Studies on Compensatory Growth in Black Head Persian (BHP) Lambs

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Abstract

A study was undertaken to investigate effects of underfeeding and re-feeding on growth performance of lambs. In the first 8 weeks of the study there were two treatments: Low (L) and high (H) planes of nutrition. In the last 8 weeks there were four treatments: continued low (LL), a change from low to high (LH), a change from high to low (HL) and continued high (HH) planes of nutrition. Low plane of nutrition consisted of ad libitum hay plus 100 g of concentrate per animal per day and high plane of nutrition was made up of hay ad libitum plus 400 g of concentrate per animal per day.

In the first eight weeks, lambs on H treatment had higher growth rates, dressing percentages, and gut and carcass fats, lower proportions of lean, bone, gut fill, lean:fat and lean:bone ratios than animals on L treatment. In the last eight weeks, lambs on LH grew faster than those on HH. When the whole period was considered (from start to 16 weeks), there was little difference in growth rate between animals on LH and HH treatments. At the end of 16th week, dressing percentages were 45.0, 51.6, 50.2 and 50.4, percentages of lean were 62.2, 60.7, 65.5 and 57.0, percentages of fat were 14.0, 19.2, 13.6 and 26.0 and those of bone were 23.8, 20.1, 20.9 and 17.0 for animals on LL, LH, HL and HH respectively. Lean growth for underfed re-fed animals was higher than for continuously well-fed animals. There were comparable profit margins between LH and HH animals as estimated from live weight gains.

Keywords: Compensatory growth, feeding, Balck Head Parsian, carcass composition

Introduction

In sheep production, the aim of the producer is to have lambs for slaughter in a short duration with maximum amount of lean, minimum bone and an amount of fat, which is desired by the market. Although there are many factors such as breed, sex and diseases, which contribute to variation in growth performance and carcass composition in sheep, the plane of nutrition plays the major role. High plane of nutrition improves performance and carcass composition of lambs (Owen, 1976; Andrew and Speedy, 1980; Mtenga and Nyakyi, 1985). It also improves other physiological development of the animal (Khokhlova *et al.*, 2000). This is associated with increased intake of dietary energy and protein by animals.

It has also been observed that under-nutrition disturbs the normal relationship between chronological and physiological ages in such a way that in case of animals on a low plane of nutrition, physiological ageing proceeds at a slower rate. When such retarded animals are given liberal amounts of feed, they tend to grow at a rate appropriate to their physiological age. This phenomenon of compensatory growth has been a subject of great interest to researchers as reviewed by various workers (Alden, 1968; Keenan and MacManus, 1969; Goodchild and Mtenga, 1982; Zubair and Leeson, 1996). Appropriate utilization of compensatory growth can result into economic benefits, as producers are interested to keep their animals alive at the lowest cost possible in the dry season. Strategic

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Accepted March, 2008

supplementation of expensive concentrates can be used profitably in feeding underfed animals at the end of the dry season in feedlot operations. Carcass compositions of underfed re-fed sheep have also been observed to vary from those of continuously growing animals (Gooodchild and Mtenga, 1982; Ryan *et al.*, 1993). Because of compensatory growth, giving supplementary food to growing sheep during the dry season is said to be of little benefit (Gatenby, 2002).

Sheep mostly found in Tanzania include Red Masai (RM) and Black Head Persian (BHP). BHP is considered to be superior in growth rate and carcass composition (Mtenga and Nyakyi, 1985; French, 1944) and has been used to upgrade local sheep. There has been little research work on the ability of BHP animals to survive during periods of less feed supply and compensate sufficiently during periods of liberal feed supply, taking into account the existence of interbreed differences in the magnitude of response in underfed re-fed animals (Goodchild and Mtenga, 1982). The aim of this study was therefore to investigate the effect of underfeeding and re-feeding on growth rate and carcass composition of BHP lambs.

Materials and Methods

Twenty-eight male BHP lambs were used. The lambs had initial live weight of 14.6±2.3 kg (mean± s.d.) and ranged between 10 and 14 months in age. This is the normal weight of Tanzanian BHP sheep at this age (Mtenga and Nyakyi, 1985). Four animals were randomly selected and slaughtered to form a base line. The remaining 24 animals were randomly allocated to two treatments (L and H), each treatment having 12 lambs. Animals were de-wormed with Panacur (fenbendazole) 14 days before the start of experiment and thereafter at monthly intervals. Lambs on treatment L were fed a basal diet of hay *ad libitum* plus 100 g of concentrate, referred to as low plane of nutrition. Animals on treatment H were fed high plane of nutrition consisting of hay *ad libitum* plus 400 g of concentrate. After 8 weeks, four lambs were randomly selected from each treatment and slaughtered to determine slaughter characteristics and carcass composition. The remaining eight sheep on treatment L were randomly allocated to two-treatment (LL and LH). The animals on treatment LL continued with low plane of nutrition while those on treatment LH were fed the high plane of nutrition. Similarly, the eight lambs on treatment H were randomly allocated to two treatments, HL and HH. Animals on HL were fed the basal diet and 100 g concentrate (low plane of nutrition) while those on HH continued with high plane of nutrition. Animals in the four treatment groups were slaughtered at the end of the 16th week. In all cases, the animals were not deprived of feed and water prior to slaughter. Daily feed intake and weekly live weights of animals were recorded. Daily feed intake of hay was calculated as the difference between total allowance given at 9.00 h and weight of refusals measured at 8.00 h on the following day. Animals were weighed every Wednesday before feeding. Daily gains were determined as the difference between initial and final weights divided by the number of days under the period of study.

Chloris gayana (Rhodes grass) hay was obtained from the University farm from two cuttings, one done at the beginning of the last quarter of the year and the second done at the beginning of the following year. The concentrate consisted of 71% maize bran, 27% cotton seed cake and 2% mineral mixture (Maclik). The mineral mixture composition (%) was 18.61 Ca, 3.5 P, 13.0 Na, 20.0 Cl, 0.12 Cu, 0.03 Co, 0.01 I, 0.31 Fe, 0.44 Mg and 0.18 S.

At specific slaughter times animals were slaughtered and weight of warm carcasses taken within one hour excluding kidney and kidney fat. Weights of non-carcass components (livers, hearts, kidney fats, spleens, lungs + tracheae, GITs, gut fats, blood, heads, skins, feet and gut fills) were also obtained. For each slaughtered animal, the left side half carcass was dissected into lean, fat and bone. Losses during dissection were small (0.4 - 1.1%) and were assumed to have mainly come from the lean (Owen, 1976). The lost weights were therefore added to lean weights. The dissected components were thoroughly mixed together, frozen to -15°C for a period of 10 days and then minced through a 2.5-mm aperture plate three times before sampling for chemical analyses (Owen, 1976).

Samples of feeds and carcasses were analysed according to AOAC (AOAC, 1990) methods. The data were subjected to the Analysis of variance (ANOVA) procedure of the Statistical Analysis System (SAS, 2005). was done for most of the studied parameters and the treatment means were compared using the least

significant difference method (Snedcor and Cochran, 1989).
The analysis of variance followed a completely randomised design with the following statistical model:

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

Where Y_{ij} = the value for the j-th animal from the i-th treatment,

μ = General effect (overall mean)

T_i = Treatment effect

e_{ij} = Random error effect

Results

Chemical composition of the feeds

Table 1 shows the chemical composition of Rhodes grass at two cuttings, maize bran and the compounded concentrate. There was an increase in crude fibre and a decrease in crude protein in the second cutting of the grass compared with the first cutting, as it was more mature and therefore more lignified.

Table 1. Chemical composition of Rhodes grass hay and concentrate feeds (means ± standard deviation g/kg DM)

Component	Hay		Concentrate feeds		
	1st cutting	2nd cutting	Maize bran	Cotton seed cake	Concentrate[1]
Dry matter (DM)	920.7±19.8	329.5±12.7	925.6±6.1	945.6±11.5	944.0±26.0
Crude protein (CP)	54.0± 8.3	44.2± 8.5	104.6±2.9	411.1±1.5	182.7±15.9
Crude fibre (CF)	365.0±34.4	378.0±17.6	121.0±3.5	133.4±3.6	65.3±4.2
Ether extract (EE)	15.2±2.3	12.3±3.3	108.4±1.8	48.3±2.4	86.2±4.8
Ash	90.1±8.8	89.2±35.1	28.1±6.3	74.1±1.9	44.2±4.1
Nitrogen free extract	395.8±30.6	476.9±47.5	636.9±22.3	332.1±30.7	621.7±22.2

[1]The concentrate was formulated to contain 12.3 MJ ME and 183 g CP per kg DM.

Growth rate and feed intake

The growth rate was higher in lambs on treatment H during the first eight weeks of the experiment, the difference of 66 g being significant (Table 2). During the last eight weeks of the experiment there was also a highly significant ($P<0.001$) difference between treatments in daily gains. Lambs on treatment LH had highest growth, the difference being largest with lambs on treatment HL followed by those on LL.

Although lambs on treatment HL and LL were on the same plane of nutrition in this period, lambs on treatment LL were superior in daily gains to lambs on HL by 16 g/day. Considering the whole experimental period, lambs on HH treatment had the highest gains, followed by those on treatments LH, HL and LL in decreasing order. No covariance was undertaken to correct for differences in live weights brought about by differences in initial live weights of the animals. This is because the differences in initial live weights were very small and non-significant between treatments.

Table 2. Treatment mean growth performances in different study periods

Para-meter[1]	Periods												
	0-8th week			8-16th week					0-16th week				
	L[2]	H	SE	LL	LH	HL	HH	SE	LL	LH	HL	HH	SE
ILW (kg)	14.4	14.9	0.67NS	15.5^{a}	17.6^{ab}	20.2^{b}	20.7^{b}	1.12*	13.7	15.3	14.9	14.8	1.15NS
FLW (kg)	16.3^{a}	20.5^{b}	0.66***	17.3^{a}	23.4^{b}	21.2^{ab}	24.3^{b}	1.36*	17.3^{a}	23.4^{b}	21.2^{ab}	24.3^{b}	1.36*
GR (g/d)	34^{a}	100^{b}	2.74***	33.0^{a}	103.6^{b}	17.0^{a}	63.0^{c}	7.58***	33.4^{a}	72.8^{b}	56.0^{c}	84.8^{b}	4.18***

[1]ILW = Initial live weight; FLW = Final live weight; GR = Growth rate
[2] In this and subsequent tables, L = Low plane of nutrition; H = High plane of nutrition; LL = continued low plane of nutrition in the 2nd period of 8 weeks of the study; LH = change from low to high plane of nutrition in the 2nd period of 8 weeks; HL = change from high to low plane of nutrition in the 2nd period of 8 weeks and HH = continued high plane of nutrition in the 2nd period of 8 weeks.
[a,b,c]Means bearing different superscripts within the same row under same study period are significantly different (P<0.05)

*, **, ***Significant at P<0.05, P<0.01, P<0.001
NS = Not significant (P>0.05)

Table 3. Treatment mean feed intakes and feed conversion ratio in different study periods

Para-meter	Periods												
	0-8th week			8-16th week					0-16th week				
	L	H	SE	LL	LH	HL	HH	SE	LL	LH	HL	HH	SE
427.5^{b}	498.4^{a}	505.2^{b}	12.18***	548.3^{a}	477.3^{b}	451.5^{b}		21.37**	495.8^{a}	491.5^{a}	446.3^{ab}	406.5^{b}	19.14*
Total g													
DM/d	558.3^{a}	765.3^{b}	13.36***	612.8^{a}	837.3^{b}	513.3^{c}	787.8^{b}	23.60***	563.8^{a}	704.8^{b}	660.3^{b}	766.5^{c}	19.26***
g/kg$^{0.75}$	72.6^{a}	88.8^{b}	10.83***	76.7^{a}	87.6^{a}	53.0^{b}	76.6^{a}	6.29**	73.0^{a}	76.9^{ab}	75.5^{ab}	83.0^{b}	2.95NS
FCR[1]	17.5^{a}	7.7^{b}	1.24***	19.4^{a}	8.3^{a}	37.5^{b}	13.8^{a}	2.33*	17.8^{a}	7.0^{a}	48.7^{b}	13.4^{a}	0.75**

[1]The feed conversion ratio (FCR) was obtained as g DM intake/g live weight gain

Lambs on treatment H ate significantly more food than animals on L treatment (P<0.001) during the first eight weeks of the study period (Table 3). During the last eight weeks of the experiment, there was also a highly significant difference between treatments in hay (P<0.01) and total dry matter followed by HH, LL and HL in decreasing order. When expressed as g per metabolic body weight, animals on LL and HH had similar DM intakes while those on LH and HL maintained highest and least values of intake respectively. Feed conversion ratio (FCR - g DM intake/g live weight gain) was lowest in animals on treatment LH and highest in animals on treatment HL in this period of study.

When the whole 16-week experiment period is considered, animals on treatment HH consumed more dry matter followed by LH,HL and LL However, differences in feed intake per metabolic body size were small and insignificant. On average, animals on LH and HH were superior in feed utilization compared with animals on LL and HL, the latter being the least efficient. FCR was lowest in animals on LH and highest on animals on HL, the difference of 31 g DM intake per g gain being significant (P<0.01). There was no difference (P>0.05) in FCR between animals on LL, LH and HH treatments.

Slaughter characteristics

Table 4 shows the effect of treatments on slaughter characteristics. Animals on treatment H slaughtered at end of the eighth week had higher live weight and dressing percentage (hot carcass weight as percentage of empty body weight) compared to animals on treatment L, the difference of 5.1 kg and 6.3% respectively being significant (P<0.05). There were little treatment differences (P>0.05) between lambs on L and H treatments on percentage of gut fill, kidney and kidney fat although the tendency was for these proportions to be higher for gut fill and lower for kidney and kidney fat in animals on L treatment. Gut fat was also higher in H lambs. At the last slaughter weight (16th week), animals on treatment HH had higher live weight at slaughter, the difference between these lambs and those on treatments LL, LH, and HL being 7.0, 0.9, and 3.1 kg. The differences in dressing percentage between lambs on treatment LH and those on HL and HH of 1.4 and 1.2% were not significant whereas the difference between LH and LL of 6.6% was significant (P<0.05). Animals on LL treatment had lowest, those on HH highest (P<0.01) whereas those on LH and HL had comparable proportions of gut fat (p<0.05) Gut fill was highest in animals on LL but this was comparable to that of animals on LH and HL treatments while animals on HH had a significantly (P<0.01) lower value. Although animals on treatment HL had significantly (P<0.05) lower kidney plus kidney fat proportions than the rest of treatment groups, treatments were however not significantly different (P>0.05).

Carcass physical and chemical composition

There were differences (P<0.01) in carcass weight between treatments (Table 4). At the eighth week, animals on treatment H had higher (P<0.001) proportions of fat and lower proportions of bone but the superiority of 3.8% of lean in animals on L was not significant (P>0.05). Lambs on treatment L had 11.8 more lean to fat ratio and 0.9 less lean to bone ratio than lambs on treatment H and the differences were significant (P<0.05). Chemical composition data in Table 4 show that animals on H were superior

Table 4. Effect of underfeeding-refeeding on killing out characteristics and carcass physical and chemical composition[1]

	End of 8th week			End of 16th week				
	L	H	SE	LL	LH	HL	HH	SE
Slaughter live weight (kg)	15.6^a	20.7^b	1.37*	17.3^a	23.4^b	21.2^{ab}	24.3^b	1.38*
Carcass weight (kg)	5.2^a	8.1^b	1.54**	5.5^a	9.0^b	7.8^a	9.7^b	1.63***
Components (% EBW)*								
Carcass	45.2^a	51.5^b	1.64*	45.0^a	51.6^b	50.2^b	50.4^b	1.30**
Gut fat	0.55^a	4.3^b	2.71**	1.7^a	3.7^b	4.3^b	13.6^c	3.40**
Gut fill	35.2	28.4	3.38NS	36.2^a	29.2^a	32.9^a	20.1^b	4.84**
Kidney and kidney fat	0.36	0.38	0.30NS	0.68^a	0.76^a	0.60^b	0.71^a	1.00*
Tissues (% carcass)								
Lean	67.8	64.0	1.67NS	62.2^a	60.7^b	65.5^c	57.0^d	1.94**
Fat	5.0^a	18.1^b	2.06***	14.0^a	19.2^b	13.6^a	26.0^c	2.80**
Bone	25.6^a	17.9^b	4.02***	23.8^a	20.1^b	20.9^b	17.0^c	2.18***
Carcass tissue ratios								
Lean:Fat	15.4^a	3.6^b	1.58**	5.3	3.4	4.9	2.0	0.91NS
Lean: Bone	2.7a	3.6b	0.15*	2.9	3.1	3.1	3.4	0.24NS
Carcass composition (% carcass)								
Dry matter	31.1^a	40.4^b	0.56***	36.4^a	41.5^a	39.8^a	45.8^b	1.27**
Crude protein	18.6^a	16.8^b	0.25***	16.3	16.1	17.8	14.4	1.01NS
Ether extract	4.2^a	9.3^b	0.54***	15.8^a	19.5^b	18.1^b	27.1^c	1.20**
Ash	13.4	12.1	0.46NS	8.9	11.4	11.0	11.2	1.17NS

*EBW = Empty body weight

to those on L in dry matter and ether extract but inferior in crude protein and ash at the 8th week of slaughter. During the end of 16th week, lambs on treatment HL had highest percentage of lean and the differences of 3.3 and 4.8% between these animals and those on LL and LH were significant (P<0.05). The difference of 8.5% between lambs on HL and HH was also significant (P<0.01). Percentage carcass fat in lambs on HH treatment was higher (P<0.05) than that in animals on LH, LL and HL by 6.8, 12.0 and 12.4 units while proportions of bones were highest in lambs on treatment LL followed by those on treatment HL, LH and HH in decreasing order. Treatment effects on lean:fat and lean:bone ratios were small and insignificant (P>0.05). Table 4 shows that underfeeding - re-feeding significantly influenced dry matter and ether extract of the carcasses, highest values being observed in animals on HH treatment. The treatments had no significant effects on crude protein or ash.

Discussion

Performance data in favour of lambs on high plane of nutrition during the first eight weeks of the experiment were expected and were mainly due to differences in concentrate intakes. High concentrate intake results into animals with increased growth rate, higher slaughter weight, dressing percentage and proportion of carcass fat and lower proportion of lean compared with animals on lower intakes of concentrates (Owen, 1976). During the growth period between 9th and16th weeks, lambs on treatment LH were superior in growth rate to those on treatment HH despite the fact that they were on the same plane of nutrition during this period. This is likely to be due to the phenomenon of compensatory growth as previously reviewed (Keenan and MacManus, 1969; Kaanen *et al.*, 1970; Goodchild and Mtenga, 1982). In this period, animals on treatment LH consumed more feed and utilized it more efficiently than their counterparts on treatment HH, and this partly accounted for their superiority in growth rate. In a concurrent study, digestibility coefficient for dry matter, crude protein and crude fibre were 59.1, 71.2 and 64.5% respectively for animals on treatment LL, 66.9, 77.6, and 65.3 for animals on LH, 59.5, 70.2 and 60.2 for animals on HL and 65.2, 76.5 and 58.3 for animals on HH. Similar observations have been reported in sheep (Alden and Young, 1964; Alden, 1970). When changed from high to low dietary regimes, lambs have been observed to tend to eat less and grow slower than lambs consistently on low plane of nutrition (ørskov *et al.*, 1976). Similar observations were made in the present study when animals on LL and HL were compared in the 8th to 16th week period.

It was once commented that re-alimentated animals tend to grow at a rate appropriate to its physiological age rather than its chronological age (Winchester and Ellis, 1957; Ryan *et al.*, 1993). The present study confirms this statement in that lambs on low plane of nutrition were physiologically younger as measured by live weight and lean and fat contents. On re-feeding, these animals grew faster and almost caught up with animals on treatment HH.

Dressing percentage is both yield and value determining factor and is therefore an important parameter in assessing performance of meat producing animals. Lambs on H treatment

Table 5. Treatment mean economic returns per animal

	Treatments			
Item	LL	LH	HL	HH
Concentrate consumed (kg DM/animal)	8.4	26.6	26.6	44.8
Hay consumed (kg DM/animal)	56.0	54.0	50.0	46.0
Cost of consumed concentrate (TSh/animal)[1]	588	1862	1862	3136
Cost of consumed hay (TSh/animal)[2]	2240	2160	2000	1840
Cost of total consumed feed (TSh/animal)	2828	4022	3862	4976
Gain in carcass (kg)	0.94	4.45	3.23	5.10
Revenue from gain[3]	1410	6675	4845	7650
Profit margin (TSh/carcass)[4]	-1418	2653	983	2674

[1]Concentrates was costing 70.0 TSh per kg
[2]Hay was costing 40.0 TSh per kg
[3]The price of meat was 150.00 TSh per kg
[4]The profit margin was calculated as (Revenue from gain - Cost of total consumed feed)

dressed higher than those on L treatment in accordance with earlier cited review (Owen, 1976). In a study with tropical sheep (El Hag and Mukhatar 1978) animals that were on roughage diet only dressed 10% units lower than those fed 3:1 concentrate to roughage rations. In this study, differences in weight, age and level of fatness in the carcass could have accounted for variation in dressing percentage according to other workers (Owen, 1976; Berg and Butterfield, 1976; Thornton *et al.*, 1979). Gut fill, which was 35% for L lambs and 28% for H lambs, also affects dressing percentage (Owen, 1976; Berg and Butterfield, 1976). Fat is the most labile tissue in the animal's body and can be easily manipulated by nutrition and management (Berg and Butterfield, 1976). The treatment effects on gut, kidney and carcass fat in the present study can be attributed to energy and protein in the diets of these animals. In accordance with the reviewed literature (Berg and Butterfield, 1976), lambs on low plane of nutrition are leaner and have less percentage of dry matter. Compensatory growth in the present study was partly due to higher lean and less fat growth rate of underfed - re-fed animals.

Higher efficiency of lean meat production is always desirable. Efficiency is sometimes defined as the ratio of total lean tissue to total feed consumed during the period under evaluation but under practical situations, carcass rather than lean weight is used. In this study efficiency of carcass deposition was 0.02, 0.6, 0.4 and 0.6 kg of carcass per kg dry matter of feed (hay and concentrate combined) consumed for treatment LL, LH, HL and HH respectively. An even more meaningful measure of efficiency of underfeeding and re-feeding animals would be to look at the profit margins of using supplements. Table 5 shows the economics of treatments imposed in this study. Although animals on HH treatment gave highest profit margins, it is shown that by utilizing only half of the concentrates in an underfeeding-refeeding technique (LH) about the same profits are obtained.

Conclusion

This study clearly shows that Tanzanian Black head Persian lambs have the ability to compensate and a number of factors such as more food intake, greater digestibility of the diets and higher protein deposition can account for this phenomenon. Extra meat would therefore be produced more efficiently when animals are supplemented after being deprived of nutrients for sometime. Supplementation aims at improving growth rates and produce better carcasses but at what critical time to supplement is an important management decision in a farm. In the present study, limited a number of animals were used. It would be of interest to carry out more studies involving more animals to firmly confirm the economics of underfeeding re-feeding under practical farm situation.

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