

A Local Supplementary Diet Improves Reproductive Performance in Does and Growth in Kids of Small East African x Norwegian Landrace Goats

*Msalya, G., G.T. Chalamila, and G. Kifaro

Department of Animal, Aquaculture and Range Sciences (DAARS), Sokoine University of Agriculture (SUA), PO Box 3004, Chuo Kikuu, Morogoro, Tanzania.

*Corresponding author e-mail: msalya@sua.ac.tz; Tel.: +255 23 260 3511-14

Abstract

In the tropical countries including Tanzania the major and economical feeds for ruminants are natural pastures. Yet, these feeds are oftentimes seasonal and are of poor quality such that they alone cannot meet optimum nutritional requirements for high producing ruminants such as dairy goats. Therefore, it has been advised to supplement such animals with concentrate to increase production and gain profit. However, commercial concentrates are expensive and are not commonly used by farmers. For this reasons, animals are either not supplemented or are supplemented at very low levels with whatsoever available feeds. We believe that in Tanzania dairy goats are underfed and this situation has negative effects on the animals. We therefore conducted this study in 117 dairy goats (43 does and 74 kids) to confirm our hypothesis on one hand and show how supplementation is not always expensive. The feed was made from ingredients obtained in the local vicinities at a cheap price. These are available all over the country. Data were collected and analyzed using relevant tools and models including weighing, body condition score (BCS) scale and statistical software. Our high level diet was 600 grams (g) of a feed comprising of maize brans, sunflower seed cake and a few mixed minerals. It is common in many farms to provide only 200 g of maize brans. We report better performance for weights and BCS in dairy does fed a high level diet and better growing kids from these animals.

Keywords: Cross breeding, Dairy goats, Indigenous goats, Nutrition, Tanzania

Introduction

In Tanzania goats are important animals particularly in the rural farming communities of Tanzania and play significant roles in income and nutrition improvement (Msalya *et al.*, 2017). In terms of priority, goats are second after cattle (URT, 2012). Of the estimated 18.8 million goats in the country, about 98 percent belong to the Small East African (SEA) breed, a major breed in East African countries (MLF, 2018). Although the SEA goats are valued for such traits as hardiness in poor production environments in the region, they are low producers of meat and milk, have been shown to grow slowly, consequently take long to reach mature weight, and thus, they become less profitable (Chenyambuga *et al.*, 2004). Governments in various African countries including Tanzania have emphasized crossbreeding the local animals such as the SEA

using exotic goats to improve productivity of meat and milk. In the country, Boer and Kamorai goats have been imported since 1960s and used in crossbreeding programmes to improve meat production (Das and Sendalo, 1991). Likewise, the authors reported that since the same time Toggenburg, Saanen, Alpine and Anglo-Nubian have been used in crossbreeding and upgrading programmes with the SEA goats to improve milk production.

Unlike meat goats, dairy goats (mainly 50 to 87 percent crosses with SEA goats) are now spread in all regions of Tanzania including Zanzibar and have been increasing in numbers (Msalya *et al.*, 2016). In addition, breeding of dairy goats is one of most remarkable and most popular among livestock breed improvement programmes conducted in the country (Msalya

et al., 2017). These animals have been shown to perform better than the indigenous (SEA) goats particularly on traits such as growth rate, milk yield and reproductive potential (Mtenga and Kifaro, 1992). In other reports, lactation yield of dairy goats has been shown to be closer to the indigenous Tanzania shorthorn zebu cattle (Msalya *et al.*, 2016; Msanga *et al.*, 2009). Dairy goats are increasingly reported to reduce income and nutrition vulnerability among the poor households in the country (Chenyambuga *et al.*, 2014; Eik *et al.*, 2008). The nutritional benefits were recently highlighted in Msalya *et al.* (2016). Furthermore, dairy goats are the suitable animals for conservation agriculture and potential for mitigating the effects of climate variability (Zervas and Tsiplakou, 2013) and are also accepted and farmed in urban and peri-urban areas of Tanzania (Mtenga and Kifaro, 1992).

However, the potential and progress of dairy goats in Tanzania are challenged by various factors including lack of clear and specific policies, thus the haphazard breeding and poor management (Nziku *et al.*, 2017; Msalya *et al.*, 2017). Sub-optimal feeding due to lack of nutritious feeds is among the major factors contributing to low productivity improvement (Rastogi *et al.*, 2006). Most ruminant animals in the country depend on natural pastures which have been shown to be less nutritious and highly seasonal due to various factors (Maleko *et al.*, 2018). The negative effects of poor feeding vis importance of nutritious feeds for improved meat production in SEA and crossbred goats in Tanzania have been researched extensively by various workers including Safari *et al.* (2009) and Hango *et al.* (2007). Dairy goats are high milk producing animals, and thus should be provided with high plane of nutrition (Gül *et al.* 2016). It has been shown that grazing alone is not sufficient for optimizing live weight gain and reproductive performance of dairy goats (Hossain *et al.* 2003; Acero *et al.* 2008). In addition, these authors underscored the importance of concentrate supplementation for improved growth and productivity. A study on sheep by Rafiq *et al.* (2007) obtained better values for body weight gain and body condition

score (BCS) in ewes supplemented with multi nutrient urea molasses blocks than those which were fed pasture alone. Challengingly, the main commercial concentrate feeds suggested by various researchers and commonly used in Tanzania have been expensive and are rarely accepted by the farmers in the rural communities (Maleko *et al.*, 2018). For this reason, cheaper supplementary diets (rations) are of great needs for dairy goats feeding in these communities. We therefore designed this study to test a cheap concentrate feed made from locally available ingredients. We were interested on seeking first-hand valuable information to farmers and we used crosses of SEA x Norwegian Landrace (NL) goats in the study. The NL goats are the majority and most researched among the introduced dairy goats.

Materials and Methods

Study animals

This study was carried out in Morogoro, Tanzania within Magadu dairy farm (MDF), a facility of the Department of Animal, Aquaculture and range Sciences (DAARS) at Sokoine University of Agriculture (SUA). A total of 43 filial generation 1 (F1) crosses of SEA and NL goats were involved in this study. All 43 animals were does and were randomly obtained from Magadu dairy goats flock and were approved for breeding based on age (about 6 month and above) and BCS according to Russel *et al.* (1969). Care was taken to have animals of almost similar age and BCS. Important management aspects such as feeding (the core of this study), housing (repair and cleaning), as well as disease control (control of internal and external parasites including deworming and spraying) were carefully planned to prepare the does for breeding. The does were mated by a well-fed and well cared buck which was allowed to follow them freely. Pregnancy was determined through visual observation of the animals' physical appearance or signs of pregnancy, re-occurrence of estrus signs as well as palpation. The buck was allowed to stay with the does until all of them were pregnant (within 60 days breeding period). All does kidded at least 150 days later and they were followed in a separate experiment.

Grazing, supplementary diet and feeding experiment

The animals were grazed in MDF pasture plots comprising of natural and improved species

the animal nutrition laboratory in DAARS using conventional techniques. The metabolizable energy (ME) in the diet was 12 MJ/kg DM and the crude protein (CP) was 19%.

Table 1. Chemical composition of the supplementary feed used in this study

Chemical component	Amount in feed
Dry matter (g/kg)	910
Crude protein (g/kg DM)	173
Ether extract (g/kg DM)	134
Ash (g/kg DM)	52
Neutral detergent fibre (g/kg DM)	391
Acid detergent fibre (g/kg DM)	223
Crude fibre (g/kg DM)	146
In vitro dry matter digestibility (g/kg DM)	546
In vitro organic matter digestibility(g/kg DM)	546
Nitrogen free extract	405
Metabolisable energy (MJ/Kg DM)	12.6

according to the farm routine. At MDF, goats are routinely grazed for five hours from 8:30 to 1330 hours (Msalya *et al.*, 2017) in natural pastures (grasses and legumes) mainly various species of *Cynodon*, *Bricharia*, *Cencrus*, *Chloris*, *Bothriochloa*, *Urochloa*, *Wondering Dew* and *Pheuleriaphaso*. The grazing fields comprise of a few natural or established browse and multi-purpose trees including *Feidhebia albida*, *Harisonia habisinica*, *Acacia tortilis*, other *Acacia* species, and *Luercene*. After returning the goats are normally provided a little (unweighted) chopped dry hay or fresh Napier grass. The lactating does are each additionally provided a maximum of 200 grams (g) of MDF mixed diet including maize bran, limestone and table salt. In our case, arrangements were made for the study animals to graze and browse separately without interference. We improved the diet by collecting improved maize bran (MB) from the local milling machines and including 70% in the diet, sunflower seed cake (SFC) from local sellers and included 27%, and minerals comprising of limestone, bone meal, table salt and commercial mineral premix at a level of 3%. The ingredients were mixed thoroughly and three samples were taken to confirm the chemical composition (Table 1) in

The does were divided into three supplementation groups and provided the same diet at 200g (T1) for group 1 (n=14) also used a control (farm level supplementation), 400g (T2) for group 2 (n=15), and 600g (T3) for group 3 (n = 14). This feeding regime was administered twice per day (a small portion in the morning before grazing and the remaining portion was provided freely after grazing) during breeding period (60 days) and gestation (150 days). At kidding, the kids were identified using ear tags and concurrently birth types (single or twins) as well as sex of kid were recorded.

Collection of data

We collected two types of data set one for the does and the second for the kids. The development of the does in particular their weights and BCS were estimated one time during gestation season (30 days before kidding), at kidding, as well as during weaning. Weighing of individual goats was accomplished by a round spring balance (Hanson™ 500g accuracy class III model No. 21, H. Enterprises, India) in locally made animal aprons. The BCS values were determined based on a five point scale ranging from 1 (very thin) to 5 (very fat) as described in Russel *et al.* (1969). The kids were only weighed, at birth (within 24

hours) to determine birth weight (BW) and each 30 days until weaning (90 days).

Data analyses

The collected data were organized into categories including does' body weights and BCS at different points, as well as the kids' BW, average daily gain (ADG), and weaning weight (WW). The ADG values were computed using a linear formula comprising of weights at different stages and time at which the records were taken (Msalya *et al.*, 2017). The data were then subjected to the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS) version 9.0 (SAS, 2004) to estimate the averages and analyses were run following the relevant analytical models. Averages for each data category were obtained from the same and statistical comparisons were made based on analysis of variance (ANOVA) in SAS. Our dependent factors were the feeding levels of does (T1 – T3) up to kidding time. Included in the models as independent factors (particularly in kids data) were birth type, sex, BW, WW and ADG of kids. In all of our analyses, P-values <0.05 were regarded significant.

Results

Body weight and body condition score (BCS) for does

All does gained weight during the experimental period (data collection). However the rate of gain was different among groups of feeding. Although all animals had approximately the same weight when they were mated (between 20 and 21 kg), does in T1 reached 28.7 kg in weight (increase of 8.7 kg) at kidding time (approximately 150 days later), while T2 and T3 gained above 10 kg, 30.2 kg and 31.6 kg respectively during the same period, a significant difference among the groups ($P<0.001$). At kidding (24 hours) all does had their weights dropped to 23.6 kg (in T1) equal to a loss of 5.1 kg, 25.6 kg or loss of 4.6 kg (in T2) and 27.9 kg or loss of 3.7 (in T3). The differences in recorded weights were significant at $P<0.001$. Similarly at weaning time, weight drop continued in all groups whereas T1 animals had lost in average 1.3 kg weight, a greater value compared to 0.8 kg loss for T2 and T3 animals. The various weights measured during the study period including overall and standard error values are summarized in Table 2. With respect to BCS, almost a similar trend

Table 2: Least squares means (\pm SE) for weights and BCS in SEA x NL does supplemented with a locally made concentrate

Overall (43)	Feeding groups				Significance
	T1 (14)	T2 (15)	T3 (14)		
Body weight					
At mating (kg)	20.7 \pm 0.53	20.7 \pm 0.6	20.2 \pm 0.6	21.2 \pm 0.5	NS
30-d pre-kidding (kg)	30.2 \pm 0.50	28.7 \pm 0.52 ^b	30.2 \pm 0.5 ^a	31.6 \pm 0.48 ^a	***
At kidding (kg)	25.7 \pm 0.51	3.5 \pm 0.55 ^c	25.6 \pm 0.5 ^b	27.9 \pm 0.48 ^a	***
At weaning (Kg)	24.7 \pm 0.48	22.3 \pm 0.49 ^c	24.8 \pm 0.5 ^b	27.1 \pm 0.45 ^a	***
Body condition score					
At mating	2.3 \pm 0.10	2.4 \pm 0.1	2.4 \pm 0.1	2.2 \pm 0.1	NS
30-d pre-kidding	4.2 \pm 0.10	3.9 \pm 0.1 ^c	4.2 \pm 0.1 ^b	4.4 \pm 0.1 ^a	***
At kidding	2.9 \pm 0.10	2.6 \pm 0.1 ^b	2.8 \pm 0.1 ^b	3.3 \pm 0.1 ^a	***
At weaning	2.8 \pm 0.10	2.2 \pm 0.1 ^c	2.7 \pm 0.1 ^b	3.4 \pm 0.1 ^a	***

Different superscript within a row represent statistical significance among feeding groups ($P<0.05$); NS: not significant; * $P<0.05$; ** $P<0.01$; *** $P<0.001$

was obtained (with very little variation) where; (i) animals in all groups had better conditions 90 days pre-kidding, (ii) there was loss of body condition at kidding, and (iii) loss of condition for animals in T1 and T2 and a small increase in condition for animals in T3 group. The values for BCS were statistically significant among groups. Summaries, including the overall values for each category of data are also presented in Table 2.

Weights of kids at different points of growth and pre-weaning daily gain (ADG)

During the study, a total of 74 kids were born.

were statistically significant ($P < 0.05$) among the feeding groups. It was of interested in our study to analyze the influence of sex and type of birth among the kids born with regard to the three parameters. We observed a significant higher weights and more growth in males compared to females kids and as expected better values in single born kids than the twins. The males were heavier in BW than females by 0.2 kg while single born kids were also heavier than twins by 0.8 kg. The differences were statically significant ($P < 0.001$). Detailed results regarding BW, WW and ADG including the overall values are presented in Table 3.

Table 3: Least squares means) for body weight weights of kids at birth and at weaning and pre weaning daily gains

	BW (kg±SE)	WW (Kg±SE)	ADG (g±SE)
Overall	2.4±0.03 (74)	11.9±0.11 (65)	104±1.19 (65)
	***	***	**
T1	2.2±0.06a (21)	11.1±0.21a (16)	98±2.32a (16)
T2	2.6±0.06b (26)	12.1±0.20b (23)	105±2.28b (23)
T3	3.0±0.05c (27)	12.7±0.18c (26)	108±2.00b (26)
	***	***	***
Male	2.7±0.04a (35)	12.5±0.15a (32)	109±1.65a (32)
Female	2.5±0.04b (39)	11.4±0.17b (33)	98±1.88b (33)
	***	***	*
Single	3.0±0.05a (18)	12.6±0.18a (17)	107±2.05a (17)
Twins	2.2±0.04b (56)	11.3±0.14b (48)	101±1.54b (48)

Different superscript within a column represent statistical significance among feeding groups ($P < 0.05$); NS: not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

Of these, thirty five (35) were males and 39 were females whereas 18 were single and 56 were twins. Five kids died before weaning for various reasons. We present the results (BW, WW, and pre-weaning ADG) in feed, sex and type of birth. In agreement with results of weights and BCS in does, the kids born from does of T3 showed greater values in BW, WW, and ADG compared to those which were born of does in T1 and T2. The kids from T3 were heavier in BW than those from those in T2 and T1 by 0.4 kg and by 0.8 respectively, a similar trend for WW and ADG factors. The difference in the three parameters

Discussion

Low quality forage, especially pasture in communal rangelands is the most economical source of feeds and nutrients for ruminants in most developing countries including Tanzania. However, these feeds are not sufficiently contributing to optimum productivity in high producing animals such as dairy goats due to the pastures' inherently or climatic influenced low nutritive values and their seasonality nature. To efficiently feed and increase profitability from animals such as these it is necessary to supplement with high quality concentrate diets

to enable them reach their genetic potential for milk production and growth (Schoenian, 2009). In kids, supplementation using concentrate diets increases rate of gain. Also, high rate of reproduction such as the short kidding intervals and high twinning rates in female dairy goats increases the animal's requirement for nutrients. However, concentrate diets which have been proposed in various countries are often times availed commercially and are becoming expensive for the poor farmers in particular those who live and work in the rural communities (Maleko *et al.*, 2018)

Although dairy goats were introduced to improve food and income security in various parts of Tanzania, the productivity and performance of these goats is still sub-optimal, and much large impact has not been realized. Low kidding weights of does, loss of condition of does during lactation, low birth weights of kids and low weaning weights of kids have been reported in these goats and most of these challenges are associated to poor nutrition. It was hypothesized in the present study that improved concentrate supplementation to SEA x NL F1 does would result into healthy and well progressing does as well as heavy kids at birth, which will grow fast, obtain high weight at weaning and thus earlier returns. Specifically we aimed to assess how the different levels of concentrate supplementation may influence performance of does and their kids. Our interest was to achieve a better supplementation level using as much as possible locally available and cheap ingredients. We obtained all of our feed resources (ingredients) within shorter distances in Morogoro, Tanzania, and most of these resources such as maize bran are purchased at a very low price. Further in the rural communities, these are expected to be cheaper.

In our study, all animals increased their weight and improved their BCS. We noted that high plane of nutrition (at least a high supplementary level) increased the weights and BCS more than the lower levels, in our case $T3 > T2 > T1$. Better nutrition improves milk production in dams (Min *et al.*, 2005). High milk yield is associated with high daily gain of the kids because they

will be having enough milk. As a result, better and thrifty kids (in BW, WW and reasonable ADG) were obtained from dams which were fed well. Furthermore, better nutrients provision results in high supply of nutrients to the fetus reflected by higher birth weights. In congruence to our observations, Rastogi *et al.* (2006) found significantly lower birth weights in kids born from dams in low level of concentrate supplementation as compared to those which were in high and medium level of concentrate supplementation. In Aduli *et al.* (2004), does supplemented with concentrate at 2% of their body weight produced heavier kids as compared to does those which were supplemented with concentrate at 1% level or those which were not supplemented at all.

As a natural phenomenon, breeding animals including does are associated with loss of body weight and condition during and after giving birth mainly due to expulsion of both young and of the placenta. It has been shown that during this period does have less appetite, eat less feed while utilize their body reserves as they require more energy for both milk production and maintenance, a situation which lead most animals into a negative energy balance (Acero *et al.*, 2008). Our does, lost both weight and body conditions during kidding. Worth to note was a significant decrease of BW and BCS in animals in the low level of supplementation than those which were in the higher levels. It has been recommended to feed does well before and during early lactation to avoid excessive body weight loss while maintaining milk production levels (Kavanagh and Murphy, 2000). In another study elsewhere, Acero *et al.* (2008) observed more pronounced loss of BCS in dams supplemented with 200g of concentrate feed compared to those which were in higher levels of supplementation. In the second to third months after kidding the does start to gain body condition scores because they are producing less milk as the kids are towards weaning and are feeding on hard feeds on top of being suckled and the goats' appetite has returned to normal. Body condition of does has pronounced effect on daily weight gain of kids and it has been advised to allow them to kid at BCS between 3

and 4. Kids from does with lower ranges of BCS had been reported to have lower weight gain compared to those kidded by high BCS mothers (Zahraddeen *et al.*, 2008). Our does were within the recommended range at kidding time. Both lower and high BCS value had negative effects on the animal. For example BCS 5 or above towards the end of pregnancy is associated with the risk of pregnancy toxemia (Luginbuhl *et al.*, 1998).

Concerning the influence of sex and type birth, male kids as well as the single born outperformed the female and twin births in all three measured parameters in our study. Our observation is in agreement with findings from previous studies conducted in other places including a report of Zahraddeen *et al.* (2009) in which male kids were superior in weight and growth than the female counterparts from birth to 120 days. Among the scientific explanations is the evidence of anabolic effect of male sex hormones in male kids (Elabid, 2008). In Tanzania, a similar observation was recently reported in the same goats in a rural setting by Msalya *et al.* (2017). In the same study, single born kids had better performance than the twin births. In this study, kids born single were gaining more than their counterparts born twins in all supplemented groups, however it was more pronounced in kids born from does supplied high plane of nutrition. It is obvious that twin or multiple kids compete for nutrients in the uterus and when they are born. In another study, Islam *et al.* (2009) observed that the higher WW are obtained in kids born from supplemented does. It has been clearly evident that supplementation significantly increase kid growth rate to weaning.

We have shown the importance of nutrition in the dams and the influence for better growth and quick gain in kids. This is attained through supplementation of does by more nutritious concentrates. Along with the importance nutrition, literature suggest other factors needed for better growth and development in goats including size, weight, and health status of does at mating and kidding (Hossain *et al.*, 2003; Kochapakdee *et al.*, 1994). We note the

importance of other factors including proper breeding, housing management and provision of good care and diseases control in goat flocks to maximize profitability.

Conclusions

The MDF is a property of the DAARS at SUA in Tanzania. In this farm dairy goats have been supplemented for years using purchased concentrates and the farm has incurred millions of money to feed the high producing animals including goats. Probably because of the feed cost which has been estimated to be 50 – 80% of farm cost in MDF and elsewhere, dairy goats are provided only 200 g of concentrate supplements per day. We have showed that this amount is far too little and ruins the dairy goats especially the does which lost weight and body condition at kidding and imparts slow growth of kids. We have shown that, an increase in amount of concentration improves both weights and BCS of the does and influence better growth in their kids. The feed was mixed using the same local ingredients as available at MDF which we regard as a cheap feed and recommend it to the farmers. We recommended finding out the best economical way of feeding the animals with much limiting to the welfare of animals. Therefore supplementation during pregnancy economizes production and minimizes reproductive wastage in goats.

Ethical approval

In Tanzania, research permits are provided by the Commission for Science and Technology (COSTECH). We received permission from the SUA Vice Chancellor on behalf of COSTECH to undertake our study. Animal welfare was not compromised during our study. No humans were needed for soliciting data of our study.

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Conflict of Interest Declaration

We have no conflict of interest for this article.

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Authors' Contributions

GTC and GCK designed the experiments. GTC and GMM carried out the analysis and drafted the manuscript. GTC did the statistical analyses. GMM, GTC and GCK structured scientific content. All authors provided editorial suggestions and revisions, and read and approved the final draft.

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