

Growth Performance of Arsi, Borana, Harar and HF-Crossbred bulls finished under similar feeding condition

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Abstract

Background: The study was conducted to evaluate the fattening performance of Arsi, Borana, Harar and Holstein Friesian crossbred bulls finished under similar feeding condition at the beef farm in Haramaya University. A total of 24 bulls with age categories of 2–3 and 4–5 years were used in the complete block design for the experiment. Total mixed ration was provided at 3% of their body weight during experimental periods.

Results: The average daily weight gain of the four breeds range from 0.49 to 0.71 kg. Feed conversion efficiency also ranges from 0.11–0.15. Simple linear regression models were used to explore the relationship between live body weight change and change in body condition score as well as seven linear body measurements for all age groups. An average change for a unite of body condition score was equivalent to 20.3, 20.61, 22.42 and 27.78kg for Borana, Arsi, Harar and Holstein Friesian crossbred bulls respectively. Body condition score was significantly influenced by breeds. There was a significant breed by age interaction effect on the initial body condition score of the four breeds. There was a significant and positive strong association between change in body weight and body condition score. There was a significant and strong correlation between change in body weight and change in Total topline, neck length, heart girth, flank circumference and rump length having correlation coefficient ranges from 0.57 to 0.97. Higher net profit of 7,380.47 ETB per head was recorded by Borana bulls followed by Harar bulls, Arsi and Holstein Friesian crossbred with net profit of 5,406.86, 5193.29 and 3,384.98 ETB per head respectively.

Conclusion: Borana bulls are more superior in weight gain and net profite. Body weight change could be predicted based on body condition score change during fattening period.

1. Introduction

The total cattle population for Ethiopia is estimated to be about 59.45 million. The majority (98.2%) of the total cattle in the country are local breeds. The remaining are hybrid and exotic breeds that accounted for about 1.62 percent and 0.18 percent, respectively. Regarding age groups, the majority of the cattle population (that is about 62.95%) was in 3 to 10 years and 16.75% is 1 to 3 years. The remaining 2.25 % was 10 and above years old (CSA, 2017).

In Ethiopia, cattle production plays an important role in the economies of the farmers and the country at large. FAO (2007) reported that cattle contribute 40% of the annual agricultural output and 15% of the total gross domestic product. There are 33 recognized indigenous cattle breeds in Ethiopia (DAGRIS 2011). Because of its multi-purpose role, farmers has been used for milk, beef, draft power, farm yard manure and source of cash income in the country (FAO, 2018). So therefore, it has been evident that those diversified cattle breeds in all diversified agro-ecology of the country has good market and brings superior prices both at domestic and foreign markets. Such a scenario created an opportunity for small-scale cattle fattening systems in different parts of the country. Therefore, Cattle fattening has gained reputation as an important business project of the livestock industry in Ethiopia (Habtamu et al., 2008). This is special in eastern part of the country in general and in Hararghe highlands in particular (Dinku 2019).

Crossbreeding work in Ethiopia was initiated in the early 1950s. Following this initiation a number of governmental and non-governmental institutions have worked on the development of the dairy sector (Aynalem et al. 2011). This resulted improvement in milk production as well as surplus crossed bulls' availability in different parts of the country. However, lack of disposal mechanism for surplus male calves at dairy farm level has been reported as one of the main constraints in improving the dairy farm profitability (Merera and Galmessa, 2013). The importance of dairy beef to minimize the problem of continuous supply of young bulls to the market was reported in different studies (Mummed 2015; Mummed and Webb 2014; Mummed and Webb 2015).

Animal feed both in terms of quantity and quality is a major bottleneck for livestock production in Ethiopia. Currently, with the rapid increase of human population and increasing demand for food, grazing lands are progressively shrinking by being converted to arable lands, and are restricted to areas that have little value (Mengistu *et al.*, 2017). It is clear that feed resource utilization (Fikru 2015); fattening and marketing of cattle are undeveloped in different parts of the country (Ayalew *et al.*, 2013). Furthermore, developing economic feeding system that enhance the existing traditional production and emerging private business is among timely interventions required to increase production and productivity of beef cattle (Negassa *et al.*, 2011) and thereby achievement to growing demand for meat and also to the country's plan of increasing meat export, by encouraging small scale beef fatteners based on scientific evidences. Most cattle supplied to market from pastoral, agro-pastoral and mixed crop livestock production were reported poor in their meat quality (Mummed and Webb 2014; Mummed and Webb 2015). Giving due emphasis on economically feasible concentrate supplementation is important in the fattening systems.

Environmental condition during fattening period, type and amount of feed, pre-fattening condition of cattle and feedlot management determine the length of fattening period. Therefore, scarcity of feed, animal in poor condition before fattening and improper management prolong the finishing period. Longer fattening periods reduces profit realized from cattle finishing (Ebrahim *et al.*, 2004).

Arsi, Harar and Borana bulls are also among the 33 recognized indigenous cattle breeds in the country. Their fattening performance has been studied and different results were reported by different scholars for example (Mohammed *et al.*, 2008; Haile *et al.*, 2009; Girma *et al.*, 2015; Bedhane and Dadi, 2016) for Borana bulls, (O'Donovan *et al.*, 1978; O'Donovan *et al.*, 1980; Merera and Galmessa 2013) for HF-Crossbred with Borana, Barca and Horro breed respectively, (Tolla *et al.*, 2002, 2003) for Arsi bulls, (Teklebrhan, 2019) for Harar bulls. As result of these works differ in time and space under different feeding condition; the performance of these breeds under similar fattening conditions were not studied before. Therefore, this study was conducted to evaluate the growth performance of Arsi, Borana, Harar and HF-Crossbred bulls finished under similar feeding condition.

2. Materials And Methods

2.1. Description of the Study Area

The study was conducted at Haramaya University beef fattening unit. It is located at 9.0°N latitude and 42.0°E longitude at an altitude of 1980 m above sea level and 515km east of Addis Ababa, Ethiopia. The area receives annual average rainfall of 790 mm and annual mean temperature of 16°C (Mishra *et al.*, 2004).

2.2. Animal management and experimental design

A total of 24 intact bulls from Arsi, Borana, Harar breeds and Holstein Frisian cross were grouped into two age groups (2–3 years and 4–5 years) were used in this experiment at the Beef Farm of Haramaya University using completely randomized design as shown in Table 1.

Table 1
Experimental design of the study

Age	Breeds				Total
	Borane	Arsi	Harar	HF-cross	
2-3yrs	3	3	3	3	12
4-5yrs	3	3	3	3	12
Total	6	6	6	6	24

The bulls were purchased from *Kofele* local market (Arsi breed), *Dida Tuyura* ranch (Boran breed) and *Chefe Bante* local markets (Harar breed) and *Sululta* local market (HF-Crossbred) and transported to Haramaya University using appropriate truck. The age of the animals was estimated using the dentition method as suggested by (Hammond *et al.*, 1971; MLA, 2011).

They were quarantined for two weeks being vaccinated against blackleg disease and also dewormed by injecting with Ivermectin against internal and external parasites. After quarantine, each animal was kept in an individual pen and acclimatized for two weeks. The experiment lasted for 90 days

2.3. Experimental feed and chemical analysis

The experimental diet consists of roughage; natural grass hay, wheat straw and concentrate; maize grain, noug (*gucia abyssica*) cake, wheat bran, limestone, salt, ruminant premix, and were analyzed for chemical composition at Haramaya university animal nutrition laboratory.

For chemical analysis 100 grams of samples of feeds were dried at 65°C for 48 hr. Then dried samples were then ground (1 mm screen) and stored for subsequent analyses of dry matter (DM), crude protein (CP), ash, neutral detergent fire (NDF) and acid detergent fire (ADF). DM, N and total ash were determined according to the official methods of (AOAC, 1990) and NDF and ADF according to (Soest *et al.*, 1991). Dry matter content of the feed was determined by drying the samples in an oven at 105°C overnight while ash content was determined by burning the samples at 550°C for 5 h in a muff furnace. Nitrogen (N) were determined by Kjeldahl method ($CP = N \times 6.25$). The chemical composition of each dietary components is indicated in Table 2.

Table 2
Chemical composition of experimental feed ingredients

Feed type	% of items on DM					
	DM	Ash	CP	NDF	ADF	ADL
Maize grain	87.35	1.80	10.06	42.68	6.64	3.79
Nuge (<i>gucia abyssica</i>) cake	90.46	8.48	45.74	42.91	27.94	10.07
Wheat brane	88.81	5.24	17.19	54.44	9.92	4.22
Total mixed ration	89.81	9.99	21.69	51.28	14.54	6.93
Grass hay	89.29	8.59	5.83	77.05	44.14	8.41
Wheat straw	94.49	5.94	3.14	80.64	45.32	6.14
DM = dry matte, CP = Crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin						

2.4. Feed formulation and feed intake measurement

The diet were formulated aiming to meet the maintenance requirements and to provide a weight gain of up to 1 kg per day as suggested by Hutcheson (2006) for beef fattening center in Ethiopia. The roughage (60% of total ration) component were natural grass hay (55% of roughage) and wheat straw (45% of roughage); the concentrate (40% of total ration) consisted of 34.78% wheat bran, 27.8% Noug cake, 33.14% maize grain, 1.7 % limestone and 1.7 % salt and 0.88% ruminant premix. It was formulated to contain CP and energy to meet the optimum recommendation of feedlot.

Three percent of their body weight per day for total mixed ration was given in two equal meals at 8:00 AM in the morning and 3:00 PM in afternoon of the day and the amount were adjusted based on body weight once per every week. Clean water was available all the time. The weight of concentrate and roughage offered and refused were recorded daily to derive feed intake.

2.5 Feed conversion efficiency

Feed conversion efficiency (FCE) were calculated for each animal as proportion of weight gain to DM intake

$$\text{FCE} = \frac{\text{Weight gain (kg)}}{\text{DM Intake (kg)}}$$

2.6 Evaluation of daily weight gain and linear measurements

Animals were weighed once every week before morning feeding. Initial weight (IW) and final weight (FW) were recorded for different feeding periods.

$$\text{ADG} = \frac{\text{Final body weight (Kg)} - \text{Initial body weight (kg)}}{\text{n day}}$$

Where; ADG= Average daily gain, n= number of days, n= 90

Body linear measurements such as total top line (the total length of the animal taken from front of the pool to back of the rump), neck length (the distance from front of the pool to the middle dip in vertebrate between the shoulder blades), hip height (height of the cattle on the vertical line passing through the hips), heart girth (the thoracic circumference), flank circumference (the total distance around the animal taken at the hips) , rump length (the distance taken from the hips to the pin bones), rump or pin bone width (the horizontal distance between the pin bones), shoulder width (the horizontal distance between shoulders) and chest depth (the distance taken with vertical caliper through the vertical transverse plane passing just to the rear of the point of the elbow) were taken immediately after acclimatization period and two days before slaughter.

2.7 Body condition scoring

Body condition scoring for each experimental animals (n=24) were recorded once in every week following body weight measurement during experimental feeding based on a 9 scale scoring method, with 1 being severely emaciated and 9 extremely obese, using the method proposed by Herd and Sprott, (1986) and modified by Jaymelynn *et al.* (2016) as briefly indicated in (Table 3) bellow. To avoid subjective biasness, an expert has scored the condition throughout the experimental periods.

Table 3. Visual method for evaluating body condition in cattle							
Physical Attribute							
	BSC	Spine	Ribs	Hooks/pins	Tailhead	Brisket	Muscling
Thin	1	Visible	Visible	Visible	No fat	No fat	None/atrophy
	2	Visible	Visible	Visible	No fat	No fat	None/atrophy
Borderline	3	Visible	Visible	Visible	No fat	No fat	None
	4	Slightly visibl	Foreribs visible	Visible	No fat	No fat	Full
Optimum condition	5	Not visible	Not visible	Visible	No fat	No fat	Full
	6	Not visible	Not visible	Visible	Some fat	Some fat	Full
Over conditioned	7	Not visible	Not visible	Slightly visible	Some fat	Fat	Full
	8	Not visible	Not visible	Not visible	Abundant fat	Abundant fat	Full
	9	Not visible	Not visible	Not visible	Extremely fat	Extremely fat	Full

BCS = body condition score

2.8 Economic analysis

At the end of the experiment, partial budget analysis was performed to evaluate the economic advantage of feeding the four breeds of intact bulls with total mixed ration. It was done by considering the variable cost of bull price, concentrates and roughage prices, labor, medication and estimated bull sell prices at the end of the experiment. At the end of experimental feeding, four experienced animal dealers were estimate the sell price of each experimental animals and the average price determined by the dealers was used as the selling price of individual bull. The difference in sell and purchase price was considered as total return (TR) in the analysis.

TR = sell price – purchase price

The cost of feed was computed by multiplying the actual DM intake of feed for whole feeding period 90 days with the purchase price of the feed. The total cost associated with each animal during the experimental period were added and the total variable cost (TVC) were calculated for each animal. Net return (NR), was calculated by subtracting TVC from TR as follows.

NR= TR – TVC

2.9 Statistical analysis

The data were analyzed using General Linear Model (GLM) procedure of Statistical Analysis System (SAS, 2018) version 9.4. Simple linear regression was used for the determination of the most suitable model in the prediction of the live weight change using various body measurements change as continuous variables and simple regression was also used for change in body weight and body condition score to establish regression equations. The model included the main effects of age and breed to determine the influence of the main effects on all dependent variables considered. The difference among treatment means was tested using Tukeys' test at 0.05 level of significance.

The models used for the analysis were:

Model I

To evaluate effects of ages and breeds on weight gains and FCE

$$Y_{ijk} = \mu + A_i + B_j + (A*B)_{ij} + e_{ijk}$$

Where

Y_{ijk} = Response variable

μ = Overall mean

A_i = age effect (i= 2 level)

B_j = breed effect (j= 4 level)

$A*B$ = interaction effect of age and breed

e_{ijk} = random error

Model II

To calculate Relationships between change in body weight and change in BCS, linear body measurement (Total topline, Neck length, Flank circumference, Heart girth, Rump width).

$$Y_i = \alpha + \beta X + \varepsilon$$

Where,

Y_i = dependent variable (Live weight change)

α = intercept

X = independent variable (BCS change, Total topline, Neck length, Flank circumference, Heart girth, Rump width change)

β = regression slopes of (BCS change, Total topline, Neck length, Flank circumference, Heart girth, Rump width change)

ε = Residual.

3. Results And Discussion

3.1. Bodyweight change, Average daily weight gain, body condition score and feed conversion efficiency

Average initial and final live weights and daily weight gain of bulls from the four breeds under two age groups are summarized in Table 4. The significant difference in final and initial body weight of bulls from the four breeds and their respective two age categories cannot be explained as the bulls were different in their initial body weight at the start of the experiment. However, animals in higher age groups attain higher ($P < 0.001$) body weight records in both initial and final body weight. This is in agreement with the previous finding by (Bassa *et al.*, 2016).

There was no statistically significant difference in average daily weight gain of the four breeds grouped to two age categories. However, the average daily weight gain in the current study ranges from 0.49 to 0.71 kg with an overall ADWG of 0.63kg. The average body weight gain in the present study was in line with the finding by Bedhane and Dadi (2016) who reported ADG 0.63 kg for Ethiopian Borana breeds with an estimated age of 4 years old.

The attained results in this study for Borana bulls were higher than the report of Haile *et al.* (2009) which reported the daily body weight gain of the same breed about 0.44 kg in low input management system. The current result also showed the higher value of ADWG than the finding of Mohammed *et al.* (2008) who reported 0.49 kg for 2 years old Borana bulls under natural grazing management. In addition, lower values of ADG were also reported by Osuji and Capper (1992) which was a 0.51 kg for Ethiopian Highland Zebu (*Bos indicus*) oxen at age between 7 to 8 years that was fed on *teff* straw with concentrate supplement and Mekasha *et al.* (2011) and 0.47 kg for Ogaden bulls grazing native pasture supplemented with agro-industrial by-products mix and hay at a ratio of 25:75 as compared to current study result, Bedhane and Dadi (2016) for Ethiopian Borana breeds with an estimated age of 2 to 6 years old ranged 0.49kg to 0.65kg ADWG. However, almost comparable finding was reported by Girma *et al.* (2015) who reported that two years old Borana bulls attained an ADWG of 0.77 to 0.8 kg.

The average daily weight gain for the HF-Crossbred bulls in this study was lower than reports by Merera and Galmessa (2013) which was 0.87kg for Horro-Friesian crossbred bulls in the age from 2 to 3 years; O'Donovan *et al.*, (1978) which was 0.88 kg for crosses between Borana bulls and Friesian dam as well as 0.98kg for a cross between Barca sire with Friesian dam at Holota research center. However, higher than the report by O'Donovan *et al.*, (1980) who reported 0.54kg ADWG for crossbreds at Bakko research center.

The ADWG of Afar bulls supplemented with different levels of concentrate under improved feeding management were between 0.54 and 0.62 kg (Weldegebrail, 2018). This is in agreement with the value of Harar bulls in the current study. Moreover, Tolla *et al.* (2003) reported comparable ADG 0.44 to 0.57 kg for Arsi bulls. In contrast to the current finding Teklebrhan (2019) reported that Hararghe highland bulls feeding different concentrate feeds revealed a higher ADG of 1.21 to 1.33 kg.

The feed conversion efficiency of the experimental bulls in this study was not significantly different ($P > 0.05$) between breed, age as well as the interaction between breed and age. This is in line with the finding of Adebabay *et al.* (2013) who revealed the absence of a significant difference between Fogera and Adet breed bulls. Tolla *et al.* (2002) also reported insignificant ($P > 0.05$) differences among Borana and Arsi breed bulls. Similarly, Merera and Galmessa (2013) reported that feed conversion efficiency was higher for the lower age group but the differences were not significant ($P > 0.05$) for Horro-Friesian crossbred bulls. The overall mean value obtained in this study was comparable with the feed conversion efficiency of Fogera (0.10) oxen reported by Adebabay *et al.* (2013) but higher than the value for Adet (0.09) oxen. Whereas higher values were reported by Tolla *et al.* (2002) for Boran (0.14) and Arsi (0.13).

Table 4
Effect of breeds and age on body weight, average daily weight gain (kg) and feed conversion efficiency.

Category	N	Body weight		ADWG	FCE
		IBW	FBW		
		Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Breeds					
Arsi	6	130.83 ± 5.71	170.33 ± 8.31	0.49 ± 0.03	0.11 ± 0.01
Borana	6	153.0 ± 8.91	209.5 ± 14.69	0.71 ± 0.15	0.13 ± 0.02
Cross	6	162.16 ± 10.18	206.33 ± 10.38	0.65 ± 0.09	0.12 ± 0.01
Harar	6	125.83 ± 9.03	179.83 ± 7.60	0.68 ± 0.06	0.15 ± 0.02
P-value		Ns	Ns	Ns	NS
Age					
2-3years	12	126.83 ± 6.02 ^b	171 ± 5.94 ^b	0.57 ± 0.05	0.13 ± 0.01
4-5years	12	159.0 ± 8.78 ^a	211.5 ± 10.73 ^a	0.67 ± 0.08	0.12 ± 0.01
P-Value		**	***	NS	NS
Overall	24	141.45 ± 5.83	191.5 ± 7.31	0.63 ± 0.05	0.12 ± 0.01
Breed * Age		NS	NS		NS
Means followed by different superscript letters within column are significantly different, NS = P > 0.05, ***=P < 0.001, **=P < 0.01; *=P < 0.05, FCE = Feed conversion efficiency, IBW = initial body weight, FBW = final body weight, ADWG = average daily weight gain, SE = standard error of mean, N = sample number, kg = kilo gram.					

The pattern of body condition score of three indigenous breeds and HF crossbred bulls for the two age categories were presented in Table 5. The mean body condition score was the highest (P < 0.05) for Arsi bulls compared to FH Crossbred while Harar and Borana bulls show intermediate body condition scores obtained during the start of experimental feeding. This variation might be due to the difference in animal management at their respective source before experimental feeding. HF crossbred bulls scored lower (P < 0.01) body condition compared to all Borana, Harar and Arsi bulls in the final period of feeding.

Meanwhile, body condition score is an excellent indicator of the nutritional status of the animals and is an indirect reflection of the body reserve, the highest body condition score obtained for Arsi bulls, as well as the higher BCS change in Borana and Harar bulls, reveals that these animals were in a better nutritional status and had better body reserve at the initial score and BCS change respectively. Therefore, change in body condition score is an indirect estimation of live body weight change. This is confirmed by several scholars in their works (Nicholson and Sayers, 1987; Osuji and Capper, 1992; Berry *et al.*, 2006).

The estimated body weight change based on the change in body weight to change in BCS ratio was significantly (P < 0.01) influenced by breeds as shown in Table 5. This result indicates that change of one condition score was significantly higher (P < 0.01) for HF-crossbred bulls (27.78 kg) than Borana bulls (20.3kg) whereas intermediate values 22.42kg and 20.61kg were recorded for Harar and Arsi bulls respectively. The higher body weight change per one condition score change for HF-Crossbred bull obtained in the current finding might be due to the heavier body size of

HF-crossbred bulls than other local cattle bulls of similar age. Therefore, fattening HF-crossbred bulls was advantageous in beef production improvement.

Table 5
Effect of breed and age on body condition scoring during the experimental feeding period

Category	N	Body condition scoring		P-value	Changes		Change BW/BCS (kg)
		Initial BCS	Final BCS		BCS	BW (kg)	
		Mean ± SE	Mean ± SE		Mean ± SE	Mean ± SE	
Breeds							
Borana	6	3.79 ± 0.19 ^{ab}	6.58 ± 0.41 ^a		2.78 ± 0.40 ^a	56.5 ± 12.71	20.3 ± 1.51 ^b
Arsi	6	4.34 ± 0.31 ^a	6.25 ± 0.28 ^a		1.91 ± 0.34 ^b	39.5 ± 3.01	20.61 ± 2.18 ^{ab}
Harar	6	3.9 ± 0.35 ^{ab}	6.50 ± 0.18 ^a		2.57 ± 0.31 ^a	54 ± 5.03	22.42 ± 2.17 ^{ab}
Crossbred	6	3.08 ± 0.26 ^b	4.66 ± 0.42 ^b		1.59 ± 0.19 ^b	44.33 ± 5.70	27.78 ± 1.73 ^a
P-value		*	**		*	Ns	**
Age group							
2-3years	12	3.77 ± 0.18	5.87 ± 0.25		2.10 ± 0.21	44.66 ± 4.11	21.93 ± 1.44
4-5years	12	3.87 ± 0.20	6.12 ± 0.25		1.95 ± 0.21	47.75 ± 2.79	23.63 ± 1.66
P-value		NS	NS		NS	NS	Ns
Overall		3.79 ± 0.15 ^b	5.99 ± 0.18 ^a	**	2.05 ± 0.20	48.08 ± 3.78	22.78 ± 1.09
Breed *Age		*	NS		NS	NS	Ns
Mean values under the same category that bear different superscript letters are significantly different, NS = P > 0.05, ***=P < 0.001, **=P < 0.01, *=P < 0.05, N = sample number, BCS = body condition score, kg = kilo gram, SE = standard error of mean.							

The two age groups are not different in the initial BCS. Similarly, the BCS of the bull was the same under the two-age group during final feeding periods. The same holds true for change in BCS and BW change. On the other hand, there was a significant breed by age interaction effect on the initial body condition score of the four breeds. i.e., the difference in initial BCS between the four breed bulls depends on the age in which they are grouped. The Arsi bulls score higher body condition in the lower age group than the higher age group. However, the reverse was true in the Borana, Harar and HF crossbred (Fig. 1).

The relationship between BW change and BCS change was presented in (Table 6). The relationship between BCS change and BW change was statically significant (P < 0.01) in all factors. Bodyweight change and body condition score change were positively and strongly correlated in the breeds of Arsi, Borana, Harar and HF-crossbred bulls. The maximum correlation coefficient ($r=0.97$) for Borana and minimum correlation coefficient ($r=0.88$) for HF-crossbred bulls were observed. Indicating a high level of association between body weight and body condition score changes. Similarly, there was a strong, positive and significant (P < 0.01) correlation between BW and BCS change in the age categories of 2–3 years, 4–5 years and overall bulls. This is corroborated by the previous work that confirms that there were strong relationship between BCS and BW change in cattle (Díaz-López *et al.* 2017; Evangelista *et al.* 2019)

Table 6
Pearson correlation coefficient between body weight change and body condition score change

		BCS change
Breeds		
Arsi	BW change	0.93**
Borana	BW change	0.97***
HF-crossbred	BW change	0.88*
Harar	BW change	0.96**
Age		
2-3years	BW change	0.89***
4-5years	BW change	0.70*
Overall	BW change	0.80***
BW = body weight, BCS = body condition score, ***=P < 0.001, **=P < 0.01; *=P < 0.05		

The regression equation predicting live weight change per body condition change for the two-age group and the entire experimental bulls were presented in Table 7. Accordingly, it means that change of one condition score is equivalent to 22.66, 20.87, 22.65 and 28.66 kg body weight in Arsi, Borana, Harar and HF-crossbred bulls respectively. When these experimental bulls were arranged in two age categories one body condition score change in 2–3 years and 4–5 years old bulls represent 23.65 and 26.53 kg bodyweight change, respectively. The average change of one condition score for all experimental bulls was equivalent to 25.99 kg body weight. Comparable with the current finding Ali and Muna (2013) reported one condition score was equivalent to 26 kg in males for Sudan cattle. The value of BW associated with the unit of BCS change in the current study was lower than previous report by Berry *et al.*, (2006) who reported a change of 31 kg BW for every unit change in BCS for Holstein-Friesian cattle in New Zealand, Fox, *et al.*, (1999) also reported the relationship between BW change and BCS in Holstein cows was 84.6 kg/BCS. However, the value of 25.99 kg from the present study agrees well with the range of 21 to 35 kg BW per unit BCS in Holstein-Friesian cattle reported by Enevoldsen and Kristensen (1997). Jaurena *et al.* (2005) reported higher values for the regression 32 to 47 kg/BCS. Differences between studies in the relationship between BCS and BW change were due to BW is affected by breed, age sex and statistical models used (Berry *et al.*, 2011). Bodyweight values obtained as per change in one unit of body condition score was increasing as the age of animals increasing. This is in agreement with earlier findings (Osuji and Capper, 1992; Berry *et al.*, 2006).

Body condition scores of experimental bulls were improved over the feeding period where bulls in the final period of feeding had the higher ($P < 0.01$) body condition score than initial BCS. This is corroborated by the works that confirm body condition scores were improved over the feeding period (Mekasha *et al.*, 2011; Merera and Galmessa, 2013).

Table 7
Relationship between live weight change and body condition change

Category		Models	R ²	MSE	P-value
Breeds	Arsi	Y = 11.84X + 10.82	0.87	2.80	**
	Borana	Y = 16.5X + 4.37	0.95	2.68	***
	Harar	Y = 16.18X + 6.47	0.93	3.42	**
	HF-crossbred	Y = 26.84X + 1.82	0.78	7.25	*
Age	2-3years	Y = 14.06X + 9.19	0.79	6.70	***
	4-5years	Y = 13.57X + 12.96	0.49	3.68	**
Overall		Y = 15.97X + 10.02	0.56	12.54	***

Where, Y = body weight change (kg), X = change in body condition score, R² = coefficient of determination, MSE = mean square error, ***=P < 0.001, **=P < 0.01; *=P < 0.05.

3.2. Correlation between change in body weight and linear measurement

Pearson's correlation coefficient (r) between body weight change and linear body measurement change was presented in Table 8. In both age categories and overall measurement, all of the changes in linear body measurements have a positive association with changes in body weight. Highly significant association were found between body weight change and total topline ($r = 0.94$, $P < 0.0001$), heart girth ($r = 0.85$, $P < 0.0001$), chest depth ($r = 0.88$, $P < 0.0001$) and flank circumference ($r = 0.81$, $P < 0.01$) change in the younger age category. There was a highly significant and positive correlation between BW change and total topline change ($r = 0.80$, $P < 0.01$) and ($r = 0.89$, $P < 0.0001$) in the second age category and overall, respectively. Whereas change in neck length ($r = 0.72$, $P < 0.05$) and ($r = 0.57$, $P < 0.05$) moderately influence body weight change in the first (2-3years) and second age group (4-5years) respectively. Change in heart girth ($r = 0.68$, $P < 0.05$), flank circumference ($r = 0.69$, $P < 0.05$) and shoulder width ($r = 0.69$, $P < 0.05$) has significant positive association with BW change in the second age group. Considering the overall experimental bulls in the relationship also shows a significant correlation between change in body weight and some of the linear body measurements. Likewise, the highest relationship was found between body weight change and change in total topline ($r = 0.89$, $P < 0.0001$), change in Heart girth ($r = 0.75$, $P < 0.0001$), change in flank circumference ($r = 0.73$, $P < 0.0001$). moreover, there was a moderately significant correlation between BW change and change in shoulder width ($r = 0.56$, $P < 0.05$) and chest depth ($r = 0.55$, $P < 0.05$). Change in ramp width was significantly correlated with BW change. However, there was no significant correlation between body weight change and change in hip length and rump length in both age groups as well as overall experimental bulls. Meaning that they did not significantly affect the change in body weight, so they were not more important in the prediction of live body weight change of the animal because of weak association with body weight change. This study is in agreement with some of the previous works by Vanvanhossou *et al.* (2018) that reported as correlation coefficients within age groups confirm the influence of these parameters on the relationships between live body weight and linear body measurements. Tsegaye *et al.* (2013) also suggest that the best estimations of body weight from linear body measurements should be developed from those that showed a strong correlation. Generally, as the result of correlation showed a change in total topline, neck length, heart girth, flank circumference, rump width and chest depth was the most important than other linear body measurement change for both age categories to estimate body weight change per unit change of linear measurement during fattening.

Table 8
Correlation coefficient between change in body weight and linear body measurements.

Age group		Change in linear body measurement								
		TLC	NLC	HLC	HGC	FCC	RLC	RWC	SWC	CDC
2–3 yrs	BWC	0.94 ^{***}	0.72 [*]	0.33 ^{ns}	0.85 ^{***}	0.81 ^{**}	0.16 ^{ns}	0.97 ^{***}	0.46 ^{ns}	0.88 ^{***}
4–5 yrs	BWC	0.80 ^{**}	0.57 [*]	0.29 ^{ns}	0.68 [*]	0.69 [*]	0.11 ^{ns}	0.95 ^{***}	0.69 [*]	0.45 ^{ns}
Overall	BWC	0.89 ^{***}	0.64 ^{***}	0.29 ^{ns}	0.75 ^{***}	0.73 ^{***}	0.16 ^{ns}	0.96 ^{***}	0.56 [*]	0.55 ^{**}

BWC = Body weight change, yrs = years, TLC = Total topline change, NLC = Neck length change, HLC = Hip length change, HGC = Heart girth change, FCC = Flank circumference change, RLC = Rump length change, RWC = Rump width change, SWC = Shoulder width change, CDC = Chest depth change, Ns = not significance * = (0.05) significance, ** = (0.001) significance level.

The prediction equations to estimate body weight change per unit change of linear body measurements were presented in Table 9. Individual linear body measurement parameters were used to establish the most appropriate models predicting the live body weight change of bulls during the fattening period. The different age categories as well as overall bulls were analyzed separately.

In the first age category regression model reveals that about 91% of the change in BW was influenced by a change in total topline and the remaining 9% was influenced by other factors outside the model such as cattle condition when measured and weighed, measurements method, the accuracy of measuring instruments and others. According to the Model, increasing 1 cm of the total topline of bulls was equivalent to increasing 8.21 kg of BW. Whereas change in 1 cm of total topline represents 9.6kg and 8.0kg BW change in the second age group and when overall experimental bulls considered in the model respectively. In accordance with the present study, Bhagat *et al.* (2016) observed the highest R² value when body length alone was included in the regression model in 2–3 year Sahiwal male cattle. The variation in live body weight was also explained by the change in neck length, in this regression model, increment in 1 cm neck length represent 16.96kg for bulls under 2-3years age, 8.24kg for 4-5years age and 12.01kg in overall experiment. However, a maximum R² value of 0.52 and a minimum R² value of 0.33 were observed in the 2-3years and 4-5years age group respectively.

The coefficient of determination (R²) value in simple linear regression using HG as the independent variable in both age groups was included in the high category (0.68 < R² < 0.81). In line with the present finding, Patel *et al.* (2019) reported the highest R² value when the heart girth alone included in the regression models of HF crossbred 2–4 years, Bhagat *et al.* (2016) also observed the highest R² value when the heart girth alone included into the regression models in 2–3 Years Sahiwal female cattle. similarly, high category of R² value (0.61 < R² < 0.80) in regression models were reported in some breeds cattle of Abyssinian 0.65, Holstein Friesian 0.61, Ongole 0.79, crossbred dairy 0.67 and 0.73 for Lagune (Goe *et al.*, 2001; Ozkaya and Bozkurt 2009; Putra, 2020; Lukuyu *et al.* 2016; Assogba *et al.*, 2017). According to the Model, increasing 1 cm of HG was followed by increasing 4.83kg, 3.27kg and 4.13kg of BW for 2-3year, 4-5years and overall estimation respectively. In line with the current finding Putra (2020) reported change in 1cm HG was equivalent to 4.55 kg for bull and 3.26 kg of BW for a heifer. Goe *et al.*, (2001) also estimated a 1 cm change in heart girth would result in a weight change of 3.4 to 4.7 kg for Ethiopian highland oxen. Odadi (2018) reported a 1 cm change in heart girth would result in a weight change of 3.37 kg for *Bos indicus* cattle in Kenya.

Change in flank circumference in all age categories indicates that about 77–79% influenced BW change. One unit change in flank circumference was equivalent to 3.18 to 4.88kg of BW in the current finding. 1 cm change in chest depth

was also equivalent to 2.35kg BW change in bulls under 2-3years, 3.2kg for 4-5years and 2.75kg BW change in overall estimation.

The higher R^2 value and smaller RMSE attained using a single predictor in each age categories showed that the linear body measurements used as independent variables were good estimators of body weight. Generally, rump width was the most determinant linear body measurement variables in establishing a regression model in predicting BW change per unit of rump width change during fattening in all age categories.

Table 9
Regression equations predicting live weight change (Kg) from linear measurement change (cm)

Age group	Regression models	R^2	RMSE	P-value
2-3yrs	Y = 8.12TL + 1.99	0.91	4.17	< 0.0001
	Y = 16.94NL + 17.83	0.52	9.85	0.0047
	Y = 4.83HG + 15.87	0.81	6.11	< 0.0001
	Y = 4.88FC + 6.19	0.79	7.12	< 0.0001
	Y = 21.03RW + 14.42	0.93	3.60	< 0.0001
	Y = 2.35CD + 12.33	0.90	4.49	< 0.0001
4-5yrs	Y = 9.60TL + 2.12	0.95	2.01	< 0.0001
	Y = 8.24NL + 35.55	0.33	8.29	0.0495
	Y = 3.27HG + 26.46	0.68	5.41	0.0005
	Y = 3.18FC + 21.31	0.77	4.61	0.0001
	Y = 19.37RW + 15.45	0.91	2.79	< 0.0001
	Y = 3.20CD + 18.70	0.51	6.77	0.0054
Overall	Y = 8.00TL + 6.20	0.82	4.97	< 0.0001
	Y = 12.01NL + 27.81	0.38	9.41	0.0007
	Y = 4.13HG + 20.49	0.76	5.88	< 0.0001
	Y = 4.02FC + 13.48	0.77	5.69	< 0.0001
	Y = 20.16RW + 14.90	0.92	3.21	< 0.0001
	Y = 2.75CD + 20.31	0.71	6.43	< 0.0001

RMSE = Root mean square error, R^2 = coefficient of determination, TL = Total topline, FC = Flank circumference, RW = Rump width, NL = Neck length, HG = Heart girth, CD = Chest depth, Kg = kilo gram

3.3. Economics of Fattening

The partial budget analysis for the experimental feeding was reported in Table 10 which involved the evaluation of overall profitability. The economic analysis shows the highest ($P < 0.001$) net benefit obtained from Borana bulls with a net return of 7,380.47 ETB per head followed by Harar bulls, Arsi and HF Crossbred with a net profit of 5,406.86, 5,193.29 and 3,384.98 ETB per head respectively. The variation of net benefit among different breeds was mainly similar to their trend in weight gain difference among breeds. BCS and physical appearance of individual bulls also

have a direct influence on the final sell price of each bull. Similar to this result, Adebabay *et al.*(2013) revealed that the net benefit of Fogera old oxen increased with increasing weight gain that resulted from the increased quantity of supplementation and final selling practice is based on body condition. According to the current result, feeding 3% of body weight of total mixed ration was highly ($P < 0.01$) profitable for Borana bulls which may be affected by total weight gain, physical appearance and body condition score. HF-crossbred bull was economically less ($P < 0.01$) profitable compared with other breed bulls but statistically similar net profit was obtained from Arsi bulls. This indicates that HF-crossbred bull was less profitable under a limited feeding system because of their feed consumption is high as compared with other indigenous zebu bulls. This is concomitant with the report by Gojam *et al.* (2017) revealed that farmers around Holota agricultural research center were not even willing to use the crossbred cows, because of high feed consumption and difficulties to handle the animals.

Even though it is obvious from this result that the bulls in both age groups are statistically similar in net profit, one can go for the older groups which gives higher net return.

Generally, feeding 3% of body weight of total mixed ration for 90 days was economically profitable providing an overall mean of 5,341.40 ETB per head of bulls. However, further investigation on fattening HF-crossbred bulls under different levels of total mixed ration offering was recommended to evaluate economic profitability based on their weight gain and condition score performance.

Table 10
Partial budget analysis of fattening different breeds of bulls fed similar total mixed ration

Category	Economic parameters (Mean) (ETB/head)							
	Purchase price	Feed cost	Medication cost	Labor cost	Sell price	TVC	TR	NR
Breeds								
Arsi	5966.66 ^b	3343.04	80.33	250	14833.33 ^b	3673.37	8866.66 ^b	5193.29 ^b
Borana	7166.66 ^b	3989.25	46.94	250	18833.33 ^a	4286.19	11666.66 ^a	7380.47 ^a
Crossbred	10383.33 ^a	4036.51	111.83	250	18166.66 ^a	4398.35	7783.33 ^b	3384.98 ^b
Harar	7233.33 ^b	3396.14	47	250	16333.33 ^{ab}	3693.14	9100 ^b	5406.86 ^{ab}
P-value	***	Ns	Ns	Ns	**	Ns	**	**
Age								
2-3yrs	6558.33 ^b	339.37 ^b	87.72	250	15125 ^b	3647.09 ^b	8566.66 ^b	4919.57
4-5yrs	8816.66 ^a	4073.10 ^a	55.33	250	18958.33 ^a	4378.43 ^a	10141.66 ^a	5763.23
P-value	***	**	Ns	Ns	***	**	*	Ns
Overall	7687.5	3691.23	71.52	250	17041.66	4012.76	9354.16	5341.40
Mean values under the same category that bear different superscript letters are significantly different. ETB = Ethiopian birr, TVC = Total variable cost, TR = Total return, NR = Net return, ns = $P > 0.05$, ***= $P < 0.001$, **= $P < 0.01$; *= $P < 0.05$, SE = standard error of mean.								

4. Conclusion And Recommendation

From the result, it was concluded that the average daily weight gain of the four breeds range from 0.49 to 0.71 kg. Change in body weight and body condition score was positively and strongly correlated in all breeds and age groups. Fattening HF-crossbred bulls was advantageous in beef production because of higher body weight change per one condition score change. Changes in linear body measurements have a positive association with changes in body weight. Moreover, rump width was the most determinant linear body measurement variable in establishing a regression model predicting BW change per unit of change in linear body measurement variables during fattening in all age categories. Feeding 3% of body weight of total mixed ration for 90 days was economically profitable in all experimental bull with the higher net return from Borana bulls. However, HF-Crossbred bulls need further investigation under different levels of offering total mixed ration to evaluate their potential for economic profitability.

5. Declarations

5.1. Ethics approval

Not applicable

5.2. Consent for publication

Not applicable

5.3 Availability of data and materials

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

5.4. Conflict of interest

The authors declared that there is no conflict of interest between authors and organizations regarding this paper.

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5.6 Author's contribution

Each author has made substantial contributions to the concept of the whole research.

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Figures

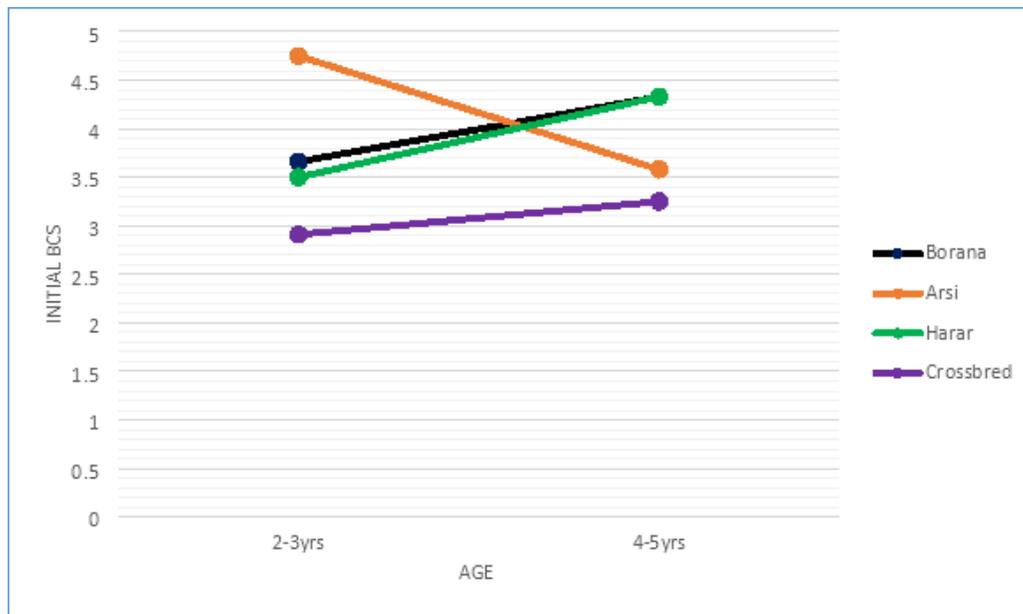


Figure 1

Breed by age interaction effect on initial body condition score