekoek) during starter phase for both sexes are 150.92, 42.75 and 3.26 respectively (Table 2).

Table 2. Average weekly total body weight(g/bird/week), weight gain (g/bird/week) and mortality in % week of female and male dual purpose breed (Koekoek) during starter phase (0 to 8 weeks)

Week	No of birds(F&M)	Av. Weekly weight (g/b/week)	Av. Weekly weight gain (g/b/week)	Mortality (%week)
Week1	508	52.08	40.00	9.84
Week2	458	89.89	6.21	3.90
Week3	440	97.29	18.62	0.50
Week4	438	115.75	17.37	0.00
Week5	438	135.68	56.34	0.20
Week6	437	189.61	30.41	0.00
Week7	437	217.22	88.29	1.80
Week8	429	309.85	84.72	9.80
Mean		150.92	42.75	3.26

Key :(g=gram b=bird)

Average Feed intake during Grower stage (12 to 20 weeks)

The average feed intake of dual-purpose breed (Koekoek) during the growers' stage in average (g/bird/day) and (g/bird/week) for female and male are 78.87, 75.68, 547.66 and 529.73 respectively

Table 3: Average feed intake (g/bird/day) and (g/bird/week) of dual breed (Koekoek) during the growers stage (12 to 20 weeks)

Weeks	No of birds		Feed intake (g/b/day)		Feed intake (g/b/week)	
	Female	Male	Female	Male	Female	Male
Week12	215	214	65.32	69.54	457.24	486.78
Week13	210	213	69.94	74.8	489.58	523.6
Week14	208	211	71.54	77.22	500.78	540.54
Week15	205	209	75.86	69.01	531.02	483.07
Week16	203	209	83.08	76.67	581.56	536.69
Week17	201	205	84.24	77.34	589.68	541.38
Week18	197	201	83.65	76.66	585.55	536.62
Week19	194	195	73.87	76.98	517.09	538.86
Week20	189	191	96.64	82.86	676.48	580.02
Mean			78.24	75.68	547.66	529.73

Key :(g=gram b=bird)

Average Weekly Body Weight during Grower Stage (12 to 20 weeks)

The average weekly total body weight (g/bird/week), weight gain (g/bird/week) and mortality (%) week of dual purpose breed(koekoek) during growers' stage for female and male are 840.03, 1085.71,88.32,133.49,1.60 and 1.41respectively but when compare our findings within (South Arica ARC-Animal production institute,2002) findings there is a difference in average body weight for example at 16 and 20 weeks of age female and male are 784.59 and 1399.09 but South Africa at the same week of age female and male are 1400 and 1840 respectively.

Table 4: Average body weight (g/bird/week), weight gain (g/bird/week) and mortality (%) week of dual purpose breed (Koekoek) during the growing stages (9 to 20 weeks).

Weeks	No of birds		Average weekly weight (g/b/week)		Average weekly weight gain (g/b/week)		Mortality (% week)	
	Female	Male	Female	Male	Female	Male	Female	Male
Week12	215	214	592.32	612.88	64.69	85.88	2.33	0.47
Week13	210	213	657.01	698.76	65.23	65.58	0.95	0.94
Week14	208	211	722.24	764.34	-106.14	161.55	1.44	0.95
Week15	205	209	616.10	925.89	178.49	142.33	0.98	0.00
Week16	203	209	794.59	1068.22	67.64	90.96	0.99	1.91
Week17	201	205	862.23	1159.18	34.45	133.36	1.99	1.95
Week18	197	201	896.68	1292.54	223.52	276.24	1.52	2.99
Week19	194	195	1120.2	1568.78	178.67	112.03	2.58	2.05
Week20	189	191	1298.87	1680.81	-	-	0.00	0.00
Mean			840.03	1085.71	88.32	133.49	1.60	1.41

Key :(g=gram b=bird)

The Average Feed Intake during the Later Stages (27 to 48 weeks)

The average feed intake of dual purpose breed (Koekoek) during the later stages in (g/b/day) and (g/b/week) for female is 118.88 and 848.42 respectively. According to the report of Ernest (1996) the amount of feed that is to be consumed /bird/ day was various because the feed intake largely depends on factors like feed quality, palatability, climates, housing systems, health, management and others.

Average Body Weight during the Layer Stages (27 to 48 weeks)

The average weekly total body weight (g/b/week), weight gain (g/b/week) and mortality (%) week of dual purpose breed (Koekoek) during layer stage (27 to 48 weeks) for female and male 1792.54, 2542.59, 0.44, 0.38 and 0.00 respectively.

Average Egg Production during the Later Stages (27 to 48 weeks)

Average weekly egg production/ week in percentages of dual purpose breed (Koekoek) during layer stage (27 to 48 weeks) are expressed below. The average egg production / week in percentages are from 57.79% to 62.63% during the later stages of (27 to 48 weeks) when we compare our finding with the South African (ARC-Animal Production Institute, 2010) egg productions in percentage are 60.35 and 61.09 respectively and that of Wondemeneh E. *etal*; 2012 atDebrezeyit agricultural research center which was reported as 56.97% to 63.73% this is a very good results for Bako area and other areas with similar agro-ecologies.

External Egg Quality Measurements

The average egg shape, egg shell color, shell thickness, average egg weight of dual purpose breed(koekoek) are Oval, brown, 0.34 and 50.8gm respectively but the average egg weight of this breed in South Africa is 55.7gm (South Africa ARC-Animal Production Institute,2010).

Internal Egg Quality Measurements

The average albumen weight, yolk weight, yolk color and yolk/albumen ratio of dual purpose breed (koekoek) are 26.13gm, 13.62gm, 3 and 56.86 respectively.

Reproductive Parameters

The dual purpose breed (koekoek) are good in fertility(90%) and hatchability(78%) and they start to lay egg at 22nd weeks of age that is comparable to the standard breed 20 weeks of age (South Africa ARC-Animal Production Institute,2010) and that of Wondemeneh E. *etal*; 2012 at Debrezeyit agricultural research center.

Conclusion and Recommendations

It is possible to conclude from the data analyzed that, the result is similar with the result found at DARC (Debrazeyt Agricultural research center) and are also comparable with their breed standard manuals, South African (ARC-Animal Production Institute, 2010) therefore; we can say that the breed is adapting the Bako Agricultural research center without any significant problems and we can recommend for our beneficiaries (Small scale farmers, researchers, NGos and others) to use the breed without any fear in Bako area and other areas with similar agro ecologies.

Figure 1.Koekoek chicken breed

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