

Interaction of protein supplementation and ecotype on growth performance and carcass traits of Nguni goats

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Abstract

Nguni goats are thought not to respond to dietary protein supplementation. The objective of the study was to determine the interaction of protein supplementation and ecotype on growth performance and carcass traits of Nongoma, Msinga and Cedara Nguni goat ecotypes. Thirty-six five-month-old castrated males were randomly allotted to a 3 × 3 factorial design experiment and provided 0, 150 and 300 g protein concentrate per day. There was an interaction of ecotype and protein supplementation on average daily gain (ADG). The ADG of the Nongoma and Cedara goats increased with protein supplementation, but the Msinga ecotype was not affected by the treatments. Goats of the Cedara ecotype weighed 34.4 kg when provided 300 g of supplement, whereas the Nongoma ecotype weighed 26.5 kg at slaughter when unsupplemented. The dressing percentage did not differ with the level of protein supplementation or ecotype. From the fifth quarter, the skin was affected by ecotype, gut fill by protein supplementation and the weight of the head by both factors. The Cedara ecotype had a heavier fifth quarter at 300 g supplementation. There was no interaction of protein supplementation and ecotype on dissectible fat. Intestine and visceral fats were affected by protein supplementation, whereas stomach fat was affected by ecotype.

Keywords: Average daily gain, carcass weight, chilling loss, fat deposits, dressing percentage, prime cuts

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Introduction

Goat farming is one of the fastest growing livestock sectors in southern Africa (Mkwazi *et al.*, 2020), especially for resource-limited households (Visser & Van Marle Koster, 2017). About 70% of the goats are kept under traditional extensive management systems where the farm has more than 20 goats (Monau *et al.*, 2020; Ndlela *et al.*, 2021). Nguni goats are exposed and adaptable to different environmental conditions and they survive and reproduce efficiently on grazing-degraded lands and low-quality forages (Lebbie, 2004; Mdladla *et al.*, 2016). They contribute to food security through provision of meat, milk (Mseleku *et al.*, 2020; Qokweni *et al.*, 2020), and income (Durawo *et al.*, 2017), and are an effective ecological method of managing bush encroachment. Their contribution, however, would be more valuable if their productivity could be improved.

Farmers hardly provide protein supplementation as they depend on natural pastures for nutrition, hence during periods of feed shortages productivity declines. However, protein supplementation can boost productivity. Goats fed on protein supplements have shown increased growth rate and low nematode burdens. Chevon reduces the risk of cardiovascular diseases and cancer as it supplies essential fatty acids, particularly linoleic acids (Mahgoub *et al.*, 2012). Protein intake improves resilience and resistance to *H. contortus* in pen-raised goats (Atiba *et al.*, 2016). Although there are perceptions that Nguni goats do not respond well to protein supplementation, non-governmental organisations such as Mdukatshani Rural Development Trust have embarked on programmes to improve goat productivity. These initiatives include identifying and developing lucrative markets and dietary supplementation. Owing to their adaptability, indigenous goats are found in a varying range of production ecotypes (Scott-Shaw & Escott, 2011). Although the importance of indigenous goats is increasingly being recognised, they are not registered as distinct breeds. The variations in climate and vegetation in KwaZulu-Natal are thought to have resulted in three

distinct goat ecotypes: Msinga, Nongoma, and Cedara. The Msinga ecotype for example is thought to be tolerant to heartwater. The Cedara ecotype has been developed from nearly a quarter of a century of selection and is adapted to receiving dietary supplementation during the dry season. The Nongoma ecotype is maintained on grazing, with limited browsing (Mdladla *et al.*, 2016). As such, there is need to determine whether there is an interaction between protein supplementation and ecotype on growth performance, health status and carcass traits of Nguni goats. Understanding the response of these ecotypes to protein supplementation would assist policymakers and goat producers in ing protein requirements to optimize growth. These efforts are designed to support the infrastructural development programme, such as construction of abattoirs and identification of niche markets. It is, thus crucial to determine whether these ecotypes respond similarly when dietary protein supplementation is provided.

The nutritional quality of natural pastures often varies with seasons, thus increasing susceptibility to parasites and diseases. Growth performance and carcass characteristics of goats supplemented with dietary proteins need to be understood to enable farmers to predict dates of sale or slaughter, making it easier for planning and developing markets. In these ecotypes, the influence of protein supplementation on dressing percentage (DP), carcass weight (CW), amount of saleable meat, and the fifth quarter, which is usually ignored, need to be determined. The objective of the study was therefore to assess the interaction of protein supplementation and ecotype on the growth performance and carcass characteristics of Nguni goats. It was hypothesised that no differences exist in the growth performance and carcass characteristics of the three Nguni goat ecotypes.

Materials and Methods

The study was approved by the Department of Agriculture and Rural Development Research Committee, Project number AS 2017 03C and complied with the standards required by the Animal Research Ethics Committee of the University of KwaZulu-Natal (Reference Number: AREC/043/017).

The study site was Cedara Research Station, located at 29°31'59.99" S and 30°16'60.00" E at 1 037 m above sea level. The mean annual rainfall is 900 mm. The study was conducted in the Animal and Poultry Science Laboratory, University of KwaZulu-Natal. The cocksfoot pasture cv. Cristobal was established in 2016 at a rate of 15 kg seed/ha. Rotational grazing of the cocksfoot pasture was practised. Limestone ammonium nitrate (LAN 28%) fertilizer was also applied at 30 kg N/ha every year. Irrigation was also practised when rain was late. Nutritional quality of the pasture was monitored weekly. Crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined for whole plant samples, using AOAC (1990). The nutritional composition of the cocksfoot pasture averaged 192, 650, and 360 g/kg CP, NDF and ADF, respectively.

The goats used in the study were born between May and June 2019 and were castrated at two weeks old, and had been obtained from Msinga and Nongoma. They were weaned and transported to Cedara College of Agriculture at three months old. All kids were of good vigour and condition, without any symptoms of ill-health or stunting. The goats were four months old at the start of the experiment. The goats were provided with 0, 150, or 300 g/goat/day of supplemental pellets. The nutritional quality of pellets is shown in Table 1.

Table 1 Nutritional composition of pellets used to assess interaction of protein supplementation and ecotype in Nguni goats

Proximate analysis	Content	Mineral	Content
Dry matter	93.6 g/kg	Calcium	9.2 g/kg
Crude protein	154.3 g/kg	Magnesium	2.1 g/kg
Acid detergent fibre	228.9 g/kg	Potassium	11.9 g/kg
Neutral detergent fibre	427.2 g/kg	Phosphorus	5.4 g/kg
Crude fat	26.9 g/kg	Zinc	285 ppm
Ash	106.7 g/kg	Manganese	251 ppm
		Copper	8 ppm
		Iron	1294 ppm

These treatments were arranged in a 3 × 3 factorial design. There were four goats for each treatment combination. After purchase, an adaptation period of two weeks was provided to adjust the goats to pastures, which formed the basal diet for all the goats. All goats were de-wormed using Lintex®, Startect® and AmiPour® to treat them against milk tapeworms, *Haemonchus contortus*, and external parasites, respectively.

All goats were provided with hay ad libitum. Exposure to cocksfoot pasture was increased gradually to prevent diarrhoea. They were vaccinated with Multivax P® (Intervet International B.V., Boxmeer, The Netherlands). The goats were weighed and allocated randomly to the experimental treatments. All goats grazed together on the cocksfoot pasture from 08h00 to 15h00, with ad libitum access to water. At around 15h30, each goat was allocated to a feeding pen based on treatment. After feeding, they were let out of the pens to access water and mineral lick. The goats were weighed and scored for degree of anaemia every second week.

After 205 days of feeding, all the goats were weighed to obtain slaughter weight. They were then transported to Estcourt Abattoir, about 80 km away. At the abattoir, they were put in a lairage overnight where they were not supplied with feed, but provided with free access to water. After spending 12 hours in the lairage, they were slaughtered humanely by severing the neck and hung to bleed out (Yildirim *et al.*, 2014). The four-compartment stomach and intestines were weighed before and after cleaning. The skin and head were also weighed.

Average daily gain (ADG) was calculated for each goat every two weeks. Final weight was recorded on the last day on pasture before goats were transported to the abattoir. Warm carcass weight refers to the weight of the carcass after the fifth quarter was removed. Carcass weight was recorded so that any chilling loss after 24 hours could be determined. A digital hanging scale was used to weigh each carcass. Carcasses were cleaned and stored at 4 °C. Dressing percentage was calculated as the weight of carcass expressed as a proportion of the slaughter weight. The difference between warm and cold carcass weights was used to estimate chilling loss (Pophiwa *et al.*, 2017)

The fifth quarter included the offal, four-compartment stomach, intestines, head, skin and dissectible fat. The full gut that was measured included the four-compartment stomach and intestines. The prime cuts comprised the neck, forelimb, dorsal trunk, ventral trunk, and hind leg and were weighed individually (Tshabalala *et al.*, 2003).

The effects of ecotype, protein intake and their interaction on carcass traits and weight of prime cuts were determined using PROC GLM of SAS (version 9.4, SAS Institute Inc., Cary, North Carolina, USA). Pair-wise comparisons of least square means were made using the PDIFF procedure.

Results and Discussion

Each goat consumed all of the protein supplement provided. Ecotype influenced ADG ($P < 0.05$). Protein intake, however, was not significant, but there was a significant interaction of ecotype and protein supplementation on ADG ($P < 0.05$). Nongoma goats given 300 g protein supplement had higher ADG than Msinga and Cedara goats at the same level of supplementation. The Nongoma and Cedara goats had a similar ADG at 150 g protein intake. The ADG of Msinga goats was similar at all levels of supplementation (Table 2).

Effects of the interaction between ecotype and protein supplementation on slaughter weight and the carcass weights were not detected. However, slaughter, warm carcass weight and cold carcass weight were affected separately by ecotype and protein supplementation ($P < 0.05$) (Table 2). Dressing and chilling loss percentages were similar for all of the treatments. The mean dressing percentage was $40.5\% \pm 13.5\%$. The overall chilling percentage was $2.3\% \pm 1.6\%$. There was no interaction between ecotype and protein supplementation on the weight of the fifth quarter components ($P < 0.05$). The combined weights of the emptied intestines and four-compartment stomach were not influenced by the ecotype and protein intake.

Protein supplementation affected the size of the head ($P < 0.05$) (Table 3). Cedara goats had heavier heads than other ecotypes, but did not affect weight of head of the Nongoma ecotype. For the goats that were unsupplemented, the Nongoma ecotype had lighter ($P < 0.05$) skin weights than the other ecotypes. Protein supplementation affected the weight of full guts ($P < 0.05$). The unsupplemented Cedara goats had lighter guts than the Msinga and Nongoma. At 150 g protein supplementation, all three ecotypes had similar weights of guts, whereas at 300 g, the Cedara goats had heavier full guts than the other ecotypes.

There was no interaction of ecotype and protein supplementation on intestinal, stomach and visceral fats ($P > 0.05$), but intestinal and visceral fats were affected by protein supplementation ($P < 0.05$), whereas stomach fat was affected by ecotype (Table 4). Nongoma and Msinga goats had the same amount of fat in all three levels of protein supplementation. For Cedara goats, there was an increase in intestinal and stomach fat weights as the level of protein increased. The trend in visceral fats followed those of stomach fats.

Table 2 Effects of ecotype of Nguni goats, protein supplementation and their interaction on growth and carcass weights

Trait	Ecotype	Level of protein, g/day			SE	Significance		
		0	150	300		ET	PS	ET x PS
Average daily gain								
	Cedara	0.031 ^a	0.047 ^{bc}	0.050 ^{cd}				
	Msinga	0.032 ^a	0.037 ^{ab}	0.036 ^{ab}	0.003	*	NS	***
	Nongoma	0.041 ^{bc}	0.052 ^{cd}	0.078 ^d				
Slaughter weight								
	Cedara	28.08 ^{ab}	32.98 ^c	34.43 ^c				
	Msinga	27.18 ^a	29.03 ^b	29.80 ^b	1.71	*	*	NS
	Nongoma	26.50 ^a	28.48 ^{ab}	29.00 ^b				
Warm carcass weight								
	Cedara	11.71 ^{ab}	14.20 ^b	15.35 ^c				
	Msinga	10.86 ^{ab}	12.03 ^b	12.72 ^b	0.87	**	**	NS
	Nongoma	10.36 ^a	11.65 ^a	12.51 ^b				
Cold carcass weight								
	Cedara	11.34 ^{ab}	14.01 ^b	15.08 ^c				
	Msinga	10.69 ^{ab}	11.94 ^{ab}	11.83 ^{ab}	0.86	*	**	NS
	Nongoma	10.15 ^a	11.40 ^{ab}	11.70 ^{ab}				

ET: ecotype, PS: protein intake; ET x PS: interaction of ecotype and protein intake

^{a,b,c,d} Values for each dependent variable with a common superscript did not differ with probability $P=0.05$ *** $P < 0.001$, ** $P < 0.01$ * $P < 0.05$, NS: $P > 0.05$ **Table 3** Effects of ecotype of Nguni goats, protein supplementation and their interaction on components of the fifth quarter

Trait	Ecotype	Level of protein, g/day			SE	Significance		
		0	150	300		ET	PS	ET x PS
Head, g								
	Cedara	1638 ^{abc}	1975 ^d	2137 ^e				
	Msinga	1550 ^{ab}	1713 ^{cd}	1638 ^{bc}	82.7	***	***	NS
	Nongoma	1463 ^a	1588 ^{ab}	1550 ^{ab}				
Skin, g								
	Cedara	1938 ^{ab}	1975 ^{ab}	2325 ^b				
	Msinga	1675 ^a	1763 ^{ab}	1863 ^{ab}	138.3	*	NS	NS
	Nongoma	1675 ^a	1763 ^{ab}	1863 ^{ab}				
Full guts, g								
	Cedara	5475 ^a	7350 ^{bc}	7675 ^c				
	Msinga	6150 ^{ab}	7200 ^{bc}	7313 ^{bc}	506.4	NS	**	NS
	Nongoma	6289 ^{abc}	7250 ^{bc}	7125 ^{bc}				

ET: ecotype, PS: protein intake; ET x PS: interaction of ecotype and protein intake

^{a,b,c,d,e} Values for each dependent variable with a common superscript did not differ with probability =0.05*** $P < 0.001$, ** $P < 0.01$ * $P < 0.05$, NS: $P > 0.05$

Table 4 Effects of ecotype of Nguni goats, protein supplementation and their interaction on weights of the dissectible fat depots

Fat depot	Ecotype	Level of protein, g/day			Significance			
		0	150	300	SE	ET	PS	ET x PS
Intestinal, g								
	Cedara	175 ^a	575 ^{bc}	613 ^c				
	Msinga	238 ^{ab}	325 ^{ab}	488 ^{bc}	109.5	NS	*	NS
	Nongoma	188 ^{ab}	225 ^{ab}	338 ^{ab}				
Stomach, g								
	Cedara	213 ^{ab}	325 ^b	488 ^c				
	Msinga	163 ^a	200 ^{ab}	313 ^{ab}	59.4	*	NS	NS
	Nongoma	213 ^{ab}	213 ^{ab}	313 ^{ab}				
Visceral, g								
	Cedara	000 ^a	338 ^{ab}	650 ^b				
	Msinga	000 ^a	200 ^{ab}	388 ^{ab}	130.9	NS	***	NS
	Nongoma	000 ^a	450 ^{ab}	463 ^{ab}				

ET: ecotype, PS: protein intake; ET x PS: interaction of ecotype and protein intake

^{a,b,c} Values for each dependent variable with a common superscript did not differ with probability =0.05

*** $P < 0.001$, ** $P < 0.01$ * $P < 0.05$, NS: $P > 0.05$

Mean weights of the prime cuts (neck, dorsal and ventral trunks, fore leg, and hind leg) were not affected by ecotype or interaction of ecotype and protein supplementation ($P > 0.05$; Table 5). However, the level of protein supplementation affected weights of prime cuts ($P < 0.05$). Relative to unsupplemented goats, the prime cuts were increased in weight by 14.8% (foreleg) to 26.5% (neck) when provided with 150 g/day, and by 20.9% (dorsal trunk) to 44.2% (neck) when provided with 300 g/day. Thus, the responses in weight of the prime cuts to the intermediate level of supplementation relative to the unsupplemented treatment were greater than the response to the high level of supplement when compared with the intermediate level.

The effects of ecotype on Nguni goat productivity have been ignored, yet there is substantial variation in frame size and growth rate. In recent years the government of South Africa embarked on a drive to reduce food insecurity through introducing abattoirs in communal areas, among other means. One of the challenges for the communities was to ensure that the abattoirs received sufficient numbers of livestock for slaughter. That forced farmers to explore opportunities for boosting productivity. It is therefore crucial that response of different Nguni goat ecotypes to dietary supplementation be explored.

Cocksfoot is a temperate species. Therefore, there is an increase in structural components such as lignin, cellulose, and hemicellulose with a rise in ambient temperature. To comprehend the performance of goat ecotypes, management and nutrition must be well understood. In the current study, the interaction of ecotype and protein supplementation on growth performance and carcass traits of three goat ecotypes was assessed under similar pasture-based environmental conditions.

Sustainable and profitable goat enterprises should be based on pastures (Goat production handbook, 2018). The interaction of ecotype with supplementation regime was observed only for ADG, highlighting the possible differences in growth among the Nguni ecotypes when protein supplementation was provided to goats with ad libitum access to pasture. Findings from the current study concur with those of Sebsibe *et al.* (2007), who observed an increase in ADG with an increase in protein supplementation in Ethiopian goat genotypes. The highest ADG recorded from Nongoma goats highlights the variations in growth performance of indigenous Nguni goat ecotypes. Such variations should not be ignored when designing feed supplementation programmes and when predicting goat off-takes from different regions of KwaZulu-Natal.

Table 5 Effects of ecotype of Nguni goats, protein supplementation and their interaction on weights of the prime cuts

Cut, g	Ecotype	Level of protein, g/day			SE	Significance		
		0	150	300		ET	PS	ET x PS
Neck	Cedara	250 ^a	338 ^{ab}	425 ^{bc}	42.1	NS	***	NS
	Msinga	263 ^{ab}	388 ^{bc}	450 ^c				
	Nongoma	338 ^{ab}	388 ^{ab}	350 ^{abc}				
Hind leg	Cedara	1650 ^{ab}	2150 ^{bc}	2350 ^c	130.3	NS	*	NS
	Msinga	1825 ^{ab}	1900 ^{ab}	1850 ^{ab}				
	Nongoma	1625 ^a	1888 ^{ab}	2063 ^{bc}				
Foreleg	Cedara	1013 ^{ab}	1250 ^{bc}	1363 ^c	94.7	NS	**	NS
	Msinga	1050 ^{ab}	1238 ^{ab}	1175 ^{ab}				
	Nongoma	975 ^a	1000 ^{ab}	1175 ^{ab}				
Dorsal trunk	Cedara	863 ^{abc}	1050 ^{bc}	1075 ^c	80.1	NS	**	NS
	Msinga	813 ^a	1100 ^c	1025 ^{bc}				
	Nongoma	838 ^{ab}	988 ^{bc}	938 ^{bc}				
Ventral trunk	Cedara	1438 ^{ab}	1700 ^c	1900 ^d	160.2	**	*	NS
	Msinga	1175 ^a	1338 ^{ab}	1213 ^{ab}				
	Nongoma	1200 ^{ab}	1550 ^{ab}	1625 ^{bc}				

ET: ecotype, PS: protein intake; ET x PS: interaction of ecotype and protein intake

^{a,b,c,d} Values for each dependent variable with a common superscript did not differ with probability =0.05

*** <0.001, ** <0.01 * <0.05, NS: >0.05

The lack of interaction between ecotype and protein supplementation on slaughter weight, warm and cold carcass weights, dressing and chilling loss percentages was not expected, given the interaction that was observed on ADG. The effects of ecotype and protein supplementation were reflected in greater weight at slaughter at 300 g protein supplementation in Msinga and Cedara goat carcasses. The Nongoma goats had the highest ADG, but lower carcass weights. The explanation is not clear. More information would be required, such as monitoring the behaviour of goats during transportation and at the lairage (Tadesse *et al.*, 2014; Pophiwa *et al.*, 2017). It is expected that stress associated with transportation depletes muscle glycogen and reduces warm and cold carcass weights (Kannan *et al.*, 2000; Webb *et al.*, 2005). All goats seemed calm during transportation and lairage and were of the same age.

The fifth quarter is usually ignored in conventional livestock slaughter operations. Although the fifth quarter is not exported, it attracts a sizeable income from local sales around the local communities. In rural communities for example the fifth quarter is regarded as meat. The overnight starvation at the abattoir could partly explain the lack of interaction between ecotype and protein supplementation on the weight of the head, skin, full guts, and emptied intestine and stomachs. The Nongoma goats that were not provided with protein supplementation had lighter head weights than other goats. When goat heads, are sold, the prices are usually similar, regardless of size. The skin is a valuable product, which can be processed into traditional attire, cushion covers and bags (De Villiers *et al.*, 1999; Bester *et al.*, 2009). The heavier skin from the Cedara ecotype could be explained because the goats were heavier at slaughter.

The observed differences in the weights of the forelegs among the ecotypes highlight the importance of assessing the various body parts to estimate income accurately. The lack of influence of protein supplementation on the weight of the hind and forelegs only of Msinga goats was also surprising. Protein supplementation should produce more protein in the carcass. Ignoring the ecotype when designing protein supplementation strategies may lead to goat farmers failing to realise profits that sustain their production.

Dissectible fats from the four stomachs, intestines and viscera were not affected by the interaction of ecotype and protein supplementation. Without protein supplementation, there were no dissected fats from any of the three ecotypes. The lack of interaction between ecotype and protein supplementation on prime cuts was a manifestation of the lack of interaction on slaughter weight and cold and carcass weights. All goats used in the current study were less than a year old at the time of slaughter. The only differences were

the locales in which they were born and raised to weaning, and to the level of protein supplementation that was provided.

Conclusion

The Nongoma ecotype performed best with high protein supplementation. That is, they attained higher ADG than the other ecotypes. For the Cedara and Nongoma goats, increased protein supplementation led to increased growth performance, whereas Msinga goats did not show any response. At slaughter, the Cedara ecotype had heavier slaughter weights, hence heavier warm and cold carcass weights than the others. To fully understand and improve the smallholder goat production system, it is important to assess the effects of age, sex and ecotype on growth performance, carcass traits and yield on various Nguni goat ecotypes. To influence consumer purchasing decisions, the quality of prime cuts must be determined, since these traits affect this decision.

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Author's Contributions

Conception and design: ZDN, MC; data collection and analyses, ZDN, MVM; drafting of paper: ZDN; critical revision and final approval of version to be published: MVM and MC.

Conflict of Interest Declaration

The authors certify that they have no affiliations with any organization or entity with financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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