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Comparison of the Efficiency of Compensatory Growth of Borana and Arsi Cattle in Ethiopia

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Abstract

The efficiency of compensatory growth of 50 Bos indicus (25 Arsi & 25 Borana) bulls with age 28 – 36 months following different levels of feed restriction for 90 days was studied. The bulls were blocked by weight and randomly assigned to five dietary treatments: ad libitum feeding for the entire period (A), maintenance requirement for 90 days followed by ad libitum feeding for 104 days (B), 15% weight loss in 90 days followed by ad libitum feeding for 104 days (C), 20% weight loss in 90 days followed by ad libitum feeding for104 days (D) and 25% weight loss in 90 days followed by ad libitum feeding for 104 days (E). The feed restriction imposed for treatments C, D and E during the initial period resulted in weight losses of 16%, 20% & 23% respectively. Both daily dry matter intake (DMI) and metabolizable energy intake (MEI) during the restriction period declined with increasing levels of feed restriction. Consequently average daily weight gain (ADG) and feed conversion efficiency (FCE) declined significantly (P<0.001). Total dry matter intake (TDMI) and metabolizable energy intake (MJ/day) during compensatory feeding period were significantly different among treatments (P<0.05) and breeds (P<0.001). ADG during the compensatory feeding period was also significantly different among treatment (P<0.001) and breeds (P<0.01). Feed restricted groups (C, D and E) exhibited rapid daily weight gains than those managed under ad libitum (control) and maintenance feeding levels. Recovery index was not significantly (P>0.05) different among treatments, but significantly (P<0.05) different between breeds. Arsi bulls had higher (59%) recovery index than Borana bulls (30%). Even though the overall TDMI and MEI during compensatory feeding were increased by four folds than during the restriction period, animals under treatments B C, D and E could not attain complete compensation within 104 days of compensatory feeding. But Arsi bulls managed under maintenance feeding level recovered 96% of their weight loss after 104 days of compensatory feeding as compared to Borana bulls (25%) managed similarly. The overall carcass weight indicated declining trend with increasing levels of feed restriction. The results of this study indicated that responses to compensatory feeding are influenced by either severity of under nutrition, breed type of cattle or duration of compensatory feeding. The optimum time and cost-benefit relationships at which complete recovery can be attained after a period of feed restriction require further investigation.

Keywords: Arsi bulls, Borana bulls, compensatory growth, feed restriction, weight, carcass, concentrate, tef straw, recovery index;

Introduction

Livestock production in Ethiopia is dependent mainly on natural pasture and is largely influenced by its availability, which fluctuates throughout the year. Obradovic and Abraham (1975) reported severe weight loss in their observation on 90 Borana cattle at Adami Tulu government ranch over an 11 months period. This observation that covered all seasons and grazing conditions, clearly demonstrated that live weight was related to grazing conditions. Grazing at certain times of the year, especially in the period January to May, was so inadequate and resulted in heavy live weight loss averaged 74. 9 kg per animal (Obradovic and Abraham. 1975). A preliminary result of the livestock production system survey conducted in the mid Rift Valley of Ethiopia strongly supports this report. Almost all-respondent farmers ascertained that feed is scarce or almost unavailable during the dry period in the area, that extends from December to May. Farmers give priority to supplement whatever they have to offer to their oxen and milking cows.

In the drier areas where drought is frequent, weight loss of animals seems to be inevitable. But the question arises as to how far, at what age, and how often may cattle be permitted to fall behind their normal growth rate before permanent damage is done to their ability to respond to better feeding. These questions can best be answered from a deeper knowledge of the fundamentals of production that influence growth and determine its subsequent development.

Although the exact phenomenon of growth and subsequent development is controversial, one of these is compensatory growth. Compensatory growth is a phenomenon that enables a starved animal to catch -up with the live weight of its un-retarded counterpart upon re-alimentation often with an advantage of superior food conversion rates for the period of most rapid growth (Ledger, 1976). It is the ability of animals to exhibit a higher growth rate after feed restriction than the unrestricted animals of the same chronological age (Wilson and Osbourn 1960). Compensatory growth is complex because it is associated with factors such as higher feed intake (Meyer *et al*., 1965; O'Donovan et al, 1972; Wright *et al*., 1986; Baker *et al*., 1992;), increase in gut fill, better efficiency of feed use (Carstens *et al*., 1991); change in the composition of tissue gained (Meyer *et al*., 1965; Fox *et al*., 1972; Baker *et al*.; 1985; Wright and Russel, 1991) or alteration in endocrine status (Blum *et al*., 1985).

The Borana cattle are assumed to be the best available local cattle, they have received attention as the best beef animal due to their relatively large framed conformation. It has long been regarded as a standard for comparison in beef production programs in East Africa. The Borana is an excellent beef animal with good potential for improvement. Borana meat is not fibrous and is often Marbled (Alberro and Solomon, 1982). Borana cattle grew at a rate of 790 g per day compared to 1090g/d for cross breeds in the feedlot (Wagner *et al.,* 1968). It has an average mature weight of 311- 478 kg, cold carcass weight 149-206 kg and dressing percentage 45.5-47.9% (Jepsen and Creek 1976).

Arsi cattle seem to have evolved from the large group of small *Zebu* in the highlands of Ethiopia especially in Arsi, Shoa and Bale. They are small, short and compact with an average height at withers of 110 cm (Alberro and Solomon, 1982). They have an average birth weight of 21 kg and average mature weight 257 kg. On average they gain 554-619 g per day under feedlot condition. They have an average carcass weight of 115-155 kg with an average dressing percentage of 50.3. They have marbled, tender, palatable and very attractive meat (Jepsen and Creek, 1976).

However, There is scarce information on their response to different levels of feed restriction and subsequent compensatory feeding. This experiment was conducted to determine the nutrient requirement of differential body weight losses at different levels of feed restriction, understand the variation in body weight changes and body condition and examine the efficiency of compensatory growth and carcass characteristics of Arsi and Borana bulls.

Materials and Methods

Study Area

The study was conducted in the year 2000 at the Adami Tulu Research Center in the middle Rift Valley of Ethiopia 170 km on the way to Awasa. The area has an altitude of 1650 m above sea level (asl) and an annual rainfall of 500-760 mm. The average maximum and minimum temperatures are 27^{o} C and 12.7^{o}C, respectively.

Animals and management

A total of 50 bulls (25 Borana and 25 Arsi) with an estimated age of 28-36 months and average weight of 230 $\pm$ 0.31 kg purchased from Borana and Arsi areas were used for the study. The bulls were separately blocked by weight and randomly assigned to the following five treatments: *ad libitum* feeding for the entire period *(A),* maintenance requirement for 90 days followed by *ad libitum* feeding for 104 days (B), 15% weight loss in 90 days followed by *ad libitum* feeding for 104 days (C), 20% weight loss in 90 days followed by *ad libitum* feeding for104 days (D) and 25% weight loss in 90 days followed by *ad libitum* feeding for 104 days (E).

The experimental rations were formulated from *Tef* straw (*Eragrostis tef)*, maize grain, noug seed cake (*G. abyssinica*) and common salt in the proportion of 42%, 32%, 25% and 1% respectively during the restriction period and *Tef* straw, wheat bran, noug seed cakes and common salts in the proportion of 29%, 53%, 17 and 1% during the re-alimentation period respectively. Composition of feed ingredients is shown in Table 1. The animals were drenched and sprayed against internal and external parasites before the commencement of the experiment. The animals were individually penned, fed and watered twice daily. During the restriction period, animals in treatments C, D and E were subjected to get below their daily maintenance requirements based on the recommendation of the NRC (1996). so as to obtain the desired live weight loss. Actual data collection started after 21 days of adaptation. Data on feed intake and oarts were collected on daily basis, while body weight changes were measured weekly. The animals were deprived of feed and water for 16 hours before each weighing. The feed provision was also adjusted weekly based on the live weight obtained. Estimated total daily metabolizable energy intake (MJ/day), total dry matter intake and ME intake per their metabolic body weight were calculated based on the proportions of the feed ingredients. Average daily weight gain was estimated by regression. Recovery index was calculated using the formula proposed by Wilson and Osbourn (1960) as follows;

[(Iwc-Iwcomp) – (Fwc-Fwcomp)]/ (Iwc-Iwcomp);

where, *Iwc* and *Iwcomp* are the weights of the control and compensatory group at the beginning of the compensation period respectively and *Fwc* and *Fwcomp* are the weights of these groups after the period of compensation. The restriction period of 90 days was selected to simulate the time of food scarcity in the area. All animals were fed to appetite for 104 days of re-alimentation following the restriction period. Two animals per treatment were then slaughtered for carcass characteristics evaluation.

Table 1: Chemical composition of experimental feeds (g/kg DM).

Ingredients	DM	OM	CP	ADF	NDF
Tef straw	902	899	56	446	794
noug cake	898	858	296	264	402
maize grain	880	963	105	58	242
wheat bran	880	959	172	93	378

Carcass Evaluation

Two bulls from each feeding level were deprived of feed and water for 24 hours prior to slaughter. Each animal was weighed before slaughter. The major blood vessels of the neck were severed or cut with a sharp knife and the hide was then removed. The entire digestive tract (esophagus, reticulo-rumen, omasum and abomasum, intestines) was removed with rumen contents and weighed. The rumen was emptied and the gastro-intestinal tract was weighed separately. Internal organs (lung, heart, liver, kidney and spleen) and internal fat deposits surrounding the stomach (omental), the intestine (mesenteric), fat lining the pelvic arch (channel fat) were also removed. Head, hide, feet including hooves, penis and bladder and tongue were also weighed. The carcass was then split two halves. Each half was weighed. The left side was then deboned and the bone, lean meat and trimmed fat separated manually and weighed.

Statistical Analyses

Data was analyzed by the general Linear Model (GLM) procedure of SAS (SAS, 1987). Analysis of variance was used to compare the effect of different feeding levels on live weight change and carcass characteristics during restriction and re-alimentation. The model used was as follows:

$Y_{ijk} = \mu + B_i + F_j + B_i * F_j + e_{ijk};$

where; Y_{ij} = individual observation, μ = over all mean, B_i = effect of breed, F_j = effect of feed , e_{ij} =estimated experimental error; $B_i * F_{j}$= interaction between main effects.

Results

Dry matter intake: Least square means for total daily dry matter intake (TDM1), metabolizable energy intake (MEI), total dry matter and metabolizable energy intakes per metabolic body weight, average daily weight gain (ADG), feed conversion efficiency (FCE) and recovery index are presented in Table 2. Most variables measured were significantly different among treatments (P<0.001) and breeds (P<0.01) during the feed restriction period as expected. The feed restriction imposed for treatments C, D and E during the initial period (0-90 d) resulted in weight losses of 16%, 20% and 23% respectively. TDMI kg/head/day and MEI MJ/day during the compensatory feeding period were significantly different among treatments (P<0.05) and breeds (P<0.001). TDMI per unit metabolic weight ($W^{-0.75}$) was also significantly different among treatments (P<0.001) and breeds (P<0.01) during both periods. TDMI declined with increasing levels of feed restriction during the initial period and the trend was reversed during the compensatory feeding period. There was interaction between level of nutrition and breed on total dry matter intake and average daily gain during the restriction phase.

Table 2: Estimated daily total dry matter intake (TDMI, total metabolizable energy intake (TMEI), average daily weight gain (ADG) and feed conversion efficiency (FCE) of Arsi and Borana bulls after different levels of feed restriction and compensatory growth

	TREATMENTS					SE	LS	BREED		SE	LS	Trt* Breed
	A	B	C	D	E			Boran a	Arsi			
RESTRICTION												
N	10	10	10	10	10	------	-----	25	25	------	------	-----
TDMI (kg/day)	5.98^{a}	3.89^{b}	1.78^{c}	1.50^{d}	1.25^{e}	0.01	***	3.37	2.38	0.01	***	***
TMEI (MJ/day)	51.4^{a}	33.4^{b}	15.1^{c}	12.9^{d}	10.7^{e}	0.11	***	28.94	20.46	0.07	***	***
TDMI /$W^{0.75}$ (g/g)	115^{a}	74^{b}	34^{c}	30^{d}	24^{e}	0.94	***	57	54	0.59	**	***
TMEI/$W^{0.75}$ (MJ/kg)	0.99^{a}	0.64^{b}	0.30^{d}	0.25^{d}	0.21^{e}	0.01	***	0.49	0.47	0.005	**	NS
ADG (g)	768^{a}	74^{b}	$- 380^{c}$	$- 471^{d}$	$- 524^{d}$	23	***	- 102	- 111	14.59	NS	***
FCE (kg gain/kg DMI)	0.13^{a}	0.02^{b}	$- 0.22^{c}$	$- 0.32^{d}$	- 0.42e	0.01	***	- 0.15	- 0.18	0.007	**	NS
COMPENSATORY												
N	10	10	10	10	9	------	-----	25	24	-----	------	------
TDMI (kg)	5.50^{a}	5.24^{ab}	4.86^{b}	5.13^{ab}	5.24^{a}	0.13	*	5.80	4.58	0.08	***	NS
TMEI (MJ/day)	51.20^{a}	48.79^{ab}	45.24^{b}	47.8^{ab}	48.79^{a}	1.21	*	54.03	42.69	0.79	***	NS
TDMI /$W^{-0.75}$ (g/g)	85^{d}	96^{c}	109^{b}	120^{a}	124^{a}	2.69	***	104	110	1.72	**	NS
TMEI /$W^{-0.75}$ (MJ/kg)	0.79^{d}	0.90^{c}	1.02^{b}	1.12^{a}	1.15^{a}	0.03	***	0.96	1.03	0.02	**	NS
ADG (g)	532^{c}	722^{b}	751^{ab}	913^{a}	911^{a}	57	***	836	697	37.6	**	NS
FCE (kg gain/kg DMI)	0.10^{c}	0.14^{b}	0.15^{ab}	0.18^{a}	0.18^{a}	0.01	***	0.14	0.15	0.006	NS	NS
Recovery index	----	0.60^{a}	0.32^{b}	0.40^{ab}	0.45^{ab}	0.084	*	0.30	0.59	0.06	**	*

Means followed by different super script letters within rows are significantly different ($p<0.05$)

NB: NS = P>0.05, *** = P<0.001, **= P<0.01, * = P<0.05; SEM= Standard error mean, LS= Level of significance

Body weight change: Average daily weight gain was significantly different among treatments (P<0.001) and breeds (P<0.01) during the compensatory feeding period. Feed conversion efficiency (FCE) was highly significant (P<0.001) among treatments but the difference was not significant (P>0.05) between breeds. Arsi bulls had faster weight loss during the restriction period and higher recovery index during compensatory feeding than Borana bulls. After 90 days of feed restriction, Arsi bulls managed under maintenance feeding level recovered 96% of their weight losses in 104 days of compensatory feeding compared to Borana bulls that recovered only 25% under similar treatments (Figure 1). There was no interaction either between level of nutrition or breed except the recovery index during the compensatory period.

Carcass evaluation: The effects of different levels of feed restriction and subsequent compensatory growth on carcass characteristics of Borana and Arsi bulls are presented in Table 3. The interaction between feeding levels and breeds of animals were consistently non-significant (P>0.05) for carcass parameters measured except for internal organs (IO) and external organs (EO) slaughter weight (SLWT) and empty body weight (EBWT) were significantly (P<0.001) different among treatments and breeds. Both declined with increasing levels of feed restriction. Consequently, total carcass yield was significantly (P<0.01) with increased levels of feed restriction. Total carcass was also significantly (P<0.001) different between breeds. Dressing percentage, fat, lean and bone yield were significantly different among treatments (P<0.01) and between breeds (P<0.05); and showed a declining trend with increasing levels of feed restriction. Although the Borana and Arsi bulls were at the same age at the commencement of the study, the preparation of lean and bone of the Borana was 27.7% and 43.2%, respectively, which was higher than the Arsi. The quantity of injesta was significantly (P<0.01) affected by breed but the difference among treatments was not significant (P>0.05). Internal organs were not significantly (P>0.05) affected by treatments but affected (P<0.01) by breeds. External organs had also similar trend with the live weight of animals at slaughter and total carcass. The overall carcass characteristics indicated declining trends with increasing levels of feed restriction.

Table 3: Effects of different levels of feed restriction on carcass characteristics of Arsi and Borana bulls.

Carcass characteristics	**Overall Mean**	**TREATMENTS**					**SE**	**LS**	**BREED**		**SE**	**LS**	**Trt* Breed**
		A	**B**	**C**	**D**	**E**			**Borana**	**Arsi**			
N	20	4	4	4	4	4	-----	-----	10	10	------	------	-----
Slaughter weight (kg)	251.8	301^{a}	266^{b}	231^{c}	241b^{c}	219^{c}	9.02	***	292^{a}	211^{b}	5.7	***	NS
Empty body weight (kg)	225.0	276^{a}	235^{b}	204^{c}	215^{bc}	194^{c}	9.05	***	261^{a}	189^{b}	5.7	***	NS
Total carcass (kg)	124.9	154^{a}	142^{a}	110^{b}	116^{b}	104^{b}	5.64	**	147^{a}	103^{b}	3.5	***	NS
Dressing %	49.2	50.7^{ab}	53.0^{a}	47.2^{c}	48.0^{bc}	47.3^{c}	0.92	**	50.2^{a}	48.3^{b}	0.58	*	NS
Lean (kg)	82.7	108^{a}	101^{ab}	55^{c}	80^{abc}	70^{bc}	10.3	*	92.8^{a}	72.6^{b}	6.48	*	NS
Fat (kg)	14.6	22^{a}	15^{b}	10^{b}	15^{b}	11^{b}	1.89	**	16.7^{a}	12.6^{b}	1.2	*	NS
Bone (kg)	26.2	30^{a} =	27^{ab}	26^{ab}	24^{b}	24^{b}	1.75	*	30.8^{a}	21.5^{b}	1.11	*	NS
Injesta (kg)	26.8	24	31	27	26	25	2.3	NS	30.8^{a}	22.8^{b}	1.46	**	NS
Internal Organs (kg)	8.3	8.9	8.6	8.8	7.6	7.5	0.44	NS	9.0^{a}	7.5^{b}	0.27	**	*
External organs (kg)	38.5	44.0^{a}	40.4^{b}	35.6^{c}	37.3^{c}	35.4^{c}	0.98	***	45.4^{a}	31.7^{b}	0.62	*	

Means followed by different super script letters within rows are significantly different ($p<0.05$)

NB: NS = P>0.05, *** = P<0.001, **= P<0.01, * = P<0.05; SEM= Standard error mean, LS= Level of significance

Discussion

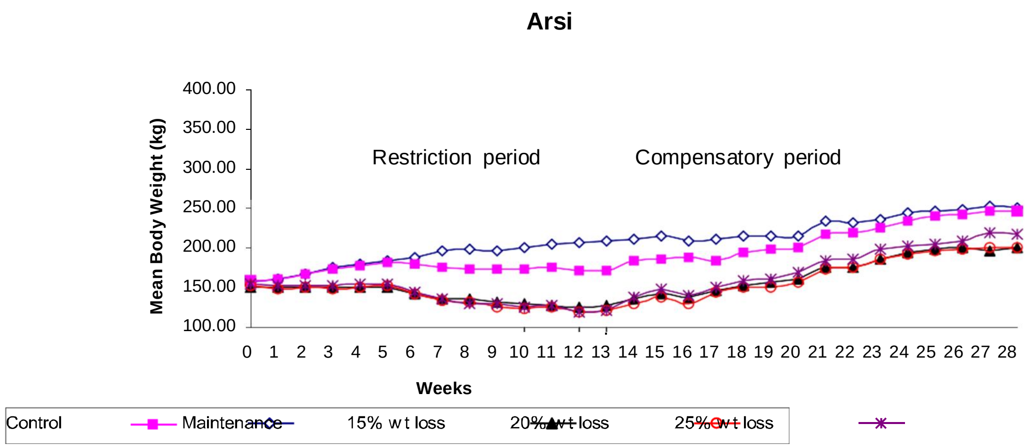
Though it was found difficult to manipulate feed restriction to obtain the predetermined weight losses of 15, 20 and 25% exactly, the results attained were very close to the expected live weight losses. Body weight of the bulls was affected by feed restriction. One Arsi bull from treatment E (severely restricted) group died at the beginning of the compensatory feeding period due to metabolic disturbances caused by sudden changes in the amount of concentrate offered. The significant ($P<0.05$) difference in TDMI during the compensatory feeding period was inconsistent with the reports of Lopez and Verde (1976).

Even though, the overall TDMI and MEI were increased by four folds during the compensatory feeding period, restricted animals under treatments B, C, D, and E could not attain complete compensation with in the given 104 days of compensatory feeding. This may be due to severe starvation and weight losses imposed during the restriction period. There is agreement with the reports of Wilson and Osbourn, (1960) in which response to compensatory growth may vary depending on the duration or intensity of under nutrition before re-alimentation. Growth response to additional crude protein may also be poor on low-density diets (Smith and Broster, 1977; Drouilard *et al* 1991). Inability of complete compensation in this work is similar to the reports of several authors (Abdala *et al* 1988, Carstens *et al* 1991; Chilliard *et al* 1998).

Both ADG and FCE were directly proportional to the levels of feed restriction. Better FCE of restricted animals during compensatory feeding was reflected in fast daily growth rates of the restricted animals during the compensatory feeding period (Ledger 1976; Carstens *et al* 1989). Though not significantly ($P>0.05$), Arsi bulls had better feed conversion efficiency (FCE) compared to Borana bulls. This result is consistent with the reports of Payne (1990) and Tesfaye (2000) in which slower maturing types of cattle respond better than fast maturing ones in terms of compensatory growth after a period of under nutrition. The different level of restricted planes of nutrition imposed on animals in this study are similar to the natural effect of nutrition on animals in the drier parts of the tropics that are caused by seasonal fluctuations in feed availability.

The overall carcass characteristics indicated declining trend with increasing levels of feed restriction. The lower values of carcass characteristics of Arsi bulls were justified by their lower body size relative to Borana bulls.

This result provides information on the performance of animals that pass through varying degrees of starvation under natural grazing prior to fattening. Except Arsi bulls on maintenance feeding treatment which attained 96% recovery index (Figure 1), there was no complete compensation by other treatment groups. These results suggest that response to compensatory feeding could be influenced by either severity of under nutrition, breed type or duration of compensatory feeding. Therefore, optimum time and cost-benefit relationships at which complete recovery can be attained after a period of feed restriction have to be investigated further.



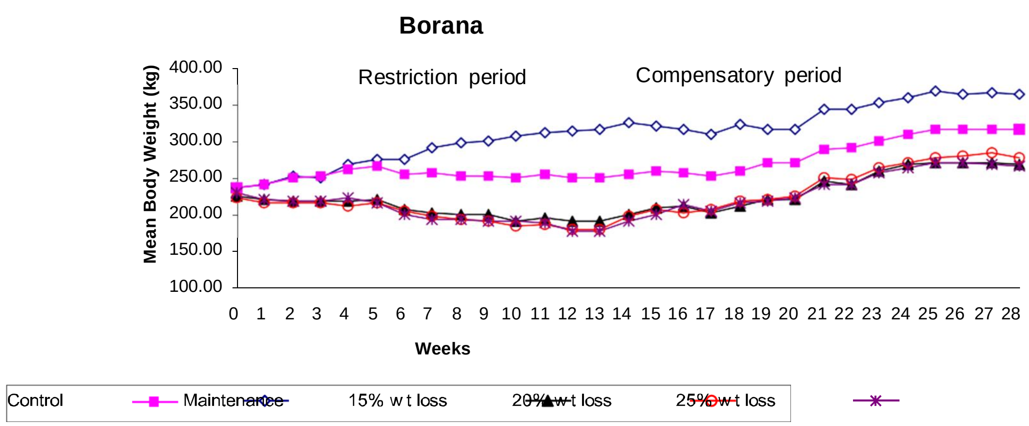


Figure 1. Weekly live weight changes of Borana and Arsi bulls fed *Tef* straw and industrial by-products during restriction and compensatory growth periods.

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