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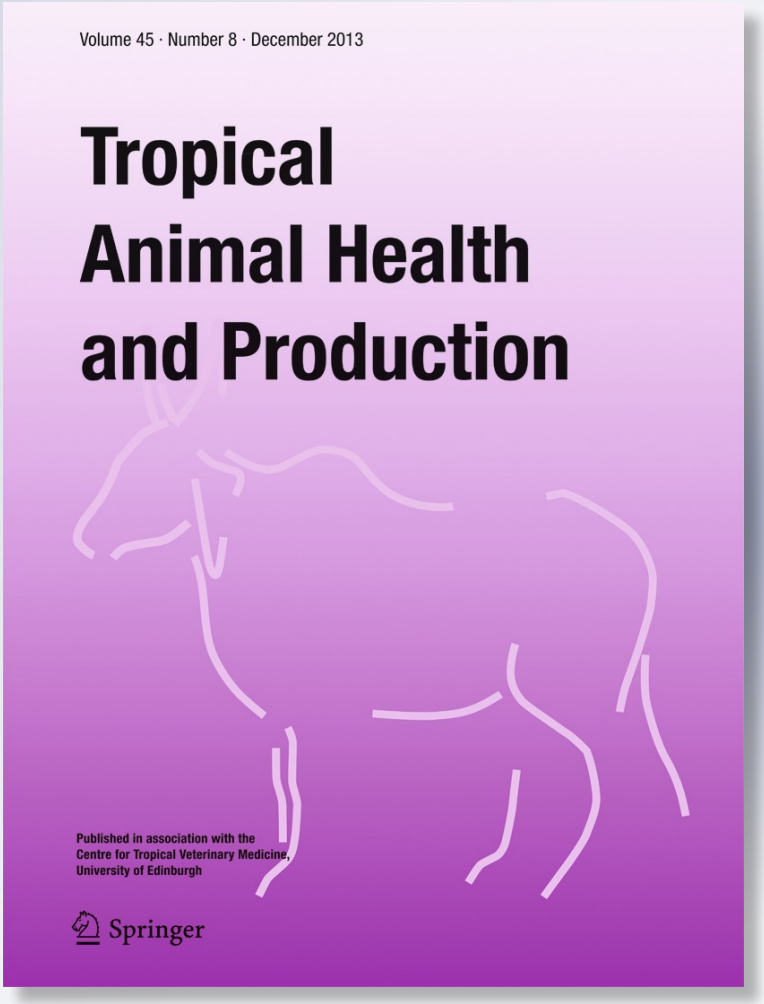

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REGULAR ARTICLES

Effect of concentrate supplementation levels on growth and slaughter characteristics of SEA and SEA × Norwegian goats under on-farm conditions

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Abstract A 2×3 factorial experiment was carried out to evaluate the effect of goat genotypes and different concentrate levels on growth and slaughter characteristics of Small East African × Norwegian crossbred (SEA × N) and Small East African (SEA) goats. The three concentrate levels were T0 (no access to concentrate), T66 (66 % access to ad libitum concentrate allowance) and T100 (100 % access to ad libitum concentrate allowance). Twenty-four castrated goats of each genotype (18 months old with an average weight of 16.7±0.54 kg) were randomly allotted into T0, T66 and T100 treatments. Daily feed intake and fortnight body weight measurements were recorded for the whole 84-day experimental period, after which the animals were slaughtered. Feed intake of T100 animals was 536 g/day, which was 183 g/day higher than that of the T66 group. Supplemented goats (T66 and T100) had significantly ($P<0.05$) higher daily gain and body condition score, and better feed conversion efficiency and dressing percentage than T0 goats. The SEA goats had higher ($P<0.05$) hot carcass weight (8.2 vs. 7.9 kg) and showed better ($P<0.05$) dressing percentage than SEA × N animals. Among supplemented goats, the cost of a 1-kg gain under T66 was Tshs 213/= cheaper than T100 (US$1≈Tshs 1,500). It is concluded that goats should be grazed and supplemented with 353 g concentrate/day for satisfactory fattening performance and higher economic return on investment.

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Keywords Concentrate supplementation · Fattening · Carcass · Economics

Introduction

Small ruminants play an important role in almost all farming systems in the tropics and sub-tropics. In the rural areas where most of the resource-poor farmers in Africa live, goats play an important socioeconomic role (Anaeto et al. 2009). The offtake from this sector has been gradually increasing, and this is thought to be enhanced by market forces. Low carcass weight and yield from goats due mainly to nutrition constraints limit the potential for availability of meat to fulfil the increased domestic and export market demands.

On-station supplementation with animals fed on low-quality roughage show improved and satisfactory fattening performance for goats when they are supplemented with concentrate (Mushi et al. 2009). In order to facilitate the adoption of new research findings by farmers, both technical and economic benefits should be proven before making recommendations. There are circumstances where on-station research outputs could be technically feasible but not profitable under on-farm conditions. At the moment, there are no research data on growth or slaughter characteristics of crossbred goats when managed under farmers' practice. The present study was therefore undertaken to evaluate the effect of feeding forage alone or in combination with different levels of concentrate on growth performance and carcass composition, and ultimately to assess the economics of fattening under rural farm conditions.

Materials and methods

Location of the study

An on-farm trial was conducted at Gairo District, Morogoro Region, Tanzania, with an altitude ranging from 1,076 to 1,631 m above sea level. The area has semi-arid climatic conditions receiving undulate rainfall between 600 and 800 mm per annum.

Experiment design, animals and diet

A 2×3 factorial arrangement (genotype × dietary levels) was used to randomly allocate 48 castrated goats (16.7±0.54 kg initial weight); 24 goats from each breed aged 18 months were divided randomly into three groups, eight each, for a fattening trial of 84 days. The three dietary levels, namely T0 (control), where animals were not fed concentrate and treatments, and T66 and T100, where goats were fed 66 % of ad lib concentrate intake and ad libitum concentrate allowing 20 % refusal, respectively, and ad libitum hay.

Feeds, feeding and growth of the experimental animals

The concentrate feed comprised maize bran (70 %), sunflower seedcake (28 %), lime (1.3 %), mineral–vitamin mixture (0.5 %) and table salt (0.2 %). Details of the chemical and physical composition of feeds are presented in Table 1. Animals were given 2 weeks of adaptation period within which they were treated for internal parasites. The initial live weight of each goat was taken at the beginning of the experiment. Thereafter, animals were weighed individually in 14-day intervals at 0800 hours (100 g sensitivity). The final body weight of each animal was taken after completion of the 84-day trial.

Table 1 Chemical composition of feeds and feed ingredients used (in gram/kilogram DM)

Component	Concentrate	Hay	Sward
Dry matter	944.5	956.7	947.8
Organic matter	923.7	951.4	913.8
Ash	72.1	46.5	81.7
Crude protein	143.7	41.0	106.9
Ether extracts	91.1	5.5	6.6
Crude fibre	141.9	359.1	268.3
Nitrogen-free extract	495.7	504.6	484.3
Neutral detergent fibre	410.6	791.4	662.7
Acid detergent fibre	170.8	481.5	365.8
In vitro DMD	540	404	391
In vitro OMD	553	411	373
Metabolizable energy (MJ/kg DM)	12.2	9.5	9.6

DMD dry matter digestibility, *OMD* organic matter digestibility

During the acclimatization period, goats were group fed with hay ad libitum, and in addition, those on T66 and T100 received 200 g of concentrate per goat per day. Animals were released to graze at 1000 hours, returned to their pens by1200-hours and fed in groups of four per pen with drinking water. Concentrate and hay were offered before grazing and in the afternoon at 1430 hours. Feed intake was obtained by difference between feed offered and refusal. Average daily gain (gram/day) was determined as a proportion of total weight change to the feeding period. During experimentation, three goats (two from Small East African × Norwegian (SEA × N) crossbreed and one from Small East African (SEA)) died from Orf disease.

Slaughter procedure and data collection

At the end of the feeding period, goats were fasted for 16 h with access to water and then reweighed to obtain slaughter body weight (SBW). Fasting loss was computed as the difference between the final body weight (FBW) and SBW. The animals were slaughtered in the halal method (Kadim et al. 2003) in which the head was removed at the atlanto–occipital joint, the forefeet at the carpal–metacarpal joint and the hind feet at the tarsal–metatarsal joint followed by flaying and evisceration. The dressed carcass comprised the body after removing the skin, head and fore- and hind feet, and the viscera was weighed within 6 h postmortem and recorded as hot carcass weight (HCW). Hot carcass includes kidney and pelvic and kidney fat. The digestive tract was removed and weighed to get the weight of the full gastrointestinal tract (GIT) then emptied of its contents, washed, drained and weighed to get the weight of the GIT content. GIT content was then subtracted from the SBW to determine empty body weight (EBW). Weight of non-edible offals—blood, hocks, head, skin and testes—and edible offals—heart, lungs, spleen, kidney, diaphragm, liver and empty GIT—were taken. The total edible proportion was obtained by subtracting weights of GIT contents and non-edible offal from SBW. Two types of dressing percentage (DP) were calculated, namely true DP=(HCW×100/EBW) and commercial DP=(HCW×100/SBW).

Economic analysis of fattening

Since smallholder farming with a small number of goats usually makes use of family labour and because the additional labour cost (concentrate supplementation) under this fattening scheme was not substantive, the cost was not included in the analysis. The mean value of feed intake, carcass yield, edible offals and skin for each pen was used to estimate feed costs and revenue from experimental goats. The weight of hay and concentrate consumed were recorded, and total costs of production based on feed costs for each treatment were calculated. Price of feeds (Tshs/kilogram) was

198 and 87 for concentrate and hay, respectively. In Tanzania, goat meat is normally sold fresh at US$2 to 5/kg. Therefore, meat was assumed to be sold at Tshs 5,000 (80 % of the premium price) and Tshs 6,000/kg of meat produced from unsupplemented and supplemented goats. The current market price of edible offal of Tshs 2,000/kg and of skin at 1,500 per piece was used in the calculation. The returns from each feeding regime were then computed, and net revenue over non-concentrate-supplemented (T0) goats was derived.

Chemical composition of feed samples

Respective samples of feed were subjected to chemical analysis for the determination of dry matter (DM), organic matter, crude protein (CP), crude fibre (CF), ether extract (EE), ash and nitrogen-free extract (NFE) following the methods of AOAC (2006). The neutral detergent fibre, acid detergent fibre, in vitro dry matter and in vitro organic matter digestibilities were determined according to the procedure of Van Soest et al. (1991). Metabolizable energy (ME) of feeds was estimated from their chemical composition using the equation developed by MAFF (1975): ME (MJ/kg DM)=0.012CP+0.031EE+0.005CF+0.014NFE

Statistical analysis

Data were analysed using the GLM procedures of SAS (2002) with genotype and dietary levels as main effects. To compare growth, the initial body weight was used as a covariate. A second model was used for carcass characteristics, and slaughter body weight was used as covariate. Except for feed intake, feed conversion efficiency and economics, each individual animal served as an experimental unit. Interaction effect was not significant ($P>0.05$); hence, only the effects of the main factors are reported and discussed. In all analyses, when differences between means were significant in the ANOVA, they were separated by PDIFF statement at $P<0.05$.

Results

Feed intake

Grass hay DM intake declined from T0 by 0.32 and 0.39 kg for T66 and T100 goats, respectively, with corresponding increased concentrate DM intake by 0.03 and 0.14 kg (Table 2). The ad libitum concentrate intake of animals was 536 g/day, which was 183 g/day higher than the concentrate intake by goats fed T66. The difference in total DM intake between goats in T100 and those in T66 and T0 was 123.9 and 154.5 g/day, respectively. DM intake of grass hay and its ME declined as amount of concentrate increased. The results showed that the animals in T100 had very little hay intake which constituted 12.7 % of the total intake. Efficiency of feed utilization improved with concentrate supplementation, and T66 and T100 animals had better feed conversion ratio, almost threefold than that in T0.

Growth performance

There was no ($P<0.05$) breed dependence for any of the growth traits studied (Table 3). The dietary effect was highly significant ($P<0.001$) on FBW, SBW, ADG and body condition score (BCS). However, feeding of concentrates promoted growth performance where T0 goats had lower ($P<0.05$) FBW, SBW, body weight change and BCS than supplemented goats, but differences in these parameters between goats in T66 and T100 were small and insignificant. T0 goats were 3.3 and 2.6 kg lower ($P<0.05$) in FBW than goats fed T100 and T66, respectively. Weight gains for T66 and T100 goats were 2.6 and 3.4 kg heavier ($P<0.05$) than that of T0 goats. Fasting loss decreased as level of concentrate increased, and ad libitum concentrate-fed goats had the lowest ($P<0.05$) fasting loss.

Killing-out characteristics

Genotype had a significant ($P<0.05$) effect on HCW and DP with SEA goats having the highest ($P<0.05$) HCW and DP (Table 4). Diet had a significant effect ($P<0.001$) on all killing-out characteristic parameters and commercial DP at ($P<0.01$). However, most killing-out characteristics increased with concentrate supplementation except weight of GIT and GIT content which followed a reverse order. Non-supplemented goats had the lowest ($P<0.05$) values for all killing-out characteristics except full GIT. DP ranged from 52.7 to 54.9 % and 37.2 to 45.7 % when weight of carcass was expressed as percentage of EBW and SBW, respectively, and these values were lowest ($P<0.05$) for non-supplemented goats. No significant difference was observed for all killing-out characteristics among supplemented goats.

Economic analysis of goat fattening

The effect of dietary levels on economics of fattening is shown in Table 5. Total feed costs increased with concentrate supplementation while cost of grass hay declined with concentrate allowance. The cost of feeds for non-supplemented goats was a half and one third of that incurred in T66 and T100, respectively. On the other hand, revenue collected from carcasses, edible offal and its gross return increased with concentrate supplementation. The net return for goats under T0 was much lower than those for T66 and T100 fattening levels; clearly indicating that T0 was uneconomical. Further comparison between T100 and T66 levels shows higher cost of feeds for the former, with a difference of Tshs 2,774.6 (27.6 %). On

Table 2 Means for feed intakes and DM intake (percent live weight) of castrated SEA × N and SEA goats under different levels of concentrate supplementation

Variable	Genotype (G)		Dietary levels (D)		
	SEA × N	SEA	T0	T66	T100
Feed intake (g DM/day)					
Concentrate	454.1	435.1	–	352.9	536.3
Hay	351.2	324.1	459.8	137.5	78
Total feed intake	805.3	759.2	459.8	490.4	614.3
Metabolizable energy MJ, ME/day					
Concentrate	5.5	5.3	–	4.3	6.5
Hay	3.3	3.1	4.4	1.3	0.7
Total ME intake	8.9	8.4	4.4	5.6	7.2
Intake (% body weight)	4.3	4.2	2.7	2.6	3.2
Feed conversion ration	27.5	35.3	39.8	12.2	10.8

SEA × N Small East African × Norwegian goats, *SEA* Small East African goats, *T0* grazing + hay supplementation, *T66* grazing + hay supplementation + 66 % of ad libitum concentrate, *T100* grazing + hay supplementation + 100 % of ad libitum concentrate

the other hand, the difference in net returns between T100 and T66 fattening levels was only Tsh 1,443.3 (2.8 %). It is intriguing to note that the cost of gain of a unit weight for goats under T66 (Tsh 2,017.9) was as low as 42.5 % compared with that of goats under T0 (Tshs 3,512.2). Thus, the present findings show that the optimal level of concentrate supplementation is T66 which is 352.9 g/goat/day.

Discussion

Feed intake

Concentrate supplementation reduced forage DM intake but increased total energy intake. Daily total ME intake for T0 goats of 4.4 MJ/kg DM was below the recommended value of 5.78 MJ/kg DM (Langston University 2000). DM intake of supplemented goats in this experiment (2.6–3.2 % of body weight) was higher than the range reported by Hamed and Eliman (2010).

Growth performance

The differences in growth performance of goats fed different dietary levels reflect variations in levels of nutrient intake. Increased growth rates from higher levels of nutrient intake have been reported (Mushi et al. 2009). The higher body weight gain for supplemented goats compared to those that received T0 can be attributed to increased availability of energy and protein from the high offer in goats fed with concentrate. The daily gain for supplemented goats was similar to Creole kids (Alexandre et al. 2009). Growth rate of 43–52 g/day for supplemented goats correspond with Somali goats of 44.7 g/day (Mellaku and Betsha 2008). On the other hand, the weight gain of kids under T0 of 12.4 g/day is higher than the −23.6- to −30.2-g/day values (weight loss) reported

Table 3 Least squares means ± SE for growth performance of castrated SEA × N and SEA goats under different levels of concentrate supplementation

Variable	Genotype (G)		Dietary levels (D)			Significance		
	SEA × N	SEA	T0	T66	T100	G	D	G × D
Body weight (kg)								
Initial	16.8±0.5	16.6±0.5	16.7±0.7	16.8±0.6	16.5±0.6	NS	NS	NS
Final	19.9±0.5	19.4±0.4	17.7±0.6 b	20.3±0.5 a	21.0±0.5 a	NS	**	NS
Slaughter	18.8±0.5	18.3±0.4	16.6±0.6 b	19.1±0.5 a	20.0±0.5 a	NS	**	NS
Total gain	3.3±0.5	2.8±0.4	1.0±0.6 b	3.6±0.5 a	4.4±0.5 a	NS	**	NS
Daily gain (g/d)	39.0±5.5	32.8±5.3	12.4±7.1 b	43.0±6.5 a	52.1±6.4 a	NS	**	NS
Fasting loss (%)	5.4±0.3	5.8±0.3	6.0±0.3 a	5.9±0.3 a	4.9±0.3 b	NS	*	NS
Body condition score (1–5)	2.8±0.1	2.9±0.1	1.7±0.2 b	3.3±0.2 a	3.4±0.2 a	NS	**	NS

Within breed and diet in the same row, least squares means with a common letter (a, b) are not significantly different ($P>0.05$)

NS not significant, *SEA × N* Small East African × Norwegian goats, *SEA* Small East African goats, *T0* grazing + hay supplementation, *T66* grazing + hay supplementation + 66 % of ad libitum concentrate, *T100* grazing + hay supplementation + 100 % of ad libitum concentrate

*$P<0.05$; **$P<0.001$

Table 4 Least squares means ± SE for killing-out characteristics of castrated SEA × N and SEA goats under different levels of concentrate supplementation

Variable	Genotype (G)		Dietary levels (D)			Significance		
	SEA × N	SEA	T0	T66	T100	G	D	G × D
Weight (kg) of empty body	14.6±0.1	14.9±0.1	13.4±0.2 b	15.3±0.2 a	15.7±0.2 a	NS	***	NS
Hot carcass	7.9±0.1 b	8.2±0.1 a	7.1±0.1 b	8.3±0.1 a	8.6±0.1 a	*	***	NS
Dressing % true	53.3±0.3 b	54.5±0.3 a	52.7±0.5 b	54.1±0.4 a	54.9±0.4 a	*	**	NS
Commercial	41.6±0.5 b	43.3±0.5 a	37.2±0.7 b	44.3±0.6 a	45.7±0.6 a	*	***	NS
Full GIT (kg)	5.6±0.2	5.3±0.2	6.7±0.2 a	5.0±0.2 b	4.6±0.2 b	NS	***	NS
GIT fill (kg)	4.06±0.2	3.81±0.2	5.33±0.2 a	3.40±0.2 b	3.07±0.2 b	NS	***	NS

Within breed and diet in the same row, least squares means with a common letter (a, b) are not significantly different ($P>0.05$)

NS not significant, *SEA* × *N* Small East African × Norwegian goats, *SEA* Small East African goats, *T0* grazing + hay supplementation, *T66* grazing + hay supplementation + 66 % of ad libitum concentrate, *T100* grazing + hay supplementation + 100 % of ad libitum concentrate, *GIT* gastrointestinal tract

*$P<0.05$; **$P<0.01$, ***$P<0.001$

by various workers (Mellaku and Betsha 2008; Mushi et al. 2009) where goats were maintained entirely on grass hay.

Killing-out characteristics

Concentrate-fed goats had higher values for all killing-out characteristics than goats on hay whereas their full GIT was reversed. The heavier full GIT from goats maintained under T0 were probably due to high forage intake in an attempt to compensate for the differences in energy contents in the grass hay. The results obtained of 7.1 kg HCW for T0 goats agree to the range of 5.9–7.1 kg for non-supplemented Black Bengal goats (Asaduzzaman et al. 2009). Superior DP found in goats under supplementation is most likely associated with relatively lower proportions of digester due to less intake of forage. Increase in DP with level of concentrate supplementation agrees with Mellaku and Betsha (2008).

Economic analysis of goat fattening

Although the total feed cost encountered in the forage-based group was relatively lower than that of supplemented goats, the system where goats were not supplemented resulted in low weight of carcasses and edible offal with higher cost of gain making this system more costly and less economical. Thus, combining grazing with concentrate supplementation is potentially more profitable than feeding without supplementation. A similar experience has also been reported in a previous study that used Arsi-Bale goats (Legesse et al. 2005). In the present study, it is noted that a gain of 1 kg under a medium level of concentrate supplementation (T66) compared with production of the same weight under T0.

Conclusion

Concentrate supplementation improved growth rate and carcass yield of SEA and SEA × Norwegian goats. The feed efficiencies and feed costs per kilogram of gain show that fattening goats in the semi-arid areas is beneficial, and the practice should therefore be promoted. It is, however, useful to collect more information on the extent of manipulating

Table 5 Effect of dietary level on economics of fattening

Variable	Dietary levels		
	T0	T66	T100
Feed costs per animal (Tshs)			
Concentrate/day	–	73.98	112.42
Hay/day/animal	41.81	12.51	7.09
Total cost, 84 days	3,512.17	7,264.40	10,039.01
Yields (kg)/animal			
Carcass	6.06	8.56	9.28
Edible offal	1.89	2.41	2.36
Skin	1	1	1
Revenue (Tshs/animal)			
Carcass	30,318.75	51,337.50	55,662.50
Edible offal	3,788.33	4,823.75	4,716.67
Skin	1,500.00	1,500.00	1,500.00
Gross return	35,607.08	57,661.25	61,879.17
Net return	32, 094.91	50,396.85	51,840.16
Cost of gain (Tshs/kg gain)	3,512.17	2,017.89	2,230.89
Net return due to supplementation	–	18,301.94	19,745.24

T0 grazing + hay supplementation, *T66* grazing + hay supplementation + 66 % of ad libitum concentrate, *T100* grazing + hay supplementation + 100 % of ad libitum concentrate

meat quality attributes of East African indigenous goats through feeding.

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